G&G Surveys Benthic

- What do they tell us about fish habitat?
- What are potential effects?
- What monitoring is planned?

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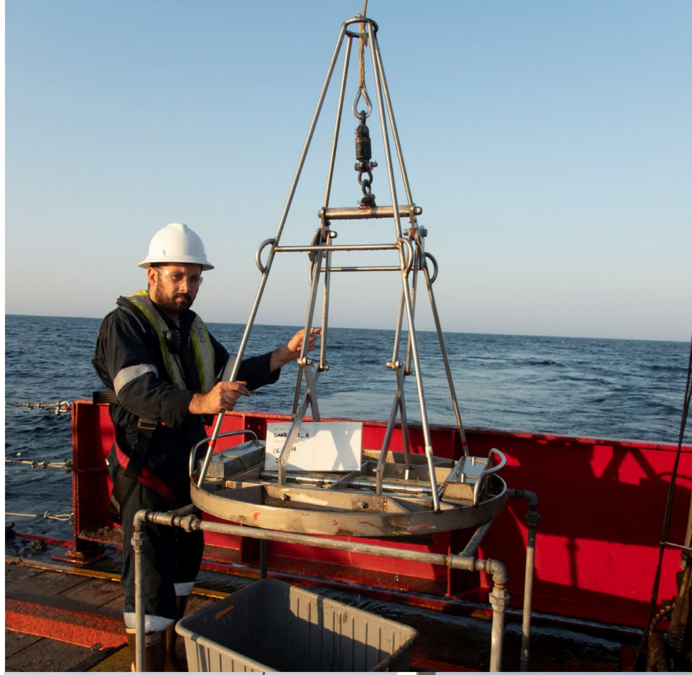
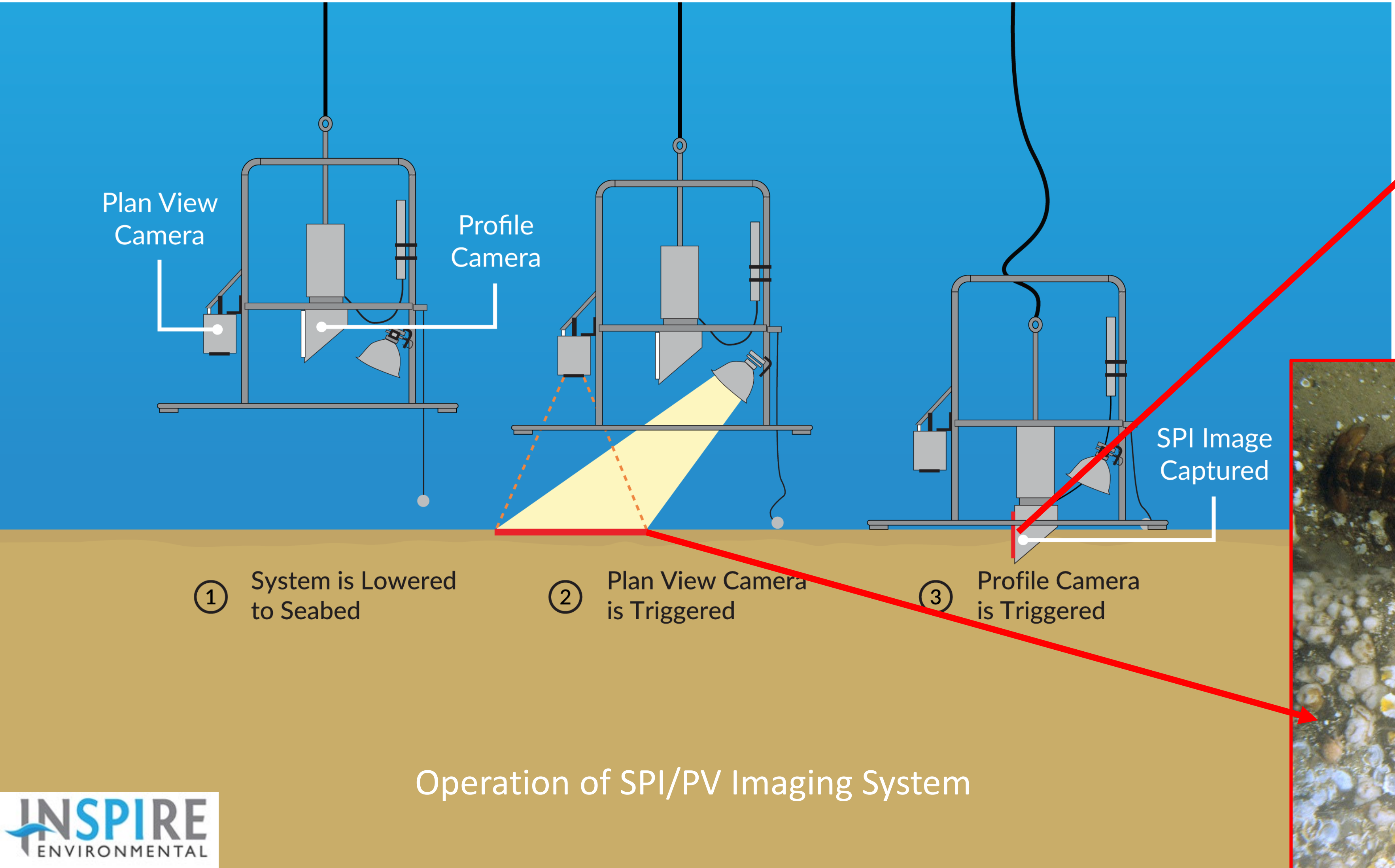
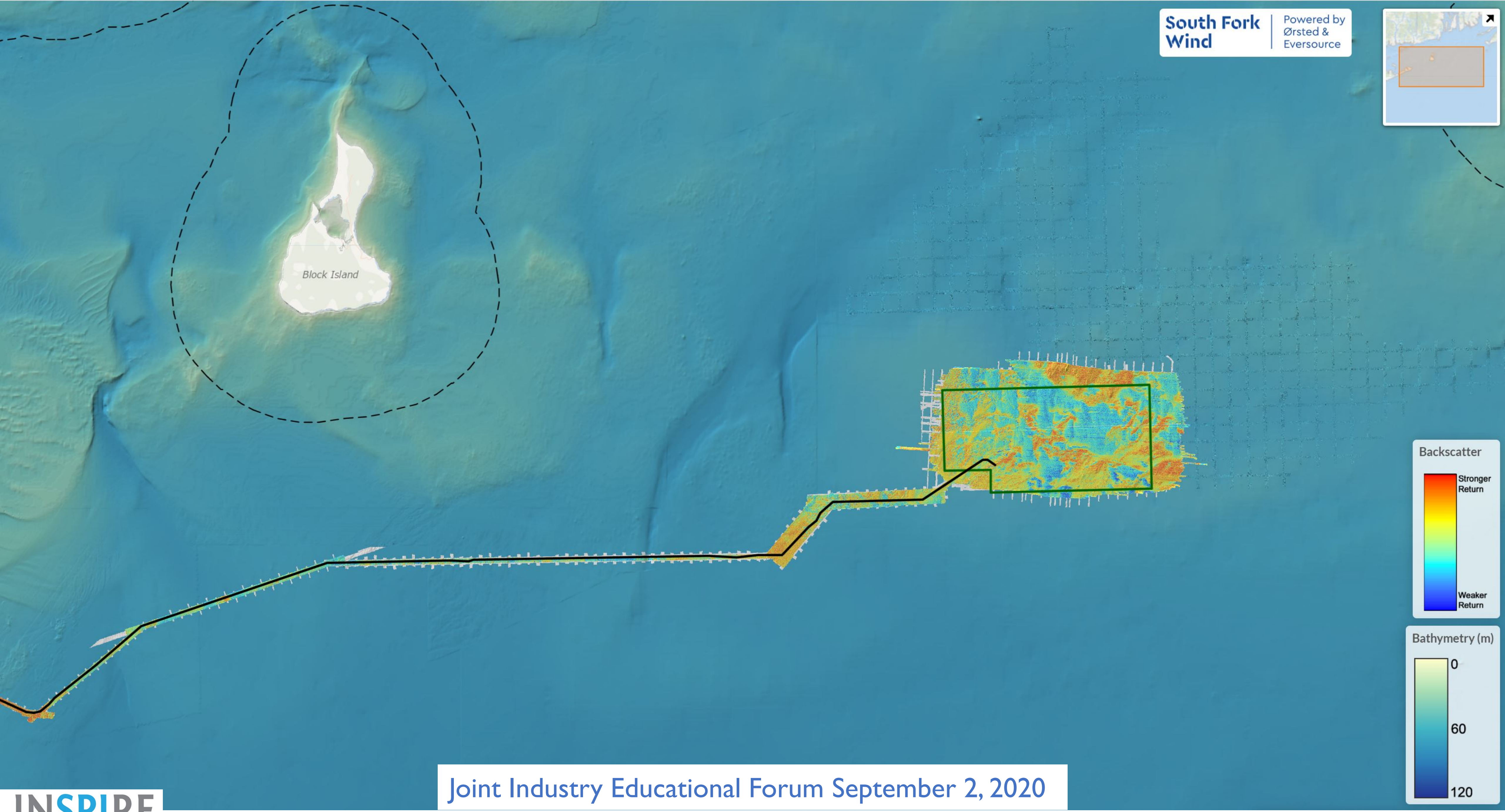
Groundtruth Geophysical Data

- Methods in BOEM Guidelines
  - Grab for grain size (sieving and lab analysis)
  - Grab + Video (addition of surface features)
  - SPI/PV (Visual grain size, layering, and surface features)
- Visual data also useful for benthic habitat characterization
  - Benthic habitats are combination of physical and biological characteristics
  - Coastal & Marine Ecological Classification System (CMECS)



Visual groundtruth





Joint Industry Educational Forum September 2, 2020

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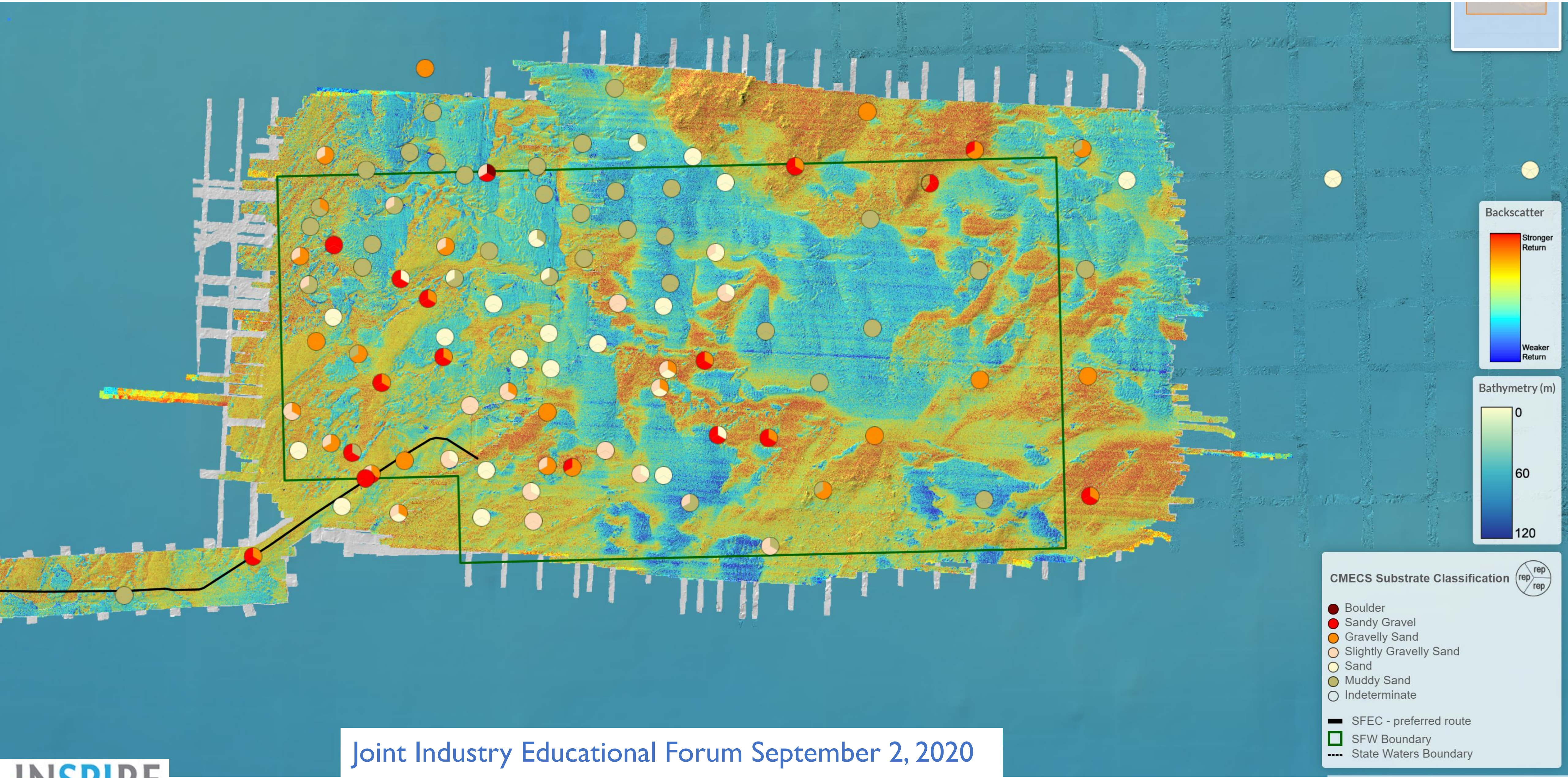

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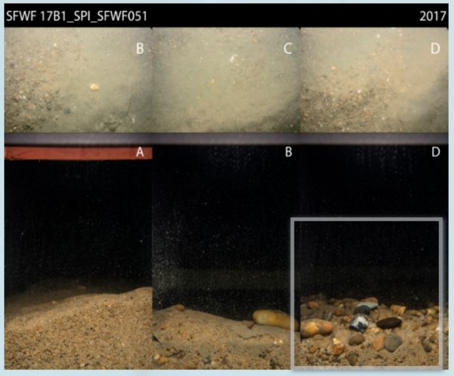
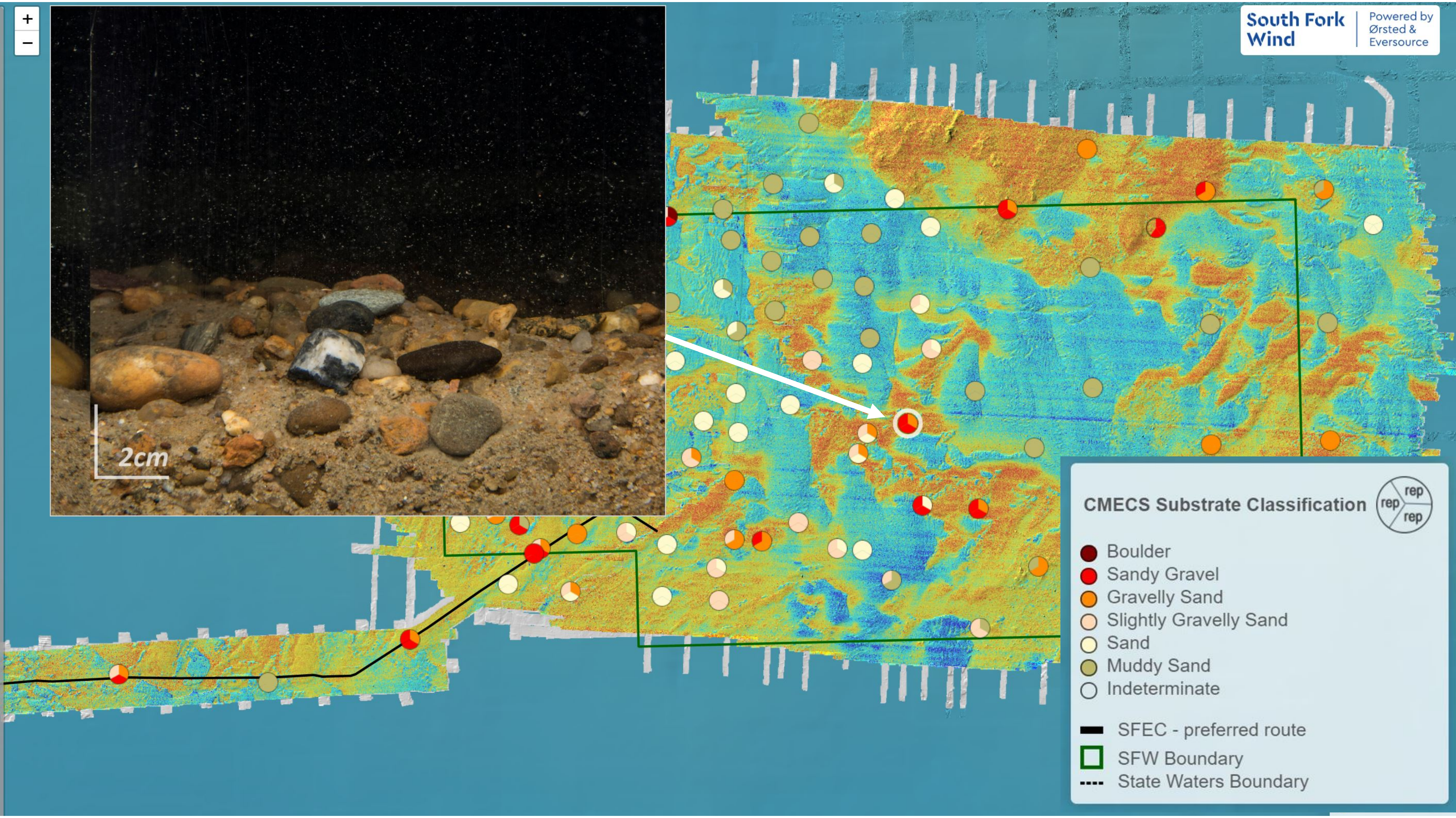
South Fork Wind : SPI/PV Station Data



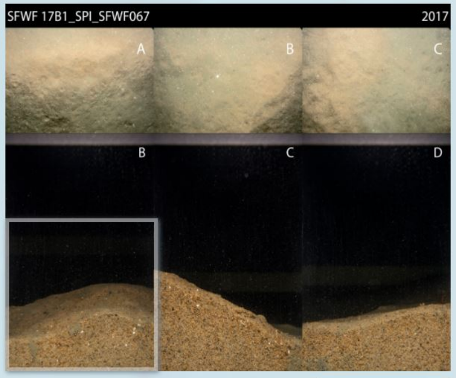
Station ID 51

SPI PV

Attributes	Results
Habitat Type	Sand with Mobile Gravel
CMECS Substrate Classification	Gravelly Sand; Sandy Gravel; Sandy Gravel
Boulder Presence	No
Bedforms	Ripples; Ripples; Ripples
CMECS Biotic Subclass	Soft Sediment Fauna
CMECS Biotic Group	IND
CMECS Co-occurring Biotic Group	None
Maximum Attached Fauna Percent Cover	None
Sensitive Taxa	None
Burrow Presence	No
Tube Presence	No



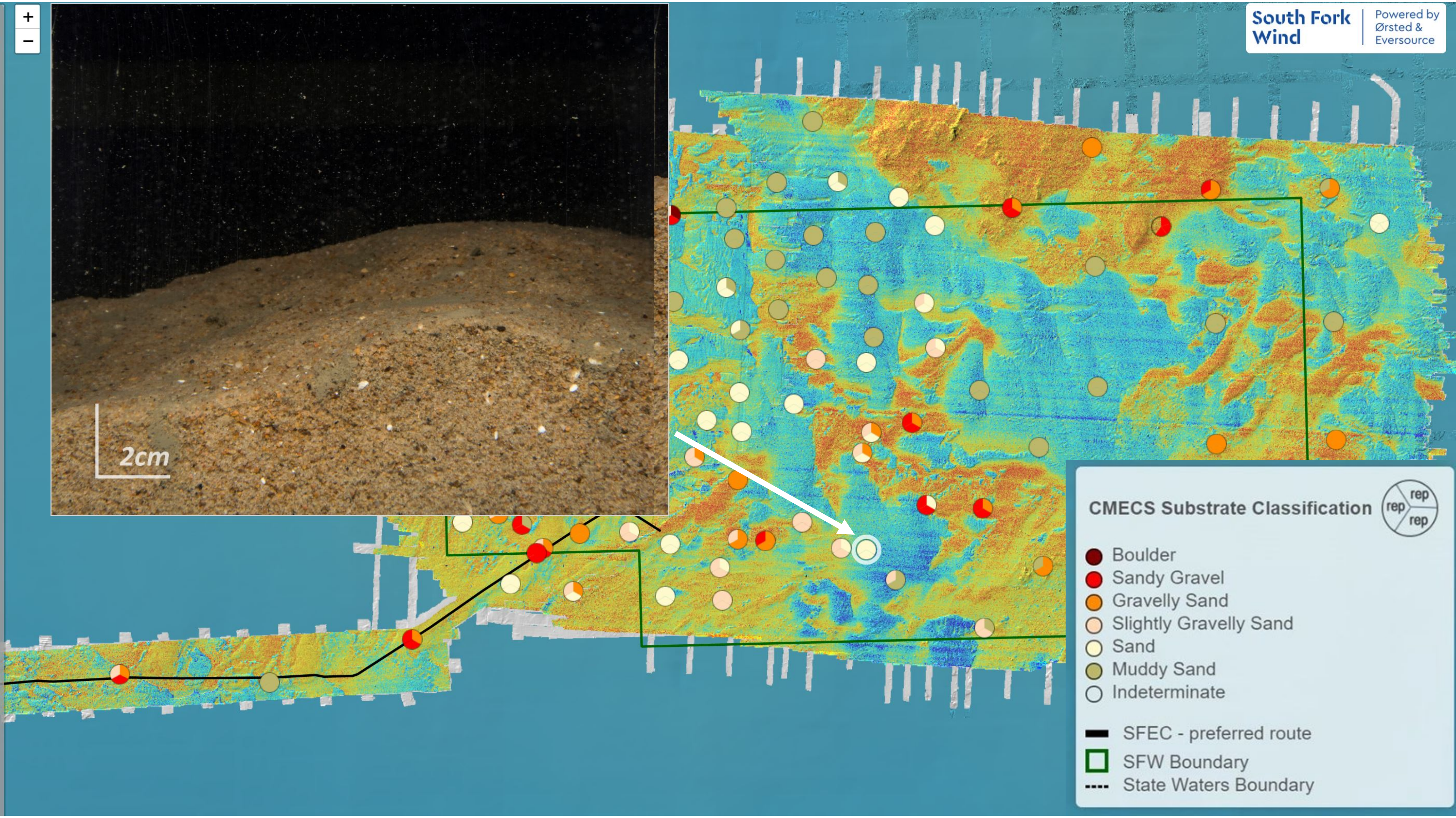
South Fork Wind : SPI/PV Station Data



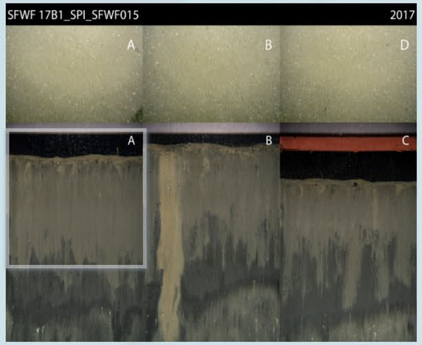
Station ID 67

SPI PV

Attributes	Results
Habitat Type	Sand Sheet
CMECS Substrate Classification	Sand; Sand; Sand
Boulder Presence	No
Bedforms	Ripples; Ripples; Ripples
CMECS Biotic Subclass	Soft Sediment Fauna
CMECS Biotic Group	Small Surface-Burrowing Fauna
CMECS Co-occurring Biotic Group	None
Maximum Attached Fauna Percent Cover	None
Sensitive Taxa	None
Burrow Presence	Yes
Tube Presence	No



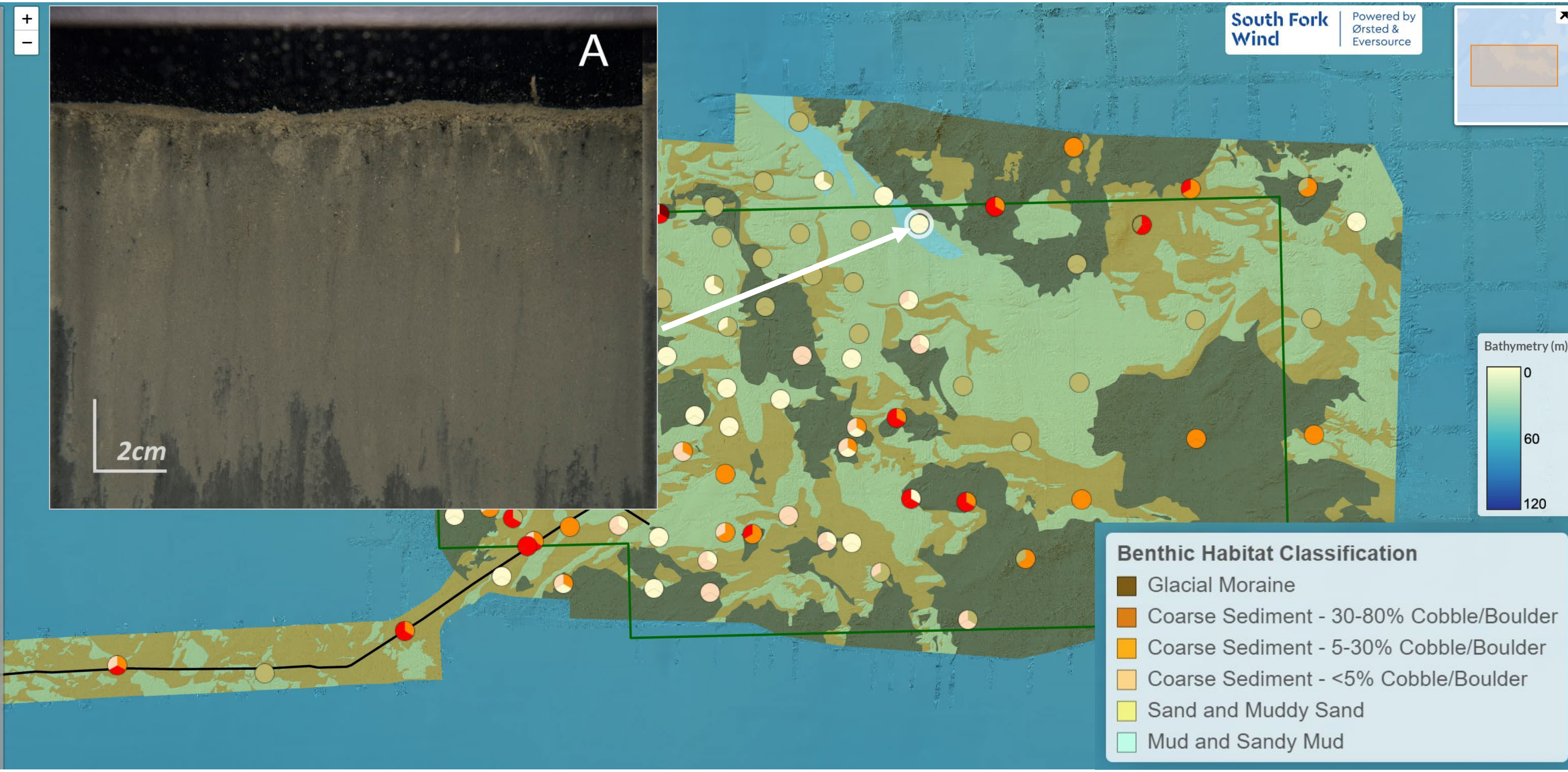
South Fork Wind : SPI/PV Station Data



Station ID 15

SPI | PV

Attributes	Results
Habitat Type	Sand Sheet
CMECS Substrate Classification	Sand; Sand; Sand
Boulder Presence	No
Bedforms	None; None; None
CMECS Biotic Subclass	Soft Sediment Fauna
CMECS Biotic Group	IND
CMECS Co-occurring Biotic Group	None
Maximum Attached Fauna Percent Cover	None
Sensitive Taxa	None
Burrow Presence	IND
Tube Presence	No



How do Fishes and Invertebrates Use Sound?

Sound cues are used by fishes and invertebrates for many important biological functions:

- Communication within species
  - Reproductive activities account for the majority of sounds produced by fishes
- Avoidance of predators
- Detection of prey

Anthropogenic noise can have negative ecological, behavioral and physiological impacts

Sound travels as a wave through a medium, such as liquid (water), solid (seafloor), or gas (air).

- Sound pressure = compression and expansion of the medium as sound energy moves through it
- Particle motion = back-and-forth motion of the particles of the medium

https://dosits.org/science/sound/what-is-sound/

https://dosits.org/animals/advanced-topics-animals/components-of-sound/

For more background: Discovery of Sound in the Sea (dosits.org)

Specific resources for Decision Makers

- Tutorials
  - Science of sound
  - Effects of sounds
  - How do you determine effects
  - Specific sound sources and their potential effects
- Instructional videos
  - Science of sound
  - Hearing in fishes, marine mammals
  - Ecological risk assessment process
- Webinars

How do Fish Detect Sound?

Without sensors, the sound pressure moves through body without effects

Inner ear

- Otoliths are denser than water and fish's body
- Move more slowly in response to sound wave, displacing the cilia on hair cells

  Respond to particle motion
- For those fishes that have been studied, greatest sensitivity from 100 to 200 Hz up to 800 Hz (.1-.8 kHz)

Lateral Line

- System of flow sensors distributed throughout the body of a fish
- Neuromasts are hair cell receptors
- Receptors on the lateral line can detect sounds that are very close to the source (within a few body lengths of the fish) at frequencies up to approximately 200 Hz

Range Groups 1-3: <3 kHz; Group 4: 3-100 kHz
Acute criteria (recoverable injury) > 210 dB rms or 207 dB peak

Swim bladders

- Respond to sound pressure, creating particle motion that inner ear can detect
- Proximity to inner ear influences sensitivity to sound (Hawkins et al. 2020), resulting in **four** basic groups of fishes

Groupings based on presumed hearing ability

1. Fishes with no swim bladder or other gas chamber (e.g., flatfish, elasmobranchs): hearing limited to well below 1 kHz
2. Fishes with swim bladder not involved in hearing (e.g., Atlantic salmon, sturgeons): hearing limited to 1 kHz
3. Fishes with swim bladder close to the ear but no specialized physical connection (e.g., Atlantic cod): can detect sound up to a few kHz
4. Fishes with swim bladder connected to the ear (e.g., herrings, Atlantic menhaden): can detect sound above 2-3 kHz, some to over 100 kHz

How do Marine Invertebrates Detect Sound?

Sensory hairs

- Found in most marine crustaceans (e.g., lobster, crab, shrimp)
- Extensive array covering their bodies
- Detect particle motion (vibrations)

  American lobster: sounds from 20 to 300 Hz

Chordotonal organs

- Found in the joints of flexible appendages (e.g., walking legs, antennae), connected to the central nervous system
- Detect particle motion (vibrations)

  Fiddler, ghost crabs: sounds to 300 Hz

  – Common prawn: 100-3,000 Hz

Statocyst

- Found in most marine invertebrates, including cephalopods and crustaceans
- Organ with dense structure (statolith) associated with hair-like cells
- Primarily provides orientation cues; may detect particle motion
  - Longfin squid: 30-500 Hz
  - Common octopus: 400-1,000 Hz

Range 0.02 – 3 kHz

No established acute criteria

Limited experimental studies

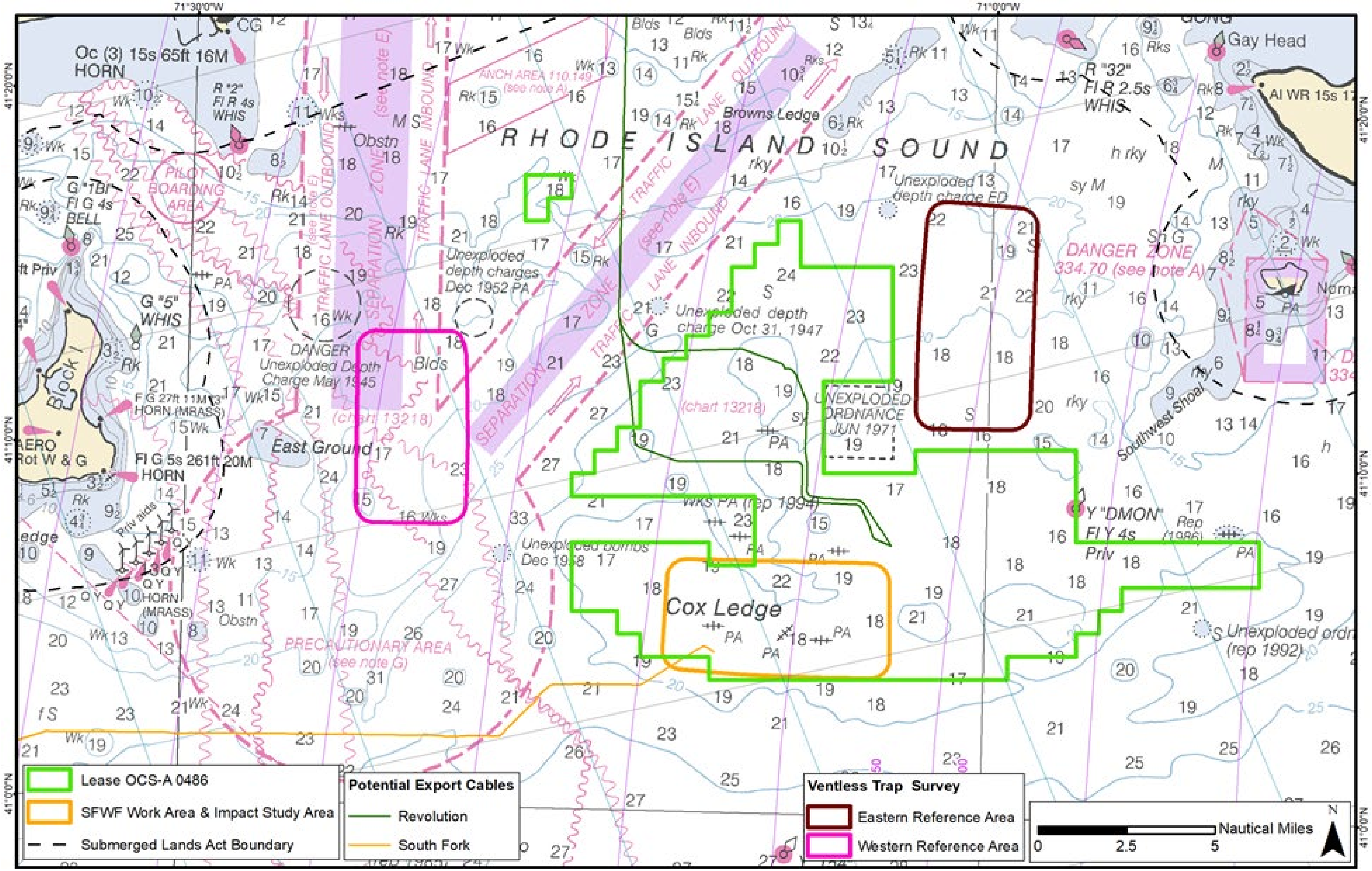
G&G Source	Type of sound source	Operating Frequency	Source Level (1 m from source)	Fish Acoustic Threshold Groups 1-3	Fish Acoustic Threshold Group 4
Multibeam echosounder	Non-impulsive ‘swept’ signal	200-400 kHz Primarily 400 kHz	220 dB rms	>210 dB rms 0.01 – 3 kHz	>210 dB rms 3 – 100 kHz
Chirp sub-bottom profiler	Non-impulsive ‘swept’ signal	2-16 kHz Primarily 9 kHz	176-197 dB rms	>210 dB rms 0.01 – 3 kHz	>210 dB rms 3 – 100 kHz
Parametric sub-bottom profiler	Non-impulsive ‘swept’ signal	6-12 kHz Primarily 10 kHz	220-232 dB rms	>210 dB rms 0.01 – 3 kHz	>210 dB rms 3 – 100 kHz
Ambient RI Sound (Kraus et al. 2016)	Non-impulsive	< 1 kHz	130 dB rms	>210 dB rms 0.01 – 3 kHz	>210 dB rms 3 – 100 kHz
Fish finder (single beam echosounder/sonar)	Non-impulsive ‘swept’ signal	3 to 200 kHz	150 – 235 dB rms	>210 dB rms 0.01 – 3 kHz	>210 dB rms 3 – 100 kHz
Sparker sub-bottom profiler	Impulsive	0.2-5 kHz Primarily 2 kHz	211 dB peak (203 dB rms)	>207 dB peak 0.01 – 3 kHz	>207 dB peak 3 – 100 kHz
Boomer sub-bottom profiler	Impulsive	0.2-8 kHz Primarily 0.6 kHz	211 dB peak (203 dB rms)	>207 dB peak 0.01 – 3 kHz	>207 dB peak 3 – 100 kHz

Monitoring of G&G

Collect baseline data in areas with survey activities
- Lease Areas
- Cable Corridors

Collect baseline data in areas outside survey activities

Example of proposed reference areas for ventless trap surveys



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