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Welcome to the Annex IV Expert Forum on

Environmental Monitoring Around Turbines

- The Forum will begin shortly
- Introductions
- This forum is expected to be very interactive, please provide your experience and thoughts
- Please IM if you are having technical difficulties with Skype

January 12, 2017

Discussion

- **Andrea Copping**, PNNL and Annex IV
  - Opening remarks, context
- **Anna Redden**, Acadia University & **Jason Wood**, SMRU Consulting
  - Marine mammal and fish monitoring in Bay of Fundy/FORCE
- **Benjamin Williamson and Beth Scott**, University of Aberdeen
  - Using FLOWBEC to investigate the effects of tidal stream turbines
- **Carol Sparling and colleagues**, SMRU
  - Marine mammal monitoring around turbines in Scotland and Wales
- **Haley Viehman**, Acadia University, **Garrett Stains**, PNNL & **Nate Johnson**, ORPC
  - Fish interactions around turbine in Maine
- **Nate Johnson**, ORPC and **Shari Matzner**, PNNL
  - Fish Interactions around turbine in Alaska
- **Jonathan Colby**, Verdant Power & **Chris Tomichek**, Kleinschmidt Associates
  - Fish interactions around turbine in New York
- **Sue Barr**, Open Hydro
  - Fish monitoring around turbine at EMEC, elsewhere

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Anna Redden
Acadia University

Jason Wood
SMRU Consulting

Marine mammal and fish monitoring in Bay of Fundy/FORCE

Canada – Environmental Monitoring at FORCE

Fish

- down-looking hydroacoustic surveys / transects for fish density and vertical distribution (UMaine, FORCE)
- up-looking sonar (AZFP, WBAT; 1 month intervals) on fixed FAST sensor platform (Acadia, FORCE)
- Gemini imaging sonar mounted on CST OH turbine; deployed Nov 2016 (Canada/ UK project)
- fish tagging/tracking data used to develop probability of encounter model for tagged fish species (Acadia)

Marine Mammals

- CPOD surveys: ~2 years baseline (SMRU Consulting, Acadia); Current deployments near CST OH turbine (SMRU Consulting, FORCE)
- 4 icListen hydrophones + Gemini sonar mounted on CST OH turbine; deployed Nov 2016 (Canada/UK project)
- experimental drifter surveys with icListen hydrophones and high flow customized drifter design (Acadia)
- land and boat visual surveys

Other

- Visual surveys of seabirds continue (Envirosphere Consultants, FORCE)
- Lobster trap surveys at/near FORCE (NEXUS Coastal Resource Mgmt, FORCE)
- Marine noise examined via hydrophone drifter surveys (Jasco and Ocean Sonics) and via fixed, bottom-mounted hydrophones, both near and far from CST OH turbine (Jasco)
- Beach walks for observations of marine life damage / strandings; public reporting of marine animal deaths and other potential indicators of effects is actively encouraged (FORCE)

Summary notes presented by

ACADIA UNIVERSITY

SMRU Consulting
Europe • North America • Asia Pacific

FORCE

Canada – Environmental Monitoring Gaps at FORCE

Fish

- lacking fish species ID and relative abundance at FORCE; need trawl surveys and/or other conventional fish collection methods (concurrent with sonar datasets); some information is available for spring / summer fish assemblages in intertidal weir catches in Minas Basin
- too few acoustic devices deployed for detecting near-field behaviour of fish; prefer additional sonars housed on both turbine infrastructure and cabled sensor platform

Marine mammals

- more acoustic devices deployed for detecting near-field behaviour of marine mammals, preferably cabled to shore, and facing turbine - desirable
- information on detection range of hydrophones/sonar in different tidal states – esp. reliability on spring flood - desirable
- reliable instruments to confirm blade strike - desirable
- challenges in successfully tracking porpoises with hydrophone arrays
- challenges in determining cause of death from stranded animals

Overall

- As the data from monitoring continues to grows, will need policies and practices related to data management and sharing; data analysis; etc.

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FORCE

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Benjamin Williamson and Beth Scott

University of Aberdeen

Using FLOWBEC to investigate the effects of tidal stream turbines

Using FLOWBEC to investigate the effects of tidal stream turbines

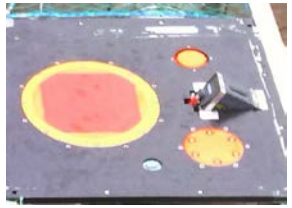
Benjamin Williamson, Beth Scott
Shaun Fraser, James Waggitt
Philippe Blondel, Paul Bell

1. How do hydrodynamics affect animal behavior in tidal energy sites?
2. How do tidal turbine structures alter the behavior of animals?

Need **concurrent** information on:

- Hydrodynamics → ADV & ADCP

- Animal distribution & ID → Multi-frequency echosounder



- Animal behavior → Multibeam echosounder
  (predator-prey and animal-turbine interactions)

Fluorometer / turbidimeter

Camera

PAM

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FLOWBEC Research Priorities

Benjamin Williamson, Beth Scott
Shaun Fraser, James Waggitt
Philippe Blondel, Paul Bell

Changes in **hydrodynamics** (flow speed, turbulence morphology and metrics, …)

Mechanistic links to predict times and increase/decrease

Changes in **predator behavior** (prey depth, type, availability, aggregation/disorientation → foraging efficiency)

Times and changes of seabird and mammal **collision risk** (e.g. vertical prey distribution, association with flow speed)

Changes to prey distribution altering predator **individual behavior** (energetics…)

PhD start Oct 2017 to relate these

Population-level effects (scaling turbines to arrays)

Ongoing FLOWBEC research:

FLOWBEC cabled to MeyGen turbine (for long-term dataset)

Algorithm development: co-registering multiple instruments
behavioral analysis

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Carol Sparling and colleagues

SMRU

Marine mammal monitoring around turbines in Scotland and Wales

Marine Mammal Monitoring around tidal turbines:

Monitoring and mitigation around MCT SeaGen, Strangford Lough, Northern Ireland

- Shore based visual observations
- Static PAM (TPODs)
- Harbour Seal tagging
- Aerial survey
- Turbine mounted upstream facing mechanical scanning sonar

Monitoring at TEL DeltaStream, Ramsey Sound, Wales

- Turbine mounted 12ch PAM array – capable of detecting, localising and tracking
- Seabed mounted, turbine facing multibeam sonar (single)

Monitoring at MeyGen, Pentland Firth, Scotland

- Turbine mounted 12ch PAM array – capable of detecting, localising and tracking
- Seabed mounted, turbine facing multibeam sonar (dual)
- Foundation mounted, upward facing hi-res video
- Harbour seal tracking

Monitoring at Cape Sharp Tidal, FORCE, Bay of Fundy, Canada (with Jason's team and Anna's team)

- Outward facing multibeam sonar
- (PAM: 4 ICListen hydrophones)

Sea Mammal Research Unit

SMRU CONSULTING Europe

understand · assess · mitigate

Needs/gaps/discussion points

- Integrated analytical tools
- Strike detection
- Early and direct engagement with engineers
- Environmental monitoring to be earlier on the agenda for project developers
- Consideration of array scale – will monitoring be required?
  - Scaling up data/findings from single dev/small arrays
  - How to monitor at arrays

Sea Mammal Research Unit

SMRU CONSULTING Europe
understand · assess · mitigate

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Haley Viehman
Acadia University

Garrett Staines
PNNL

Nate Johnson
ORPC

University of Maine: research with ORPC in Cobscook Bay

University of Maine: research with ORPC in Cobscook Bay

- Physical sampling of fish community, May-November 2011-2013; (Vieser 2015)
  - 46 species sampled, most under 20 cm, dominant species were sticklebacks, herring, and winter flounder
- Nearfield fish interactions with Beta TidGen®, 2010; (Viehman and Zydlewski 2015)
  - 24 hours of data from 2 DIDSON units, up- and downstream of test turbine; viewed device cross-section, spanned 3 m up and downstream
  - Most fish ~10 cm length, moved with current, milled at slack tide
  - Fish in line with turbine typically entered turbine; fish often milling in turbine wake; strike detection impossible
- Stationary, downlooking hydroacoustic surveys, 2010-2014; (Viehman et al. 2015; Staines et al. 2015)
  - Tidal/diel comparisons before device installation; BACI comparisons of fish density and vertical distribution
  - Potential differences before/after deployment, possibly related to construction/on-water activity (not quantified)
  - Need more samples with turbine present (only had 3, turbine in different operational state each time)
- Mobile hydroacoustic transects (tidal drifting), 2014; (Shen et al. 2015)
  - Probability of encounter calculated based on BACI study vertical distributions + change in vertical distribution and abundance over course of transects
  - ~5% chance that fish upstream of the turbine arrives at turbine at same depth as turbine
  - Decrease in number of fish beginning 140 m upstream of device; suggests avoidance
- Stationary, sidelooking, continuous hydroacoustic data collection
  - bottom-mounted, side-looking echosounder, spanned 7-15 m from turbine face (upstream during flood, downstream during ebb)
  - Fish movement in horizontal plane compared between turbine present & static to not present
    - Small deflection from current to avoid turbine; no wake effect evident (suggests limited to within 7 m of device)
  - Two-year time series of hourly fish passage rate, turbine not present
    - Patterns in fish presence were mainly cyclic, related to tidal, diel, lunar, seasonal cycles, but relationship changed seasonally
    - Study designs should take these patterns into account to avoid observing incorrect trends

* Current UMaine monitoring at FORCE with mobile hydroacoustics

Gaps

- Need more information collected with turbines present and operational (“devices in the water”)
- Regulatory process makes single or small scale deployments burdensome
- Long-term monitoring
- Observations on multiple spatial scales: especially near-field
- Better understanding of natural fish movements/behaviors to estimate likelihood of encountering tidal turbines and to inform models
- Begin planning to assess potential scaling-up effects (>10 devices) based on observations at smaller scales
- Sensor technology and data processing burdens

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Nate Johnson
ORPC

Shari Matzner
PNNL

Fish Interactions around turbine in Alaska

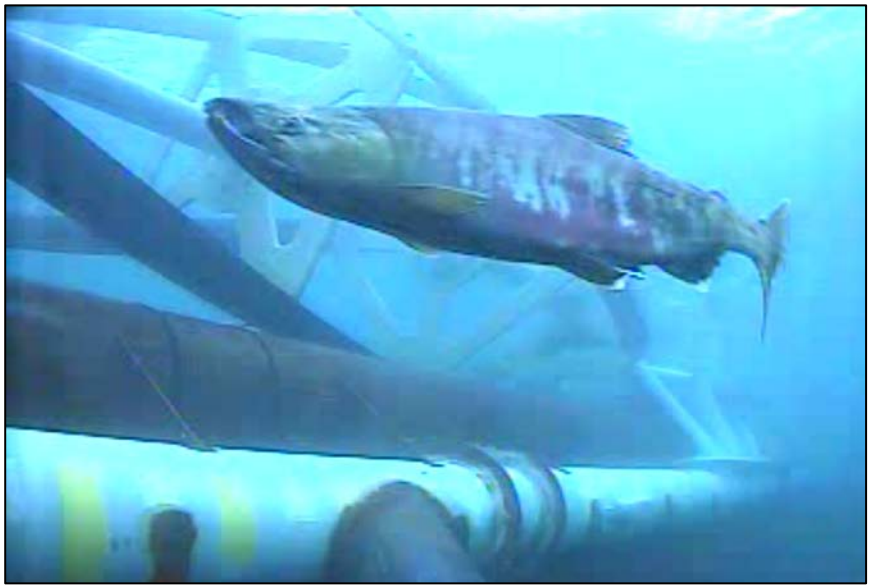
Fish Interactions around Turbine in Alaska

- Nate Johnson, ORPC
- ORPC's RivGen® Power System operated in Kvichak River near Igiugig, Alaska in 2014 and 2015
  - Fish monitored using 5 underwater video cameras, data recorded continuously
  - Evaluate viability of underwater camera system
  - Describe behavioral responses of wildlife to devices
- Findings to date
  - Reviewed 10-minute samples of 111 hours of data for each of 5 cameras (555 hours total)
  - No detections of fish contact with turbines, no evidence of passage delay, injuries or mortality
  - Lights placed behind cameras were effective at night
  - Water turbidity limited detection range

- Shari Matzner, PNNL
- Developing algorithms to automatically detect and track fish in underwater video.
  - Using Igiugig video data for development and testing.
  - Human analysis for comparison.
  - Fish4Knowledge codebase
  - UW collaboration
- Findings to date
  - Combination of optical flow and background subtraction is promising
  - Automation is necessary to make video practical.
  - Fish are easier to detect at night.
  - Difficult to characterize fish interactions with turbine.

Fish Interactions around Turbine in Alaska

- Gaps
  - Need a way to confirm strikes
  - Better quality underwater video
  - Combine sonar and video



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Environmental Monitoring of Tidal/Hydrokinetic Turbines and Arrays

“Environmental Monitoring of Tidal/Hydrokinetic Turbines and Arrays”

Annex IV/ORJIP Expert Forum
January 12, 2017

Jonathan Colby
Director of Technology Performance
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Chris Tomichek
Senior Manager
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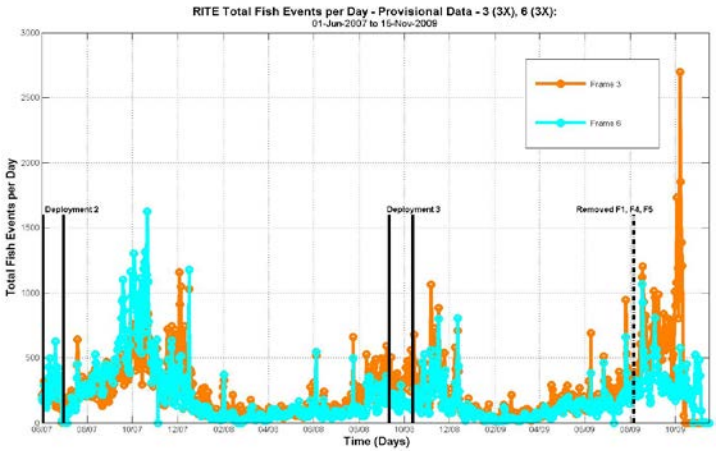
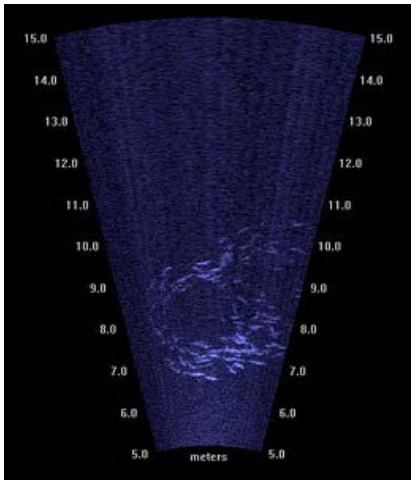
RITE – Environmental Findings

- Seasonal Fixed Hydroacoustics (SBT)
  - Strong seasonal signature = migration
  - *Clear spatial/temporal distribution = near shore at slack*
- Seasonal High-Resolution Sonar (DIDSON)
  - *Very limited number at rotor disk while operational*
  - Some evidence of avoidance
- Seasonal Netting
  - *Very few fish mid-river at peak Vw*
- Tagged Species Detections (VEMCO)
  - Majority of fish use West Channel
  - *Majority of fish at/near slack*
- Seasonal Bird Observations
  - No change in bird behavior
- Underwater Noise
  - Anthropogenic noise > turbine noise
- Collision Risk Modeling
  - Likelihood of interaction is de minimis





Environmental Gaps

Proportionality

- Achieve monitoring of key issues in proportion to project and impact scale
- Fund monitoring at full-scale demonstrations to inform needs at commercial size operating arrays

Cost/Value Proposition

- Use collision risk modeling for large vertebrates and marine species with behavioral complexity
- Develop monitoring equipment that is:
  - Robust enough to survive in the high-energy tidal environment
  - Cost-effective to own/rent, deploy, and operate

Funding/Technology Transfer

- Fund multiple year adaptive management efforts of full-scale devices in utility size arrays to confirm long-term environmental compatibility
- Encourage the research community to share data regarding tagged species detections to ensure broader understanding of fish passage and behavior to support modeling efforts

Thank You

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Sue Barr

Open Hydro

Fish monitoring around turbine
at EMEC, elsewhere

Thank you!

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- Recordings of the presentation and discussion will be posted on Tethys at:

  https://tethys.pnnl.gov/expert-forums-marine-renewable-energy

- For more information or ideas for future forums, please contact:

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OES OCEAN ENERGY SYSTEMS

ANNEX IV