Environmental Monitoring, Modelling and Forecasting for Instream Tidal Energy Development at the FORCE Test Site

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Background

Tidal currents are a promising source of renewable energy. Canada has in the Bay of Fundy one of the world's richest tidal resources and a world-leading test site for large grid-connected in-stream tidal turbines. But decisions regarding the development and regulation of the tidal energy industry are hindered by a lack of scientific evidence related to animal/turbine interactions and flow variability as infrastructure specific to the task of characterizing and monitoring high-energy tidal sites has not been previously available.

This project aims to address this issue by combining the necessary equipment and scientific expertise to carry out the research, generate the evidence and inform the critical decisions necessary to mitigate technological, market, environmental and regulatory risks. This research, led by Canada's leading tidal energy research team, has received a CFI Innovation Fund award to pursue two research themes: impact of turbines on the environment, and impact of the environment on turbines.

FISH TRACKING: QUANTIFYING FISH –TURBINE INTERACTIONS

Project Lead: Dr. Michael Stokesbury (Redden, Karsten)

Fig 1. Atlantic sturgeon tagging in the Minas Passage (Photo: Aaron Spares)

Cutting edge High Residency (HR) VEMCO fish tags engineered for high flow environments will be used to track Atlantic salmon, alewife, American shad and Atlantic sturgeon in the Minas Passage using an array of acoustic receivers (Fig 3).

The high resolution of these data will enable future 3D tracking of fish movement in and around the FORCE site. Tagging results will inform the development of models of fish behaviour near tidal turbines

ACOUSTIC DETECTION OF FISH AND MARINE MAMMALS

Project Lead: Dr. Anna Redden (Zedel, Stokesbury, Barclay, Karsten)

Tritech Gemini imaging sonar (Fig 2, Fig 3) will be deployed to assess the presence, vertical distribution and movement of fish and marine life at the FORCE test site. Simultaneous sonar datasets will be compared between sites with and without turbines to asses critical near-field (<50m) turbine effects.

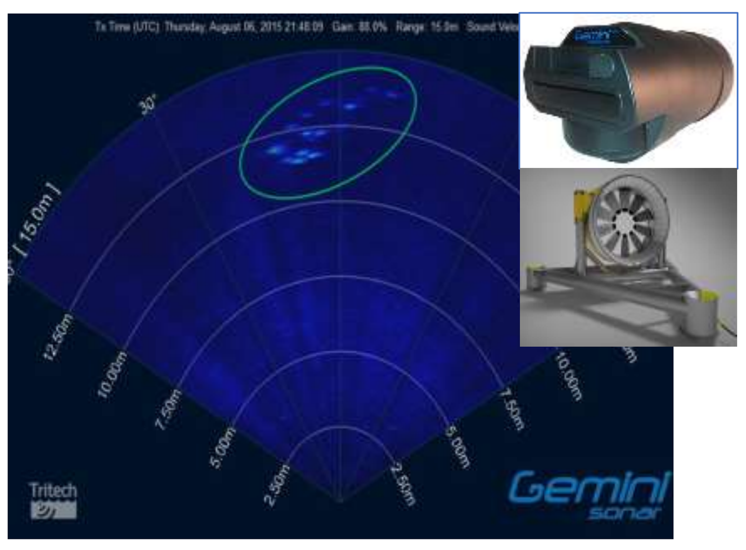

Fig 2. Gemini imaging sonar (top right) and sample sonar image (left), Cape Sharp Tidal turbine (right)

Other objectives include:

- Validating datasets from FORCE's ongoing echosounder fish surveys
- Detecting and localizing marine mammals using passive acoustic recordings from drifting hydrophone arrays
- Combining data from fish tracking and turbulence modeling projects to simulate fish behaviour near tidal turbines (in collaboration with Swansea University)

MEASURING AND SIMULATING THE ACOUSTIC ENVIRONMENT

Project Leads: Dr. Joseph Hall and Dr. David Barclay

A drifting hydrophone array (Fig 3) will be used to quantify the spatial and spectral distribution of turbine-generated noise and propagation. The sound field will be decomposed into natural (biological and environmental) and anthropogenic (turbine and industrial) components. Simulations of turbine generated noise, supported by computational fluid dynamics (CFD) models from the turbulence project will be used to estimate exposure levels and explore design changes to minimize the impact of turbine noise on marine life.

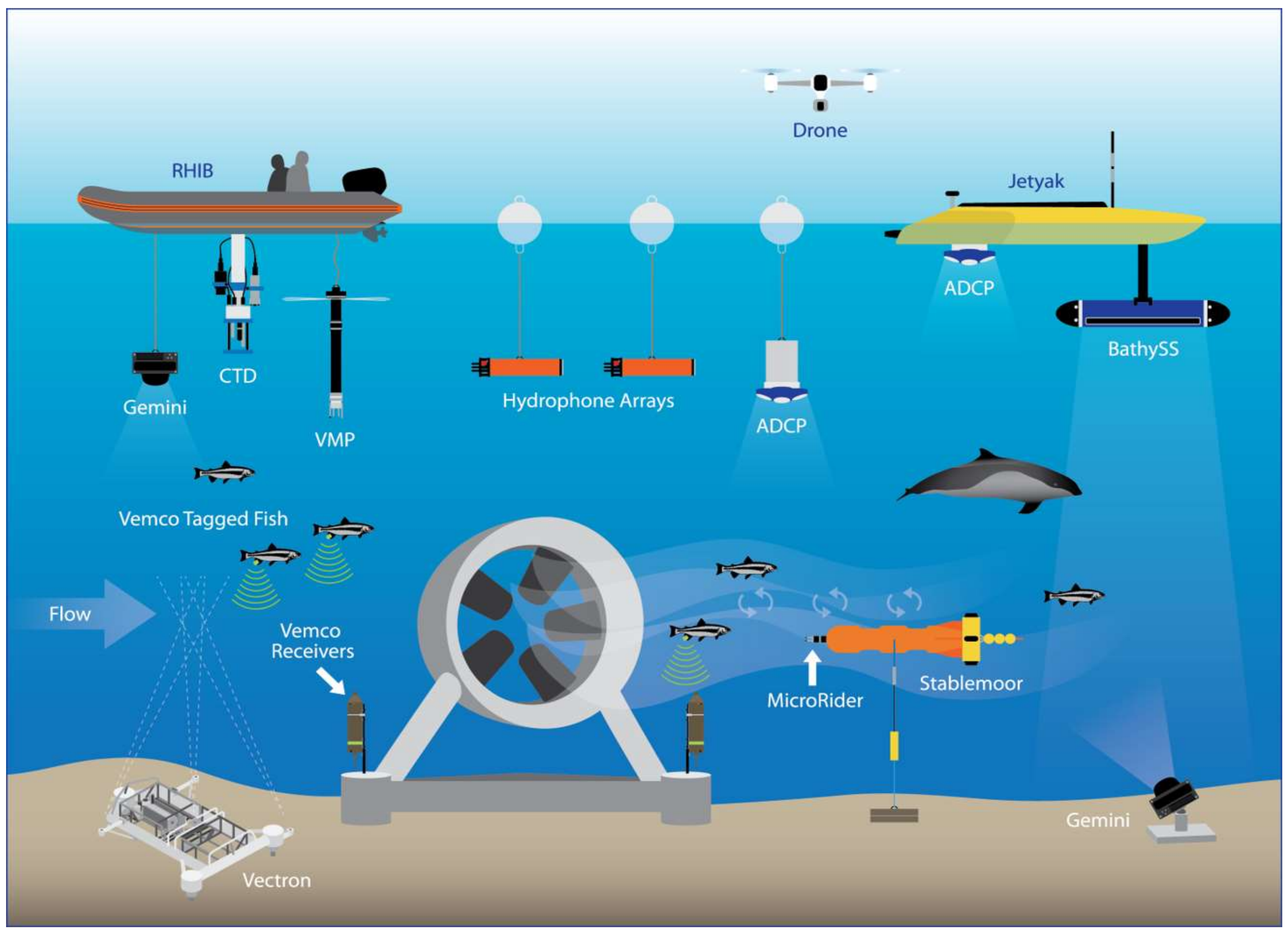

Fig 3. Integrated use of field work infrastructure. Fish tracking: VEMCO tags/ receivers; Acoustic detections: Gemini imaging sonar; Acoustic environment: Hydrophone arrays; Turbulence: Jetyak, BathySideScan, ADCPs, VPM, CTD, Stablemoor/ MicroRider, Vectron, drones (Jan Sykora)

QUANTIFY, CHARACTERIZE AND SIMULATE TIDAL TURBULENCE

Project Leads: Dr. Alex Hay and Dr. Andrew Gerber (Zedel, Barclay, Hill, Hall, Jeans, Karsten)

Mobile equipment (Fig 3) will be used to quantify the spatial and temporal variation of flow and turbulence in Minas Passage. Equipment includes drone-borne video, the Jetyak for mapping wakes and bathymetric sidescan sonar for mapping seabed changes over time.

Stationary measurement systems will be deployed to provide complimentary data. These include the Stablemoor/ MicroRider to measure the wake field downstream of turbines throughout the tidal cycle.

High resolution regional and turbine-level CFD simulations of 3D turbulent flow will be developed, including unsteady forces and noise to quantify impacts on turbines. Simulations will be validated against measurements from the field.

Fig 4. Researchers from Dalhousie University and Rockland Scientific International with Stablemoor equipment (Photo: Alex Hay)

Fig 5. Front and rear view of vorticity iso-surface of a ducted turbine from CFD simulations (Farhad Baratchi)

OCEAN FORECASTING SYSTEM FOR THE BAY OF FUNDY

Project lead: Dr. Richard Karsten (Gerber, Jeans, Hay)

Advanced research computing (ARC) equipment from ACENET will be used to run regional-level simulations of tides and tidal currents. Designs of turbines and environmental impacts will be assessed through extra-high resolution environmental simulations, in order to improve efficiency and reduce turbine impacts. The effects of weather, waves and turbines on tidal currents will be simulated to support the development of real-time forecasts of sea conditions in order to plan field campaigns and tidal turbine deployments.

Acknowledgements

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