RISK ASSESSMENT PROGRAM FOR TIDAL STREAM ENERGY

Annual Report 2021

Overview

Canada is witnessing a new wave of interest in tidal stream technology development in the Bay of Fundy, but uncertainty around potential impacts on marine life has left the federal regulator, Fisheries and Oceans Canada (DFO), challenged to adequately assess the risk, particularly in relation to fish. This uncertainty challenges the regulatory permitting process; without regulatory approval, developers cannot execute the planned project scope nor raise additional private sector funding to move forward.

Regulators perceive the greatest potential risk of tidal turbine operations as collisions between marine animals and turbines blades (Sparling et al., 2020). However, these types of interactions are difficult to observe directly: both because of the fast flowing, often turbid waters of tidal energy sites and because of the limitations of monitoring instruments which have been designed for use in more benign marine environments.

The Risk Assessment Program (RAP) for tidal stream energy creates a way forward. RAP is a collaborative effort between the Fundy Ocean Research Centre for Energy (FORCE), Ocean Tracking Network at Dalhousie University, the Confederacy of Mainland Mi'kmaq/Mi'kmaw Conservation Group, Acadia University, Marine Renewables Canada, local fishers and knowledge holders to create a detailed, credible assessment tool to gauge the probability that fish will encounter a tidal device.

Encounter rate modelling, or ERM (i.e., estimating the predicted frequency with which a stationary entity encounters a moving one), has become a standardized permitting tool for offshore wind projects, but little work has been done to date in North America to apply that concept to assessing risks presented by tidal turbine projects.

RAP will assess the co-occurrence of fish and tidal turbines in the Bay of Fundy's Minas Passage, where the probability of encounter will be determined by combining two data sets: physical oceanographic (flow) and biological (fish distribution).

RAP partners will be able to estimate, for the first time, the probability that a fish will encounter a turbine. That will give regulators, Rights holders, community stakeholders, and technology developers a better understanding of the potential risks to fishes of commercial, cultural, and conservation value in the Bay of Fundy in *advance* of tidal turbine deployments, and will assist in the development of future environmental effects monitoring programs.

The RAP project is entering its second year. This report provides an update of the outcomes accomplished to date in each of the pillars of the program, and the next steps for each pillar.

FORCE, Acadia University

Flow Atlas

Hydrodynamic flow features (e.g. turbulence, eddies, wakes, etc.) are known to influence the distribution of marine animals in tidal channels.

As part of the RAP, a high-resolution radar network is being established in the Minas Passage to generate spatiotemporal (space and time) data on physical oceanographic features. This will be the basis for real-time mapping and developing a flow atlas of the Minas Passage.

Installing a high-resolution marine radar at the FORCE facility, overlooking the Minas Passage.

Flow Atlas continued...

These new marine radars reflect off the sea surface with high resolution in space and time, providing a birds-eye view of the moving wave field, from which the wave statistics, current velocity, and eddy structures can be derived; all features that can affect the spatiotemporal distributions of fish.

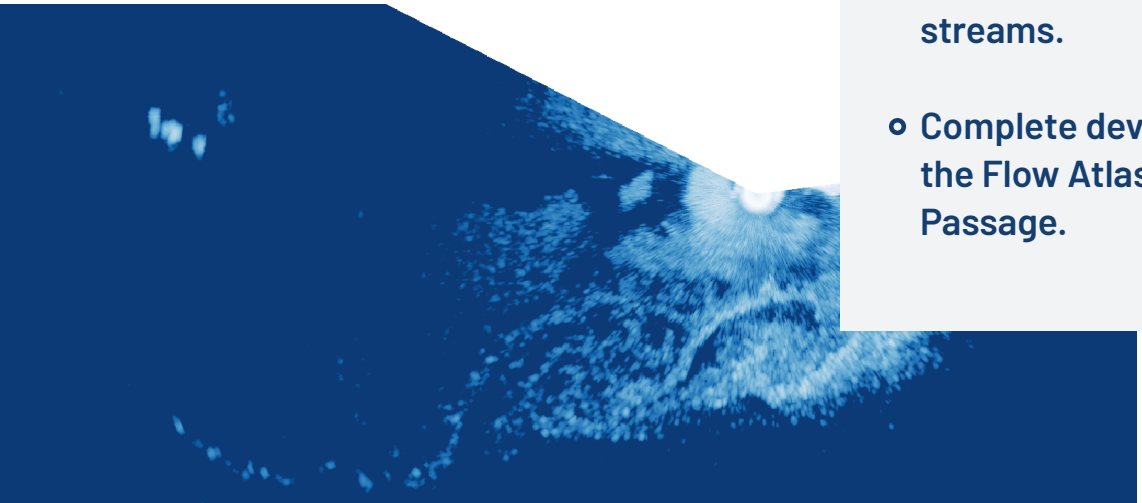
The first data set, composed of physical oceanographic data, is being generated using a high-resolution radar network, combined with mobile and stationary acoustic Doppler current profiler (ADCP) and hydrodynamic model data, to create the first flow atlas for Minas Passage.

Key Outcome to Date

Installation and integration of two (2) radar systems in the Minas Passage, one on the FORCE Visitor Centre, and one next to the Cape Sharp Lighthouse, providing full coverage of the Minas Passage.

Next Steps

- **Complete assembly and commissioning of the third mobile radar system that can be set-up anywhere to develop a spatiotemporal flow atlas.**
- **Conduct mobile and stationary ADCP hydrographic surveys of currents, eddies, and waves through the water column to validate the radar data.**
- **Develop full suite of software for mapping and real-time monitoring of currents, wakes, and waves in tidal streams. This builds on existing National Oceanography Centre software, adapted to tidal streams.**
- **Complete development of the Flow Atlas for the Minas Passage.**



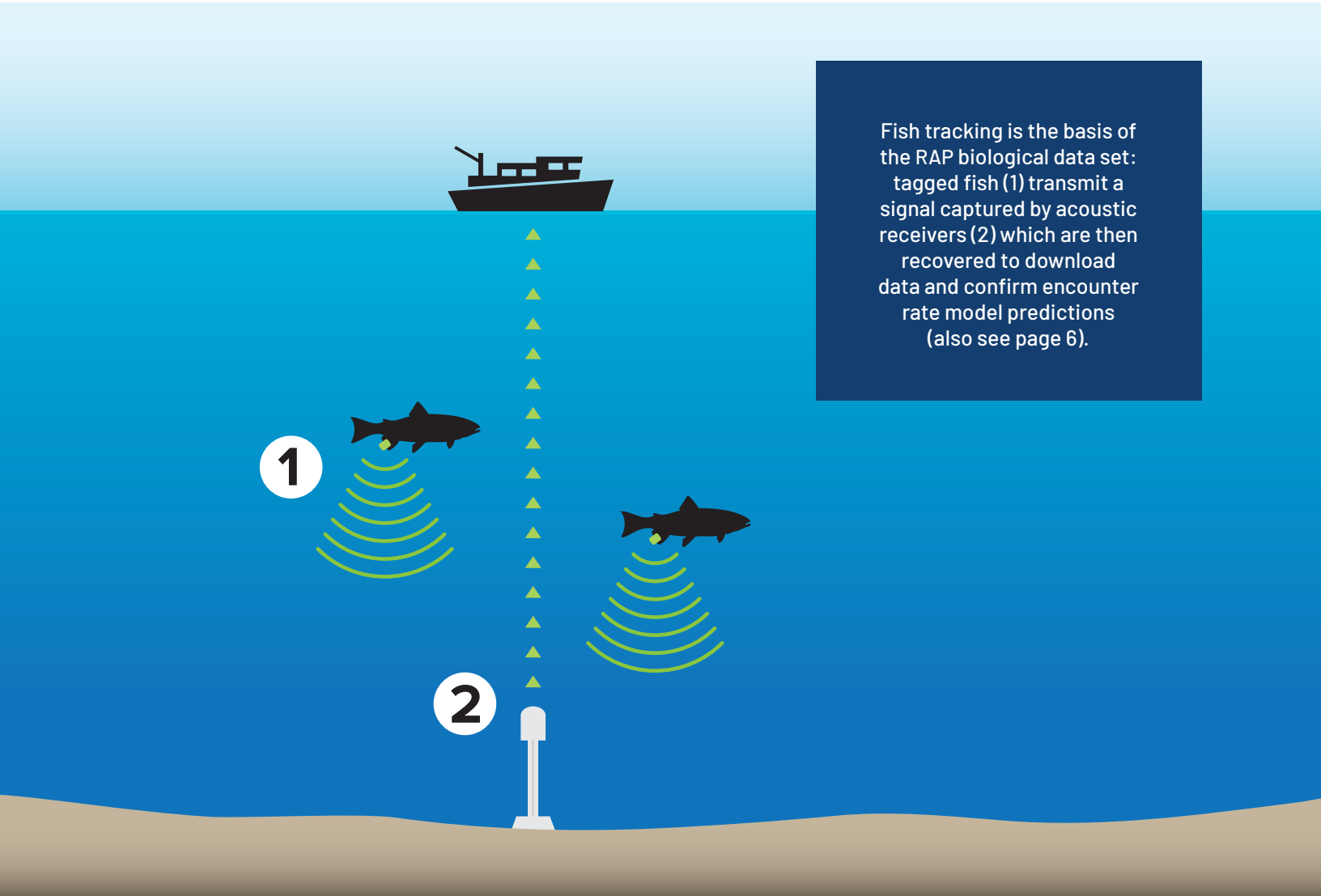
New radar imaging reveals spiralling eddies, in real time, generated during an ebb tide by Cape Sharp in the Minas Passage, Bay of Fundy. Oceanographic features like these can significantly impact the distribution of fish. See time-lapse video of radar data in the Minas Passage: fundyforcelive.ca/#!/radar

Dalhousie University, Ocean Tracking Network (OTN), Mi'kmaw Conservation Group (MCG), Acadia University

Biological Atlas

Over the last decade, hydroacoustic receivers deployed throughout the Bay of Fundy have collected movement data from a variety of fish carrying acoustic tags.

These data originate from a series of separate research programs in Canada and the United States, and provide a tremendous resource for understanding the spatiotemporal distributions for a number of fish species in the Bay of Fundy.



Fish tracking is the basis of the RAP biological data set: tagged fish (1) transmit a signal captured by acoustic receivers (2) which are then recovered to download data and confirm encounter rate model predictions (also see page 6).

Biological Atlas continued...

The first step to determine where and when a fish is likely to be located, is to determine the relationship between the presence of fish and the environmental conditions affecting their distribution. To this end, RAP is building the largest multi-species, spatiotemporal data set of fish distribution in the Bay of Fundy, through the combined compilation and analysis of the hydroacoustic fish-tagging studies outlined above for nine (9) species (thanks to partnerships with OTN, MCG and Dalhousie and Acadia Universities). The nine species were chosen based on expected availability, conservation concern or value to commercial, recreation, and Mi'kmaq fisheries, and current coverage through already-existing tracking studies.

The fish spatiotemporal distributions for each species will be combined with the environmental hydrodynamic conditions (Flow Atlas), to develop nine (9) distribution models (one per species), aka the Biological Atlas or "fish forecast maps".

Next Steps

- **Finish developing fish distribution models for all nine (9) species: complete the Biological Atlas.**
- **Draft a peer-reviewed scientific publication providing the first ecosystem-wide assessment of migratory and resident fish movement patterns in the Minas Passage and Minas Basin within the Bay of Fundy.**

Key Outcomes to Date

- *OTN gained approval for the project to utilize acoustic tag data from 22 data holders, covering nine (9) species of fish of interest in the Bay of Fundy (alewife, American shad, American eel, Atlantic salmon, Atlantic sturgeon, Atlantic tomcod, spiny dogfish, striped bass, and white shark).*
- *All data sets have been analyzed and the development of the fish distribution models has begun.*

Dalhousie University, Ocean Tracking Network, Mi'kmaw Conservation Group, Acadia University, fishing community members

Encounter Rate Models Development

The Flow and Biological Atlases will be combined to develop nine (9) encounter rate models (ERMs) that consider the proposed location and design of the turbines.

Once the first iteration of the ERMs are developed, a fish tagging program being managed by the MCG will be used to validate the models and refine predictions about their spatiotemporal distributions. The new tagging data will determine whether new tag detections fall within the model-predicted areas of fish presence. Fish tagging efforts are planned to occur in 2021 and 2022.

Acoustic receivers (69 kHz and 180 kHz) mounted on yellow mooring buoys for deployment in Minas Passage. See a video of the deployment: vimeo.com/552989257

Encounter Rate Models Development continued...

For the 2021 program, beginning in late May, a total of 111 fish for four target species (alewife, American shad, Atlantic sturgeon and spiny dogfish) are being captured and are having acoustic tags surgically implanted. The tags emit "pings", which will be heard by 12 receivers that will be deployed in the Minas Passage. The data from other fish tagging programs, in addition to Rights holder and stakeholder input, will additionally be utilized to validate the models.

The ERMs will ultimately be combined with turbine-specific information (e.g. deployment depth, swept area, etc.) to develop a user-friendly graphical user interface where stakeholders can adjust inputs for variables of interest (species, time of year, turbine characteristics) to develop species-specific risk profiles.

Next Steps

- **Develop first iteration of ERMs.**
- **Complete fish tagging program.**
- **Recover receivers quarterly and use data, and data from other projects, to validate the ERMs.**

Key Outcomes to Date

- *A preliminary test deployment of the receivers was conducted to validate the hearing range of the receivers and to determine where the receivers were to be placed for the validation study.*
- *Deployment of 12 receivers within Minas Passage in early June.*
- *Commencement of fish tagging program.*

Mi'kmaw Conservation Group, Marine Renewables Canada (MRC), Ocean Tracking Network, FORCE

Engagement

The Flow Atlas, Biological Atlas and ERMs will only be successful if they translate into a credible and useful tool for stakeholders (regulators, industry, Rights Holders, fishers, community members, etc.).

Engagement with existing and potential project partners has been ongoing since the start of the project. The fish tagging data set owners' willingness to not only share their data but also join as project partners reflects the collaborative spirit of the project as well as its broad, far-reaching benefits.

The project team has held regular meetings with regulators, and established an advisory group. Mi'kmaw Conservation Group and FORCE are jointly leading engagement efforts with Bay of Fundy mainland Mi'kmaq communities. This includes gathering visual material and learning, combining traditional and scientific knowledge to understand how principles of Netukulimk (appropriate resource use) and Etuaptmumk (two-eyed seeing) align with the Biological Atlas, reaching out to key community contacts for information sharing, preparing a final report and video that support the graphic user interface.

Key Outcomes to Date

- *All 22 data holders with spatiotemporal data sets curated by OTN agreed to share their data with and be partners in this groundbreaking project.*
- *An advisory group was created and engaged to provide input and advice on developing the Biological Atlas and ERMs, consisting of academic, regulatory, and Mi'kmaw members.*
- *A co-led engagement agreement and scope of work between MCG and FORCE has been developed.*
- *Initial industry engagement meetings complete.*

Next Steps

- **Continue to collaborate with all project partners and regulators.**
- **Develop detailed engagement plan with MCG.**
- **Deliver industry engagement plan with MRC.**
- **Engage with communities of Mainland Mi'kmaq.**

Summary

RAP is a critical addition to work currently underway to monitor and assess any environmental impacts related to tidal stream energy development.

The Government of Canada has invested $90 million in MRE technology research and development in the Bay of Fundy, intended to help meet clean energy and climate change goals. However, a lack of biological information has made it difficult to accurately assess potential risks of this emerging clean energy sector to marine life, particularly fish species of conservation concern. This assessment is needed to help inform marine planning and policy, regulation, monitoring, mitigation, offsets and/or other strategies to ensure that MRE development can proceed responsibly.

Through its support of RAP, the Government of Canada has made a critical, strategic investment in protecting a Canadian industry with the potential to contribute up to $1.7 billion in gross domestic product (GDP), create up to 22,000 full time positions and generate as much as $815 million in labour income by 2040.[1]

RAP is building the largest data set of fish distribution and movement patterns in the Bay of Fundy and developing a graphical user interface to make this data available to all stakeholders for the first time. Both the integration and accessibility of this data set is unprecedented, and can serve as an important tool for considering the potential impacts of any activity in the Bay of Fundy on the marine ecosystem. The project also provides a novel platform for scientific, Mi'kmaw, fishing and other communities to observe the spatiotemporal distribution of multiple fish species in the region, supporting important collaborations in multiple ocean sectors.

Key Project Benefits:

A Tool for Regulators
To quantify risk and inform parameters around authorization and potential conditions.

An Ecosystem-wide Approach
Making information from multiple projects accessible, and facilitating the collection of species-level information, for assessing potential impacts.

Species-specific Risk Assessment
To support evidence-based discussion around the concept of Netukulimk for Mi'kmaq, Wəlastəkwewiyik and Passamaquoddy communities.

Improving Accuracy
Ongoing fish data collection will serve to update and validate risk metrics, and to improve the integrity of the model with longer term data sets.

A Single User Interface
Responsive to key variables such as type of turbine, location, and species of fish.

[1] "Value Proposition for Tidal Energy Development in Nova Scotia, Atlantic Canada and Canada" (commissioned by the Offshore Energy Research Association (OERA) of Nova Scotia)

Key Project Partners

Acadia University
A leading academic institution conducting research in the Bay of Fundy as well as tidal energy research, training, education and outreach to promote responsible approaches to tidal energy development.

Confederacy of Mainland Mi'kmaq, Mi'kmaw Conservation Group (MCG)
MCG's mandate is to restore the concept and practice of Netukulimk in the region's watersheds; Netukulimk is based on showing respect to the lands by taking only what is needed and wasting nothing. MCG endeavours to respond to watershed challenges such as commercial use, population growth, pollution and global warming.

Fundy Ocean Research Centre for Energy (FORCE)
FORCE is Canada's leading research facility for tidal stream energy technology. FORCE provides offshore and onshore electrical equipment to connect devices to the power grid, and conducts monitoring and research to understand any potential environmental effects.

Marine Renewables Canada (MRC)
MRC is Canada's lead wave, tidal, river and offshore wind energy association, representing local and international developers, utilities, researchers, and suppliers. Since 2004, MRC has supported the development of the marine renewable energy industry with collaborative opportunities, information and outreach.

Ocean Tracking Network (OTN), Dalhousie University
OTN is a global aquatic animal tracking, technology, data management and partnership platform. OTN and its partners are using electronic tags to track more than 240 keystone, commercially important, and endangered species worldwide.

Related Science

Since the start of tidal stream technology activity in the Bay of Fundy in 2009, research partners have conducted baseline environmental studies, applied research, and environmental monitoring work at the Minas Passage test site. Much of this work is informed by ongoing advice from regulators, regional and international scientific communities, as well as FORCE's independent environmental monitoring advisory committee, with membership from the scientific, fishing, and First Nations communities.

To date, international research studies of tidal stream devices indicate that fish and marine mammals generally avoid turbines. But this must be proven conclusively in the Minas Passage. This remains difficult: the intense hydrodynamics of the Minas Passage makes it challenging for sensors to capture optical and acoustic data. This means not only environmental monitoring but also research and data modelling programs are all critical to retiring risk and uncertainty about potential impacts.

Monitoring

The environmental effects monitoring program at the FORCE site 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, marine noise, benthic habitat and other variables. This work now represents more than 4,300 'C-POD' marine mammal monitoring days, over 400 hours of hydroacoustic fish surveys, bi-weekly shoreline observations, 49 observational seabird surveys, as well as lobster surveys, drifting marine sound surveys and additional sound monitoring. All documents are available online: fundyforce.ca/document-collection

Monitoring work includes contributions from the University of Maine, the Sea Mammal Research Unit Consulting (Canada), Envirosphere Consultants, Acadia University, TriNav Fisheries Consultants, JASCO Applied Scientists, Ocean Sonics, Dalhousie University, Nexus Coastal Resource Management, and Geospectrum.

As well, a partnership with Dalhousie University under the *Pathway Program* is using artificial intelligence software to standardize and automate the processing of hydroacoustic monitoring data. This approach should make it easier and faster to compare monitoring results from different locations and tidal energy devices, and should help improve the collective understanding of fish distribution and density in the vicinity of individual turbines, and how this changes temporally and in relation to key environmental variables.

Research Assets

Onshore assets at the FORCE facility 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. Research projects include:

Hydroacoustics Platform: comparing bottom-mounted fish profiling data collection to downward facing fish profiling data from vessel transects; this may determine both the most effective

way to monitoring fish long-term in tidal energy sites.

Cabled Platform: delivering real-time monitoring data from near-turbine locations using a variety of sensors (like the Tritech Gemini imaging sonar) to detect marine life in the vicinity of operating turbines. This platform may prove to be an essential piece of monitoring equipment.

The Vectron: the world's first stand-alone instrument to remotely measure turbulence in the mid-water column in high resolution. Vectron analysis will help tidal energy companies to better design devices, plan marine operations, and characterize the tidal energy resource.

International Effort

Canada's research and monitoring are part of an international effort to evaluate the risks tidal energy poses to marine life. Presently, countries such as China, France, Italy, the Netherlands, South Korea, the United Kingdom, and the United States are exploring tidal energy; Canada is working to inform the global body of knowledge pertaining to environmental effects associated with tidal power projects. This includes participation in the Fundy Energy Research Network,[2] the UK-based Offshore Renewables Joint Industry Programme,[3] TC114,[4] the Atlantic Canadian-based Ocean Supercluster,[5] and OES Environmental (formerly Annex IV) – a forum to explore the present state of environmental effects monitoring around MRE devices.[6]

FORCE collaborated with 14 co-authors from around the world to produce *'Environmental Monitoring Technologies and Techniques for Detecting Interactions of Marine Animals with Turbines' as part of the OES 'State of the Science Report 2020'*. Lead author Dr. Andrea Copping, an oceanographer with the U.S. Department of Energy's Pacific Northwest National Laboratory, made the following general comments regarding the 2020 report:

- *We believe that small numbers of operational marine energy devices are unlikely to cause harm to marine animals, including marine mammals, fish, diving seabirds, and benthic animals; change habitats on the seafloor or in the water significantly; or change the natural flow of ocean waters or waves.*

- *Despite our findings, we still need more data about what might, or might not, happen to animals swimming close to operating turbines underwater. In the years to come, we will continue to focus our research on examining this issue and building our knowledge base to help progress this important renewable energy industry.*

FORCE will continue to work closely with the international research community to document and improve the state of knowledge pertaining to tidal energy devices' interactions with the marine environment.

[2] FERN is a research network designed to" coordinate and foster research collaborations, capacity building and information exchange" (Source: fern.acadiau.ca/about.html).

[3] ORJIP is a UK-wide collaborate programme of environmental research with the aim of reducing consenting risks for marine energy projects. Learn more: www.orjip.org.uk

[4] 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

[5] 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

[6] Annex IV was established by the International Energy Agency (IEA) Ocean Energy Systems (OES) in January 2010 to examine environmental effects of marine renewable energy development. Further information is available at https://tethys.pnnl.gov