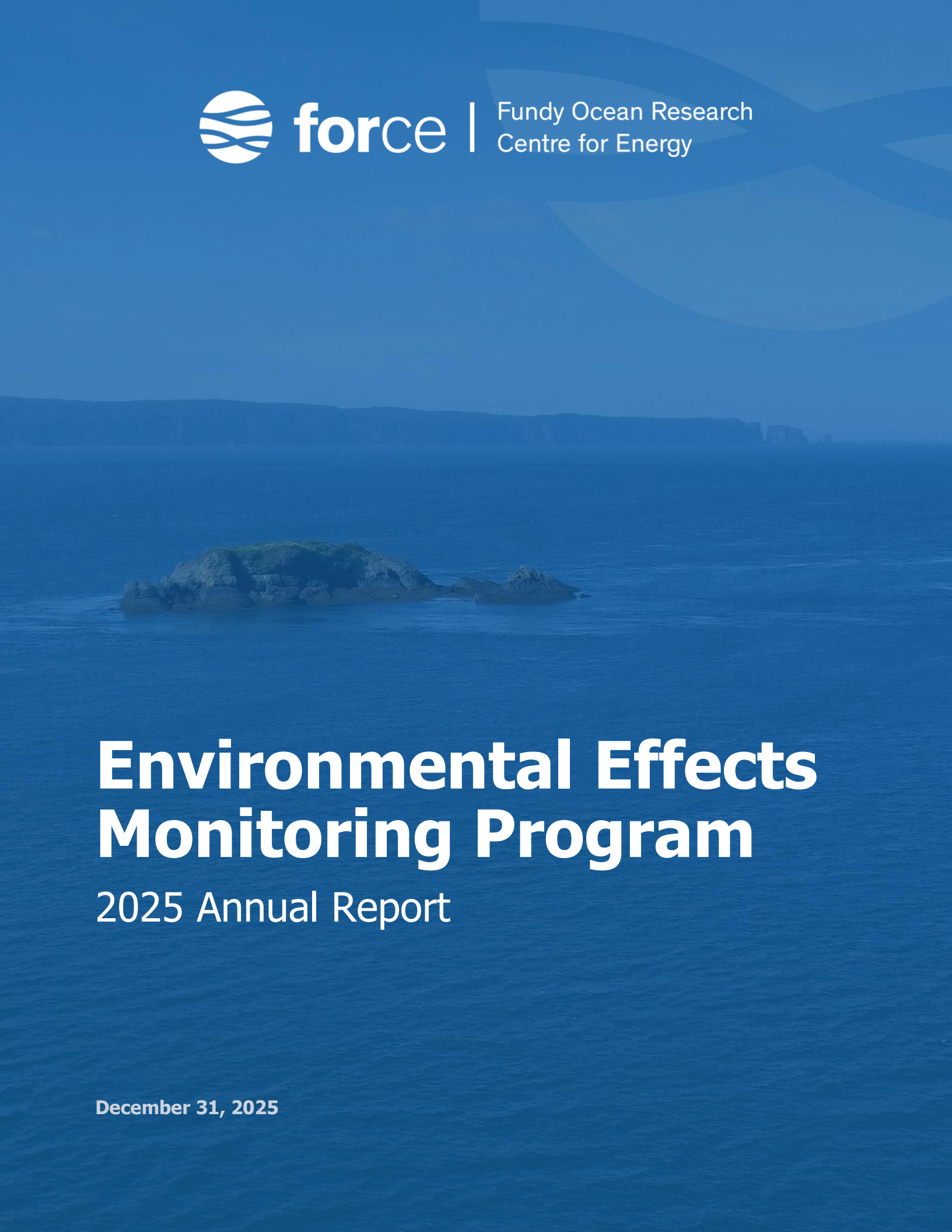

Fundy Ocean Research Centre for Energy

Environmental Effects Monitoring Program

2025 Annual Report

December 31, 2025

What's New?

DFO AUTHORIZATION

As part of the *Tidal Task Force on Sustainable Tidal Energy Development in the Bay of Fundy* Final Report in 2024, Fisheries and Oceans Canada (DFO) adopted a new "staged approach" into *Fisheries Act Authorizations* for tidal stream projects. In November 2025, the **Eauclaire Orbital Tidal Array 1** became the first project at FORCE to receive an authorization following this staged approach, enabling the deployment of up to three O2-X tidal energy devices at FORCE. read more

NEW INITIATIVES

FORCE has designed a new governance model – which includes a Board of Directors independent of developers – to strengthen FORCE's role as a site steward and create a more transparent, sustainable framework for protecting FORCE's regulatory and other commitments. read more

FORCE has partnered with Innovasea and a series of other collaborators on an Ocean Supercluster funded project to advance the application of artificial intelligence for monitoring fish around hydroelectric and tidal stream energy projects called **Hydroaware**. This quarter, *standard contrast* and *reflective* targets were added to the field of view of the cameras mounted on the platform currently in use by the project. read more

FORCE has initiated a **Mi'kmaq Ecological Knowledge Study** in partnership with the Confederacy of Mainland Mi'kmaq (CMM). The study will draw on Mi'kmaw knowledge and engagement to inform tidal planning; work has commenced including an initial site visit, desktop research, and Knowledge Holder interviews. read more

FORCE organized a workshop at the 2025 Marine Renewables Canada Conference entitled *Stronger Relationships: Netukulimk, Etuaptmumk and the Future of Ocean Energy* which brought together Chief Sidney Peters (Glooscap First Nation; Co-Chair, ANSMC), Angeline Gillis (Executive Director, CMM), Patrick Butler (Senior Mi'kmaq Energy and Mines Advisor, KMK) to discuss opportunities to integrate Mi'kmaw knowledge, leadership, values, and practices into tidal energy research and development. read more

In September, Natural Resources Canada announced $8.2M for the **Ocean Sensor Innovation Platforms** (OSIP) project led by FORCE in collaboration with Acadia University, CMM, Pacific Northwest National Laboratory and many other partners. Central to the project is the deployment of a floating platform for sea-surface environmental monitoring alongside submersible sensor systems deployed on the seafloor. In future tidal turbine deployments, sensors and methods tested by these platforms will capture essential data on fish–turbine interactions, addressing one of tidal energy's greatest challenges: accurately measuring and monitoring risk to marine species. read more

In December, as part of the OSIP project, FORCE completed a vessel-based testing campaign aboard the *Nova Endeavor* to evaluate optical camera and lighting configurations for subsea monitoring, including multiple camera systems, lighting arrangements, and target types at

depths of 5–25 m. The work also included pre- and post-deployment CTD casts with additional sensors, supporting the selection of an optimized camera and lighting setup for future subsea deployments in the Minas Basin. read more

ONGOING MONITORING ACTIVITIES

To support the year-round continuity of fish monitoring, FORCE has collaborated with the Ocean Tracking Network (OTN) to recover and re-deploy a line of **acoustic receiver stations** across Minas Passage to detect the movement of acoustically tagged fish. Data recovered from the HR2 receivers for the spring and summer 2025 deployment period has been processed and shared with OTN for further study by the broader research community. Discussion and design work continues with the aim to improve efficiency and redeployment timing – planning for 2026 recoveries is underway. read more

Executive Summary

Tidal stream energy devices are a maturing renewable energy technology that use the ebb and flow of the tides to generate electricity. These devices are in various stages of research, development, operation and testing in countries around the world.

FORCE was established in 2009 after undergoing a joint federal-provincial environmental assessment with the mandate to enable the testing and demonstration of tidal stream devices. Since that time, more than 100 related research studies have been completed or are underway with funding from FORCE, the Offshore Energy Research Association (OERA; now NetZero Atlantic (NZA)), and others. These studies have considered physical, biological, socioeconomic, and other research areas.

The current suite of monitoring programs implemented by FORCE build off those initiated during 2016-2020 that were conducted in anticipation of tidal stream energy device deployments at FORCE's tidal demonstration site. These efforts are divided into two components: FORCE 'site-level' monitoring activities (>100 metres from a device), and developer or 'device-specific' monitoring led by project developers (≤100 metres from a device) at the FORCE site. All monitoring plans are reviewed by FORCE's independent Environmental Monitoring Advisory Committee (EMAC) and federal and provincial regulators prior to implementation.

FORCE monitoring presently consists of monitoring for fish, marine mammals, seabirds, lobster, and marine sound. During monitoring from 2016 through 2020, FORCE completed over 550 hours of hydroacoustic fish surveys, more than 5,000 'C-POD' marine mammal monitoring days, bi-weekly shoreline observations, 49 observational seabird surveys, 11 days of lobster surveys, and four drifting marine sound surveys and additional sound monitoring.

The 2021-2023 EEMP was designed to prepare for effects testing with the deployment of operational tidal stream energy devices and adhered to the principles of adaptive management by evaluating existing datasets to ensure appropriate monitoring approaches are being implemented. Moreover, the plan adopted internationally accepted standards for monitoring where possible, including feasibility assessments for new monitoring approaches that were planned to be implemented. The 2021-2023 EEMP was intended to be implemented as designed and reviewed by FORCE's environmental monitoring advisory committee. However, because device deployments did not occur during the 2021-2023 time frame, an opportunity for effects testing was not presented. Given these circumstances, FORCE requested an extension of the 2021-2023 EEMP to 2024 and 2025; these requests were approved by the *Nova Scotia Department of Environment and Climate Change*. In 2026, FORCE will revise the EEMP based on the latest information on environmental monitoring best practices for review by EMAC and review/approval by NSECC.

Since the beginning of the 2021 EEMP, FORCE has completed 8 days of lobster surveys, 6 multi-month deployments of acoustic receivers to detect tagged fish, a preliminary radar feasibility study to monitor for seabirds, and bi-weekly shoreline observations.

FORCE has also been working with academic, Indigenous, and other partner organizations to develop credible and statistically robust encounter rate models for migratory and resident fish species in Minas Passage with tidal stream energy devices.

This work began with the Risk Assessment Program in 2020, which combined physical oceanographic data related to flow and turbulence in the Minas Passage with acoustic tagging information for various fish species in the region curated by the Ocean Tracking Network at

Dalhousie University. FORCE established a high-resolution radar network in Minas Passage to quantify hydrodynamic features in the region and build a tidal flow atlas to integrate with acoustic tracking data. In addition to existing data, the Mi'kmaw Conservation Group, local fishers, Acadia University and FORCE worked in partnership to complete additional fish tagging to build the knowledge base.

In 2025, FORCE launched the Ocean Sensor Innovation Platforms (OSIP) project, supported by $8.2M from Natural Resources Canada. OSIP brings together developers, scientists, technologists, Indigenous knowledge holders and regulators to advance environmental sensing solutions for high-flow marine environments. OSIP is preparing to deploy a floating platform for sea-surface environmental monitoring alongside submersible sensor systems deployed on the seafloor. In future tidal turbine deployments, sensors and methods tested by these platforms will capture essential data on fish–turbine interactions, addressing one of tidal energy's greatest challenges: accurately measuring and monitoring risk to marine species. OSIP is designed to:

- Test and compare new uses for instruments such as optical cameras, imaging sonars, and acoustic receivers in high-flow conditions
- Analyze multiple datasets to create a more complete picture of marine life near turbines
- Trial rapid, wireless sea-to-shore data transfer to improve real-time monitoring

Ultimately, this work will contribute towards understanding the risk of tidal stream energy development for fishes in the Bay of Fundy and will assist in the development of future environmental effects monitoring programs.

This report provides a summary of monitoring activities and data analyses completed by FORCE during the fourth quarter of 2025. In addition, it also highlights findings from international research efforts, previous data collection periods at the FORCE site, and additional research work that is being conducted by FORCE and its partners. This includes supporting fish tagging efforts with Acadia University and the Ocean Tracking Network, radar research projects, and subsea instrumentation platform deployments. Finally, the report presents details regarding future research and monitoring efforts at the FORCE test site. This includes work in support of the adaptive nature of the EEMP and OSIP programs.

All reports, including quarterly monitoring summaries, are available online at www.fundyforce.ca/document-collection.

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Introduction

This report outlines monitoring activities and results of data analyses conducted at the Fundy Ocean Research Centre for Energy test site in the Minas Passage, Bay of Fundy during October through December 2025. Specifically, this report highlights results of environmental monitoring activities conducted by FORCE and other research and development activities conducted at the FORCE site. This report also provides a summary of international research activities around tidal stream energy devices.

About FORCE

Established in 2009 and located in Minas Passage, Bay of Fundy, the Fundy Ocean Research Centre for Energy (FORCE) is North America's lead research facility for the demonstration of tidal stream technology. FORCE is a not-for-profit and has received funding support from the Province of Nova Scotia, the Government of Canada, and participating developers. FORCE acts as a catalyst to the tidal energy sector, providing:

- A technology site, connected to the grid
- Environmental monitoring data, shared with public
- Services and solutions to help projects succeed safely, bringing together industry, government, academia and other partners

Tidal stream energy technology operates much like a wind turbine placed under the water – passively harnessing the kinetic energy of flow and ebb tides to generate electricity. To date, a total of six devices have been built in Nova Scotia for deployment at FORCE: three by OpenHydro; two by Sustainable Marine Energy; one by Occurrent Power. Eauclaire Tidal has partnered with Orbital Marine Power (Orbital) to deploy its technology at FORCE; Orbital currently operates the world's most powerful tidal turbine in Scotland, the O2: a floating device 74 meters in length, supporting two 1-MW turbines.

The FORCE facility, located approximately 10km west of Parrsboro, NS, is designed to connect tidal stream devices to the provincial power grid. Its assets include:

- Subsea cables: Four double-armoured, 34.5kV subsea power cables, each 2 to 3 km in length, running from the ocean site to and underground vault at shore.
- Substation: This includes a 30 MW transformer, turbine control bays, switch gear and collector circuits, and revenue class metering.
- Transmission lines: 10km of overhead 69kV transmission line connecting the FORCE substation to the provincial power grid near the existing substation in the community of Parrsboro.
- Visitor Centre/Observation Facility: Free and open to the public from May to November, the centre has welcomed over 30,000 visitors from around the world, as well as supporting crews during marine operations.

FORCE's science program, which includes both in-house expertise as well as partnerships with world-leaders in marine science, is designed to support informed discussion among policymakers, regulators, rights holders, industry, scientists, and stakeholders. FORCE helps:

- Design and execute monitoring programs
- Support regulatory review and authorization processes
- Bring AI and machine learning to data collection and analysis
- Publish peer-reviewed research in collaboration with academic partners, including Acadia University and Dalhousie University

The global evidence so far is encouraging: in over 15 years of international research, the few observed fish interactions have not resulted in obvious harm, and marine mammals appear to have adapted without harm to a turbine installation. But these interactions must be modeled and tested in Minas Passage. FORCE's environmental effects monitoring program (EEMP) is designed to better understand the natural environment of the Minas Passage and the potential effects of turbines as related to fish, seabirds, marine mammals, lobster, and marine noise.

All of FORCE's monitoring reports are available publicly at https://fundyforce.ca/document-collection.

Background

The FORCE demonstration project received its environmental assessment (EA) approval on September 15, 2009, from the Nova Scotia Minister of Environment. The conditions of its EA approval[1] provide for comprehensive, ongoing, and adaptive environmental management. The EA approval has been amended four times since it was issued to accommodate changes in technologies and inclusion of more berths to facilitate provincial demonstration goals.

In accordance with this EA approval, FORCE has been conducting its EEMP to better understand the natural environment of the Minas Passage and the potential effects of tidal stream energy devices.

Since 2009, more than 100 related research studies have been completed or are underway with funding from FORCE, the Offshore Energy Research Association (OERA; now NetZero Atlantic (NZA)) and others. These studies have considered socioeconomics, biological, and other research areas.[2]

Monitoring at the FORCE site is currently focused on lobster, fish, marine mammals, seabirds, and marine sound and is divided into developer led 'device-specific' (≤ 100 m from a device) monitoring and FORCE led 'site-specific' (> 100 m from a device) monitoring. As approved by regulators, individual berth holders complete monitoring in direct vicinity of their device(s), in recognition of the unique design and operational requirements of different technologies. FORCE completes site level monitoring activities as well as supporting integration of data analysis between these monitoring zones, where applicable.

All developer and FORCE led monitoring programs are reviewed by FORCE's Environmental Monitoring Advisory Committee (EMAC), which includes representatives from scientific, First Nations, and local fishing communities.[3] These programs are also reviewed by federal and provincial regulators prior to device installation. In addition, FORCE and berth holders also submit an Environmental Management Plan (EMP) to regulators for review prior to device installation. EMP's include environmental management roles and responsibilities and commitments, environmental protection plans, maintenance and inspection requirements, training and education requirements, reporting protocols, and more.

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[1] FORCE's Environmental Assessment Registration Document and conditions of approval are found online at: www.fundyforce.ca/document-collection.

[2] Net Zero Atlantic Research (formerly Offshore Energy Research Association) Portal (https://netzeroatlantic.ca/research) includes studies pertaining to infrastructure, marine life, seabed characteristics, socio-economics and traditional use, technology, and site characterization.

[3] Information about EMAC may be found online at: www.fundyforce.ca/about-us

Device Deployments

Since FORCE's establishment in 2009, tidal stream energy devices have been installed at the FORCE site three times: once in 2009/2010, November 2016 – June 2017, and July 2018 – present; all of these have been bottom-mounted OpenHydro devices. Given the limited timescales in which a device has been present and operating at the FORCE site, environmental studies to-date have largely focused on the collection of baseline data and developing an understanding of the capabilities of monitoring instruments in high flow tidal environments.

In November 2025, with berth A already in development, an independent procurement administrator awarded Eauclaire/Orbital two additional berths at FORCE, allowing the companies to pursue a total of 16.5 MW at the site. The award includes tidal energy licences and power purchase agreements with Nova Scotia Power. Also in November, DFO issued a *Fisheries Act Authorization* to Eauclaire/Orbital to deploy up to three O2-X tidal energy devices at FORCE – marking the first project to proceed under Canada's revised, staged approach for tidal stream energy development.

DFO's staged approach – resulting from the federal *Tidal Task Force on Sustainable Tidal Energy Development* led by DFO and Natural Resources Canada – enables projects to begin with a single device supported by comprehensive environmental monitoring; insights gained from this data collection, interpretation and analysis inform requirements for additional device deployments. DFO's authorization outlines clear requirements for fish-protection measures, adaptive environmental-effects monitoring, and data-reporting protocols consistent with the *Fisheries Act* and the *Species at Risk Act.* More information on the *Task Force's* key findings are provided below.

The *Eauclaire Orbital Tidal Array Project* is now licensed by the Province to develop berths A, B and E at the FORCE test site. Orbital's O2X technology is a 2.4-megawatt floating device with two horizontal axis turbines. The project aims to ultimately install up to six floating tidal turbines at FORCE. The O2-X specifications include:

- Rated power output: ~2.4 MW (enough for about 2,000 homes)
- Maximum rotor speed: 12.8 RPM (about one rotation every five seconds)
- Swept area of both rotors: 452 m²
- Rotor depth during operation: 3 - 27 m below surface
- Mooring spread: ~515m x 220m, with ~225m-long lines and gravity or rockbolt anchors

The project's final description and Environmental Effects Monitoring Program continue to be developed in consultation with regulators, Rights Holders, and other partners.

Eauclaire/Orbital and future incoming berth holders are required to develop a device-specific monitoring program for their project, reviewed by FORCE's EMAC and federal and provincial regulators including Fisheries and Oceans Canada, the Nova Scotia Department of Environment and Climate Change, and the Nova Scotia Department of Energy, prior to device installation.

Relative scale:

Figure 1: The scale of a single turbine (based on the dimensions of the OpenHydro turbine deployed by CSTV, indicated by the red dot and above the blue arrow) in relation to the cross-sectional area of the Minas Passage. The Passage reaches a width of ~ 5.4 km and a depth of 130 m.

Overall, the risks associated with single device or small array projects are anticipated to be low given the relative size/scale of devices (Copping 2018). For example, at the FORCE site a single two-megawatt OpenHydro turbine occupies ~ 1/1,000th of the cross-sectional area in the Minas Passage (Figure 1). A full evaluation of the risks of tidal stream energy devices, however, will not be possible until more are tested over a longer-term period with monitoring that documents local impacts, considers site-level and cumulative effects, and adds to the growing global knowledge base.

International Experience & Cooperation

The research and monitoring being conducted at the FORCE test site is part of an international effort to evaluate the risks tidal energy poses to marine life (Copping 2018; Copping and Hemery 2020). Presently, countries such as China, France, Italy, the Netherlands, South Korea, the United Kingdom, and the United States (Marine Renewables Canada 2018) are exploring tidal energy, supporting environmental monitoring and innovative R&D projects. Tidal energy and other marine renewable energy (MRE) technologies such as tidal range, tidal current, wave, and ocean thermal energy conversion, and salinity gradients offer significant opportunities to replace carbon fuel sources in a meaningful and sustainable manner. Some estimates place MRE's potential as exceeding current human energy needs (Lewis et al. 2011; Gattuso et al. 2018). Recent research includes assessments of operational sounds on marine fauna (Schramm et al. 2017; Lossent et al. 2018; Robertson et al. 2018; Pine et al. 2019), the utility of PAM sensors for monitoring marine mammal interactions with turbines (Malinka et al. 2018) and collision risk (Joy et al. 2018b), demonstrated avoidance behavior by harbour porpoise around tidal turbines (Gillespie et al. 2021), a synthesis of known effects of marine renewable energy devices on fish (Copping et al. 2021), and the influence of tidal turbines on fish behavior (Fraser et al. 2018).

Through connections to groups supporting tidal energy demonstration and R&D, FORCE is working to inform the global body of knowledge pertaining to environmental effects associated with tidal power projects. This includes participation in the Bay of Fundy Ecosystem

Partnership[4], TC114[5], the Atlantic Canadian-based Ocean Supercluster[6], and OES-Environmental[7].

FORCE continues to work closely with OES-Environmental and its members to document and improve the state of knowledge about the interactions of MRE devices interactions with the marine environment. For instance, OES-Environmental incorporated new research topics for the 2024 State of the Science Report related to i) knowledge of environmental effects as the tidal energy industry scales up from single devices to arrays, ii) understanding the cumulative impacts of marine renewable energy with other anthropogenic effects, and iii) an ecosystem approach for understanding environmental effects, including interactions between trophic levels, between ecosystems and between ecosystem services. FORCE was involved in the development of all three of these topics and led the effort to understand the 'scaling up' of environmental effects of devices as the tidal energy sector transitions towards the development of commercial-scale arrays. A synopsis of this work and the other topics outlined above is included in chapter 9 of the OES-E 2024 State of the Science Report that was released in 2024.

Also in 2024, FORCE chaired a workshop at the Pan American Marine Energy Conference (PAMEC) entitled 'Monitoring for Interactions Between Marine Animals and MRE Devices,' which included 11 presentations by leading international researchers from Canada, the United States and United Kingdom on topics ranging from specific monitoring technologies (e.g., optical cameras, imaging sonars, acoustic telemetry) to applications of artificial intelligence, data management, and modelling approaches for understanding encounter rate and collision risk. FORCE staff attended the 2024 *Environmental Interactions of Marine Renewables* (EIMR) conference, a bi-annual conference focused exclusively on environmental effects, with delegates from across Europe and the United States, and with a strong contingent from Nova Scotia, including colleagues from the Acadia Tidal Energy Institute at Acadia University, and Fisheries and Oceans Canada.

Also in 2024, in collaboration with the European Marine Energy Centre (EMEC), FORCE hosted the 11th annual *International WaTERS Workshop* in Halifax. International WaTERS focuses on the experience of MRE test centers and associated organizations around the globe, with an aim to share knowledge, build relationships and foster collaboration. The workshop focused on permitting for wave and tidal energy projects at test centers, and included sessions focused on Canada's Tidal Energy Task Force and streamlining consenting processes in the UK, and breakout groups focused on regulatory uncertainty and managing risks associated with project delays. The International WaTERS Workshop was well attended, with 27 delegates from eight MRE test centers (AMEC, EMEC, PacWave, PRIMED, FORCE, Jennette's Pier, KRISO, K-TEC) and affiliated organizations (US. Department of Energy, National Renewable Energy Laboratory) from around the world.

[4] BoFEP is a 'virtual institute' interested in the well-being of the Bay of Fundy. To learn more, see www.bofep.org.
[5] TC114 is the Canadian Subcommittee created by the International Electrotechnical Commission (IEC) to prepare international standards for marine energy conversion systems. Learn more: tc114.oreg.ca.
[6] The OSC was established with a mandate to "better leverage science and technology in Canada's ocean sectors and to build a digitally-powered, knowledge-based ocean economy." Learn more: www.oceansupercluster.ca.
[7] OES Environmental was established by the International Energy Agency (IEA) Ocean Energy Systems (OES) in January 2010 to examine environmental effects of marine renewable energy development. Member nations include: Australia, China, Canada, Denmark, France, India, Ireland, Japan, Norway, Portugal, South Africa, Spain, Sweden, United Kingdom, and United States. Further information is available at https://tethys.pnnl.gov.

FORCE Monitoring Activities

FORCE has been leading site-level monitoring for several years, focusing on a variety of valued ecosystem components. FORCE's previous environmental effects monitoring program (2016-2020) was developed in consultation with SLR Consulting (Canada)[8] and was strengthened by review and contributions by national and international experts and scientists, DFO, NSECC, and FORCE's EMAC. The most recent version of the EEMP (2021-2023) was developed in consultation with Atlantis Watershed Consultants Ltd. with input from national and international experts, including FORCE's EMAC, and was submitted to regulators for approval. The 2021-2023 EEMP was modified from the 2016-2020 EEMP based on results of previous monitoring activities, experience and lessons learned, and has been extended to 2024 and 2025. This is consistent with the adaptive management approach inherent to the FORCE EEMP – the process of monitoring, evaluating and learning, and adapting (AECOM 2009) that has been used at the FORCE site since its establishment in 2009.[9] A similar process will be used for the development of the next iteration of the EEMP (i.e., 2026-2030).

FORCE's EEMP currently focuses on the impacts of operational tidal stream energy devices on lobster, fish, marine mammals, and seabirds as well as the impact of device-produced sound. Overall, these research and monitoring efforts, detailed below, were designed to test the predictions made in the FORCE EA. Over the course of the 2016-2020 EEMP, FORCE completed approximately:

- 564 hours of hydroacoustic fish surveys;
- more than 5,083'C-POD' (marine mammal monitoring) days;
- bi-weekly shoreline observations;
- 49 observational seabird surveys;
- four drifting marine sound surveys and additional bottom-mounted instrument sound data collection; and
- 11 days of lobster surveys

Since the beginning of the 2021 EEMP, FORCE has undertaken:

- 8 days of lobster surveys;
- 6 multi-month deployments of acoustic receivers to detect tagged fish;
- a preliminary radar feasibility study to monitor for seabirds; and
- bi-weekly shoreline observations

The following pages provide a summary of the site-level monitoring activities conducted at the FORCE site during October - December 2025, including data collection, data analyses performed, initial results, and lessons learned, that builds on activities and analyses from previous years. Where applicable, this report also presents analyses that have integrated data collected through developer and FORCE monitoring programs to provide a more complete understanding of device-marine life interactions.

[8] This document is available online at: www.fundyforce.ca/document-collection.

[9] The adaptive management approach is necessary due to the unknowns and difficulties inherent with gathering data in tidal environments such as the Minas Passage and allows for adjustments and constant improvements to be made as knowledge about the system and environmental interactions become known. This approach has been accepted by scientists and regulators.

Monitoring Objectives

The overarching purpose of environmental monitoring is to test the accuracy of the environmental effects predictions made in the original EA. These predictions were generated through an evaluation of existing physical, biological, and socioeconomic conditions of the study area, and an assessment of the risks the tidal energy demonstration project poses to components of the ecosystem.

A comprehensive understanding of device-marine life interactions will not be possible until device-specific and site-level monitoring efforts are integrated, and additional data is collected in relation to operating tidal stream energy devices. Further, multi-year data collection will be required to consider seasonal variability at the FORCE test site and appropriate statistical analyses of this data will help to obtain a more complete understanding of device-marine life interactions.

Table 1 outlines the objectives of the site-level monitoring activities conducted at the FORCE demonstration site. FORCE led site-level monitoring summaries will be updated as devices are scheduled for deployment at FORCE. At this time, and considering the scale of device deployments in the near-term at FORCE, it is unlikely that significant effects in the far-field will be measurable (SLR Consulting 2015). Far-field studies such as sediment dynamics will be deferred until such time they are required. However, recent discussions with scientists serving on FORCE's EMAC suggests that the natural variability inherent to the upper Bay of Fundy ecosystem far exceeds what could be measured by far-field monitoring efforts. Moreover, the scale of tidal power development would need to surpass what is possible at the FORCE tidal demonstration site to extract sufficient energy from the system to have any measurable effects (Whiting et al. 2023*)*. In short, far-field monitoring would be futile unless tidal power development transitions from demonstration scale to commercial scale arrays. As more devices are scheduled for deployment at the FORCE site and as monitoring techniques are improved, monitoring protocols will be revised in keeping with the adaptive management approach. These studies will be developed in consultation with FORCE's EMAC, regulators, and key stakeholders.

Table 1: The objectives of each of the environmental effects monitoring activities, which consider various Valued Ecosystem Components (VECs), led by FORCE.

Environmental Effects Monitoring VEC	***Objectives***
Lobster	● to determine if the presence of a tidal stream energy device affects commercial lobster catches
Fish	● to test for indirect effects of tidal stream energy devices on water column fish density and fish vertical distribution ● to estimate probability of fish encountering a device based on fish density proportions in the water column relative to device depth in the water column
Marine Mammals	● to determine if there is permanent avoidance of the study area during device operations ● to determine if there is a change in the distribution of a portion of the population across the study area
Marine Sound (Acoustics)	● to conduct ambient sound measurements to characterize the soundscape prior to and following deployment of the tidal stream energy device
Seabirds	● to understand the occurrence and movement of bird species in the vicinity of tidal stream energy devices ● to confirm FORCE's Environmental Assessment predictions relating to the avoidance and/or attraction of birds to tidal stream energy devices

Lobster

FORCE conducted a baseline lobster catchability survey in fall 2021 (Fishermen and Scientists Research Society (FSRS), 2023) following the study design developed by TriNav Fisheries Consultants Ltd. in 2019. This study design was implemented in partnership with the FSRS (Figure 2) and with the assistance of a local lobster fisher. The report from this work was provided in 2023, and the results indicated a 'high' catchability rate (i.e., CPUE ≥ 2.4 kg/trap haul) during the fall survey. This is consistent with a prior baseline survey at the FORCE site in 2017 (NEXUS Coastal Resource Management Ltd. 2017) and is comparable to available commercial landings data provided by Fisheries and Oceans Canada (DFO). The study design will be repeated once an operational device has been deployed at FORCE to gather effects testing data and test the predictions of the EA.

Figure 2: Lobster scientist from the Fishermen and Scientist Research Society showing a tagged lobster prior to release.

Fish

FORCE conducted 25 mobile hydroacoustic fish surveys from May 2016 – October 2020 to test the EA prediction that tidal stream energy devices are unlikely to cause substantial impacts to fishes at the test site (AECOM 2009). To that end, the surveys are designed to:

- test for indirect effects of tidal stream energy devices on water column fish density and fish vertical distribution; and
- estimate the probability of fish encountering a device based on any 'co-occurrence' relative to device depth in the water column.

Moreover, these surveys follow a 'BACI' (Before/After, Control/Impact) design to permit a comparison of data collected before a device is installed with data collected while a device is operational at the FORCE site, and in relation to a reference site along the south side of the Minas Passage. These 24-hour mobile surveys encompass two tidal cycles and day/night periods using a scientific echosounder, the Simrad EK80, mounted on a vessel, the Nova Endeavor (Huntley's Sub-Aqua Construction, Wolfville, NS). This instrument is an active acoustic monitoring device and uses sonar technology to detect fish by recording reflections of a fish's swim bladder.

Analyses of hydroacoustic fish surveys completed during baseline studies in 2011 and 2012 (Melvin and Cochrane 2014) and surveys during May 2016 – August 2017 (Daroux and Zydlewski 2017) evaluated changes in fish densities in association with diel stage (day/night), tidal stage (ebb/flood), and device presence or absence (an OpenHydro turbine was present November 2016 – June 2017). Results support the EA prediction that tidal stream devices have minimal impact on marine fishes. However, additional surveys in relation to an operating device are required to fully test this prediction.

In 2019, the University of Maine conducted a thorough analysis for 15 fish surveys conducted by FORCE from 2011-2017. The hydroacoustic data set included six 'historical' surveys conducted between August 2011 and May 2012, and nine 'contemporary' surveys conducted between May 2016 and August 2017. The analyses included comparisons of fish presence/absence and relative fish density with respect to a series of temporal (historical vs. contemporary, or by survey), spatial (CLA vs. reference study area, or by transect) and environmental (tide phase, diel state, or with/against predicted tidal flow) explanatory variables. The report identified a statistically significant difference in fish presence/absence and relative fish density between the historical and contemporary data sets that may be attributable to differences in the survey design/execution between the time periods or could reflect changes in fish usage of the site. As such, remaining analyses were restricted to the contemporary data sets. The results revealed that: i) data collection during the ebb tide and at night are important for understanding fish presence in the CLA, ii) various explanatory variables and their additive effects should be explored further, and iii) increasing the frequency of surveys during migratory periods (consecutive days in spring/fall) may be required to understand patterns and variability of fish presence and density in Minas Passage. Importantly, the report suggested a statistically significant difference in fish presence/absence and relative density between the CLA and reference site, suggesting that the reference site may not be sufficiently representative to serve as a control for the CLA, and for testing the effects of an operational device on fish density and distribution in Minas Passage. Additional work is underway using data from eight additional contemporary fish surveys (2017-2018) to determine whether this finding is biologically meaningful, or whether it is simply a statistical artefact of how the data was aggregated in the original analysis.

Because complex hydrodynamic features of the Minas Passage introduce turbulence and bubbles into the water column that interfere with the use of hydroacoustics, FORCE's mobile fish surveys have been optimized for collecting data during the best neap tidal cycle per month when turbulence is greatly reduced. However, this approach limits the number of surveys that can be conducted, and regulators have suggested that the scope of the program be expanded so that survey results are more representative of how fish use the Minas Passage. To that end, FORCE conducted multiple fish surveys during each of three neap tidal cycles in fall 2020 (i.e., September 25, 27, 29; October 7, 9, 13; and October 24, 26, 29) to determine whether variation in fish density and distribution for any given survey within a neap cycle was representative of the other surveys conducted during that same time frame. Previous work comparing stationary and mobile hydroacoustic surveys in Minas Passage found that the temporal representative range of a 24-hr mobile was approximately three days (Viehman et al. 2019).

A recent study (Viehman et al. (2022)) examined entrained air contamination in echosounder data collected at the FORCE test site. It found that fish abundance estimates in the lower 70% of the water column and current speeds less than 3 m/s were well represented in that there was little contamination of the data set from entrained air. However, undersampling of the upper water column and faster speeds strongly affected fish abundance estimates especially during strong spring tides. This means that data collected during neap tides are more likely to yield a more accurate picture of fish abundance and distribution than those collected during spring tides. The study also highlighted how estimates of fish abundance may be affected differently depending on where fish are in the water column. For example, (hypothetical) fish located at mid-depths were omitted from the data more often as current speeds increased. These findings indicate a complex and dynamic ecosystem where the interactions of water movement and fish distribution affect our ability to infer how fish populations may interact with tidal power devices in the Minas Passage. The use of acoustic telemetry being studied under the RAP program could be used to fill gaps in datasets and optimize what can be learned about fish abundance and distribution at tidal energy sites.

Another issue with the entrained air found in high flow environments is the need to remove the contaminated data prior to analysis which is often a tedious and time-consuming process. Existing algorithms used to identify the depth-of-penetration of entrained air are insufficient for a boundary that is discontinuous, depth-dynamic, porous, and varies with tidal flow speed. Using a case study from data obtained at the FORCE test site a recent study (Lowe et al. (2022)) described the development and application of a deep machine learning model called Echofilter. Echofilter was found to be highly responsive to dynamic range of turbulence conditions in the data and produced an entrained-air boundary line with an average error of less than half that of the existing algorithms. The model had a high level of agreement with human data trimming. This resulted in 50% reduction in the time required for manual edits to the data set when using currently available algorithms to trim the data.

FORCE commissioned the development of a comprehensive fish synthesis that brings together existing knowledge of fish distribution, abundance, and use of the Minas Passage using existing literature from stock assessments, prior hydroacoustic surveys, acoustic telemetry-based surveys, as well as other relevant sources of information. This synthesis focuses on aquatic species at risk, those of cultural relevance, and commercial and recreational value. The results of this synthesis project will be available in early 2026 and will help to determine the extent to which questions regarding fish and tidal energy project permitting have been answered and identifying remaining knowledge gaps. Dr. Graham Daborn at Acadia University is leading this work; the final report is expected to be published shortly.

Marine Mammals

Since 2016, FORCE has been conducting two main activities to test the EA prediction that project activities are not likely to cause significant adverse residual effects on marine mammals within the FORCE test site (AECOM 2009):

- passive acoustic monitoring (PAM) using 'click recorders' known as C-PODs; and
- an observation program that includes shoreline, stationary, and vessel-based observations.

Passive Acoustic Monitoring

The first component of FORCE's marine mammal monitoring program involves the use of PAM mammal detectors known as C-PODs, which record the vocalizations of toothed whales, porpoises, and dolphins.[10] The program focuses mainly on harbour porpoise – the key marine mammal species in the Minas Passage that is known to have a small population that inhabits the inner Bay of Fundy (Gaskin 1992). The goal of this program is to understand if there is a change in marine mammal presence in proximity to a deployed tidal stream energy device and builds upon baseline C-POD data collection within the Minas Passage since 2011.

From 2011 to early 2018, more than 4,845 'C-POD days'[11] of data were collected in the Minas Passage. Over the study period, it was found that harbour porpoise use and movement varies over long (i.e., seasonal peaks and lunar cycles) and short (i.e., nocturnal preference and tide stage) timescales. This analysis, completed by Sea Mammal Research Unit (Canada) (Vancouver, BC), showed some evidence to suggest marine mammal exclusion within the vicinity of CSTV turbine when it was operational (November 2016 – June 2017) (Joy et al. 2018a). This analysis revealed that the C-PODs in closest proximity to the turbine (230 m and 210 m distance) had reduced frequency of detections, but no evidence of site avoidance with a device present and operating. These findings also revealed a decrease in detections during turbine installation activities, consistent with previous findings (Joy et al. 2017), but requiring additional data during an operational device to permit a full assessment of the EA predictions.

This monitoring program demonstrates the prevalence of harbour porpoise at FORCE, with the species being detected on 98.8% of the 1,888 calendar days since monitoring with C-PODs commenced in 2011. Harbour porpoise detections at FORCE varies seasonally, with peak activity occurring during May – August, and lowest detections during December – March. Harbour porpoise detections also vary spatially, with C-PODs deployed at locations W2 and S2 recording the greatest detection rates, and D1 values typically low. Mean lost time across C-PODs, due to ambient flow noise saturating the detection buffer on the C-POD, averaged 22.6%. Interestingly, an analysis against past datasets that controlled for time of year, indicated that the effects of the non-operational CSTV turbine structure had no detectable effect on the rate of harbour porpoise detection.

SMRU provided their 4th year final report of harbour porpoise monitoring using C-PODs at the FORCE test site (Palmer et al. 2021). The report describes the results of C-POD deployments #11-12 (i.e., 1,043 days of monitoring from August 2019 – September 2020) and places the

[10] The C-PODs, purchased from Chelonia Limited, are designed to passively detect marine mammal 'clicks' from toothed whales, dolphins, and porpoises.

[11] A 'C-POD day' refers to the number of total days each C-POD was deployed times the number of C-PODs deployed.

results in the broader context of the overall marine mammal monitoring program at FORCE. The final report includes summary data that revealed that harbour porpoise was detected on a least one C-POD every day, with a median value of 11 and 17 minutes of porpoise detections per day during deployments 11 and 12, respectively. The mean percent lost time due to ambient flow and sediment noise was 19.5% and 23.8%, respectively, comparable to previous deployments. Overall, the final report supports previous findings of monitoring activities that harbour porpoise are prevalent at the FORCE test site.

The final report also reiterates that sufficient baseline data has been collected to meet the goals of the EEMP. Consequently, FORCE recommended in its 2021-2023 EEMP that the collection of additional baseline harbour porpoise data using C-PODs be suspended until an operational device is deployed at the FORCE site. Upon receiving confirmation that a device will be deployed at the tidal demonstration area, FORCE will deploy C-PODs prior to the construction phase to begin collecting data and assessing any changes to harbour porpoise detections in the presence of an operational device.

Figure 3: Harbour porpoise (Phocoena phocoena) monitoring at the FORCE Test Site, Canada featured on Tethys (by FORCE and SMRU): https://tethys.pnnl.gov/stories/harbor-porpoise-phocoena-phocoena-monitoring-force-test-site-canada

Observation Program

FORCE's marine mammal observation program in 2025 includes observations made during bi-weekly shoreline surveys, stationary observations at the FORCE Visitor Centre, and marine-based observations during marine operations. All observations and sightings are recorded, along with weather data, tide state, and other environmental data.

FORCE uses an Unmanned Aerial Vehicle (UAV) for collecting observational data along the shoreline and over the FORCE site using transects by programming GPS waypoints in the UAV to standardize flight paths. FORCE staff received training to operate FORCE's UAV and have acquired UAV pilot certification by successfully passing the 2019 Canadian Drone Pilot Basic Operations Examination, administered by Transport Canada. Staff are now licensed to safely operate the UAV at the FORCE site. FORCE also hosts a public reporting tool that allows

members of the public to report observations of marine life: mmo.fundyforce.ca.

Marine Sound (Acoustics)

Marine sound – often referred to as 'acoustics' or 'noise' – monitoring efforts are designed to characterize the soundscape of the FORCE test site. Data collected from these monitoring efforts will be used to test the EA predictions that operational sounds produced from functioning tidal stream energy devices are unlikely to cause mortality, physical injury or hearing impairment to marine animals (AECOM 2009).

Results from previous acoustic analyses completed at the FORCE site indicate that the CSTV turbine was audible to marine life at varying distances from the turbine, but only exceeded the threshold for behavioural disturbance at very short ranges and during particular tide conditions (Martin et al. 2018). This is consistent with findings at the Paimpol-Bréhat site in France where an OpenHydro turbine was also deployed – data suggests that physiological trauma associated with a device is improbable, but that behavioural disturbance may occur within 400 m of a device for marine mammals and at closer distances for some fish species (Lossent et al. 2018).

In previous years, regulators have encouraged FORCE to pursue integration of results from multiple PAM instruments deployed in and around the FORCE test site. To that end, FORCE, and its partner JASCO Applied Sciences (Canada) Ltd. pursued a comparative integrated analysis of sound data collected by various hydrophones (i.e., underwater sound recorders) deployed autonomously and mounted on the CSTV turbine. That work revealed that flow noise increased with the height of the hydrophone off the seabed but had little effect on hydrophones deployed closer to the sea floor. The comparative integrated analysis provided valuable information about future marine sound monitoring technologies and protocols while building on previous acoustics analyses at the FORCE site.

In its 2021-2023 EEMP, FORCE recommended conducting a test survey in the presence of an operational device using an internationally recognized standard methodology for monitoring sound (International Electrotechnical Commission 2019). This would permit the feasibility of the approach to be tested in the Minas Passage to ensure the method can be implemented as described. This work is pending an operational device being deployed at the FORCE tidal demonstration area. FORCE will work with JASCO to collect and analyze marine sound data once a device is deployed.

Seabirds

FORCE's seabird monitoring program is designed to test the EA prediction that project activities are not likely to cause adverse residual effects on marine birds within the FORCE test area (AECOM 2009). However, there has been limited opportunity to determine potential effects of an operational device on seabirds at the FORCE test site and to test the EA predictions.

Since 2011, FORCE and Envirosphere Consultants Ltd. (Windsor, NS) have collected observational data from the deck of the FORCE Visitor Centre, documenting seabird species presence, distribution, behaviour, and seasonality throughout the FORCE site (Envirosphere Consultants Ltd. 2017). Envirosphere Consultants Ltd. recently published the results of their monitoring from 2010-2012 and demonstrated that the species and seasonal cycles of seabirds in Minas Passage reflect patterns that are typical of the inner Bay of Fundy and the northeast Atlantic coast of North American. The report also highlights the importance of the Minas

Passage as a migratory pathway for black scoter (*Melanitta americana*) and Red-throated loon (*Gavia stellata*).

In 2019, FORCE commissioned Envirosphere Consultants Ltd. and Dr. Phil Taylor (Acadia University) to synthesize the results of its observational seabird surveys (2011-2018) at the FORCE test site, and to evaluate advanced statistical techniques for analysing seabird count data in relation to environmental predictor variables. The seabird count data were examined using Generalized Additive Models (GAMs) to characterize seabird abundance and to better understand the potential impacts of tidal stream energy devices on seabirds at the FORCE test site. The results of the analyses revealed that overall model fit is suitable to characterize count data for some species, and that there are clear patterns of effects of time of year, wind speed and direction, tide height and time of day on the number of seabirds observed. However, the analyses also revealed that not all species reported at FORCE have been observed frequently enough to be modelled effectively using the GAM approach. This is due in part to the variability in count data that is particularly relevant for modelling abundance of migratory species that are only present at the FORCE site for brief periods during annual migrations. This is consistent with observational data collected over the course of these surveys that have demonstrated that the FORCE site has a lower abundance of seabirds in relation to other areas of the Bay of Fundy, and even other regions of Atlantic Canada. Given these results, the report recommends that future monitoring and analyses focus on locally resident species (i.e., great black-backed gull, herring gull, black guillemot, and common eider) so that the EA predictions can be tested most effectively. This work contributes to the development of appropriate analytical methods for assessing the impacts of tidal power development in the Minas Passage on relevant seabird populations and supports the continued responsible development of tidal energy at FORCE.

In 2022 FORCE began working with Strum Consulting to test radar-based seabird monitoring capabilities and to adapt existing data processing algorithms and statistical analysis tools for quantifying seabird use of the FORCE site. Strum provided a technical report which highlighted challenges and options to move forward with this approach. Challenges with the quality of the radar data limited the assessment and the full study could not be completed. The feasibility study continued in 2023 with FORCE providing a new radar data set to Strum, but the challenges in locating avian targets from the radar data could not be resolved using current methods. A commercially available software option may resolve these issues but requires further examination.

Developer Monitoring Activities

While FORCE completes site-level monitoring activities at the FORCE site, device specific monitoring is led by individual berth holders. Like the FORCE monitoring programs, the developer monitoring plans and reports undergo review by FORCE's EMAC and regulators.

In September 2018, it was confirmed that that CSTV turbine rotor was not spinning. CSTV provided written confirmation to regulators monthly that the turbine is not operational by monitoring its status during the peak tidal flow of each month. However, because of the insolvency of OpenHydro Technology Ltd., all reporting activities by CSTV ceased as of March 1, 2019. Data collection from the turbine-mounted ADCPs to confirm the turbine is no longer spinning was managed and reported by FORCE to regulators monthly from March 2019 to May 2020 but was discontinued following an amendment to this requirement.

As the Eauclaire/Orbital project progresses towards deployment, requiring the implementation of device-specific environmental effects monitoring programs, project updates will be included as appendices to future reports.

Other FORCE Research Activities

Tidal Task Force on Sustainable Tidal Energy Development in the Bay of Fundy

The *Tidal Task Force on Sustainable Tidal Energy Development in the Bay of Fundy* was struck on June 20, 2023. Co-chaired by NRCan and DFO, the Task Force includes members from the Government of Nova Scotia, industry, and research organizations, and released its final report on February 28, 2024. Among several important topics discussed, the final report provides an introspective examination about how risk for proposed tidal energy devices is determined, examines the *Fisheries Act* authorization process, and outlines a "revised staged approach" to tidal stream project permitting in Minas Passage that is intended to provide clarity for proponents and flexibility to regulators to ensure strong environmental protection. This revised staged approach was developed in collaboration with DFO and supports the staged deployment of small arrays of tidal energy devices at the FORCE tidal demonstration site with clear requirements for fish protection and monitoring. More specifically, the revised staged approach:

- reinforces the protections afforded to marine animals (and habitats) under the *Fisheries Act* and *Species at Risk Act*,
- aligns with Nova Scotia provincial licensing for developers at FORCE (i.e., a 5 MW licence for up to 15 years, per berth),
- outlines rigorous adaptive management conditions around environmental monitoring (development of an EEMP) that require proponents to demonstrate (through monitoring activities) how fish interact with their tidal energy device,
- includes stages that progressively advance the collective understanding of the impacts of tidal devices on fish, and
- provides confidence that developers can advance their projects and deploy additional devices under the same *Fisheries Act* authorization, provided that monitoring is effective and no unacceptable impacts to fish are observed.

For the revised staged approach to be effective, improved monitoring approaches are required to inform risk assessment. To that end, the Task Force has struck the *Risk & Monitoring Working Group* (RAM WG) to advance this work (see below).

New Initiatives

New Governance Model

FORCE is in the process of establishing a new model to help tidal projects succeed responsibly, anchored by a revised governance structure, and relationships with tidal developers defined under a new Licensee Agreement. Combined with deeper engagement with regulators, Rights Holders, and academia, these changes are designed to create a much stronger, more sustainable foundation for new projects at the site. This includes:

- **Independent Board of Directors**: This new governance model strengthens FORCE's role as site steward and coordinator. This change creates a more transparent, sustainable framework for provincial tendering and future deployments by clarifying developer responsibilities, protecting FORCE's infrastructure and regulatory commitments, and aligning with provincial marine renewable energy strategy.

- **Licensee Agreement:** This new agreement governs how developers engage with the site while protecting FORCE's assets and regulatory standing. It grants developers rights to access and operate in FORCE's test area and use its electrical infrastructure to connect to the grid. In return, developers must pay annual fees and deposits, follow FORCE's procedures, rules, and environmental approvals, and maintain insurance.
- **Licensee Advisory Committee:** The committee serves as a forum for developers to share information and provide policy advice to the FORCE Board related to facility operations, tidal energy development and regulation, engagement, organizational stability, and other relevant matters.

Mi'kmaq Ecological Knowledge Study (MEKS)

The Mi'kmaq Ecological Knowledge Study (MEKS) is being undertaken by the Confederacy of Mainland Mi'kmaq (CMM) in collaboration with the Fundy Ocean Research Centre for Energy (FORCE) to inform tidal energy development in the Bay of Fundy. Designed and led by CMM's MEKS Team, the study draws on Mi'kmaw knowledge and community engagement to document traditional use, environmental values, and cultural significance within the project area.

The study is structured in two phases. Phase 1 focuses on background research and planning, including a review of historical and cultural data, mapping of resource users and knowledge holders, and the development of study tools. Phase 2 involves interviews, workshops, field verification, and analysis, culminating in a comprehensive MEKS report. CMM will work closely with community members to ensure findings reflect Mi'kmaw perspectives and priorities.

The project leverages CMM's broad experience in aquatic and terrestrial research, community engagement, and rights-based stewardship. The MEKS will support sound planning, risk assessment, and culturally appropriate decision-making for FORCE and berth holders. Initial work has commenced and is expected to span 10–12 months.

Scottish Delegation

In April 2025, a delegation of Mi'kmaw Chiefs traveled to the Orkney Islands in Scotland — a global hub in tidal technology — to explore how marine renewable energy can support clean energy goals, environmental stewardship, and sustainable economic development. The visit, organized by FORCE and hosted by Orbital Marine Power and the European Marine Energy Centre, included representatives from the Assembly of Nova Scotia Mi'kmaw Chiefs, the Confederacy of Mainland Mi'kmaq, Marine Renewables Canada, Eauclaire Tidal, and community partners. The itinerary included:

- A visit to Orbital's operational facility and viewing their O2 turbine in action – the world's most powerful tidal turbine.
- A tour of the European Marine Energy Centre (EMEC).
- Cultural visits to significant neolithic sites, reflecting on shared heritage and the importance of respecting historical stewardship principles.

Along the way, participants shared perspectives, reflected on stewardship responsibilities, and laid the groundwork for future collaboration.

Key takeaways from the exchange included the importance of environmental monitoring, site compatibility with traditional fishing areas, the importance of partnership and early community

involvement — all crucial elements as Canada moves toward its net-zero emissions commitments and evaluates future tidal deployments in the Bay of Fundy.

MRC Conference Workshop

At the 2025 Marine Renewables Canada Conference, FORCE organized a workshop entitled *Stronger Relationships: Netukulimk, Etuaptmumk and the Future of Ocean Energy* which brought together Chief Sidney Peters (Glooscap First Nation; Co-Chair, Assembly of Nova Scotia Mi'kmaw Chiefs), Angeline Gillis (Executive Director, The Confederacy of Mainland Mi'kmaq), Patrick Butler (Senior Mi'kmaq Energy and Mines Advisor, Kwilmu'kw Maw-klusuaqn), and Lindsay Bennett (Executive Director, FORCE). Panelists reflected on the Chiefs' delegation to Kirkwall, Scotland, and discussed opportunities to integrate Mi'kmaw knowledge, leadership, values, and practices into marine renewable energy development. Framed through *Netukulimk* (respectful resource use) and *Etuaptmumk* (Two-Eyed Seeing), the session offered practical insights on strengthening partnerships and advancing industry collaboration with the Mi'kmaq.

Chief Sidney Peters addresses the audience at the 2025 MRC Conference Workshop

Risk & Monitoring Working Group

FORCE has partnered with the Acadia Tidal Energy Institute (ATEI) to lead activities under the Risk & Monitoring Working Group that was established by the Task Force. This initiative includes a series of four complementary desktop studies (i.e., modules) that will be used to inform a larger field-based project to understand how fish interact with tidal stream energy devices at FORCE. The modules are as follows:

1. Develop a standardized Adaptive Environmental effects Monitoring Program (AEMP) Template and Guidance Document to assist tidal energy proponents with the development of project specific AEMPs in support of *Fisheries Act* Authorization and *Species at Risk Act* Permit applications,
2. Review approaches to measuring and modelling fish distribution and both encounter rate and collision risk probabilities, with probabilities determined for inner Bay of Fundy (iBoF) Atlantic salmon kelt,
3. Review and provide recommendations for underwater cameras and their practical and integrated/synchronized use in Minas Passage,
4. Review the needs and options for a data management system for analyzing, storing and sharing environmental effects monitoring data, and recommend a data management system that best suits the needs of FORCE and the tidal stream energy sector

Module 1 – the AEMP Template and Guidance Document – continues to be developed. This includes collaboration with ATEI and DFO to standardize the overall structure of the document and develop draft materials included in various sections of the AEMP Template. Standardized text for various sections is being finalized (e.g., regulatory context, AEMP approach, comprehensive fish and fish habitat description for Minas Passage, effects of tidal devices on fish and fish habitat, offsetting).

In support of module 2, ATEI and OES-E co-hosted a workshop at the 2024 EIMR Conference entitled 'modeling fish interactions with tidal turbines'. The workshop included a series of presentations, including encounter rate modeling for fish in Minas Passage by Dr. Richard Karsten (ATEI) (Figure 3), and break-out groups to discuss the usefulness of existing modeling frameworks for understanding risk to fish, and the adequacy of current data collection methods to provide the data necessary for modeling. Workshop participants identified that current collision risk models are not suitable for very low probabilities of encounter and highlighted that there are challenges incorporating fish behaviour (i.e., avoidance, evasion) into existing model frameworks. However, agent-based fish models currently being developed in the United States may help refine collision risk models with behavioural inputs. Workshop participants also identified a series of data gaps in our understanding of fish in tidal channels (e.g., residency time, identification and tracking of individual animals, and turbulence measurements) that also impact encounter rate and collision risk modeling efforts. There are few reliable estimates of fish population size, even though this is an important parameter to know when regulators request information about the expected mortality in a certain area, or request information about population-level consequences of harm or mortality stemming from collisions. Overall, workshop participants agreed that there are too few datasets available to create or validate fish collision risk models and that more acoustic fish tagging studies need to be conducted, especially localized near turbines to inform an assessment of avoidance. The workshop report has been completed after having undergone review and approval by the Pacific Northwest National Laboratory and the Water Power Technologies Office of the US Department of Energy, and is available in Appendix II and on the Tethys website here.

FORCE staff have been working with ATEI to explore the suitability of various current 'off-the-shelf' optical camera technologies (module 3) for testing at the FORCE tidal demonstration site and are currently working to develop a short-list of recommended options for field testing. Some preliminary field experimentation was conducted by FORCE and ATEI during September in Minas Passage to test capabilities of optical cameras for detecting a Secchi disk at 2m range at various depths.

Work to define the requirements of a data management system (module 6) to support multiple high-bandwidth monitoring instruments at FORCE has been completed. This work was led by PISCES Research Project Management with input from ATEI and FORCE. A final report was submitted and is proving a valuable resource in the design and build of the data management infrastructure needed to support future environmental monitoring activities at the FORCE tidal demonstration site.

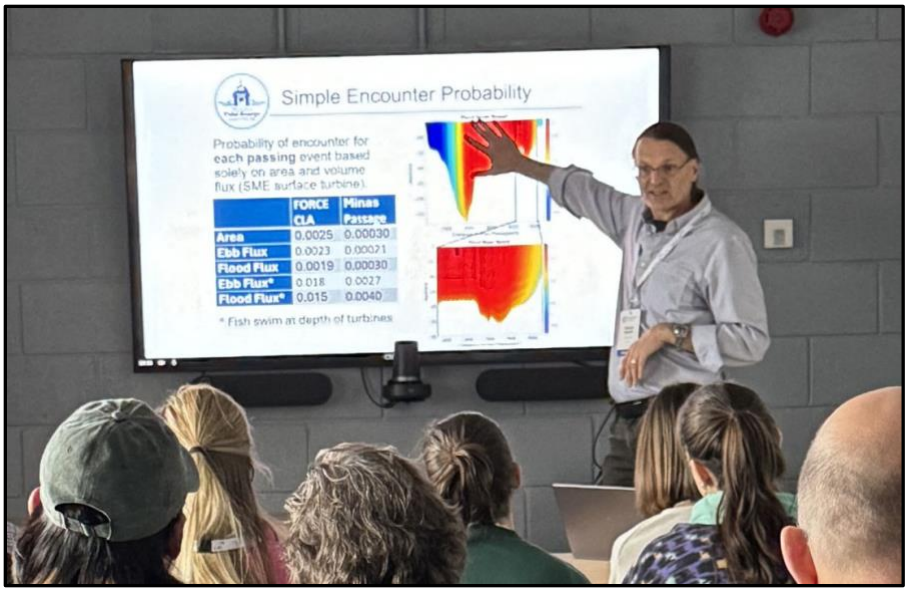

Figure 4: Dr. Richard Karsten (ATEI) presents finding of fish encounter rate modeling in Minas Passage at the EIMR 2024 workshop on modeling fish interactions with tidal turbines.

Risk Assessment Program

The Risk Assessment Program (RAP) for tidal stream energy is a collaborative effort between FORCE, academic partners, Mi'kmaw organizations, and industry to advance our understanding of the environmental risks of tidal stream energy development in Minas Passage. The greatest potential risk of tidal stream energy device operations is believed to be from collisions between marine animals and turbine blades (Copping and Hemery 2020). However, these types of interactions are difficult to observe directly due to the environmental conditions under which they would occur (i.e., fast flowing, turbulent waters) and using the suite of environmental monitoring instrumentation currently available (i.e., standard oceanographic and remote sensing instruments intended for use in more benign marine conditions) (Hasselman et al. 2020). However, the potential for fish-turbine interactions can be predicted using appropriate baseline data. The objective of the RAP program is to develop statistically robust encounter rate estimates for migratory and resident fishes with tidal stream energy devices at the FORCE site using a combination of physical oceanographic data related to flow in Minas Passage and acoustic tag detection data for various fish species curated by the Ocean Tracking Network (OTN) at Dalhousie University.

Recent research has revealed how hydrodynamics in tidal stream environments can influence the distribution of marine animals, including fish (Lieber et al. 2018, 2019; McInturf et al. 2019). Indeed, during periods of elevated tidal flow, advection by tidal currents are the primary determinants of the horizontal movement of 'small-bodied' fish like alewife (Tsitrin et al. 2022), striped bass (Broome 2014; Keyser 2015; Keyser et al. 2016), and iBoF Atlantic salmon post-smolt (Sanderson et al. 2023) and kelt (Sanderson et al. *in prep.*) through Minas Passage (Sanderson et al. 2021). Acoustic tag detection data curated by OTN for various fish species in the Bay of Fundy is being used to develop encounter rate estimates that will then be refined and validated through acoustic tagging and acoustic receiver deployments efforts. Ultimately, the RAP will contribute towards improving our understanding of the risks of tidal stream energy

development for fishes of commercial, cultural, and conservation importance in the Bay of Fundy, and will assist in the development of future environmental effects monitoring programs.

Since the program commenced in 2020, OTN has facilitated access to baseline acoustic tag detection data from 22 contributors (17 projects), covering nine fish species in the Bay of Fundy (i.e., alewife (*Alosa pseudoharengus*), American shad (*A. sapidissima*), American eel (*Anguilla rostrata*), iBoF Atlantic salmon (*Salmo salar*), Atlantic sturgeon (*Acipenser oxyrhinchus oxyrhinchus*), Atlantic tomcod (*Microgadus tomcod*), spiny dogfish (*Squalus acanthias*), striped bass (*Morone saxatilis*), and white shark (*Carcharodon carcharias*)). Fish tagging was undertaken during 2021-2024 in collaboration with the Mi'kmaw Conservation Group (MCG), Acadia University, Ocean Tracking Network, and DFO Science to improve baseline data for generating encounter rate estimates and focused on alewife, American shad, Atlantic sturgeon, spiny dogfish, and Inner Bay of Fundy Atlantic salmon post-smolts and kelts (Figure 4). Tagging efforts in 2025 are being led by Acadia University and DFO and include plans to tag iBoF Atlantic salmon post-smolts (Gaspereau River) and American eel (Avon River, Shubenacadie River).

In 2021 and 2022, the FORCE array of acoustic receivers consisted of 12 stations set approximately 150 metres apart and extended from the FORCE site out towards the middle of Minas Passage. However, this resulted in incomplete coverage of Minas Passage for detecting tagged fish. Since 2023, FORCE and OTN have collaborated to establish more complete coverage of the area by merging their respective lines of acoustic receivers into a 24-station array that spans most of the Minas Passage (Figure 5), thereby increasing the probability of detecting tagged fish as they navigate through the area. This array was established in May 2023 and is now supported year-round to increase the temporal scale of monitoring.

FORCEs acoustic receiver SUBs were recovered for routine maintenance, data offloading and battery replacement following the reworked recovery and replacement methodology developed over the past quarter to incur minimal measurement down time of the fish monitoring network over the CLA. SUBs at locations 13 through 18 were successfully recovered on August 12th and brought in for maintenance.

Once the maintenance was complete, SUBs from locations 19, and 21 through 24 (spanning the CLA) were recovered on August 20th. As these SUBS were recovered, the refurbished SUBS from locations 13 through 18 were deployed at locations 19 through 24. During the August 20th operation, the SUBS at location 20 was not present. Subsequent data analysis shows that it left its mooring June 20th. The recovered SUBs were then refurbished and redeployed at locations 19 through 24 on September 16th.

Data recovered from the HR2 receivers for the spring and summer 2025 deployment period has been recovered, processed and shared with OTN for further study by the broader research community. Discussion and design work has been continuing to improve the efficiency and time required to refurbish and redeploy SUBs. Designs are being finalized for manufacturing, and it is expected that these will be implemented in the upcoming 2026 recoveries.

Figure 5: Acoustic tagging of American shad from the Kennetcook River by Acadia University in 2024.

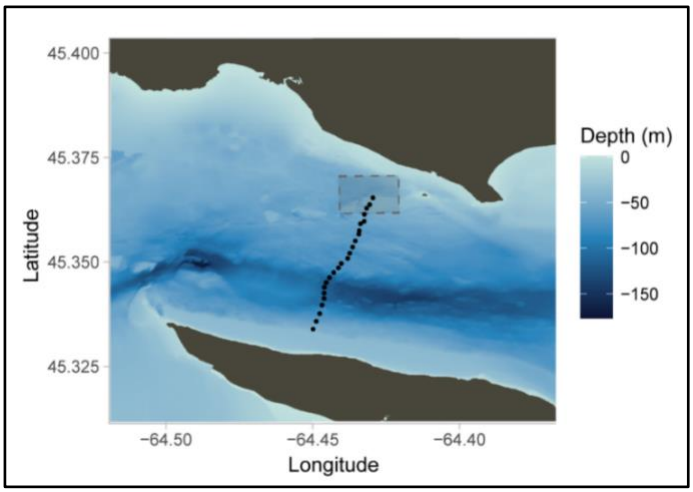

Figure 6: Acoustic receiver array deployment configuration (24 stations) in Minas Passage in 2023 and 2024. This more thorough coverage of Minas Passage for detecting tagged fish is made possible through collaboration between FORCE and OTN.

Several organizations have been independently conducting acoustic telemetry research for various fish species in the Bay of Fundy in recent years. To improve coordination of tagging activities and acoustic receiver deployments among these groups, improve efficiencies and knowledge sharing, FORCE met with ATEI, OTN, DFO Science (St. Andrews Biological Station), and The Confederacy of Mainland Mi'kmaq on October 28, 2024. Participants were enthusiastic to share knowledge about recent acoustic telemetry research and to explore ways to coordinate future activities. FORCE subsequently distributed a survey to meeting participants to gauge interest in their level of engagement and to identify potentially important groups not included in the initial meeting that ought to be engaged with going forward. Interest in open dialogue and a coordinated approach to future acoustic telemetry research was well supported, and key participants in the initial meeting discussed their work and the value of a coordinated effort at the Atlantic Policy Congress Fisheries Conference and Awards Ceremony in Moncton, NB, in January 2025. Since then, this collaborative effort has expanded under OTN's leadership to include additional academic institutions (University of New Brunswick), non-governmental organizations (Atlantic Salmon Federation, NS Salmon Association, Canadian Parks and Wilderness NS), First Nations programs (Fort Folly Habitat Recovery), and government agencies (Parks Canada). The next meeting is scheduled for mid-April where discussions will focus on plans for tagging and acoustic receiver deployments during 2025. FORCE remains an important contributor to these discussions.

The RAP program has generated cutting-edge and award-winning research on the application of acoustic telemetry for understanding the risk of tidal stream projects to fish in Minas Passage. Specifically, three manuscripts led by Dr. Brian Sanderson (Acadia University) have been published in a special issue of the *Journal of Marine Engineering and Science* entitled 'Interface between offshore renewable energy and the environment', and collectively highlight the efficacy of acoustic telemetry for estimating probability of fish-turbine encounter at the FORCE tidal demonstration site. The first of these papers, 'Measuring detection efficiency of high-residency acoustic signals for estimating probability of fish-turbine encounter in a fast-flowing tidal

passage' was recently awarded the best paper for 2023 in the *Journal of Marine Science and Engineering.* All three of these papers are publicly available here.

Fundy Advanced Sensor Technology (FAST) Activities

FORCE's Fundy Advanced Sensor Technology Program is designed to advance capabilities to monitor and characterize the FORCE site. Specifically, the FAST Program was designed to achieve the following objectives:

1) To advance capabilities of site characterization;
2) To develop and refine environmental monitoring standards and technologies; and
3) To enhance marine operating methodologies.

FAST combines both onshore and offshore monitoring assets. Onshore assets include a meteorological station, video cameras, an X-band radar system, and tide gauge. Offshore assets include modular subsea platforms for both autonomous and cabled data collection and a suite of instrumentation for a variety of research purposes. Real-time data collected through FAST assets will be broadcasted through the Canadian Integrated Ocean Observing System (CIOOS) later this year. Static ADCP data is currently available on the CIOOS website.[12]

Platform Projects

The first and largest of the FAST platforms houses an instrument called the Vectron. Developed in partnership with Nortek Scientific (Halifax, NS), Memorial University (St. John's, NL), and Dalhousie University (Halifax, NS), the Vectron is the world's first stand-alone instrument to remotely measure, in high resolution, turbulence in the mid-water column. Measurements and analysis from the Vectron will help tidal energy companies to better design devices, plan marine operations, and characterize the tidal energy resource.

FORCE recently collaborated with Innovasea to test innovative new acoustic receiver technology in Minas Passage to assess instrument capabilities in high flow environments. Five different acoustic receiver technologies (with duplicates for redundancy) were mounted on the FAST-2 platform and deployed at the FORCE site in September 2023 (Figure 6). A Nortek Signature 500 Acoustic Doppler Current Profiler (ADCP) was deployed alongside the acoustic receivers to record flow speed, along with an OceanSonics icListen HF hydrophone to record underwater noise that can impact the detection of acoustic signals. A series of passive drifts were then conducted over the platform using acoustic tags of various frequencies deployed at differing depths. The drifts were conducted on the flood tide during the strong spring tides of late September and early October 2023. The platform was recovered in mid-October and the acoustic detection data downloaded from the receivers for analyses. Although preliminary, results of this work are encouraging, and suggest that a prototype acoustic receiver technology that is currently under development can detect acoustic tags at flow speeds up to 5 m/s; a considerable improvement over current 'off-the-shelf' acoustic receivers. FORCE continues to work with Innovasea to develop additional study designs to further assess the capabilities of this prototype technology.

[12] This is available online at: https://catalogue.cioosatlantic.ca/dataset/ca-cioos_db15458d-df2c-4efb-b5a0-791e7561a0cb

Figure 7: FAST-2 platform equipped with five Innovasea acoustic receiver technologies (with duplicates for redundancy), an ADCP and hydrophone for recording flow speed and underwater noise.

FORCE is also collaborating on an Ocean Supercluster funded project lead by Innovasea, and in partnership with DeepSense (Dalhousie University), Nova Scotia Power Incorporated, and New Brunswick Power Corporation to advance the capabilities of artificial intelligence (AI) for monitoring fish around hydroelectric facilities and tidal stream energy devices. The HydroAware project will build off recent advances in the application of AI for detecting, identifying and tracking fish by Innovasea and DeepSense (Kandimalla et al. 2022), and shows promise for the renewable energy community, as improved fish monitoring capabilities may help address some of the challenges facing tidal stream energy projects in Canada.

On September 16, 2025, standard contrast and reflective targets were added to the field of view of the cameras being used in the HydroAware project. Through conversations with the Innovasea team and the longevity of the sensing platform on the shore of the FORCE test site, it was determined that the addition of “standard” target might be beneficial to the ongoing study of fish detection and AI applications particularly to aid in quantifying the current visibility level in the tidal current. These targets can be viewed in Figure 8.

Figure 8: A view from two different cameras after reflective (left) and standard contrast (right) targets were installed as part of the HydoAware project.

In November, after seven months of data collection, the FAST-2 platform being used to conduct the work for the HydroAware project was was recovered from the intertidal zone before winter weather would become a significant threat to the equipment; Innovasea is reviewing the datasets.

Fish Tracking

To enhance fish monitoring and to expand its data collection capacity, FORCE partnered with the Ocean Tracking Network (OTN)[13] and attached one Innovasea (formerly VEMCO)[14] fish tag receiver (a VR2W receiver) to each C-POD mooring/SUBS (Streamlined Underwater Buoyancy System) package (see above). These receivers are used to supplement OTN's ongoing data collection program within the Minas Passage and are referred to as 'Buoys of Opportunity.' Upon retrieval of the C-PODs and receivers, instruments are shared with OTN where data is offloaded prior to redeployment. This effort will support increased knowledge of fish movement within the Minas Passage, which has applicability beyond tidal energy demonstration, as well as complement FORCE's hydroacoustic data collection efforts that do not allow for species identification. No C-POD mooring/SUBS have been deployed since 2020, however ongoing data collection for fish monitoring is occurring through the RAP acoustic receiver line.

OTN data managers are in the process of acquiring information, including species identification, and sharing this with FORCE. Initial results show that the OTN receivers deployed by FORCE have detected tags from the following projects:

- USGS Gulf of Maine Sturgeon (Kieffer, M., 2024);
- Maritimes Region Atlantic salmon marine survival and migration (Hardie, D.C., 2017);
- Quebec MDDEFP Atlantic Sturgeon Tagging (Verreault, G., Dussureault, J., 2013);
- Gulf of Maine Sturgeon (Zydlewski, G., Wippelhauser, G. Sulikowski, J., Kieffer, M., Kinnison, M., 2006);
- OTN Canada Atlantic Sturgeon Tracking (Dadswell, M., Litvak, M., Stokesbury, M., Bradford, R., Karsten, R., Redden, A., Sheng, J., Smith, P.C., 2010);
- Darren Porter Bay of Fundy Weir Fishing (Porter, D., Whoriskey, F., 2017);
- Movement patterns of American lobsters in the Minas Basin, Minas Passage, and Bay of Fundy Canada (2017);
- Shubenacadie River Monitoring Project: Tomcod (Marshall, J., Fleming, C., Hunt, A., and Beland, J., 2017);
- MA Marine Fisheries Shark Research Program (Skomal, G.B., Chisholm, J., 2009);
- UNB Atlantic Sturgeon and Striped Bass tracking (Curry, A., Linnansaari, T., Gautreau, M., 2010);
- Inner Bay of Fundy Striped Bass (Bradford, R., LeBlanc, P., 2012);
- Minas Basin Salmon Kelt (McLean, M., Hardie, D., Reader, J., Stokesbury, M.J.W., 2019);
- New York Juvenile White Shark Study (Tobey Curtis)
- Massachusetts White Shark Research Program (Greg Skomal); and
- St. Lawrence River Fish Monitoring (Valiquette, E., Légaré, J., Soulard, Y. 2020)

Further information about these Buoys of Opportunity, and the projects listed above, can be found on OTN's website: https://members.oceantrack.org/project?ccode=BOOFORCE

Starting in 2018, FORCE has worked in collaboration with Dr. Mike Stokesbury at Acadia University to install additional Innovasea receivers of a new design on FORCE's C-POD moorings/SUBS packages. These new receivers are expected to be even more effective in picking up acoustic detections in high flow environments, where tag signals can be obscured by noise. This partnership will contribute additional information regarding movement patterns of Atlantic salmon, sturgeon, striped bass, and alewife in Minas Passage and Basin. This work is

[13] Ocean Tracking Network's website: www.oceantrackingnetwork.org.

[14] Innovasea is "the world leader in the design and manufacture of acoustic telemetry equipment used by researchers worldwide to study behaviour and migration patterns of a wide variety of aquatic animals." Learn more: www.innovasea.com.

sponsored by the OERA, NRCan, NSNRR, the Natural Sciences and Engineering Research Council of Canada (NSERC), and the Canadian Foundation for Innovation (CFI).[15]

Ocean Sensor Innovation Platforms (OSIP) Project

On September 19, 2025, NRCan announced Ocean Sensor Innovation Platforms (OSIP) project, led by FORCE, in combination with the research project *Reducing Fish-Turbine Collision Risk Uncertainty in the Minas Passage, Bay of Fundy*, led by Acadia University (figure 9, below). The overall project objective is to better understand the potential for interactions between fish and tidal energy devices deployed in the Minas Passage. FORCE will develop floating and bottom-mounted environmental monitoring platforms to test the capabilities and limitations of monitoring instruments at the sea surface and sea floor, respectively.

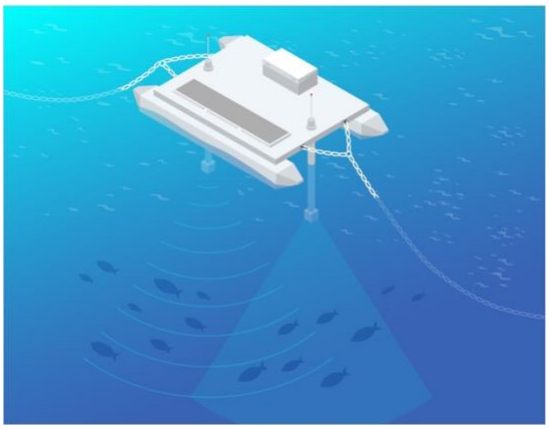

Illustration: OSIP will trial different optical and acoustic sensor configurations to test their effectiveness in monitoring fish around tidal devices.

In future tidal turbine deployments, sensors and methods tested by these platforms will capture essential data on fish-turbine interactions, addressing one of tidal energy's greatest challenges: accurately measuring and monitoring risk to marine species. OSIP is intended to:

- Offer regulators confidence that environmental effects data can be reliably collected,
- Provide evidence-based metrics for project review and approval, and
- Provide regulatory clarity to encourage investment and advance the sector

Figure 9: (Wolfville, NS, Sept 19/2025) NRCan announces $10M tidal energy research investment to FORCE and Acadia University

[15] Information about this project, and others funded through this program, is available online at: https://netzeroatlantic.ca/sites/default/files/2020-04/2020-04-09%20NRCan%20Public%20Report%20Final%20-%20Resize.pdf

OSIP directly responds to *Task Force* recommendations to address environmental risk and supports companion initiatives by Acadia University to reduce environmental effects uncertainty. Partners include:

- **Natural Resources Canada**, supporting OSIP through its Energy Innovation Program, which advances clean energy technologies that will help Canada maintain a competitive, reliable, and affordable energy system while transitioning to a low-carbon economy.
- **Acadia University**, the project's central research partner, providing scientific leadership, experimental design, data analysis, and student training in fish sensing through the Acadia Tidal Energy Institute (ATEI).
- **The Confederacy of Mainland Mi'kmaq** (CMM), supporting OSIP with a Mi'kmaw Ecological Knowledge Study, ensuring Indigenous perspectives inform monitoring priorities.
- **Pacific Northwest National Laboratory** (PNNL), advising on study design, sensor configuration and data interpretation.
- Innovasea, providing support and expertise with fish tracking and monitoring technology.
- **Orbital Marine Power**, **reconcept**, and **Nova Innovation**, providing input on study design and technical considerations for monitoring platforms and equipment.
- **Huntley's Diving and Marine**, providing vessel services, enabling deployment, recovery, and maintenance of bottom-mounted platforms.
- **Ocean Tracking Network** (OTN), loaning acoustic tracking receivers and offering expert support in design, deployment, and maintenance of receiver arrays. Data collected will be stored in OTN's system and shared per FAIR principles and OTN's data policy.
- **The University of the Highlands and Islands – Environmental Research Institute**, contributing expertise in sensor platform design, sensor selection, field deployments and data analysis.

Additional partners, including DFO, researchers, and equipment suppliers are providing critical input and guidance. OSIP supports and integrates ongoing initiatives led by ATEI aimed at reducing the uncertainty about the environmental effects of tidal projects at FORCE.

OSIP Camera Frame Vessel Testing

On Thursday December 18, 2025, the initial vessel testing campaign for optical cameras and lighting was completed with a full day of on water testing aboard the Nova Endeavor. The tests conducted were focused on determining the best configuration for lighting to best capture objects specific distances from fixed subsea cameras. The lighting arrangements were tested with two configurations of standard targets, one utilizing high contrast posts positioned at fixed distances to the cameras and the second, having a fixed white target used to view shadows of objects positioned between itself and the cameras.

Image: Camera testing frame being prepared for deployment from the Nova Endeavour in Minas Basin.

The cameras used for this initial testing were a standard 4k GoPro in a depth rated enclosure along with a i2S Orphie camera and Rayfin Subsea camera. The final arrangement of these cameras and the camera frame are shown in **Error! Reference source not found.**. Lighting was provided by several LED lights, one of which was controllable from the deck of the NE through software.

Once arriving at the work site, a CTD (conductivity, temperature and depth) cast with additional PAR and turbidity sensors was conducted to 30m. The first camera and light arrangement was then deployed stopping at 5m depth increments from 5 to 25m (pending conditions) while the vessel was drifting. At each stop, a series of still images were taken on both the i2S Orphie camera and Rayfin Subsea camera while the 4k GoPro continuously ran in timelapse photo mode for the duration of the day. The light intensity levels were modified and the experiment was reconducted. Once satisfied with the data collection for the first experimental arrangement, the lights we're moved closer to the targets, and the same procedure was followed for data collection. A final adjustment was made to the lights for the last frame deployment. Once data collection was completed, another CTD cast was completed before returning to shore.

Discussion

FORCE and its partners continue to build on previous experiences, incorporate regulatory guidance, and to re-evaluate approaches to research and monitoring in the high flow environment of the Minas Passage. These efforts were advanced during Q4 2025 alongside important developments, including the first-ever *Fisheries Act Authorization* under DFO's staged approach, and the launch of the OSIP project, which will provide sustained support for monitoring innovation from 2025 through 2028. The EEMP design remains focused on preparing for effects testing with the deployment of operational devices and adheres to the principles of adaptive management by evaluating existing datasets to ensure appropriate monitoring approaches are being implemented. Moreover, the plan adopts internationally accepted standards for monitoring where possible, including feasibility assessments for new monitoring approaches that are planned to be implemented.

Advances in monitoring capabilities made possible through projects like OSIP enhance our ability to understand how animals use Minas Passage and contributes towards a better understanding of risk from the development of tidal stream power in the Upper Bay of Fundy. During Q4, efforts continued to maintain and refine year-round fish monitoring through collaboration with the Ocean Tracking Network, including recovery, refurbishment, and redeployment planning for acoustic receiver arrays. These activities contribute to improving data continuity and analytical confidence as the sector transitions toward staged device deployment. Ongoing research and the development of peer-reviewed publications add credibility to the innovative science activities that FORCE continues to undertake in support of its role as environmental steward. FORCE and its partners continue conducting monitoring, engaging in meaningful assessments of monitoring technology capabilities, and providing data analyses and interpretation that advance our ability to effectively monitor the effects of tidal stream energy devices in high flow environments, and specifically at the FORCE test site. Reports from FORCE's partners and updates are routinely subjected to review by FORCE's EMAC and regulators, along with continued results from FORCE's ongoing monitoring efforts.

FORCE continues to implement lessons learned from the experiences of local and international partners, build local capacity, and enhance skills development, test new sensor capabilities, and integrate results from various instruments. Cumulatively, these efforts provide an opportunity for adaptive management and the advancement and refinement of scientific approaches, tools, and techniques required for effectively monitoring the device and site-level areas of tidal stream energy devices in dynamic, high-flow marine environments.

Ongoing monitoring efforts will continue to build on the present body of knowledge of marine life-device interactions, with important input from Acadia University and other partners. While it is still early to draw conclusions, initial findings internationally and at the FORCE test site have documented some disturbance of marine mammals primarily during marine operations associated with device installation/removal activities, but otherwise have not observed significant effects.

FORCE will continue to conduct environmental research and monitoring to increase our understanding of the natural conditions within the Minas Passage and, when the next devices are deployed, test the EA prediction that tidal energy is unlikely to cause significant harm to marine life. In the long term, monitoring will need to be conducted over the full seasonal cycle to understand potential impacts. FORCE will continue to report on progress and release results in keeping with its mandate to inform decisions regarding future tidal energy projects.

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Appendix I:

Acronyms

AAM	Active Acoustic Monitoring
ADCP	Acoustic Doppler Current Profiler
AMAR	Autonomous Multichannel Acoustic Recorder
BACI	Before/After, Control/Impact
BC	British Columbia
BoFEP	Bay of Fundy Ecosystem Partnership
CFI	Canadian Foundation for Innovation
CIOOS	Canadian Integrated Ocean Observing System
CLA	Crown Lease Area
cm	Centimetre(s)
CPUE	Catch Per Unit Effort
CSTV	Cape Sharp Tidal Venture
DFO	Department of Fisheries and Oceans (Canada)
DEM	Department of Energy and Mines (Nova Scotia)
EA	Environmental Assessment
EEMP	Environmental Effects Monitoring Program
EMAC	Environmental Monitoring Advisory Committee
EMP	Environmental Management Plan
FAD	Fish Aggregation Device
FAST	Fundy Advanced Sensor Technology
FAST-EMS	Fundy Advanced Sensor Technology – Environmental Monitoring System
FERN	Fundy Energy Research Network
FORCE	Fundy Ocean Research Center for Energy
GPS	Global Positioning System
hr	Hour(s)
IEA	International Energy Agency
kg	Kilogram(s)
km	Kilometre(s)
kW	Kilowatt(s)
m	Metre(s)
MET	Meteorological
MRE	Marine Renewable Energy
MREA	Marine Renewable-electricity Area
NL	Newfoundland and Labrador
NRCan	Natural Resources Canada
NS	Nova Scotia
NSDEM	Nova Scotia Department of Energy and Mines
NSE	Nova Scotia Department of Environment
NSERC	Natural Sciences and Engineering Research Council
NSPI	Nova Scotia Power Inc.
OERA	Offshore Energy Research Association of Nova Scotia
OES	Ocean Energy Systems
ONC	Ocean Networks Canada
ORJIP	Offshore Renewables Joint Industry Programme
OSC	Ocean Supercluster
OTN	Ocean Tracking Network
PAM	Passive Acoustic Monitoring

Q1/2/3	Quarter (1, 2, 3), based on a quarterly reporting schedule
R&D	Research and Development
TC114	Technical Committee 114
SUBS	Streamlined Underwater Buoyancy System
SME	Sustainable Marine Energy (Canada)
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
VEC(s)	Valuable Ecosystem Component(s)