The Pathway
A program for regulatory certainty for instream tidal energy projects

Presentation

*Imaging sonar review for marine mammal and fish monitoring around tidal turbines*

**Principle Investigators**
Dr. James Joslin, MarineSitu

June 2015

Monitoring for environmental interactions of tidal turbines presents many unique challenges and requires instrumentation that can withstand extreme environments. One of the best instruments for this task are acoustic imaging sonars which can provide high resolution imagery in turbid waters without the need for artificial illumination. This project presents a review of imaging sonars that are currently available to consumers along with recent examples of how they are used for marine mammal monitoring. Further discussion will include considerations for data collection and processing to enable long term monitoring of tidal turbines.

*This project is part of “The Pathway Program” – a joint initiative between the Offshore Energy Research Association of Nova Scotia (OERA) and the Fundy Ocean Research Center for Energy (FORCE) to establish a suite of environmental monitoring technologies that provide regulatory certainty for tidal energy development in Nova Scotia.*
Imaging sonar review for marine environmental monitoring around tidal turbines for Pathway 2020

James Joslin
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June 12th, 2019
Overview

• Motivation
• Literature Review Summary
• Imaging Sonars
• Applications
• Key Considerations
• Common Issues
• Summary and Recommendations
• Acknowledgements
Motivation – Pathway 2020

• To develop an integrated, robust and cabled multi-instrument subsea platform to monitor interactions between tidal turbines and marine life in Minas Passage by December 2020.

• Phase 1 – Comprehensive literature review and current status survey of imaging sonars.

• Imaging sonars can provide high resolution imagery in turbid waters with ranges >100 m without artificial illumination.
Literature Review Summary

• 20+ papers and reports on relevant uses of imaging sonars for marine life monitoring in high float environments.

• Deployment methods:
  • Vessel based surveys or short term testing monitoring
  • Bottom lander in close proximity to tidal turbines
  • Integrated with turbine platform

• Applications: 6 specific application presented here in more detail
  • Marine mammal monitoring: harbor seals, grey seals, porpoises
  • Fish monitoring

• Challenges:
  • Data management and processing delays
  • Biologic vs. non-biologic target detection and tracking
  • Instrument durability for long term deployments
Imaging Sonars - General Specifications

Operating manuals for each sonar contain the following specifications:

- Operating Frequency: >260 kHz to 3 MHz
- Swath/Field of view angles
- Range: 5 to 200 m
- Resolution
- I/O trigger option
- Connector type
- Power requirements
- Housing material
- Software and SDK
- Typical applications
<table>
<thead>
<tr>
<th>Instrument/ Sensor Category</th>
<th>Instrument / Sensor</th>
<th>Manufacturer(s)/ Vendor(s)</th>
<th>Technology/ Software</th>
<th>Commercially/ R&amp;D</th>
<th>Imaged area</th>
<th>Typical Swath/ Field of View</th>
<th>Rating Power Requirements</th>
<th>Connector Type</th>
<th>Flows</th>
<th>Experience with High Flows</th>
<th>Flows</th>
<th>Power Requirements</th>
<th>References/ Web Links</th>
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<tbody>
<tr>
<td>Imaging Sonars – Assessment Table</td>
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# Imaging Sonars – Summary Table

<table>
<thead>
<tr>
<th>Sonar</th>
<th>Frequency</th>
<th>FOV</th>
<th>Range</th>
<th>Trigger</th>
<th>SDK?</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tritech Gemini</td>
<td>720 kHz</td>
<td>120 x 20 deg</td>
<td>&lt;120 m</td>
<td>Yes</td>
<td>Yes</td>
<td>SeaGen, AMP</td>
</tr>
<tr>
<td>Teledyne Blueview</td>
<td>900/2250 kHz</td>
<td>130 x 20 deg</td>
<td>&lt;100 / &lt;10 m</td>
<td>Yes</td>
<td>Yes</td>
<td>AMP, vessel surveys</td>
</tr>
<tr>
<td>Kongsberg Mesotech</td>
<td>500 kHz</td>
<td>120 x 3, 7, 15, or 30 deg</td>
<td>&lt;150 m</td>
<td>Yes</td>
<td>No</td>
<td>AMP, vessel surveys</td>
</tr>
<tr>
<td>Blueprint Subsea Oculus</td>
<td>375 or 750/1200 or 1200/2100 kHz</td>
<td>130 x 20 deg or 70 x 12 deg or 60 x 12 deg</td>
<td>&lt;200 or &lt;120 / &lt;40 or &lt;30 / &lt;10 m</td>
<td>Yes</td>
<td>Yes</td>
<td>Other, vessel surveys</td>
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<tr>
<td>Imagenex Delta T</td>
<td>260 kHz</td>
<td>120 x 10 deg</td>
<td>&lt;150 m</td>
<td>Yes</td>
<td>Yes</td>
<td>FLOWBEC</td>
</tr>
<tr>
<td>Sound Metrics Aris</td>
<td>1200/700 or 1800/1100 or 3000/1800 kHz</td>
<td>28 x 14 deg or 28 x 14 deg or 30 x 15 deg</td>
<td>&lt;80 / &lt;35 or &lt;35 / &lt;15 or &lt;15 / &lt;5 m</td>
<td>No</td>
<td>No</td>
<td>ORPC, Verdant RITE</td>
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Imaging Sonars - Tritech Gemini 720is

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- **Key features:**
  - Most use cases across industry.
  - Adjustable range up to 120 m with high resolution and 120 x 20 deg swath
  - Good software control with built in target detection and optional SDK
Imaging Sonars - Teledyne BlueView M900/2250

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<td>130 x 20 deg</td>
<td>&lt;10 / &lt;100 m</td>
<td>Yes</td>
<td>Yes</td>
<td>AMP, vessel surveys</td>
</tr>
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- **Key Features:**
  - Dual frequency head provides options for monitoring range
  - Short range head has very high resolution good for target classification
Applications – Vessel Surveys


• Broad applications of vessel based multibeam surveys using many different sonars

• Generally short duration with continuous data collection and post processing

• Complicated by vessel motion and continuously changing background

Example data from survey to track sharks in Australia
Applications – FLOWBEC-4D


- Flow, Water column and Benthic Ecology 4-D (FLOWBEC-4D), developed in the UK for monitoring at wave and tidal energy sites.

- Integrates Imaginex Delta T multibeam sonar with EK60 echosounder, an ADV, and fluorometer.

- Battery powered for 2 week deployments with continuous data collection and post processing

*FLOWBEC platform during deployment*

*Example data from deployment*
Applications – SeaGen, Strangford Lough


• Tritech Gemini integrated with turbine platform for harbor seal and porpoise monitoring.

• One of the longest term marine mammal monitoring demonstrations.

• Helped to develop native target detection and tracking software.

• Good review of sound levels produced by active acoustics and animal response to that sound.
Applications – ORPC, Cobscook Bay


- Fish monitoring with 2 DIDSONs from vessel based turbine test platform.

- High resolution sonars able to track individual fish through cross flow turbine.

- Short term data collection with post processing.

**Example of annotated data**

**Sonar configurations on test platform**
Applications – Verdant, RITE Project


- Fish tracking with a DIDSON mounted on a pan and tilt platform.

- Collected data continuously for 19 days with post processing.

- Evaluated fish behavior relative to turbine to look for avoidance.
Applications – AMP, Sequim Bay

• Integrated instrumentation platform with Gemini, BlueView, WBTmini echosounder, stereo-optical cameras with illumination and wipers, ADCP, Vemco fishtag receiver, 4x icListen hydrophones, ecoBB water clarity sensor, and tilt motor for instrument head.

• Versions of the AMP have been tested in cabled and autonomous configurations on both bottom landers and surface buoys.

• Much more information available…
Key Considerations - Mounting and orientation

• For a bottom mounted lander deployment both horizontal and vertical orientations have been shown to be effective.

• Key Variables:
  • Turbine range
  • Deployment orientation control
  • Water depth
  • Sonar angle

• Pan/tilt mount option
• U-bolt of clamp mount options
Key Considerations - Electrical and communications connections

• Sonars use a variety of electrical connectors but they will all need DC power, I/O lines, and Ethernet comms
• Some require a secondary connector for trigger I/O, this can be “wyed” into a single connector for a control bottle
• Electrical isolation for ground faults
Key Considerations - Software for instrument control and data acquisition

- Every sonar developer has their own software, but not all play well with others.
- Integration requires custom software to synchronization control.
- Custom software is easier to develop with an SDK supported by instrument developer.

Examples of sonar VIs developed in LabView for the AMP
Key Considerations - Software for data processing

- Development and testing of autonomous data processing algorithms is an active area of research.
- While some lessons can be taken from other deployments, every new deployment will require tuning of detection algorithms.
- Develop data collection objectives early and process data continuously throughout deployment to allow for algorithm optimization.

Examples of AMP data of seal and fish detection and classification with optical cameras
Common Issues – Corrosion

• Durability of instrumentation is often complicated by corrosion.

• Many sonars have housings, connectors, and locking sleeves with dissimilar metals.

• Solution:
  • Ensure there is no dissimilar metal contact or, if this is not possible, add a sacrificial anode.
  • Test for and eliminate ground faults during pre-deployment testing.

Examples of corrosion on anodized aluminum housing and connectors with dissimilar metals
Common Issues – Biofouling

• While biofouling does not inherently decrease sonar performance, it will damage the transducer over long deployments.

• Solutions:
  • Limiting deployment lengths for maintenance and cleaning
  • UV lights are a good option for mitigation over longer terms
  • Antifouling paint and zinc-oxide paste can be used on some transducers
Common Issues – Electrical interference

- Electrical noise on integrated instrumentation platforms can cause noise in sonar data.
- Often due to DC/DC converters.
- Solution: Power and comms channels should have electrical filtering and isolation.

Example data from BlueView deployment where thin radial lines appear when strobe lights fire.
Common Issues – Noisy images

• Many common issues with sonar data processing that include:
  • Persistent moving targets in the field of view
  • Boat or turbine wakes entraining bubbles
  • Turbulence entrained bubbles
  • Non biologic drifters in the water column

• Solution:
  • This is currently an active research problem
  • More development is needed for common data processing algorithms

Example data from BlueView deployment with multiple targets creating non-biologic triggers
Common Issues – Sound levels

• Imaging sonars operate by generating sound pulses that are generally considered to be above marine animal hearing. However, they do generate some noise at lower frequencies.

• More information is needed to understand animal response to this sound.

Source level of Tritech Gemini from G. Hastie Report
Summary and Recommendation

- Best in class recommendations are the Tritech Gemini 720is and the Teledyne BlueView M900/2250 depending on range requirements
- Software integration and data processing options should drive selection process
- Mounting and deployment orientations will have a large impact on data quality
- Considerations for electrical isolation, corrosion resistance and biofouling are essential for the overall platform
- Pre-deployment testing and data collection is essential
Acknowledgements

• Thank you to everyone that assisted in assembling this information:
  • The AMP team: Emma Cotter, Brian Polagye, Paul Murphy, Paul Gibbs, Mitchell Scott, and Andy Stewart
  • Benjamin Williamson from the University of Aberdeen
  • Tyler Whitaker from Teledyne BlueView
  • Aaron Marburg and Chris Bassett from APL
  • And many others...
Thank you

For further questions, please contact me: jbjoslin@uw.edu