Fish interaction with ORPC TidGen™ in Cobscook Bay

Gayle Zydlewski, University of Maine

Development of an ELAM Fish Behavior Model

Gayle Zydlewski, University of Maine
Mark Grippo, Argonne National Laboratory

Acknowledgments

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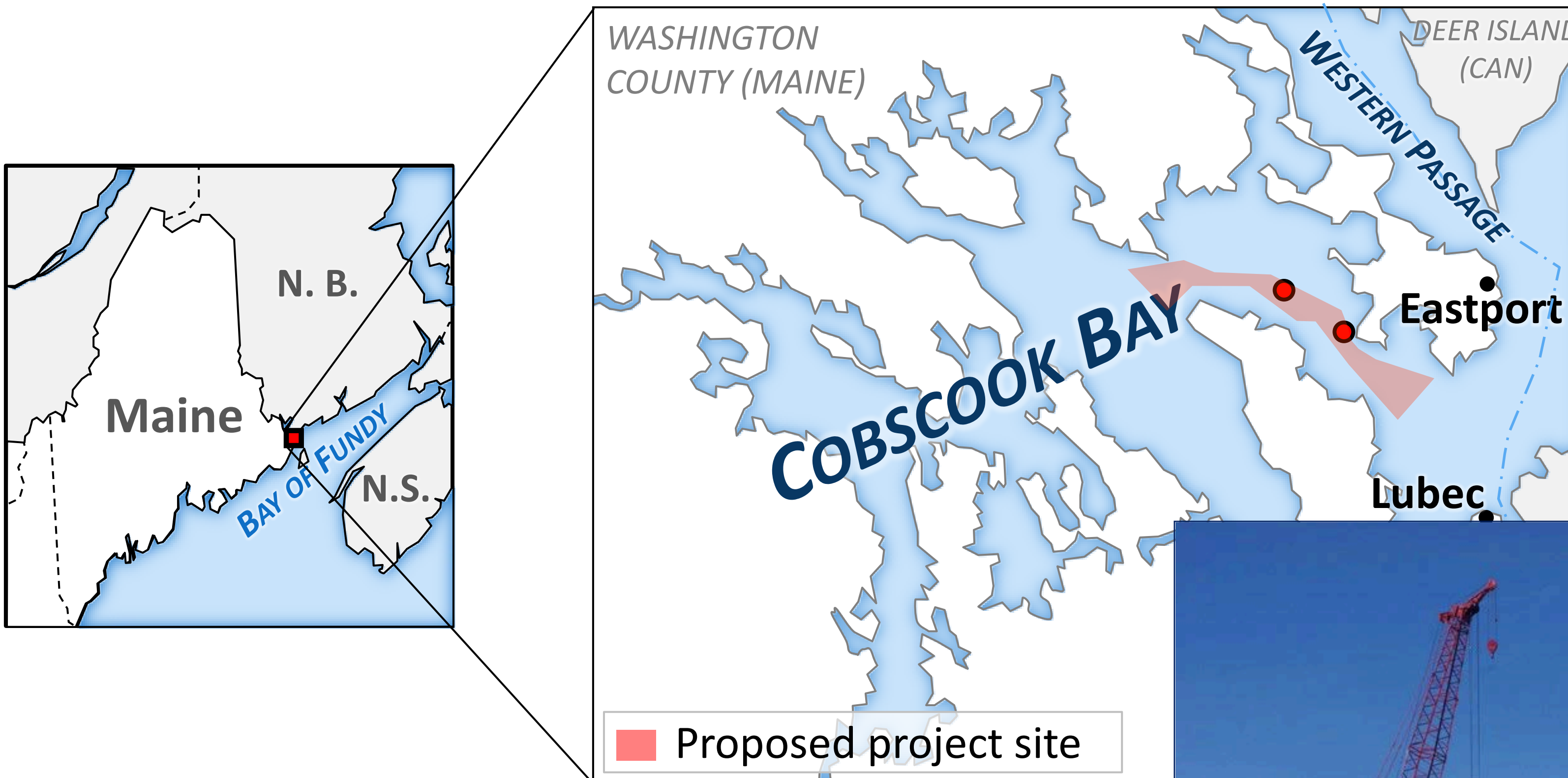
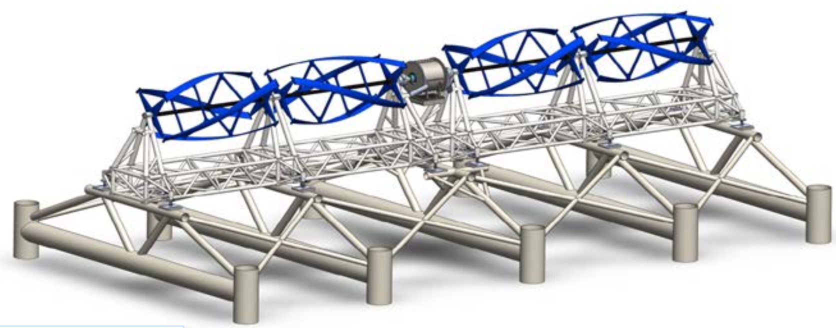
  - Amy Wyman
- Chris Bartlett
- Fishermen and community partners.
- UMaine's Sustainability Solutions Initiative
- ORPC

Award EPS-0904155





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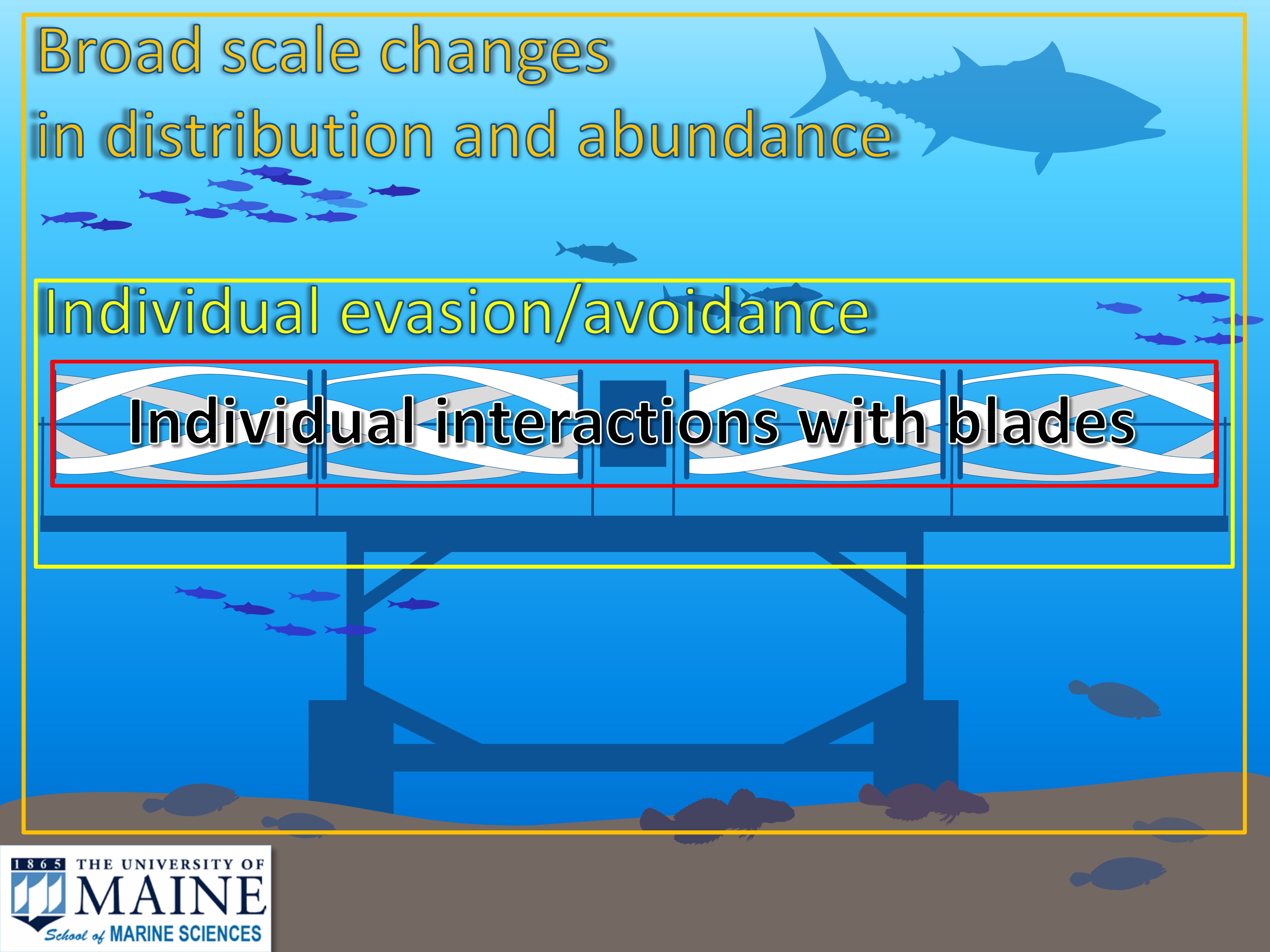
Broad scale changes
in distribution and abundance
Individual evasion/avoidance
Individual interactions with blades
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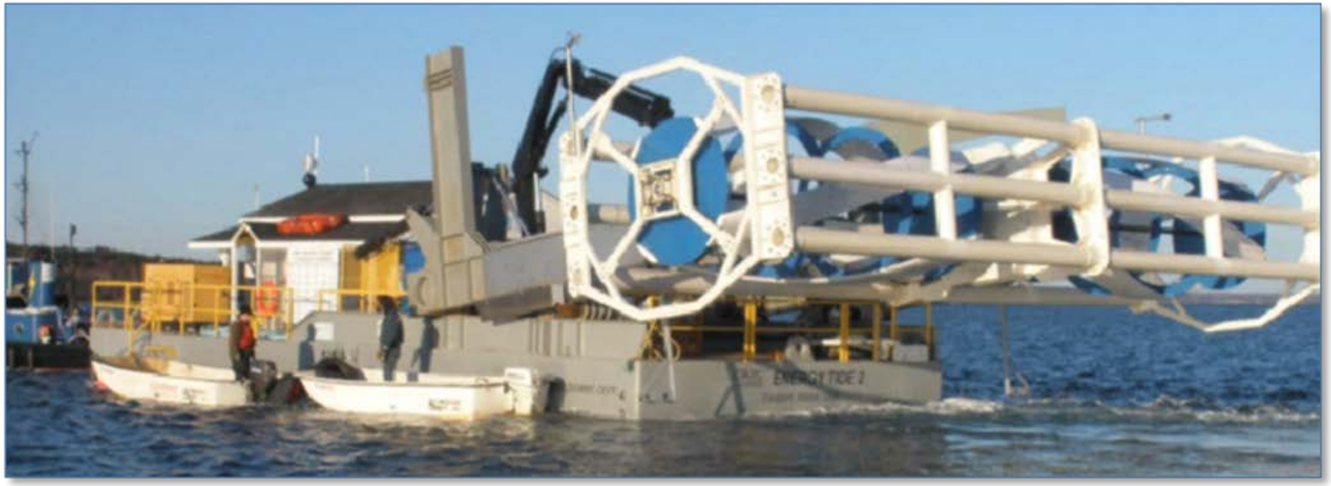
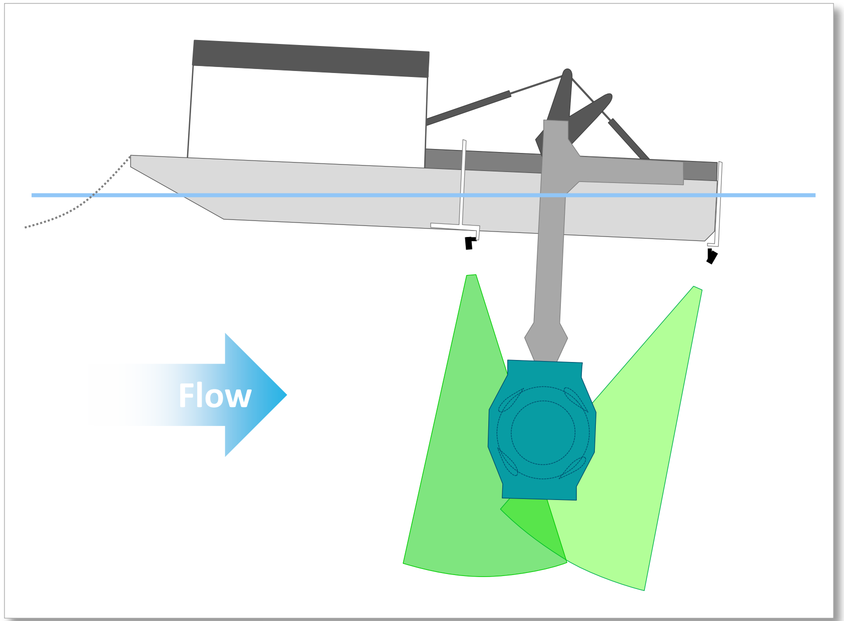
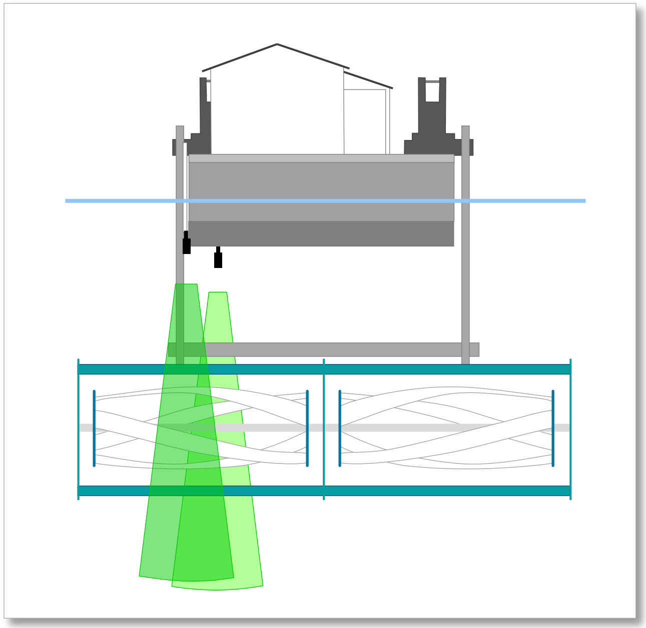
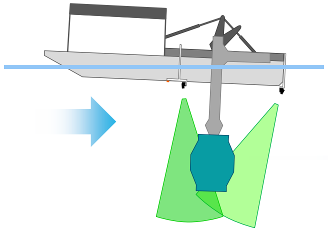
Individual evasion/avoidance



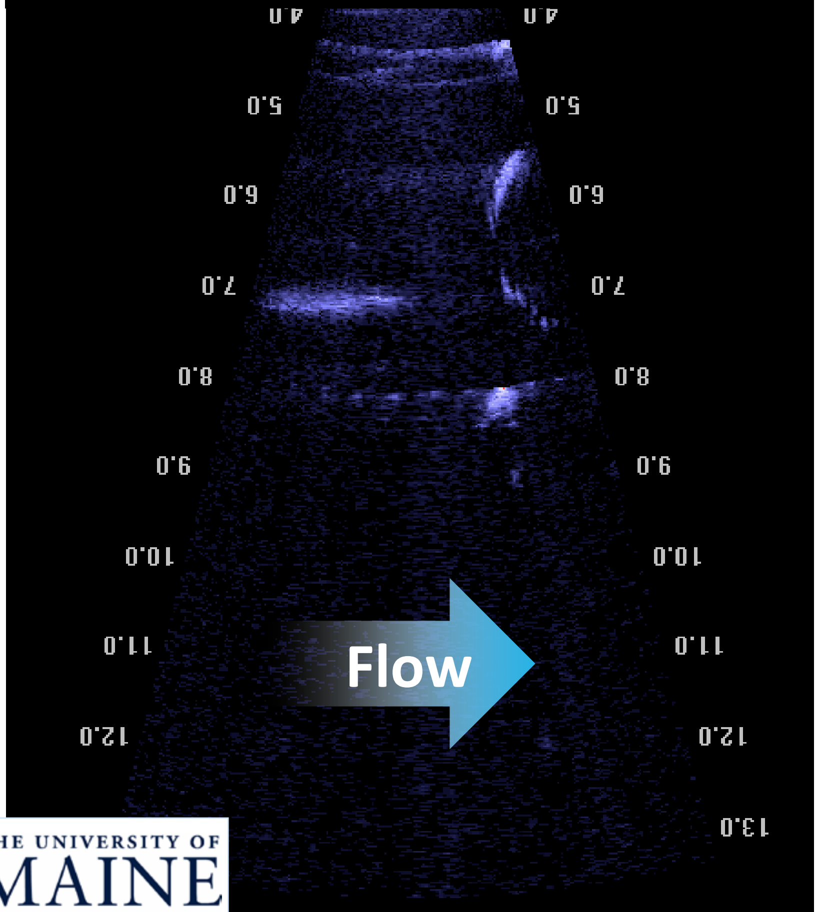




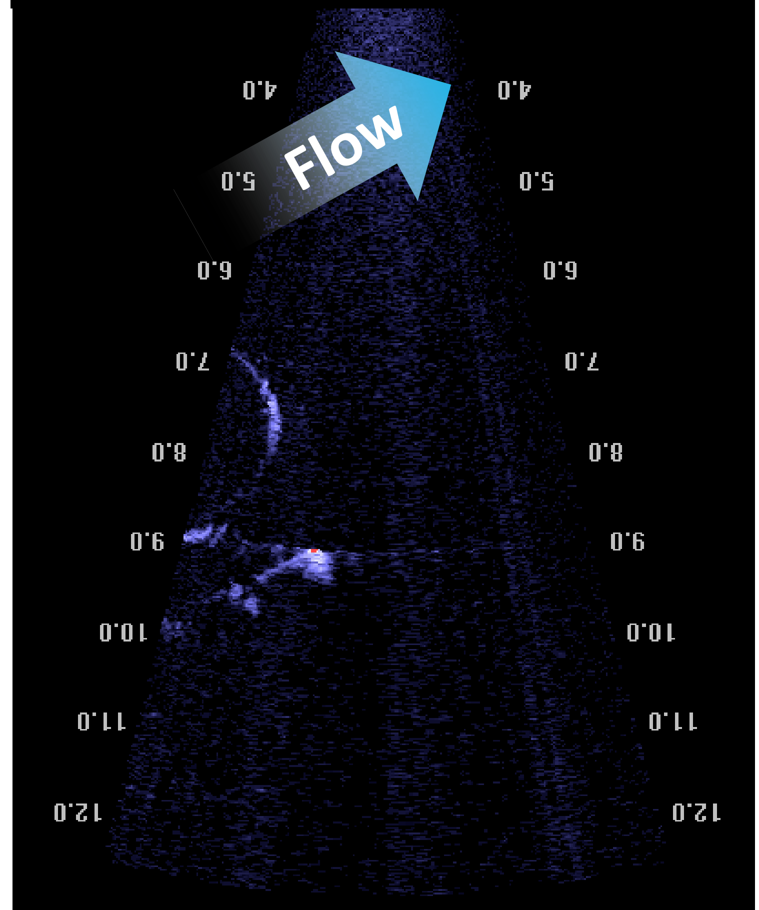
Example DIDSON Footage



Upstream (approach)



Downstream (depart)



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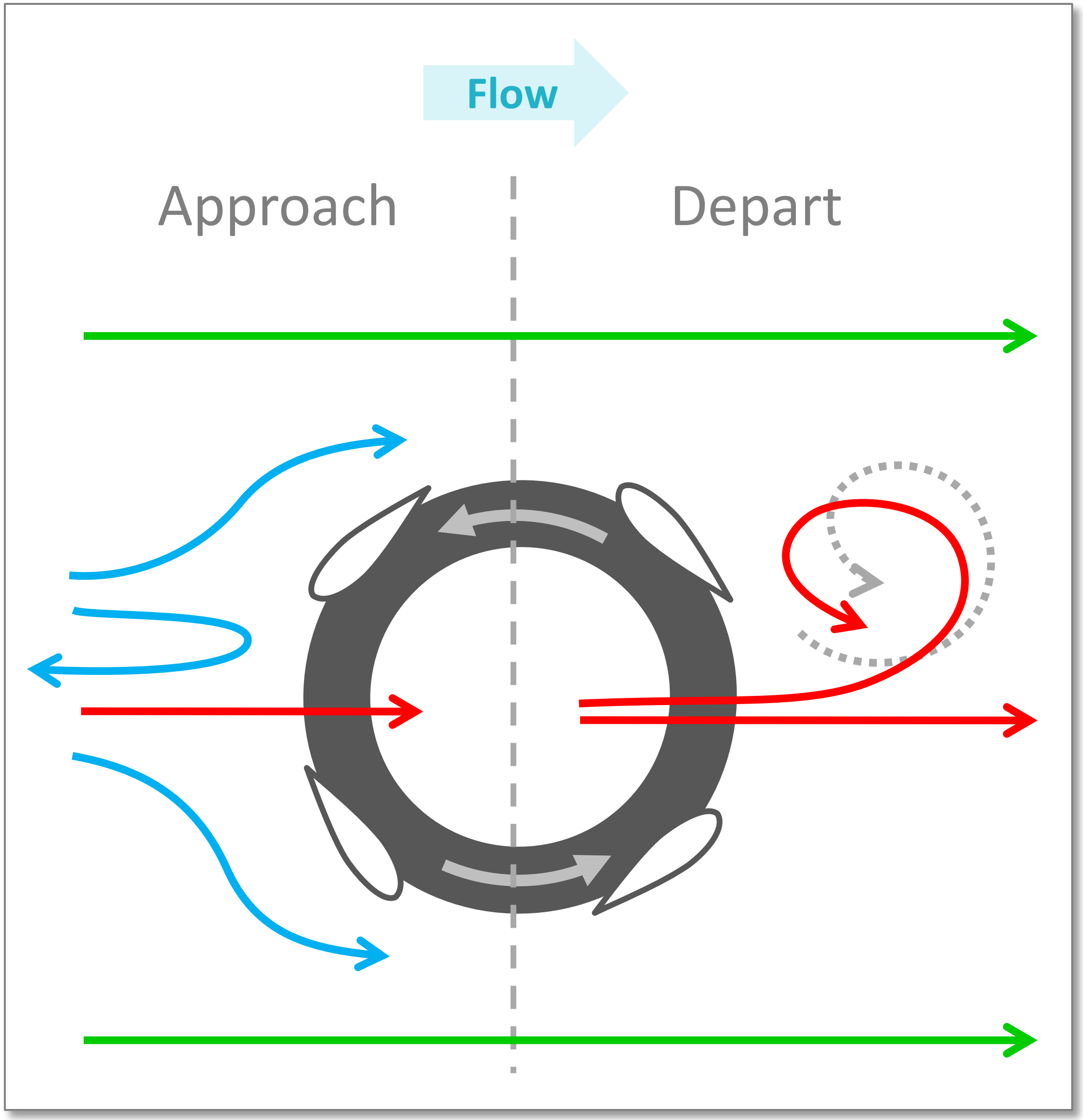
Individual Behavior

- Pass By
- Through Turbine:
  - Into Turbine
  - Out of turbine
- Active Avoidance:
  - Above
  - Reverse
  - Below
- In Wake



Viehman and Zydlewski. In revision. *Estuaries and Coasts*.

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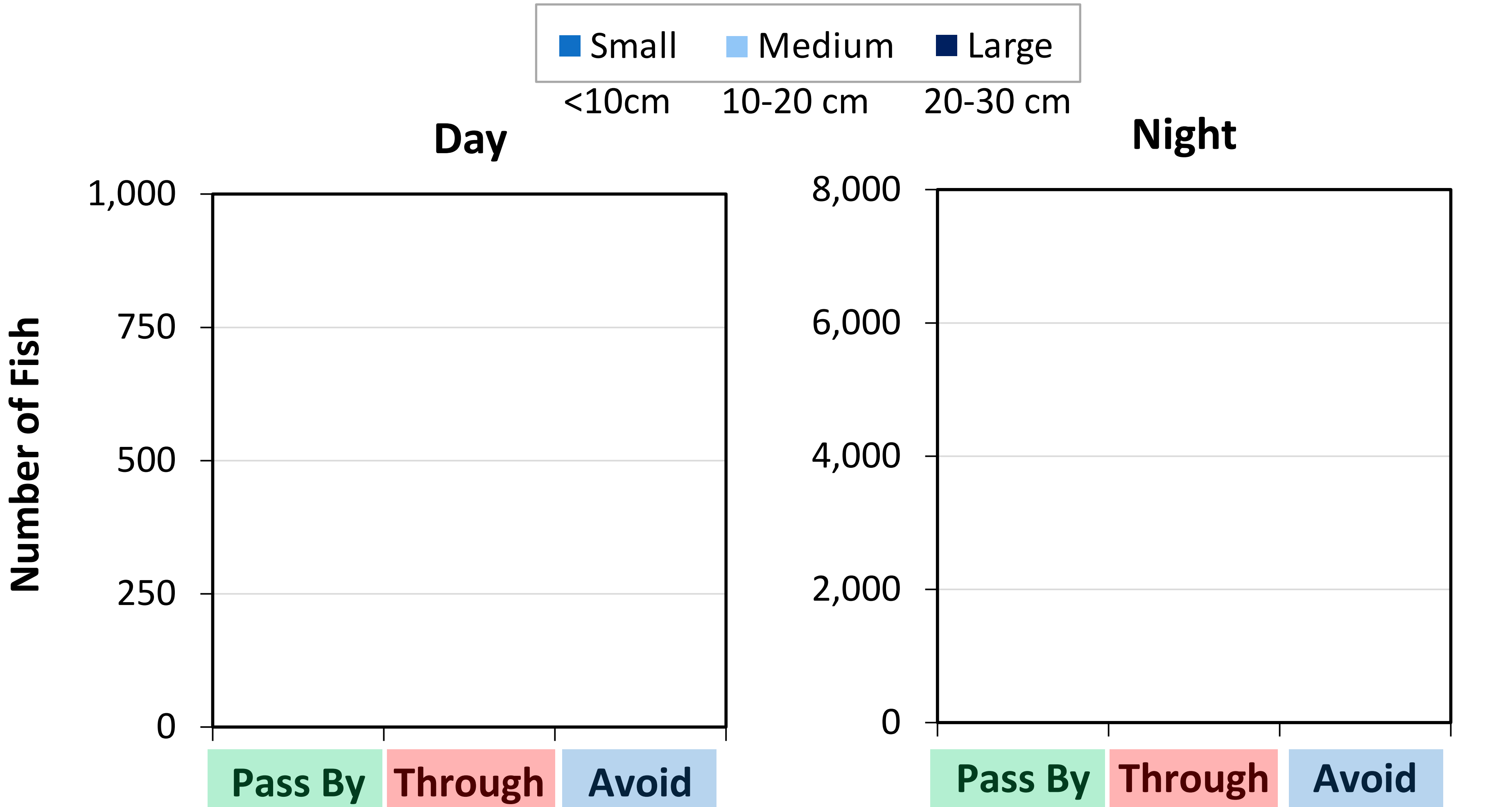
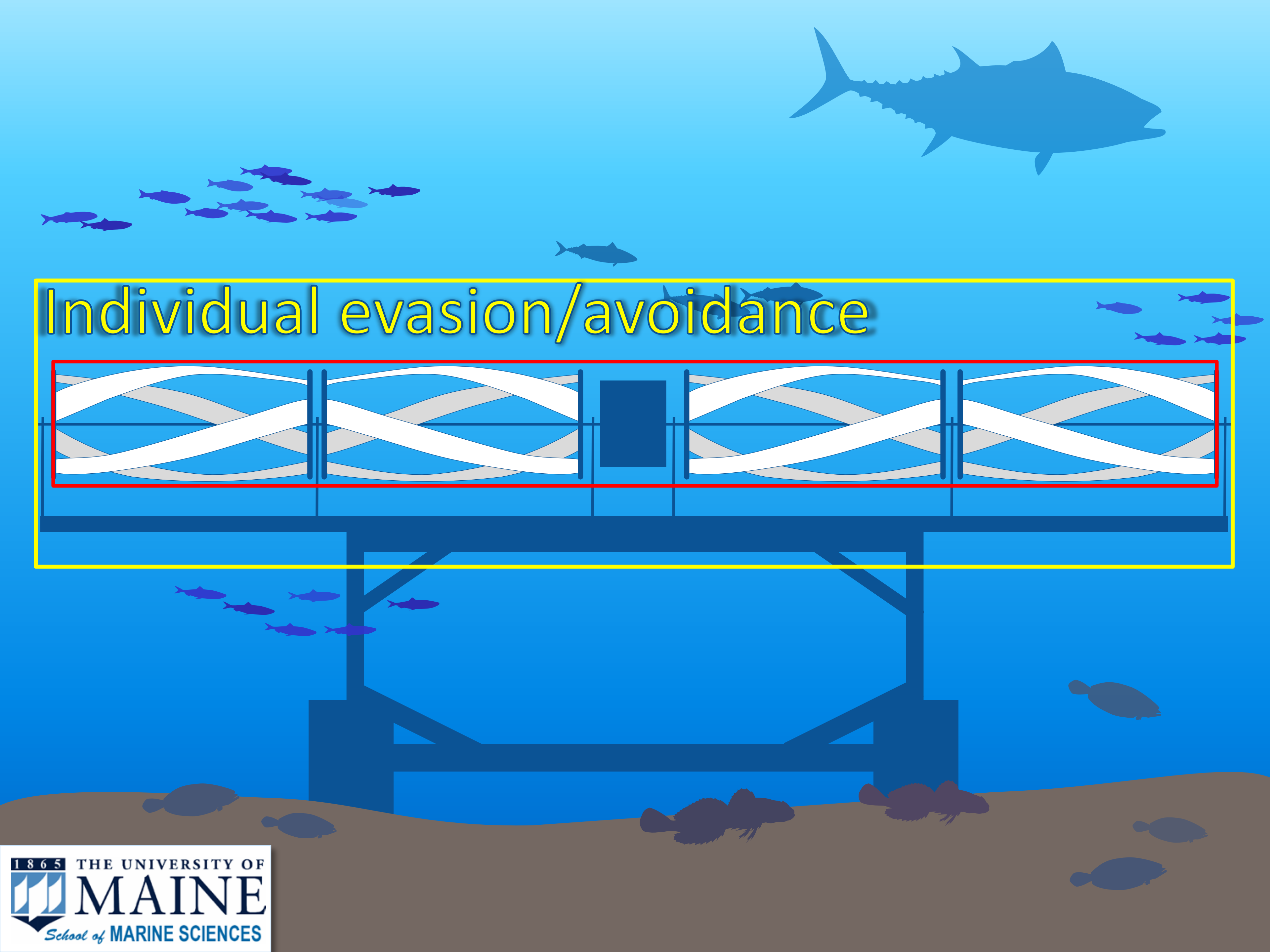
Behavior by Size, Day v. Night



(when turbine is moving)

Viehman and Zydlewski. In revision. *Estuaries and Coasts*.


Individual evasion/avoidance
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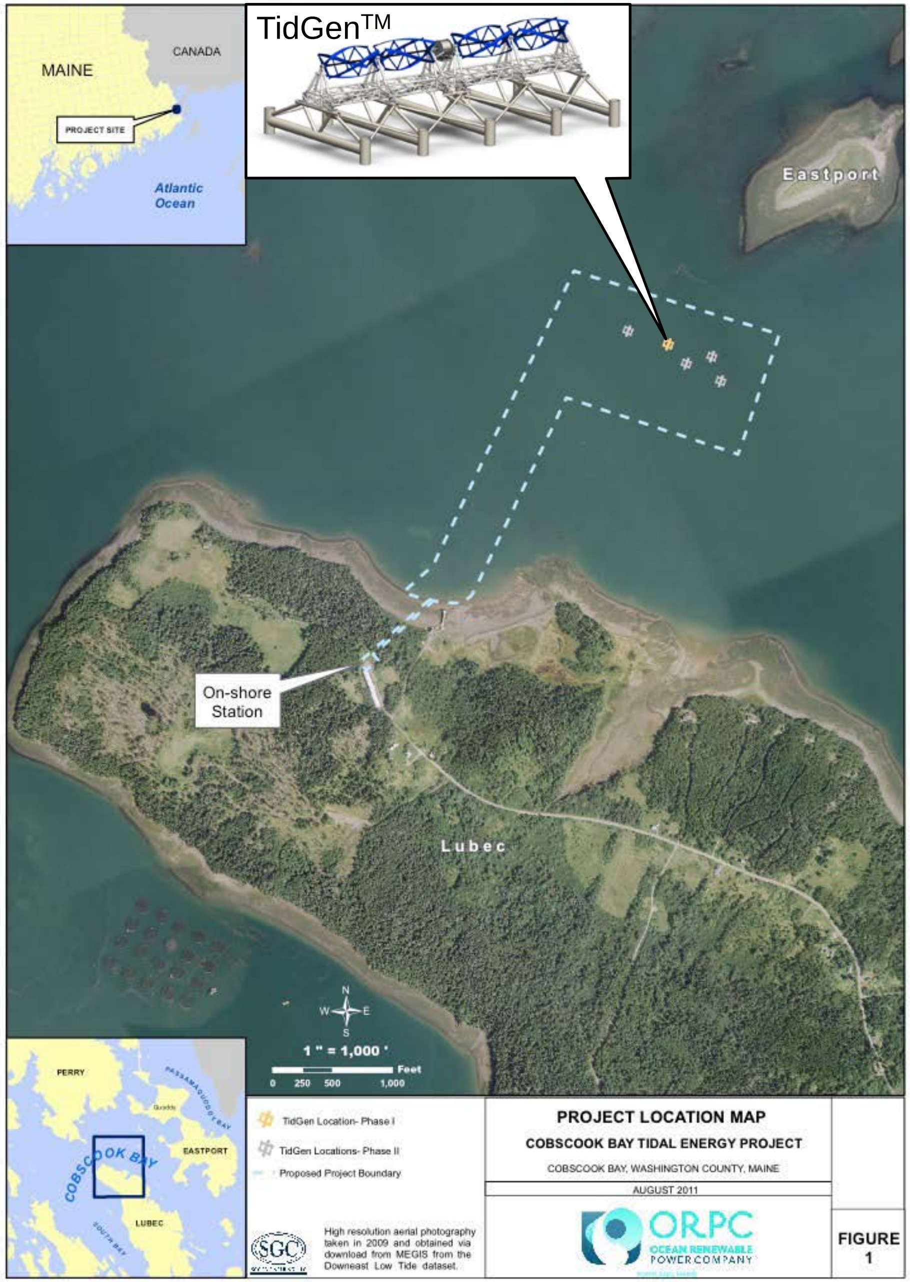

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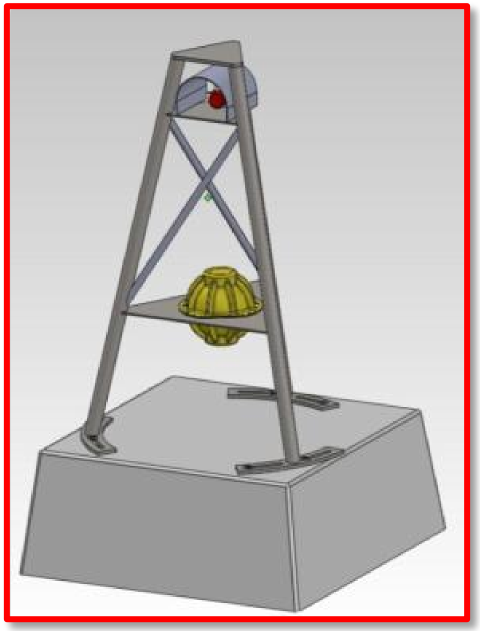
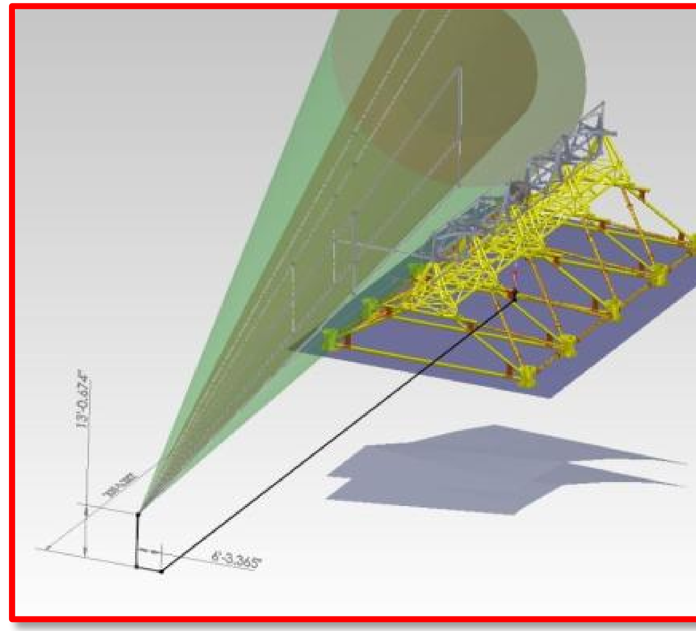
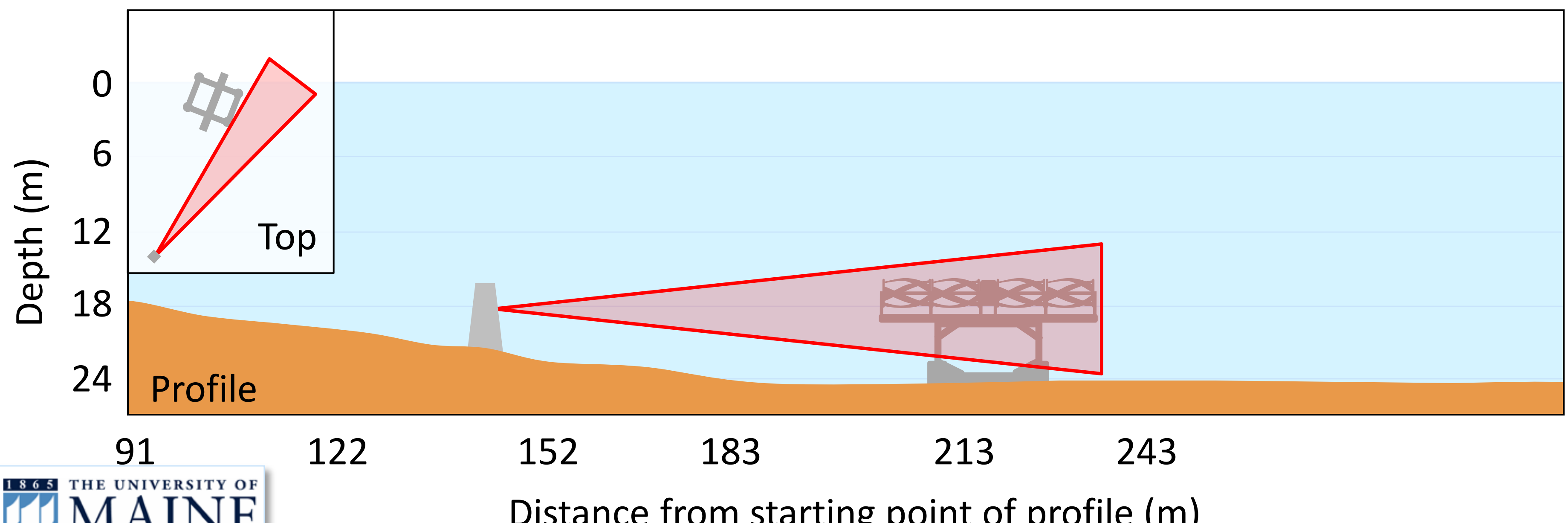
Maine Sea Grant Marine Science for Maine People







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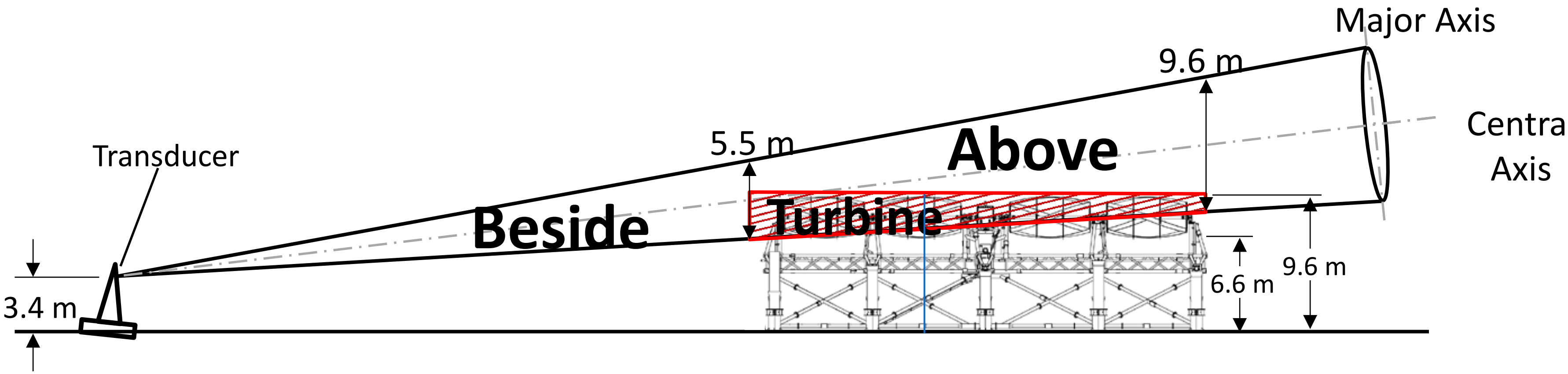

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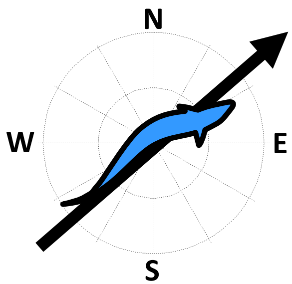
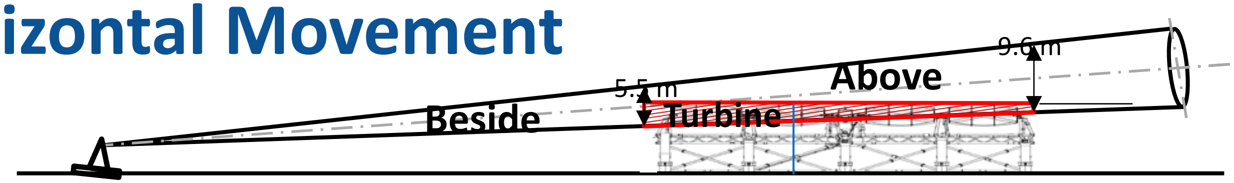
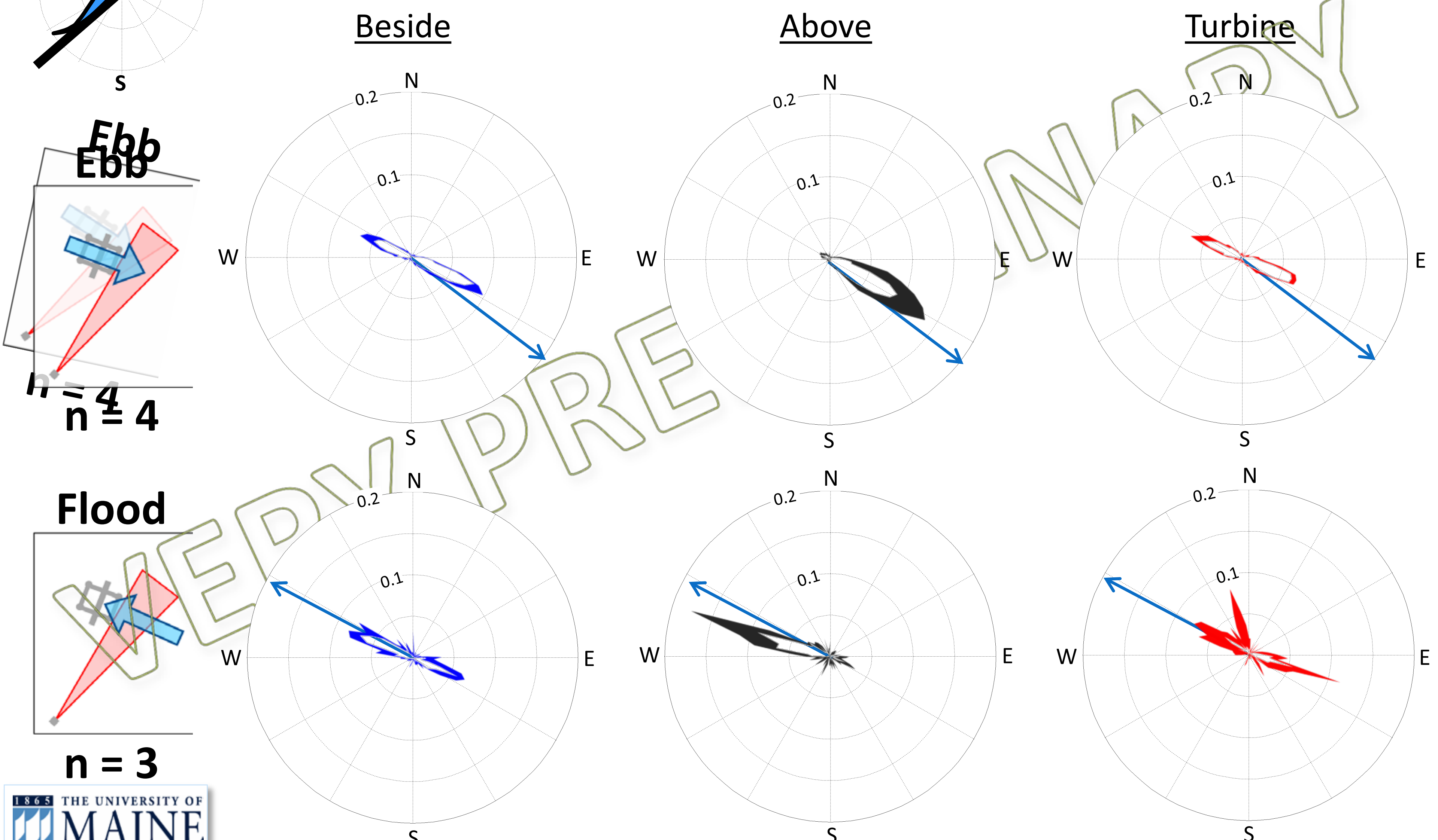
Types of Data: Horizontal Movement







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Broad scale changes in distribution and abundance

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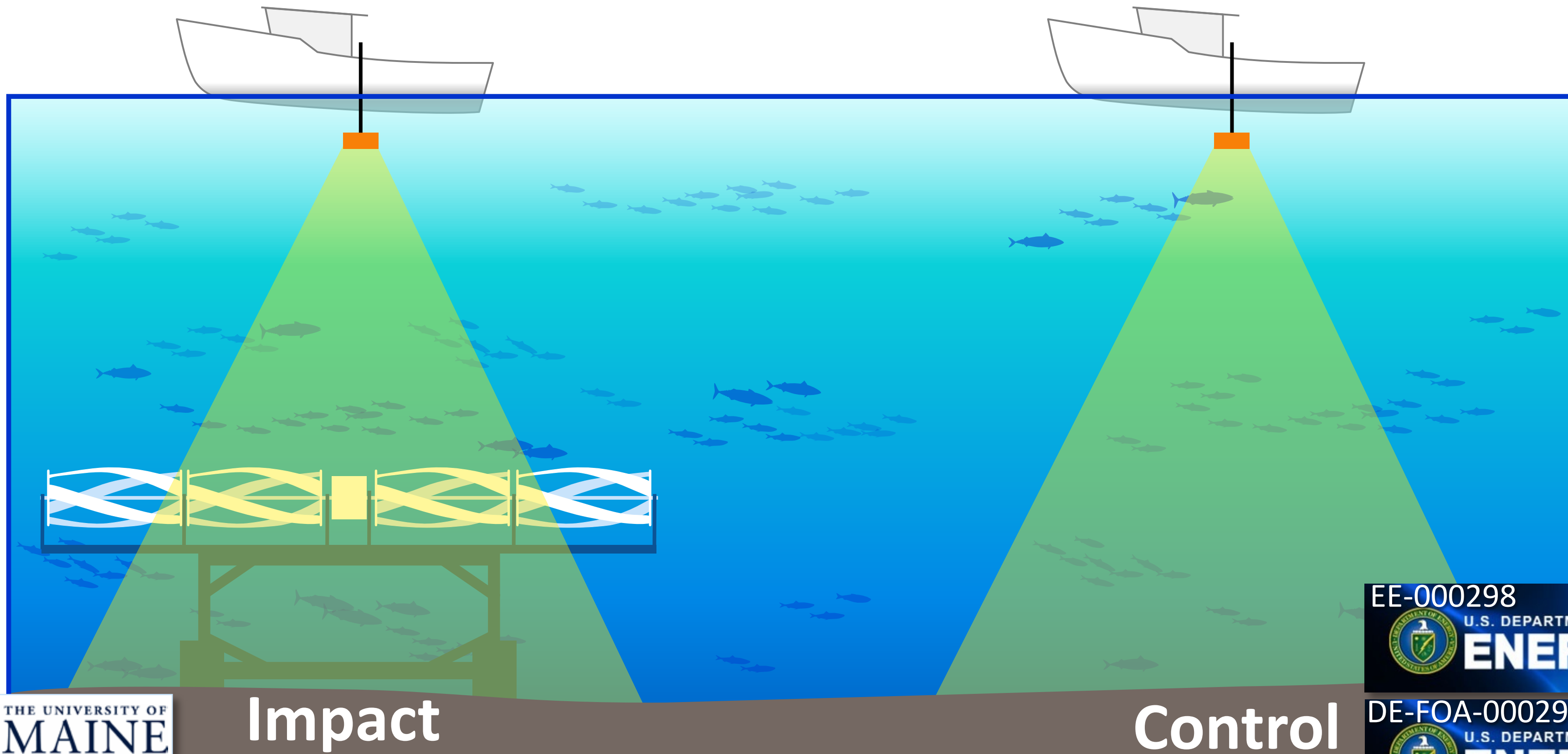
Broad Scale: Study Design

- Wide-angle, single-beam echosounder
- Before-After-Control-Impact



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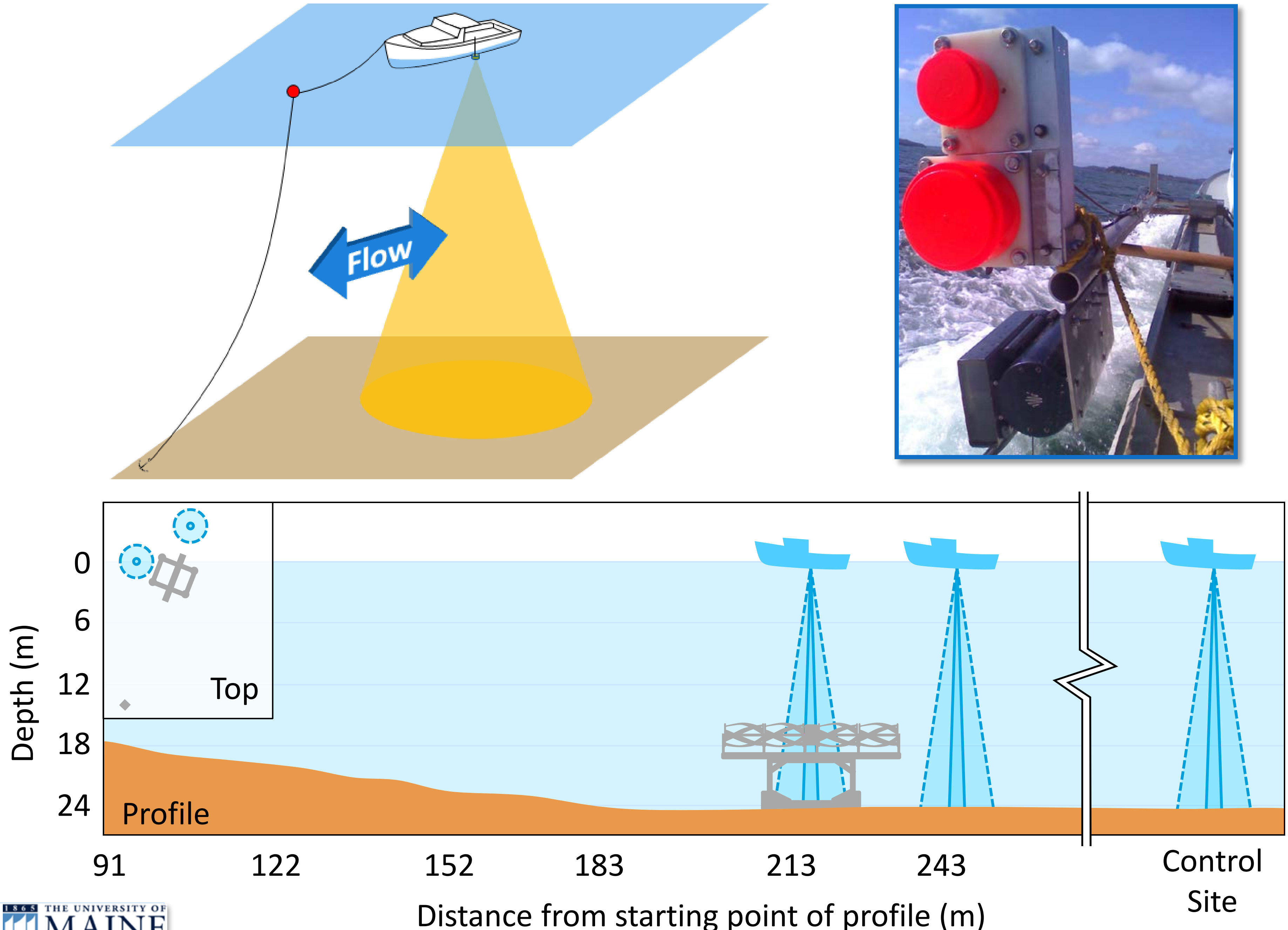
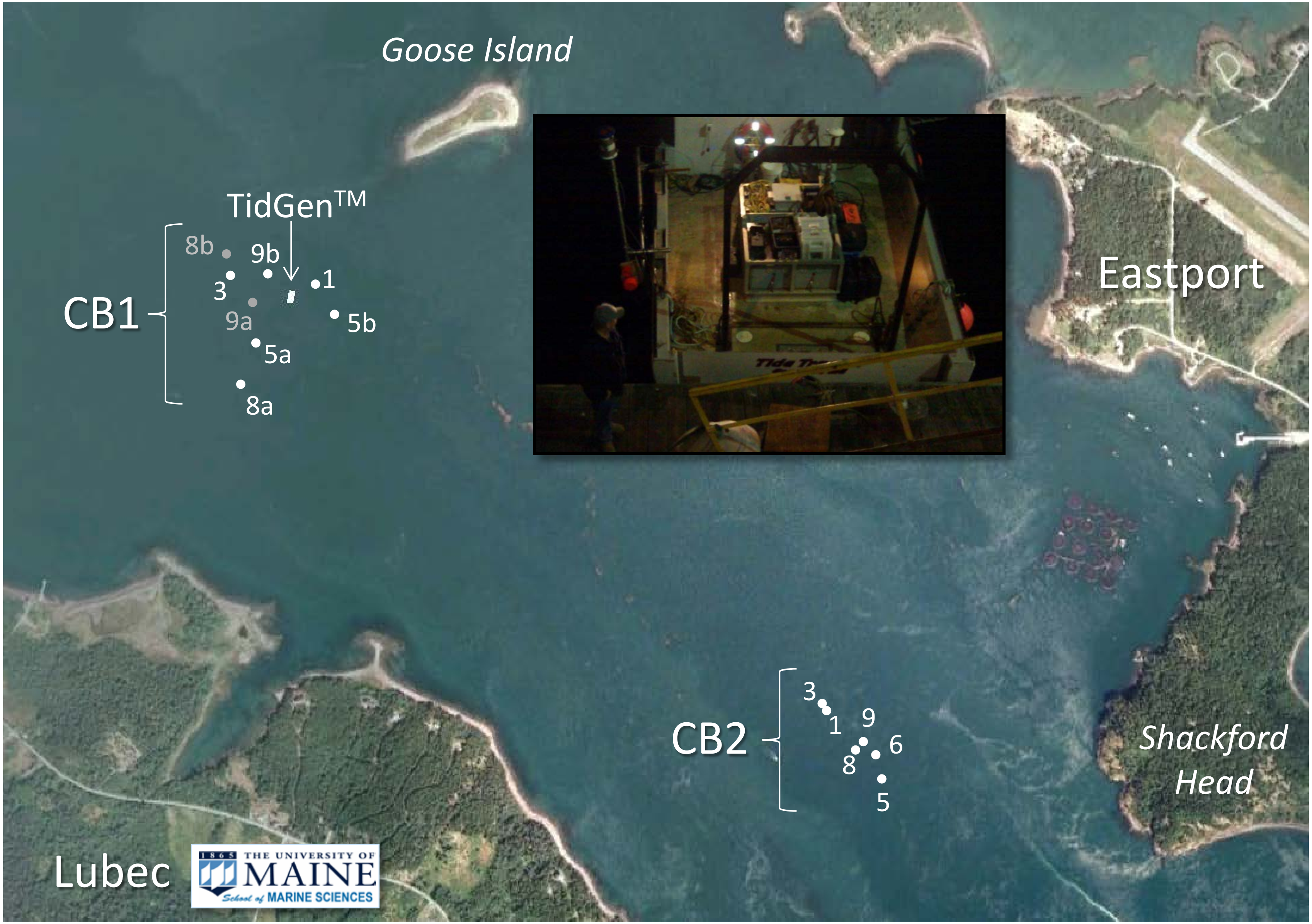
DE-FOA-000293 U.S. DEPARTMENT OF ENERGY

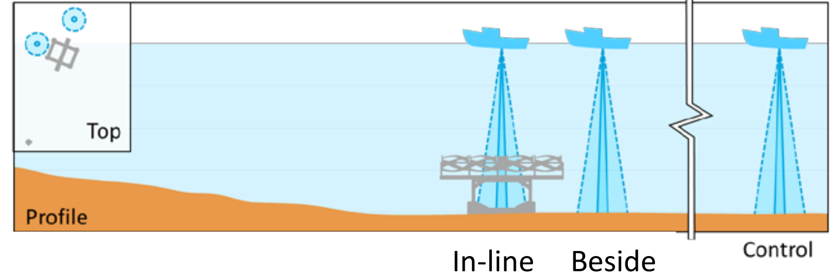


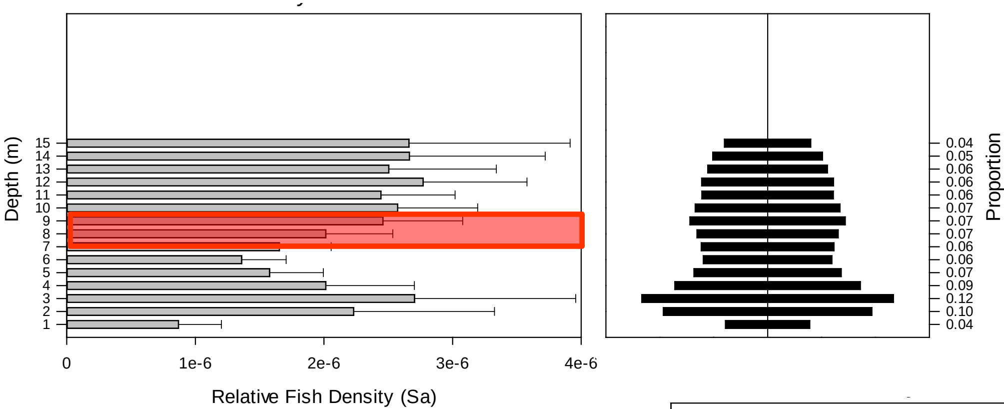
Flow
0
6
12
18
24
Depth (m)
Top
Profile
91
122
152
183
213
243
Control Site
Distance from starting point of profile (m)



Year	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2010					1, 2			1, 2	1, 2	1, 2	1, 2	
2011			1, 2		1, 2	1,2		1, 2	1, 2		1, 2	
2012	1, 2		1, 2		1a, 1b, 2	2		1a, 1b, 2	1a, 1b, 2			

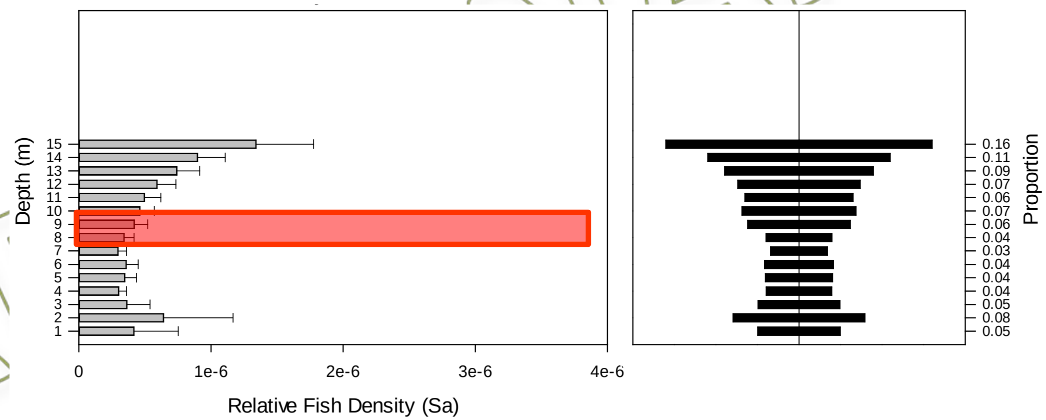
Vertical Distribution



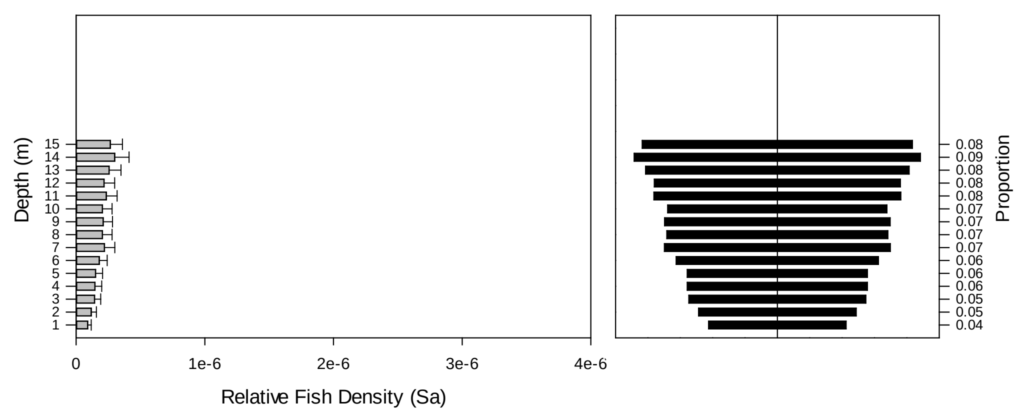


May 2012 'Beside'

May 2012 'In-line'



May Control



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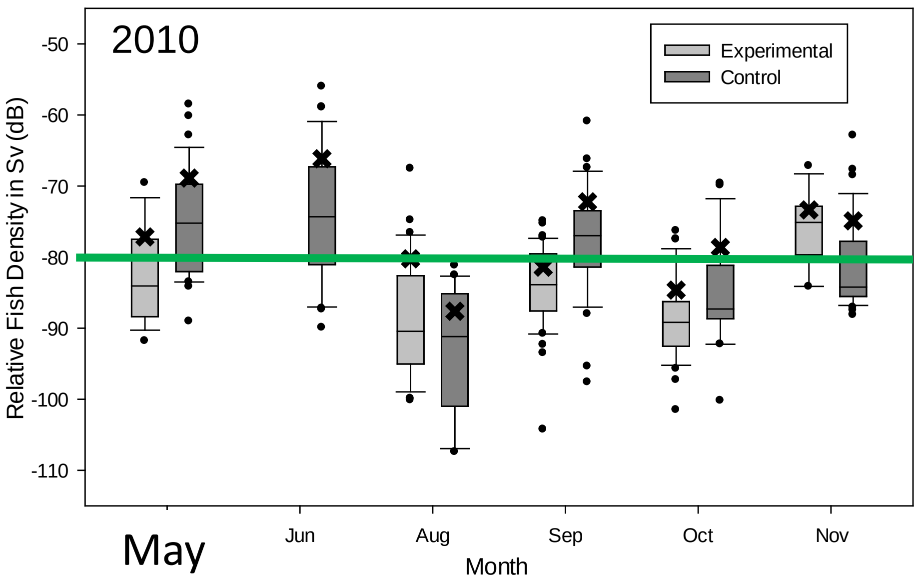
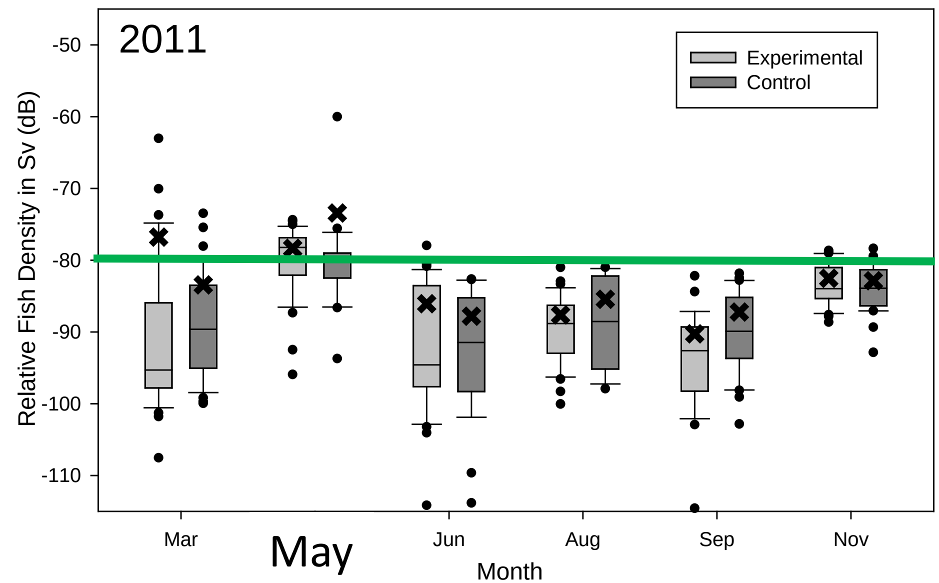
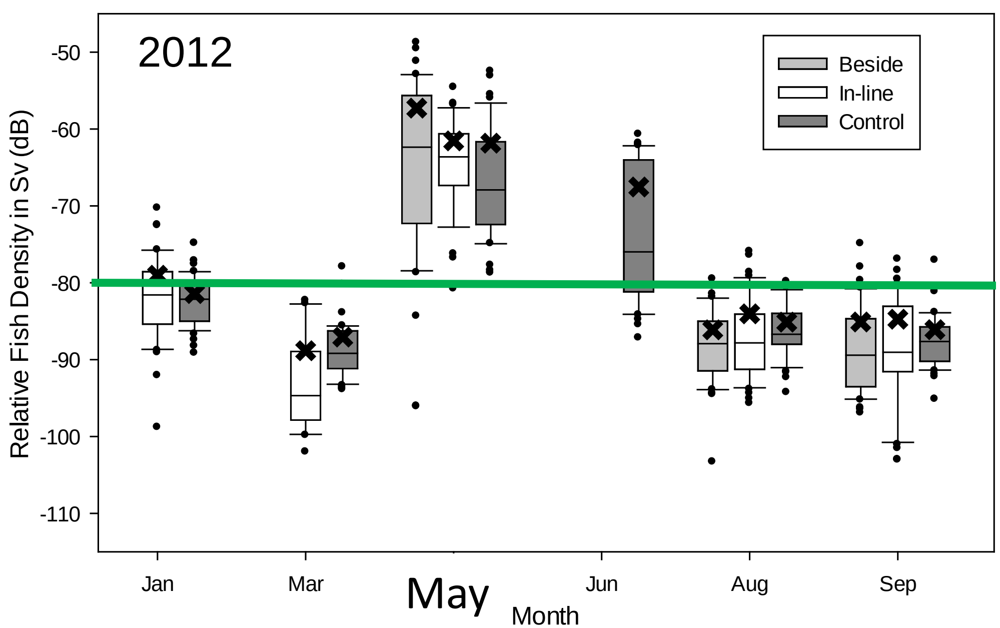
Site Abundance (relative density)







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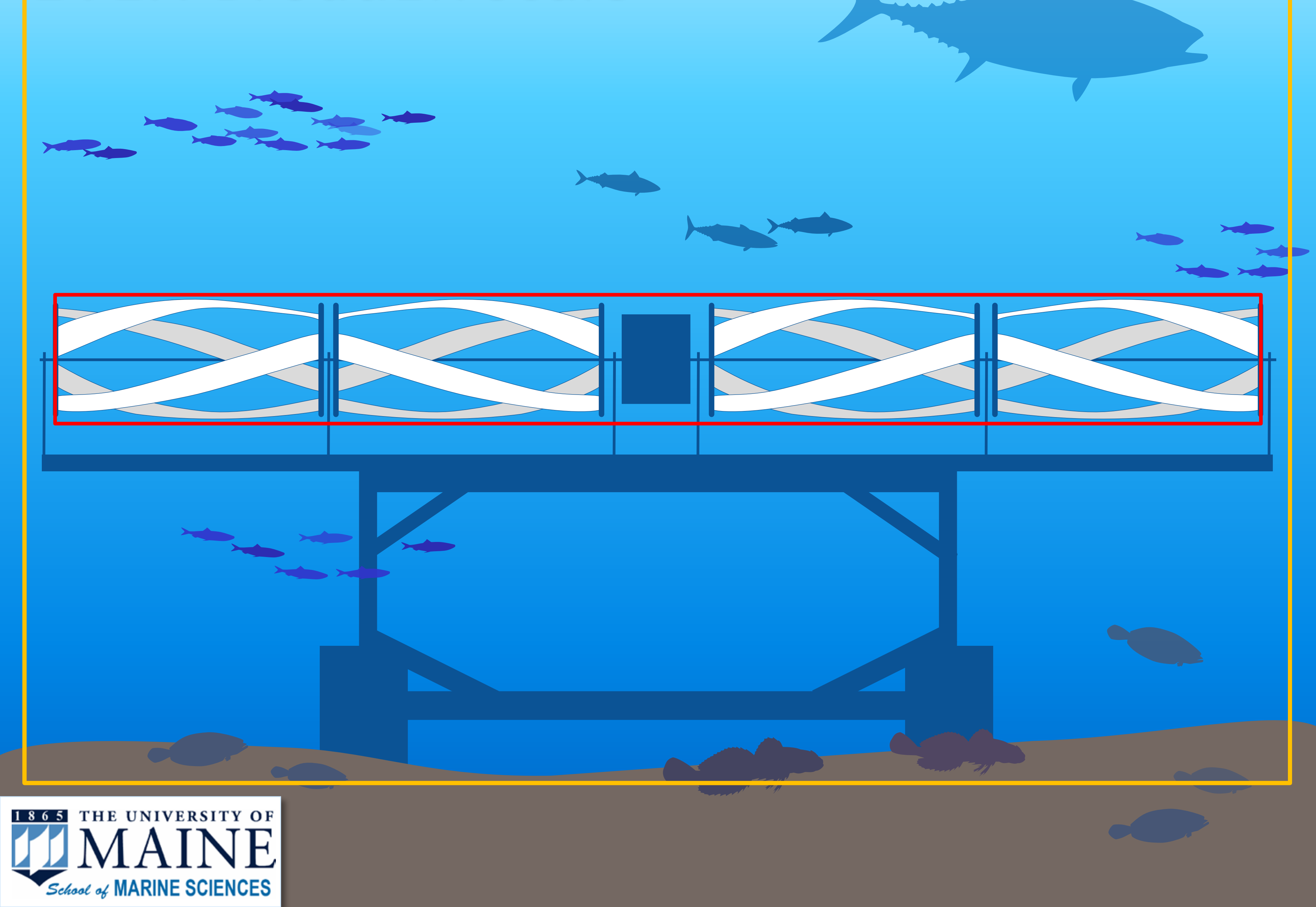
EVEN BroadER scale



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WASHINGTON
COUNTY (MAINE)
DEER ISLAND
(CAN)
WESTERN PASSAGE
COBSCOOK BAY
Eastport
Lubec
Proposed project site
67°05′
67°00′
CAN
USA
tral Bay
Outer Bay
Inner Bay

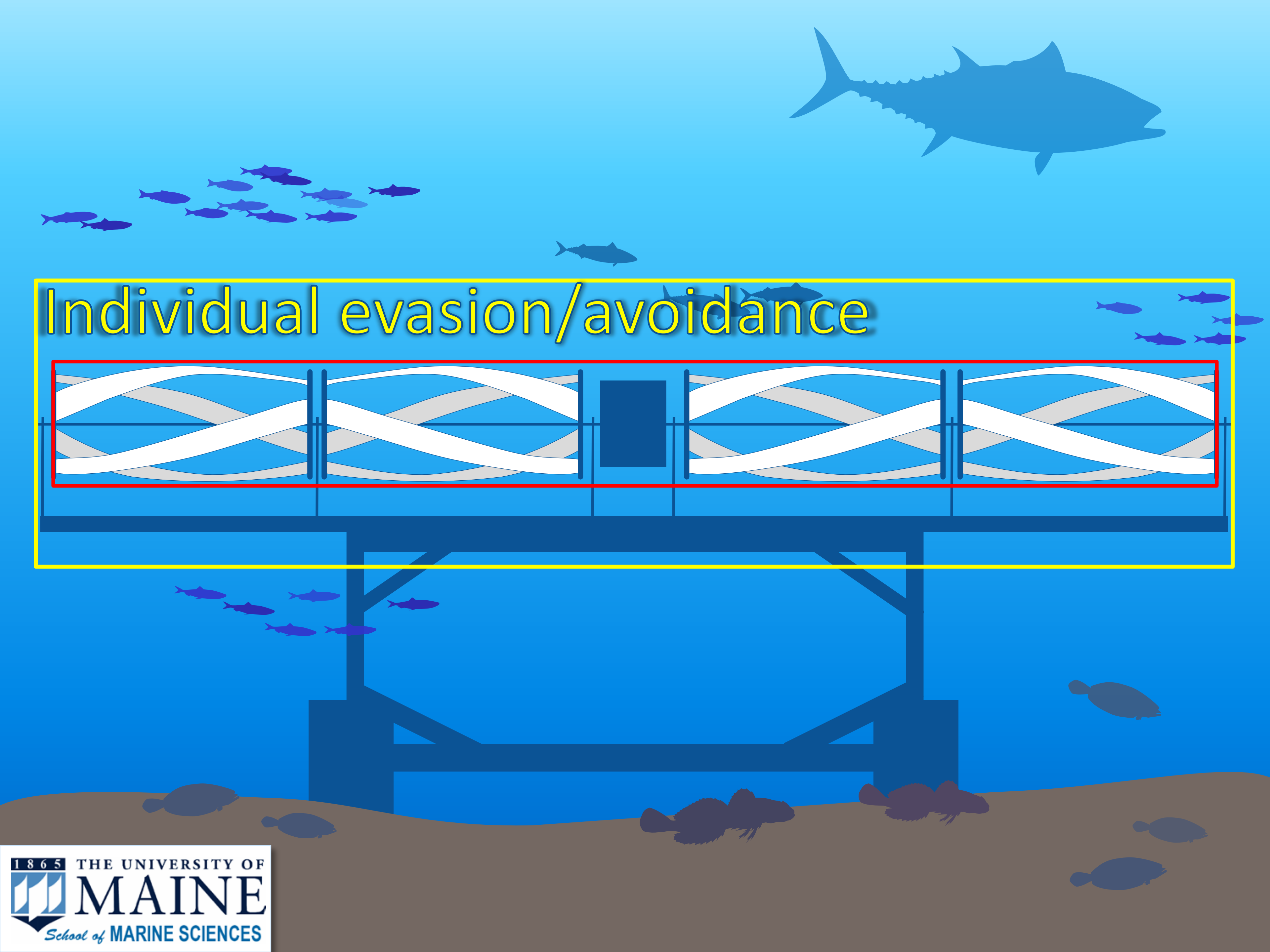
Fish interaction with ORPC TidGen™ in Cobscook Bay

Gayle Zydlewski, University of Maine

Development of an ELAM Fish Behavior Model

Gayle Zydlewski, University of Maine
Mark Grippo, Argonne National Laboratory

Environmental Science Division (EVS)
Advancing informed environmental decision making


Individual evasion/avoidance
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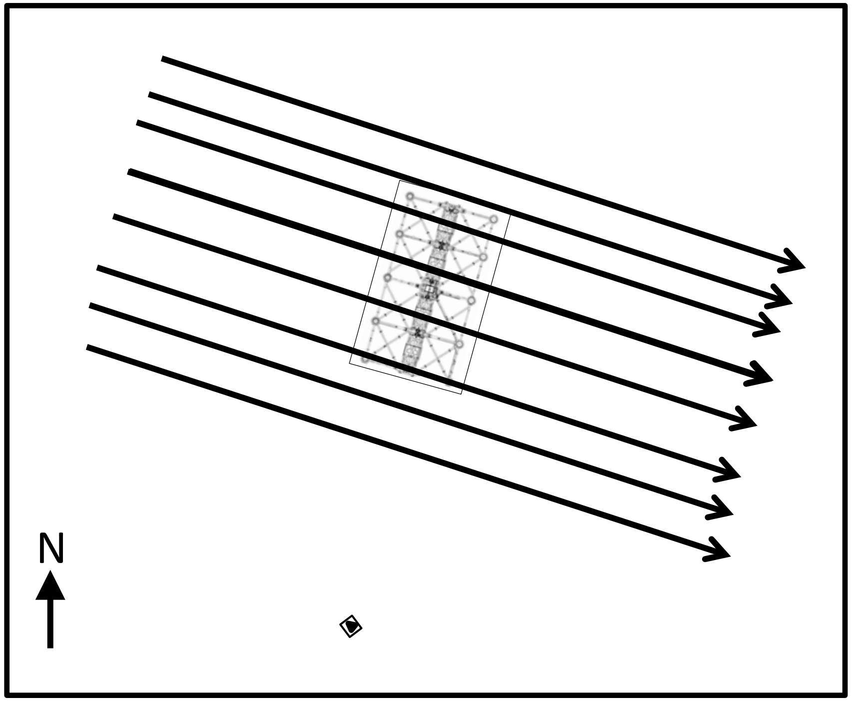
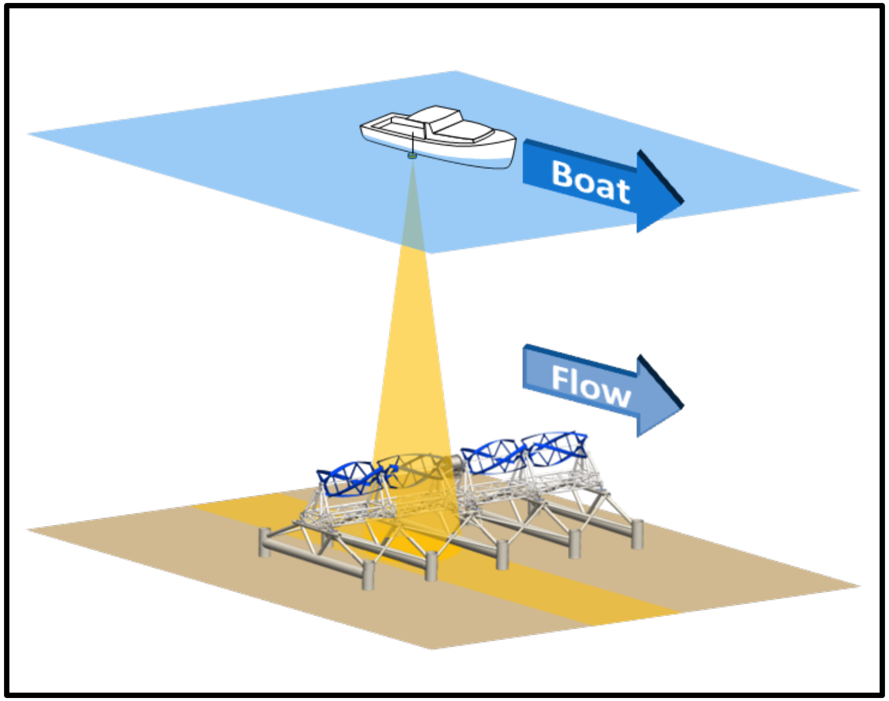
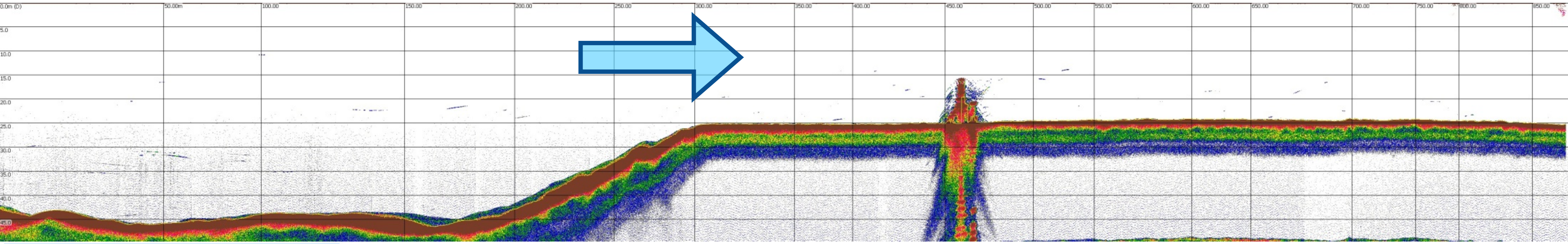
Mobile Hydroacoustics







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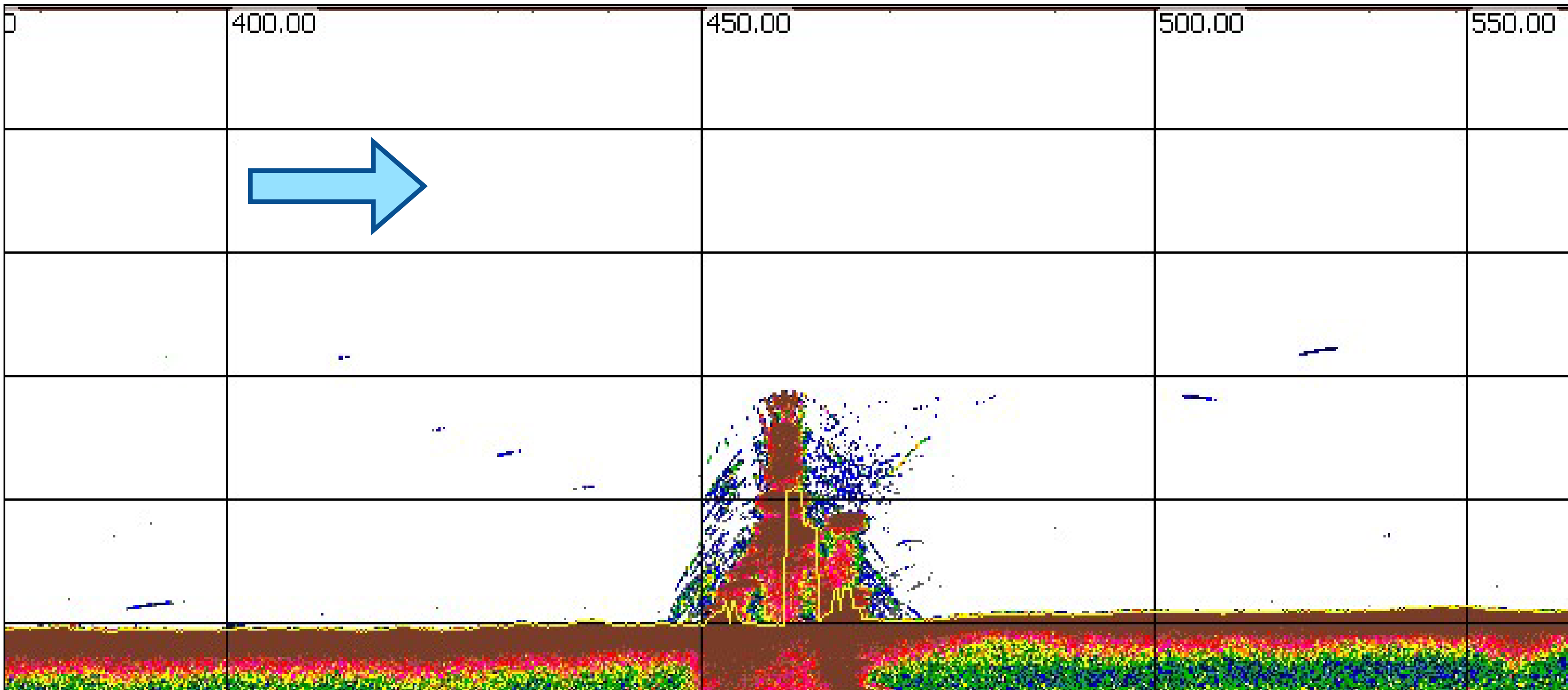
Behavioral Change Points - Avoidance and Evasion



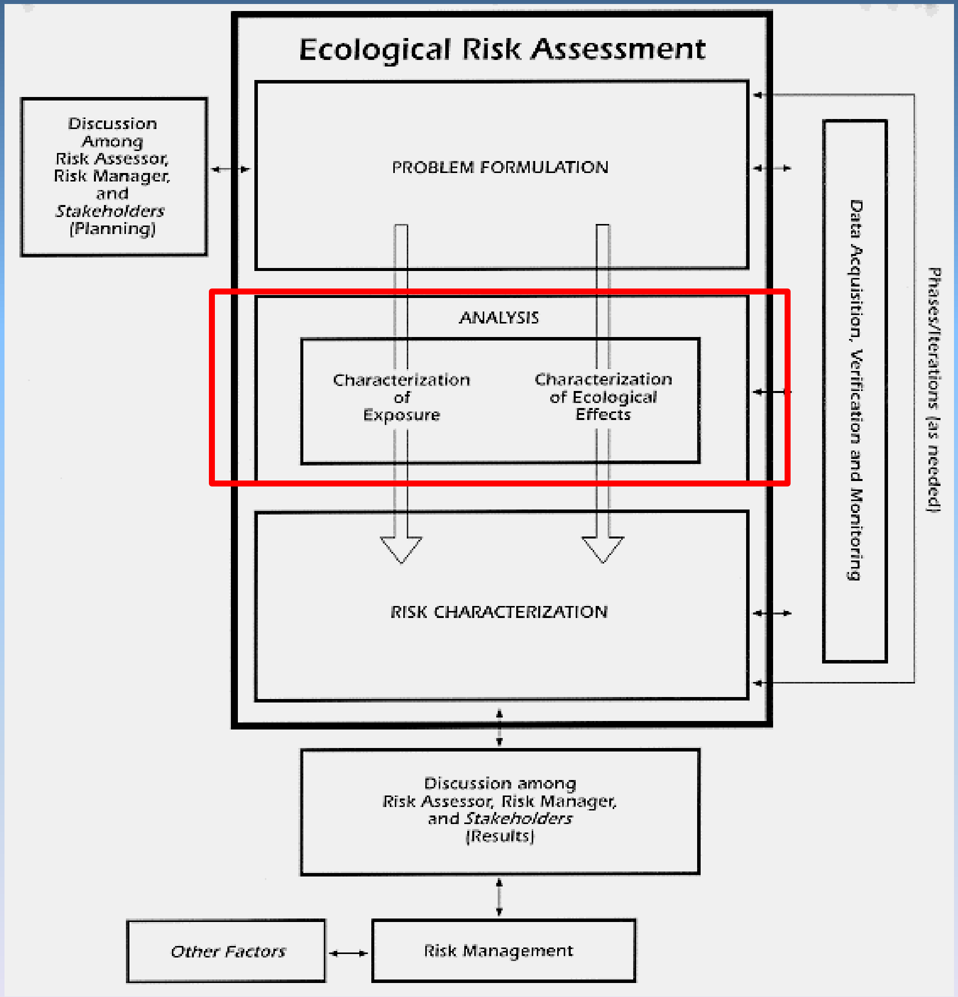
USE OF ELAM to Assess Behavioral Risks Associated with an MHK Turbine

M. Grippo
Environmental Science Division
Argonne National Laboratory

MHK Market Acceleration

The overall goal is to reduce the time and costs associated with siting and deploying MHK projects

Aid developers in meeting NEPA requirements by addressing concerns of regulatory and management agencies



EPA RISK ASSESSMENT

Analysis Phase

1. Characterization of Exposure

   - Exposure of ecological receptors based on species life history and ecology

2. Characterization of Effects

   - What are the effects of exposure

Source:Guidelines for Ecological Risk Assessment (EPA, 1998)

Behavioral Risk

Determining the behavioral responses of fish to MHK devices is critical to characterizing risk

- Avoidance or attraction
- Risk of blade strike
- Which species could be affected?
  - -Migratory species
  - -Structure oriented fish
- Do turbines occupy preferred habitat

Understanding Behavioral risk becomes even more important at full commercial build out

Mechanistic Behavior Models

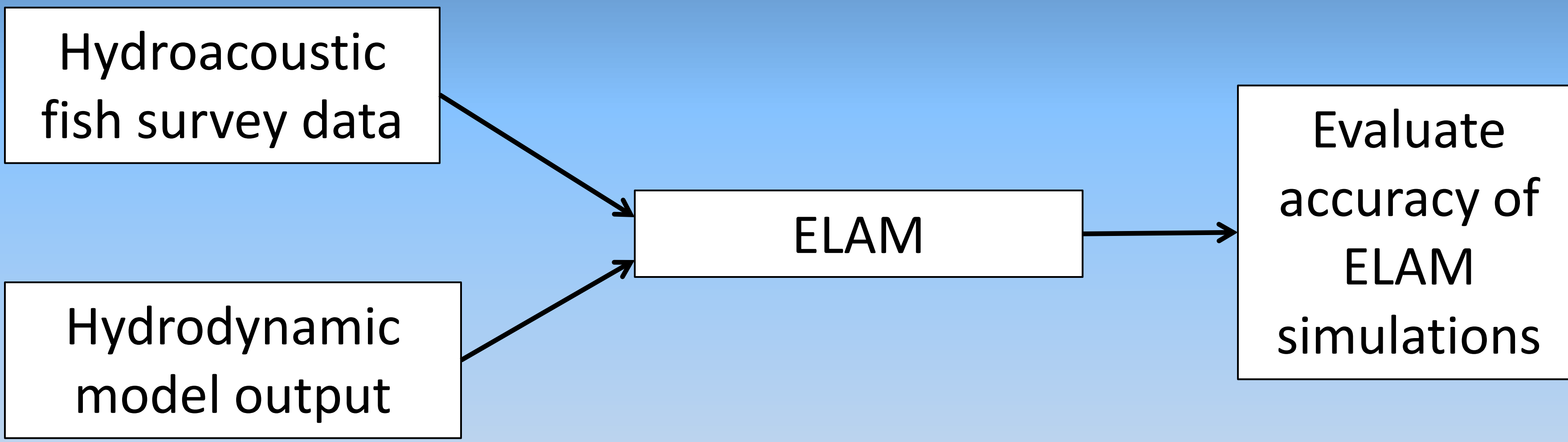
- An attempt to understand the drivers of observed behavior
- Models animal movements based on various decision rules about how individual organisms respond to changing environmental variables.
- Allows one to forecast behavioral change under different environmental conditions

Mechanistic Behavior Models

Eulerian-Lagrangian-Agent Method (ELAM)

- The ELAM simulates fish behavior based primarily on hydrodynamic cues
- Developed by the US Army Corps of Engineers (USACE), Engineer Research and Development Center (ERDC; Goodwin et al. 2006)
- The ELAM has been applied to dam operations and fish bypass designs
- First application of the ELAM to MHK technology.

Method Overview



Hydrodynamic model development and initial mobile hydroacoustic surveys are ongoing

Completion by Fall 2014

Method

Hydrodynamic model development - Huijie Xue (UMaine)

- Increase spatial resolution of existing model to 1 m with 500 m upstream and downstream of the ORPC turbine
- Simulate hydrology for the time period corresponding to the mobile hydroacoustic survey

Hydrodynamic model development – Jesse Roberts (SNL)

- High resolution hydrodynamic model for Cobscook Bay using SNL-EFDC
- SNL-EFDC is used by ORPC and has wide familiarity within the MHK industry.

Method

Hydroacoustic fish data - Dr. Gayle Zydlewski (UMaine)

- Side-looking passive hydroacoustics data
- Mobile down-looking hydroacoustic drift surveys covering 100s of meters on either side of ORPC turbine
- Surveys conducted on flooding tide in spring and summer

Method

ELAM - Dr. Andrew Goodwin (US Army Engineer R&D Center)

- Synchronize the fish position data and the hydrodynamic model output
- Evaluate whether the ELAM simulates actual fish density and movement patterns more accurately than treating the fish as passive particles
- Refine to increase the correspondence between real-world fish data and ELAM model patterns

Ecological Risk Evaluation

- Place ELAM analysis results in an ecological risk context
  - -characterization of exposure
  - -inform the probability of blade strike
- Characterization of effects
  - Assess the nature and magnitude of movement changes
  - -before and after encountering the ORPC turbine
  - -with and without the turbines
- The analysis will include species specific evaluations

Potential Applications of the ELAM

- The modeled response of fish to a single MHK device would provide information on the potential responses of fish to an array of turbines
- Forecast fish responses to alternative turbine designs, turbine locations within the channel, and turbine configurations within an array
- Evaluate alternatives that may minimize impacts to fish movement behavior

Acknowledgements

Jocelyn Brown-Saracino
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Hoyt Battey
US Department of Energy

Ocean Renewable Power Company