Underwater Noise Level Study during Impact Pile Driving

FDOT Project No. BDV34 985-03, Katasha Cornwell, Office of Environmental Management, Project Manager

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Motivation

- Pile driving may make enough noise to kill/injure fish and other marine animals

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Project Background

- 2009 – Ten federal agencies formed interagency task force on anthropogenic sound and the marine environment. Agencies agreed to:
  - Develop and validate mitigation measures to minimize demonstrated adverse effects from anthropogenic noise.
  - Test/validate mitigating technologies to minimize sound output and/or explore alternatives to sound sources with adverse effects
  - Explore need for and effectiveness of time/area closures versus operational mitigation measures

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Project Background

- 2016 – duties associated with anthropogenic noise assigned to FDOT in Florida
- Issue – Florida does not have reliable local guidelines to predict anthropogenic noise during pile driving and it has been using CalTrans' "Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish" (Buehler et al. 2015)
- Lack of reliable guidelines can lead to inaccurate noise transmission estimates that may either harm wildlife or lead to unnecessary mitigation measures
- Practical spreading loss model (PSLM): $TL = F \log\left(\frac{R_2}{R_1}\right), F = 15$

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Project Objectives – Main Objective

- Main Objective – Characterize underwater noise levels during impact pile driving throughout the State of Florida

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Project Objectives – Objective 1

- Sample noise levels of in-water pile driving events and limited drilled shaft pile installations at pre-determined project locations throughout the State of Florida. In addition, the relative noise attenuation ability of different sound attenuation techniques will be evaluated. Specific goals include:
  - Measure ambient noise levels at all sample sites to obtain baseline data.
  - Sample a representative number of noise levels using a standard data collection form from designated project sites to determine sound impact areas and present these data to the Department.
  - Evaluate the effectiveness of different types of sound attenuation methods when available; specifically bubble curtains, cofferdams, isolation casings, and preformed holes.
  - Correlate hammer stroke height to recorded noise levels.
  - Monitor noise levels during test pile installation evaluate dynamic testing results to develop correlation between transfer energy and noise level. If the project contains less than five test piles, correlate the remaining date from production piles.

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Project Objectives – Objective 2

- Using the data collected during Objective 1, calculate attenuation factors based on Florida's specific marine, estuarine, and riverine environments that can be used as reference when assessing the need for noise attenuation in future bridge projects that involve pile driving. Sub-objectives include:
  - Calculating the attenuation factor for all projects monitored based upon the empirical data using the PSLM
  - Using the environmental and noise analysis data from Objective 1, determine attenuation factors best fit for different types of marine, estuarine, and riverine environments found throughout Florida.
  - Create a programmatic method to determine attenuation factor based on site-specific variables that can be used by project leads during project design.
  - Generate a user-friendly guide of attenuation factors for bodies of water throughout the State of Florida derived from the data collected and other data obtained from the literature.
  - Develop/apply more-sophisticated model to describe sound attenuation in Florida

Project Objectives – Objective 3

- Develop a technical guidance document and programmatic consultation biological assessment with the National Marine Fisheries Service (NMFS), US Fish and Wildlife (USFW), and other stakeholders. Sub-objectives include:
  - Forming and convening a technical working group composed of government agencies and other stakeholders to review the data and results from Objectives 1 and 2.
  - Developing a programmatic approach for the FDOT to determine the necessary noise reduction measures needed to minimize impacts to aquatic organisms using programmatic consultation with NMFS, USFWS, stakeholders, and data collected as part of Objective 1.
  - Refine and finalize technical guidance that explains pile driving impacts and how to mitigate for those impacts using the agreed upon programmatic approach

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Field Data Collection

- Data collection system components – hydrophones, charge converters, temperature gauges, calibrator

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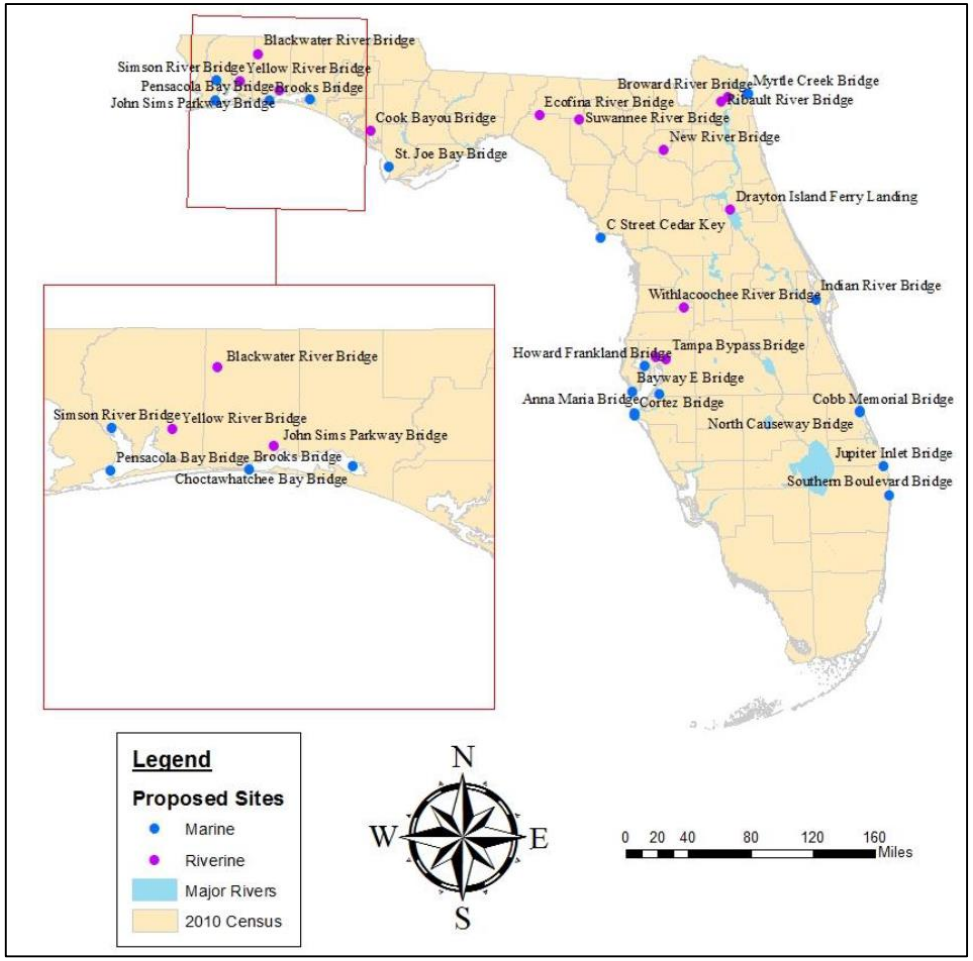
Field Data Collection



- Collect data from “a number” of bridges through 2022
  - Hydrophones
  - Acoustic Doppler Current Profiler (ADCP)
  - Temperature System
- Record data in field in real-time using ArcGIS Survey 123

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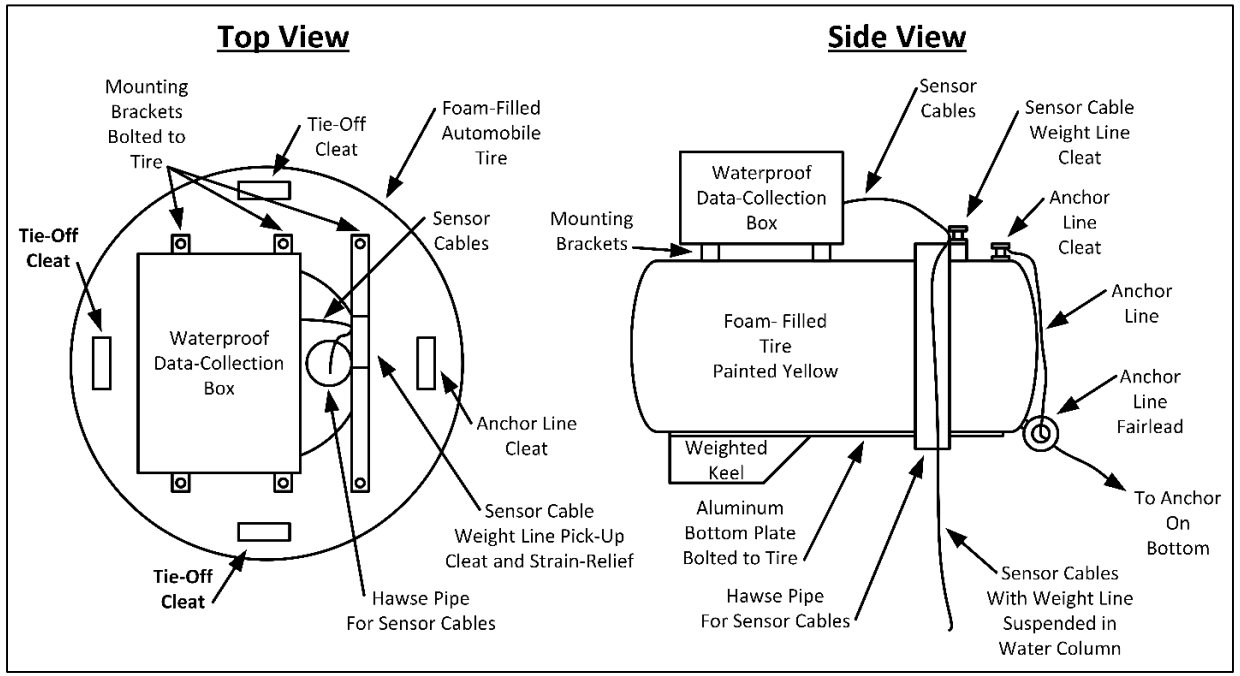
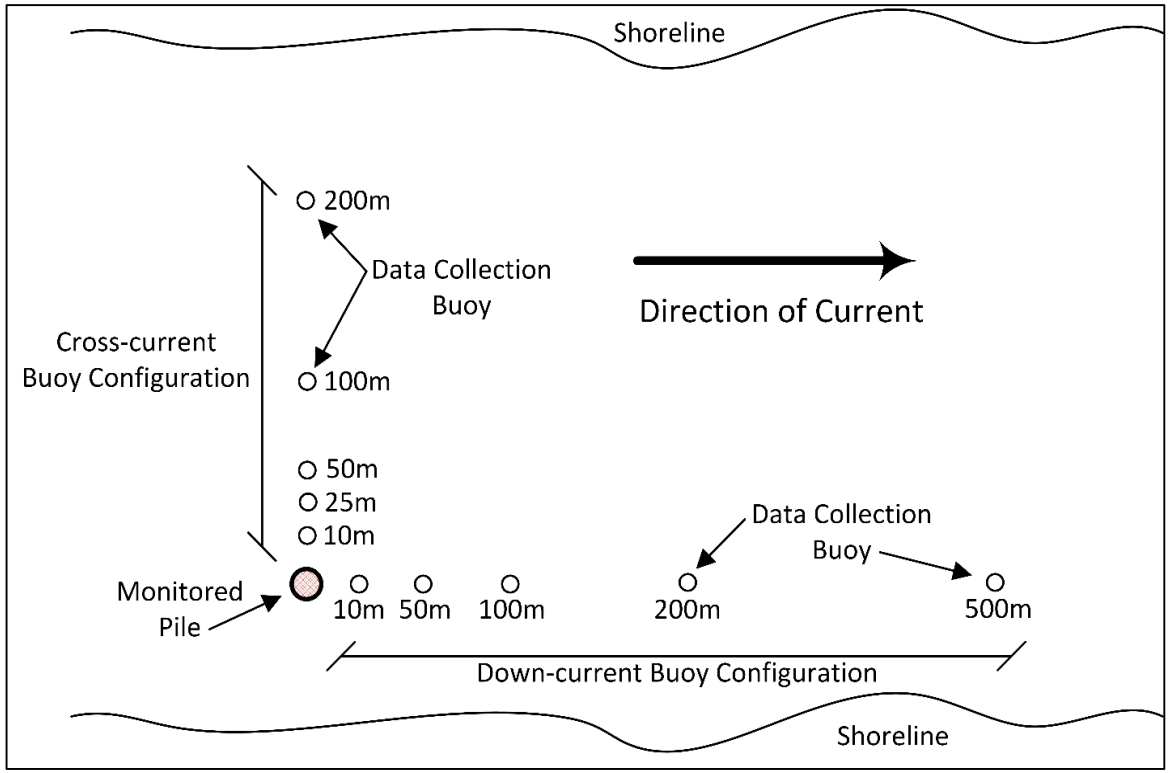
Field Data Collection



Field data collection buoy schematic



Field data collection buoy layout

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Data Analysis

- Use data to define
  - Peak pressure
  - Root mean squared sound pressure across 90% of strikes' energies
  - Sound exposure level (SEL) across 90% of accumulated sound energies
  - Cumulative SEL
  - Frequency spectra
- Use data to calibrate transmission loss coefficient
- Use data to develop/apply more sophisticated *TL* model (maybe Raven Pro)

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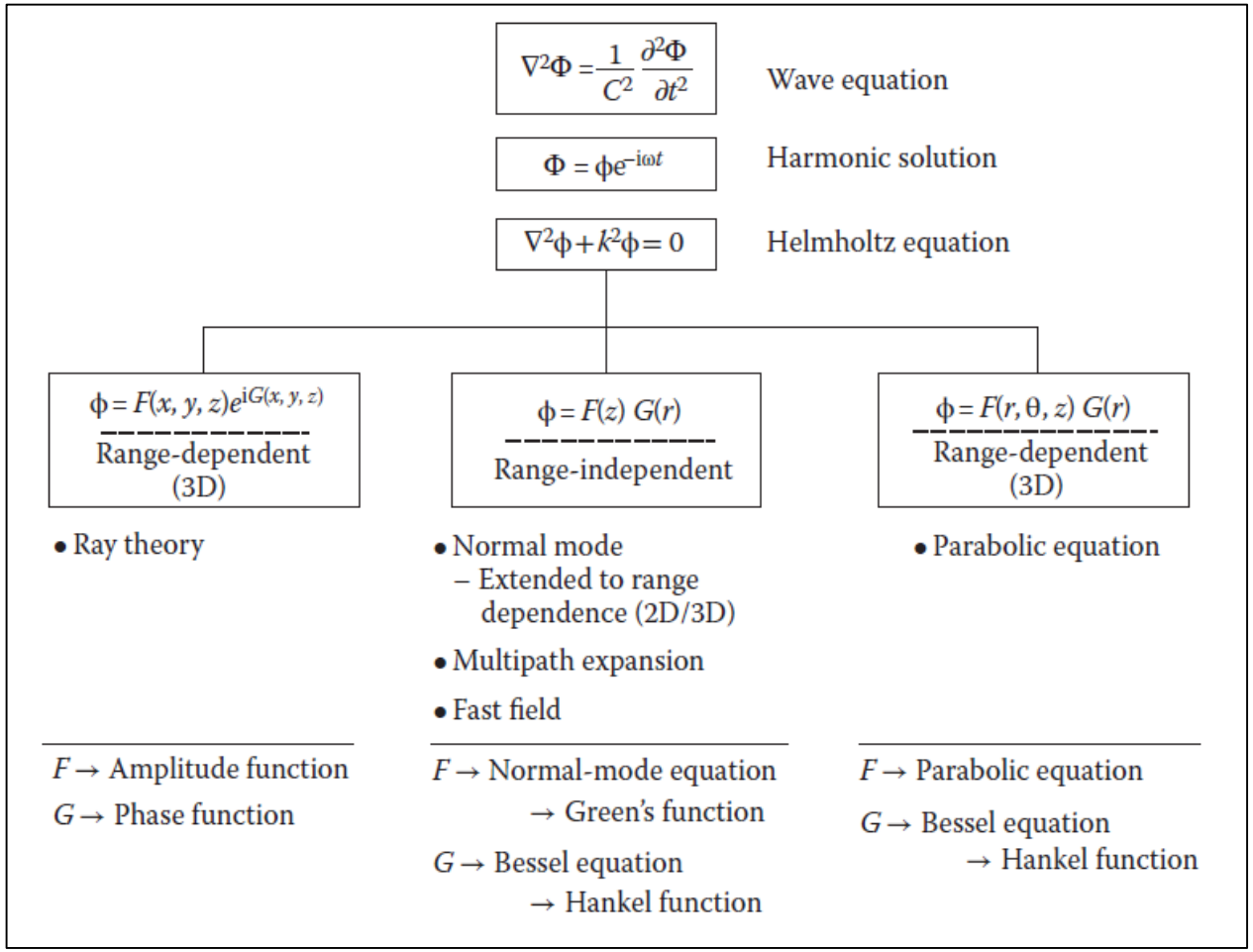
Data Analysis – More-sophisticated *TL* Methods



Harmonic solutions to the wave equation

Model Type	Shallow Water				Deep Water			
	Low-Frequency		High Frequency		Low Frequency		High Frequency	
	RI	RD	RI	RD	RI	RD	RI	RD
Ray Theory								
Normal								
Parabolic								

Appropriate ranges for wave equation solutions

Practical spreading loss model:

$$TL = F\log\left(\frac{R_2}{R_1}\right), F = 15$$

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Stakeholder Meeting & Working Group

- Define and invite stakeholders in collaboration with PM
- Review data
- Evaluate need for a working group
- If working group is necessary, meet at least three times

- Create programmatic biological assessment and outline of technical guidance that
  - Defines attenuation factors in Florida for different environmental types
  - Outlines sound reduction methods based upon pile type
  - Explains impacts of pile driving, best management practices, and how to use programmatic approach

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Thank you!

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