



**VERDANT POWER**

***Kinetic Hydropower Operational Monitoring  
Strategies and Technologies for Pilot Arrays***

**Mary Ann Adonizio**

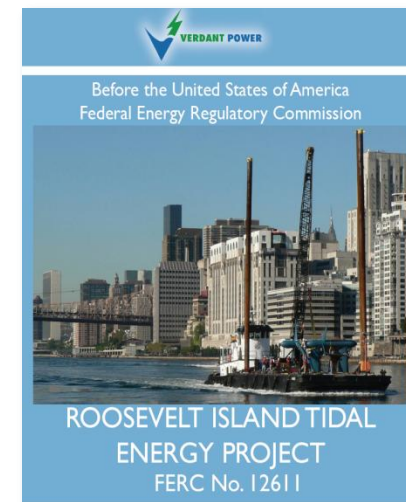
DOE MHK Environmental Webinar

September 2011

- (1) a: the science and art of employing the political, economic, psychological forces to afford the maximum support to adopted policies in peace or war



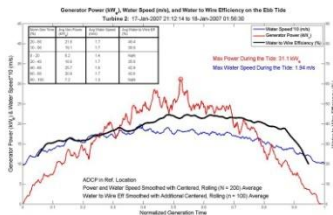
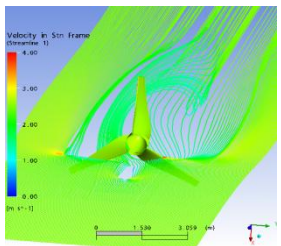
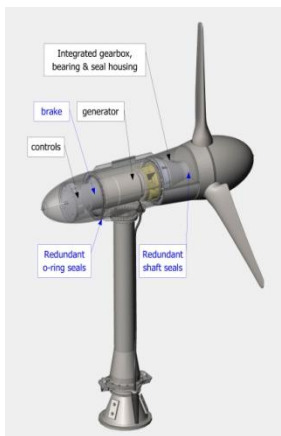
- (2) **a: the art of devising or employing plans toward a goal**



RITE Demonstration: 2005-09  
World's First Tidal Array (6 turbines)

RITE Pilot Project: Dec 2010 (FERC LA)  
up to 30 turbines (1 MW)

# Generate clean renewable energy in an environmentally compliant way



MHK developers

Policy & Regulation

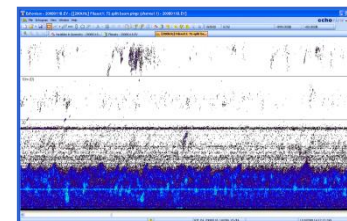
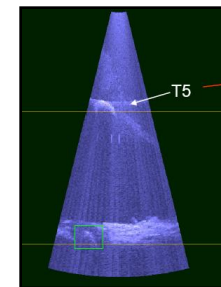
Environmental

Project economics

Technology

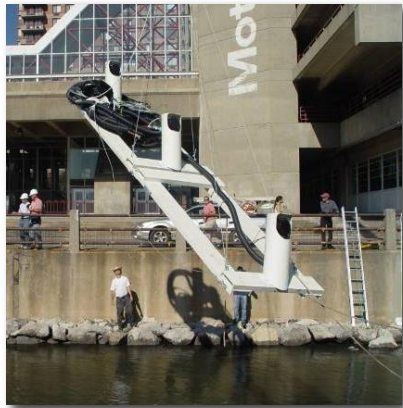
Multiple stressors

RPS Policy & Mandates



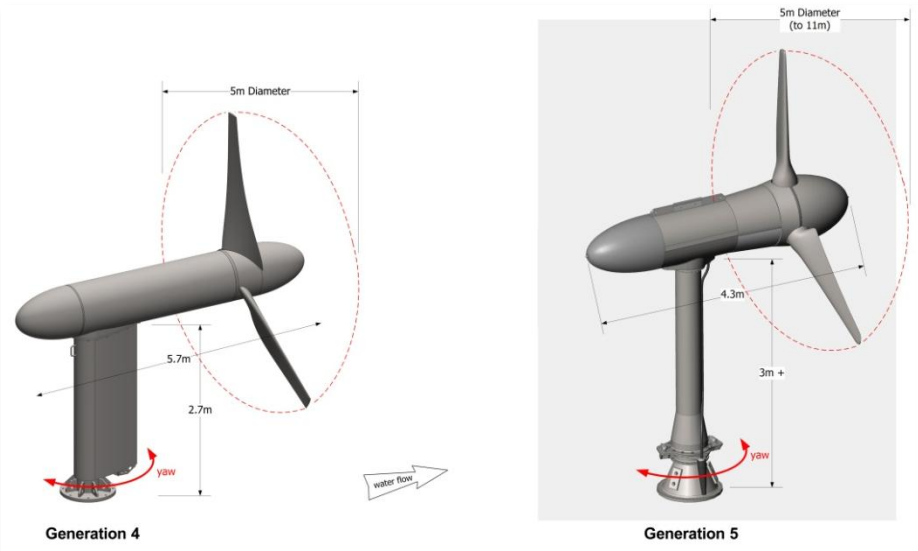
- Array environmental monitoring: 2005-09
  - Observations from RITE Demo
- Strategies for operational array monitoring: 2011-14
  - Matching techniques to scales and proportionality of risk
- VP observations for “next” generation array operational monitoring

## RITE Demo (2005-09): 6-Turbine KHPS



- Multi-turbine field array (6) operation for 9000 turbine-hours
- Fully bidirectional tidal operation
  - Water-to-wire efficiencies consistently >30%
  - Power quality excellent (2 end users)
  - High capacity factor; 18 hr generation
- No observed adverse environmental effects
  - 11 study plans, before and during operation
  - Active hydroacoustics:
    - Stationary, mobile and multiple
  - Bird observations
  - Multiple fish species (2 ESA)
  - No marine mammals

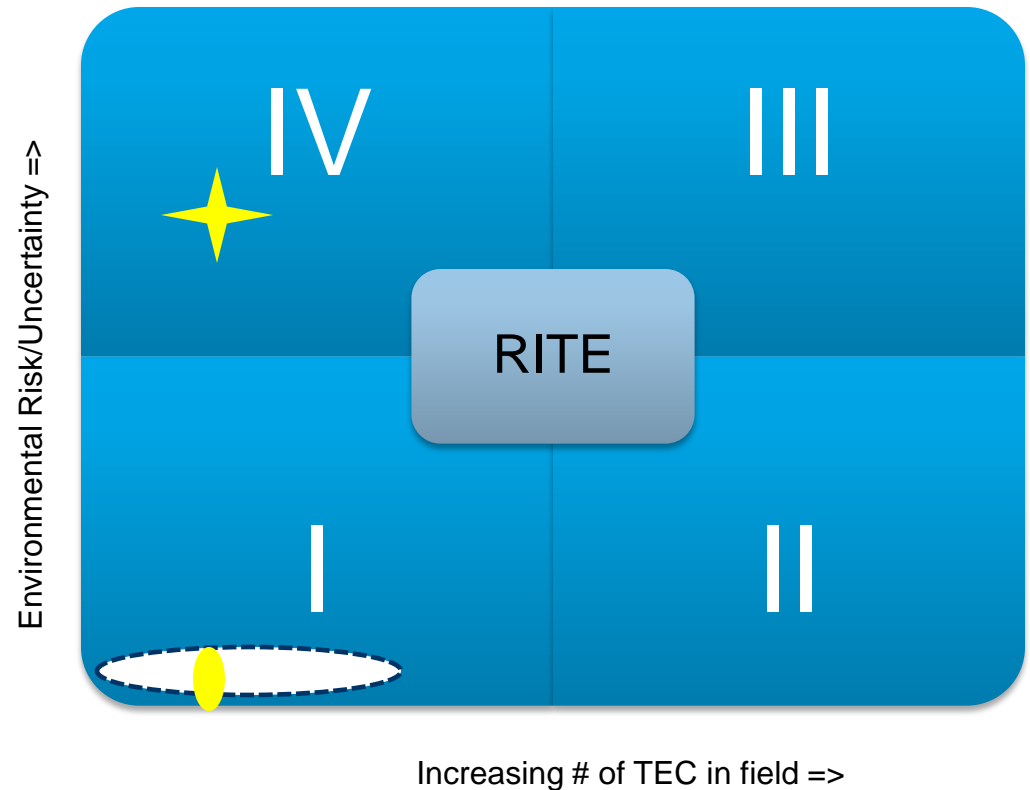
## RITE Pilot - to 30 Turbines (Gen5)



- Staged installation (2, 3, 12, 30-T)
- 10-Year Pilot Term
  - Longevity, reliability
  - Cost reduction of O&M
  - Environmental compatibility
- RITE Monitoring of Environmental Effects (RMEE) plans
  - Progressive plans
  - Seasonal active hydroacoustics:
    - At machine
    - Later in array
  - Netting – for species
  - Telemetry (passive)
  - Bird observations
  - Acoustic – in field

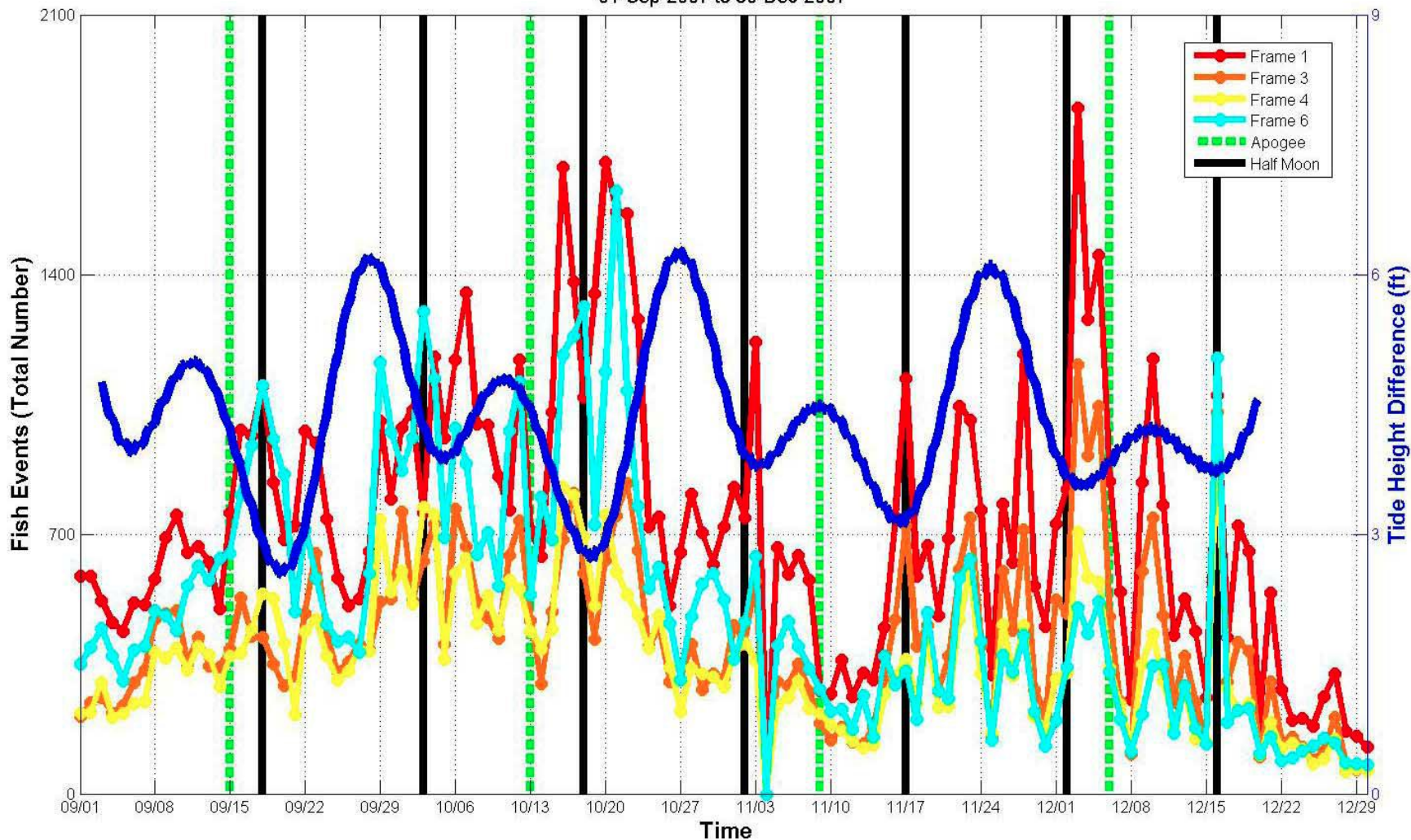


- Initially: Multiple Unknowns
- Demo Results:
  - Significant body of data
  - Monitoring limitations
  - No indication of injury or mortality
- Moving Forward:
  - Build on 'knowns'
    - Seasonal/movement abundance
    - Zonal presence/avoidance
  - Match scale to technique
    - Acknowledge limitations
  - Observe machines in operation



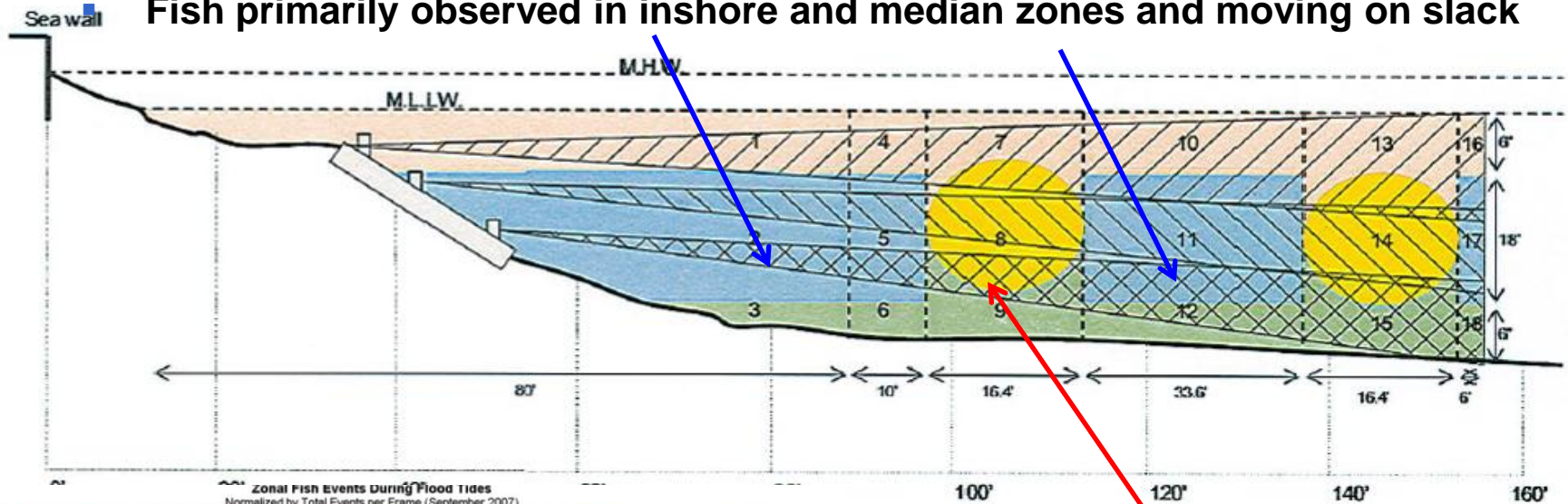


RITE Fish Events per Day w/ Tide Height - Provisional Data - Valid Frames:  
01-Sep-2007 to 30-Dec-2007

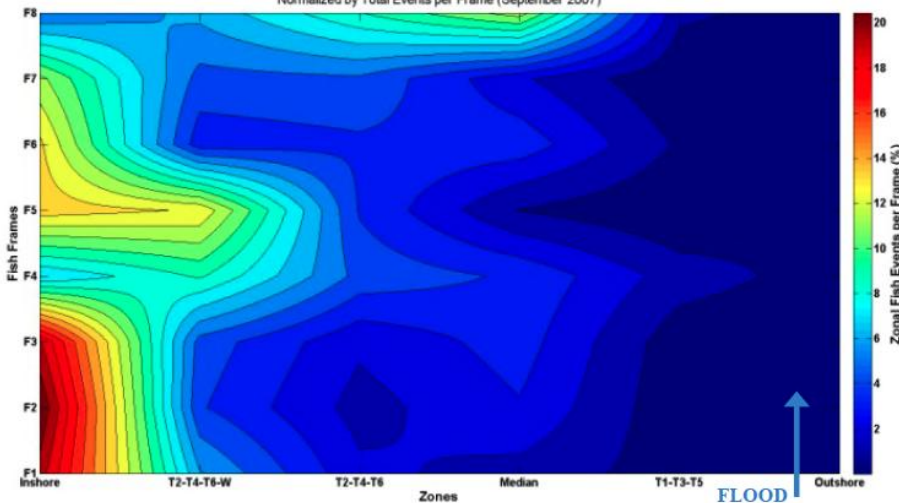




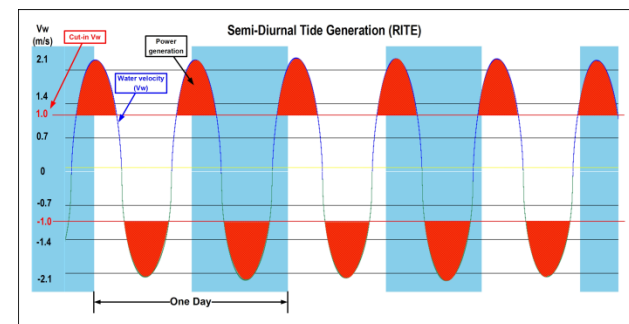
Fish primarily observed in inshore and median zones and moving on slack

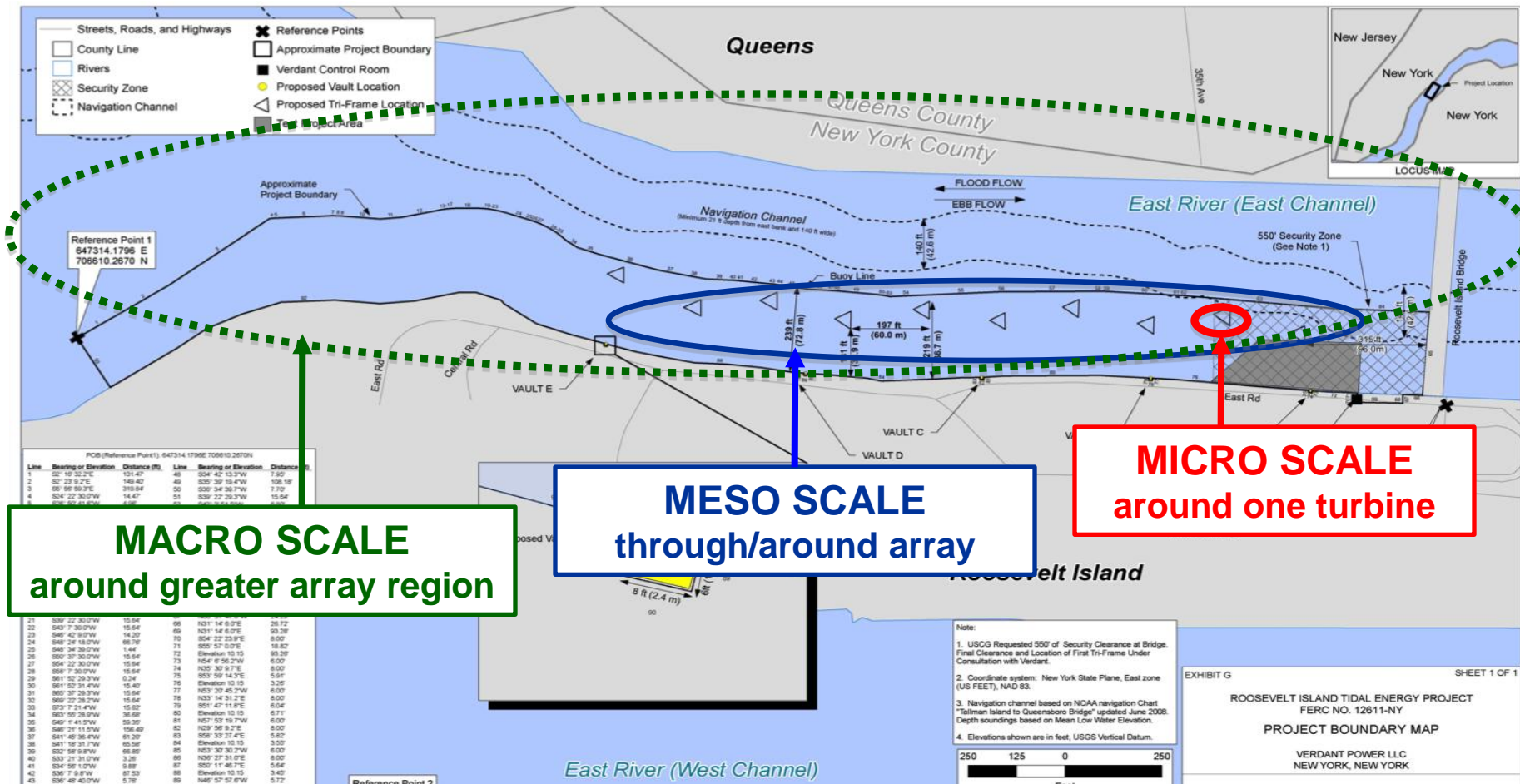


Zonal Fish Events During Flood Tides  
Normalized by Total Events per Frame (September 2007)

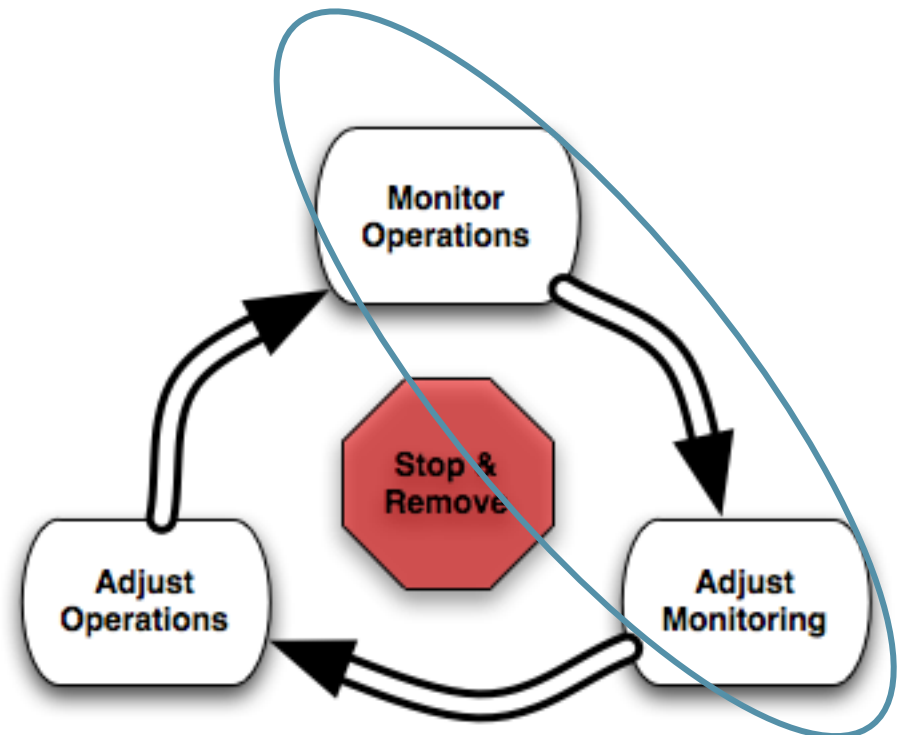


- Limited numbers of fish observed in operating KHPS zones or when operating





- Verdant monitoring:
  - Produces results
  - Answers questions
- Agencies review:
  - Adaptive Management:
    - Adjust the monitoring:
      - Same, More, **Less or abandon**
    - Worst case:
      - Adjust the operations
    - Ultimate safety net:
      - Stop and remove



- \$2.3+million suite of monitoring executed while KHPS is operating to evaluate the environmental compatibility and effects at the Micro, Meso and Macro Scales:
  - **RMEE-1: Seasonal Fixed Hydroacoustics**
  - **RMEE-2: Seasonal DIDSON Observation Monitoring**
  - RMEE-3: Seasonal Species Characterization Netting
  - **RMEE-4: Tagged Species Detection**
  - RMEE-5: Seasonal Bird Observation
  - RMEE-6: Underwater Noise Monitoring and Evaluation

*Details in Volume 4 of Final License Application*

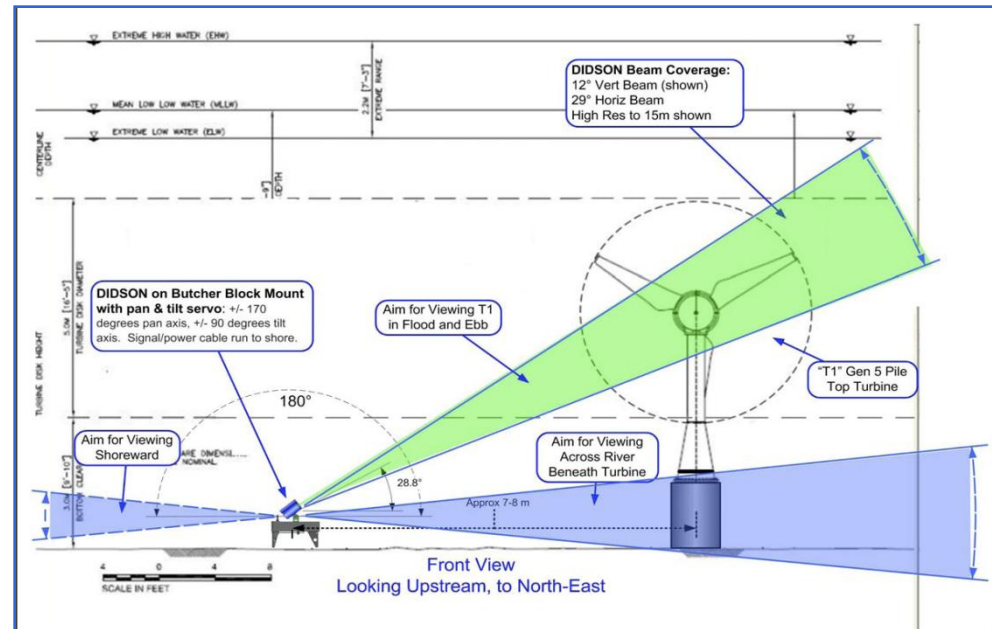
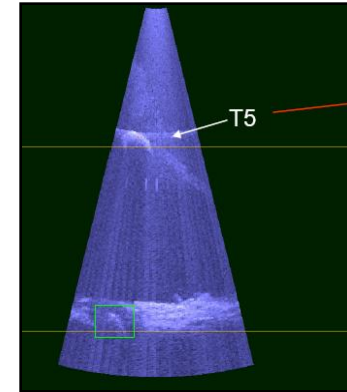
(1) *Balance of monitoring environmental effects with prudent application of available technology*

(2) *Monitoring increases when more turbines are operating*

RMEE	Scale	Install A (2-T)	Install B-1 (3-T)	Install B-2 (12-T)	Install C (30-T)
1 - Fixed Hydroacoustics	Meso-Macro			✓	✓
2 - DIDSON	Micro	✓	✓	✓	TBD
3 - Netting	Macro	✓	✓	✓	✓
4 - Tagging	Macro	✓	✓	If study continues	If study continues
5 - Bird	Meso-Macro		✓	✓	
6 - Noise	Micro-Meso-Macro		✓		✓



- Dual-frequency Identification Sonar (DIDSON)
- High quality video - for *short-term seasonal deployment* periods (~3 weeks)
- Objective of RMEE-2:  
Observe/confirm fish behavior at slack; ebb and flood with KHPS operating



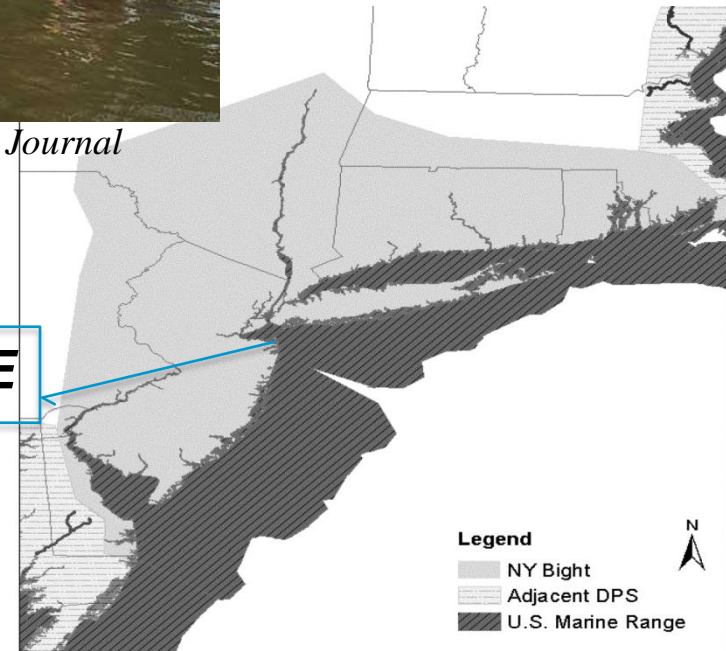
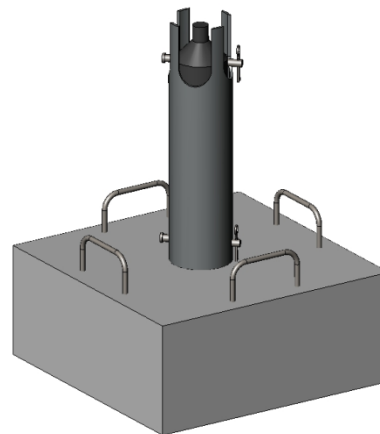
# Macro Scale Passive Telemetry with VEMCO

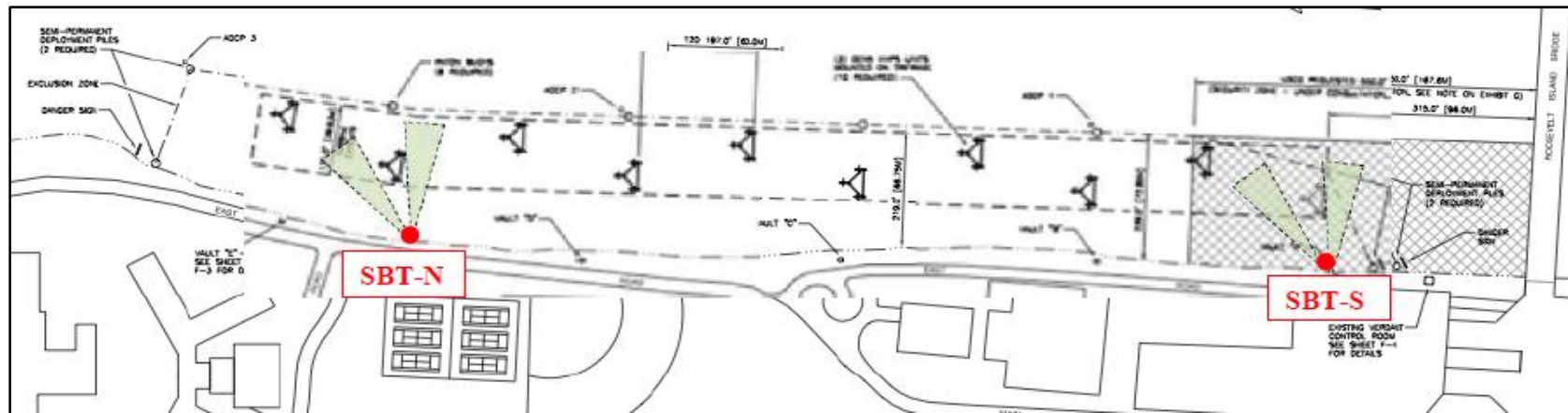
- Stationary VEMCO receivers
- **Long term** detection of large (>84cm) species **tagged by others**
- Objective of RMEE-4:  
Detect presence, abundance and movement of tagged fish in vicinity of operating KHPS; verification of predictive models



*Poughkeepsie Journal*

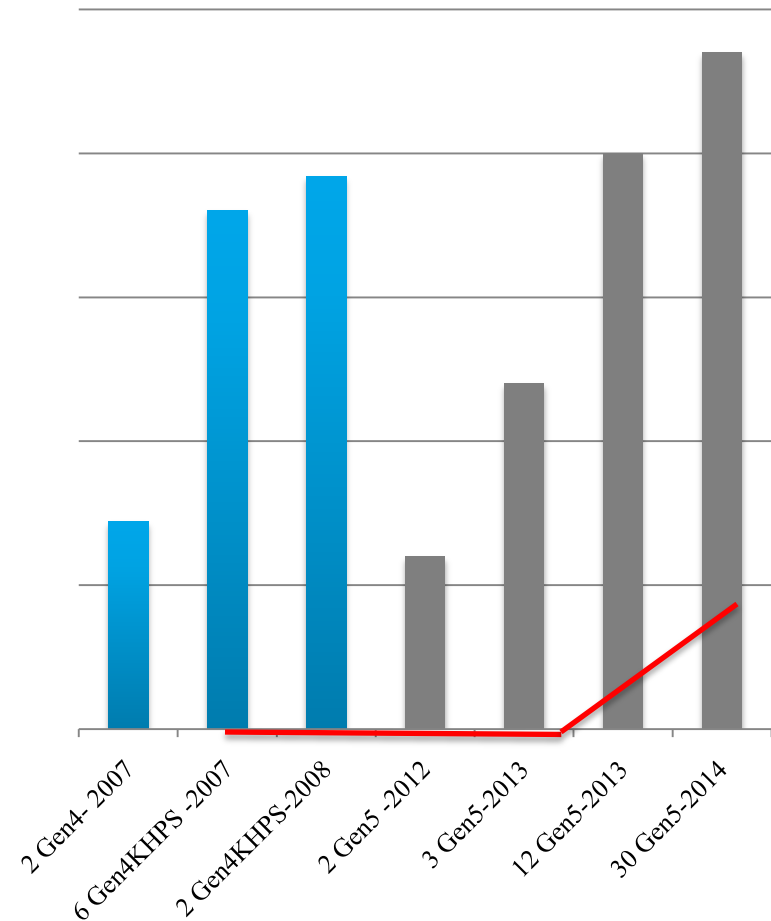
**RITE**





- Stationary Biosonics split-beam transducers (SBT)
- **Short-term** deployment during operation in front of and in back at two locations
- Objective of RMEE-1:
  - Monitoring of fish presence, abundance movement and behavior through the array

- RITE Demo:
  - Results “*instructive*”
  - Basic understanding
- RITE Pilot:
  - New ground for multiple machines in staged approach
  - Monitoring costs still significantly more than power revenues



Micro	Meso	Macro
Presence	Presence/ Abundance	Abundance
	<i>Species and Size</i>	
<i>Movement/ behavior/ interaction</i>	<i>Movement and Behavior</i>	<i>Migration</i>
Injury/mortality		

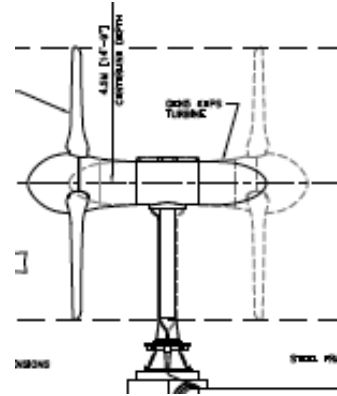
- *Can micro results be transferred to arrays?*
- *Can “understandings” be transferred to other sites?*
- *Goal: Can environmental monitoring of MHK arrays move to a reasonable cost level?*



# Start to Think Meso/Macro – Multiple Structures in Water



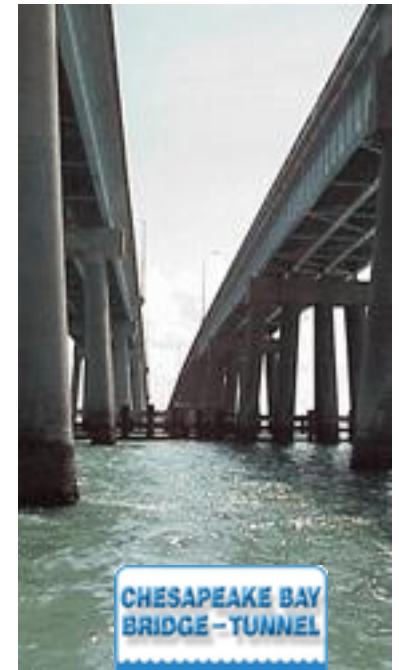
*Jiaozhou Bay Bridge ( 26.4 miles long)  
Dailymail.co.uk*



*Operating (and non operating) KHPS array*



*Ormond Offshore Wind Farm UK  
(31 structures)  
Image via Vattenfall*



*1964 - 1999*

# Tidal Energy is Renewable Energy



- Remember the Goal: Renewable energy production in an environmentally compatible way
- Learn from the early stage experiences at projects with monitoring to reduce costs
  - Understand, transfer and GROW from prior work
  - Be realistic regarding costs and expectations in an OPERATING mode
  - Be prepared to adapt the protocol (and operation) based on results – More, LESS, or move on
  - Avoid attempts at BACI in an energetic environment
- Work in a risk-based framework to proportionally reduce monitoring in the future
- Begin to focus on the array and site challenges – drawing from other fields





# For Further Information

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The Octagon