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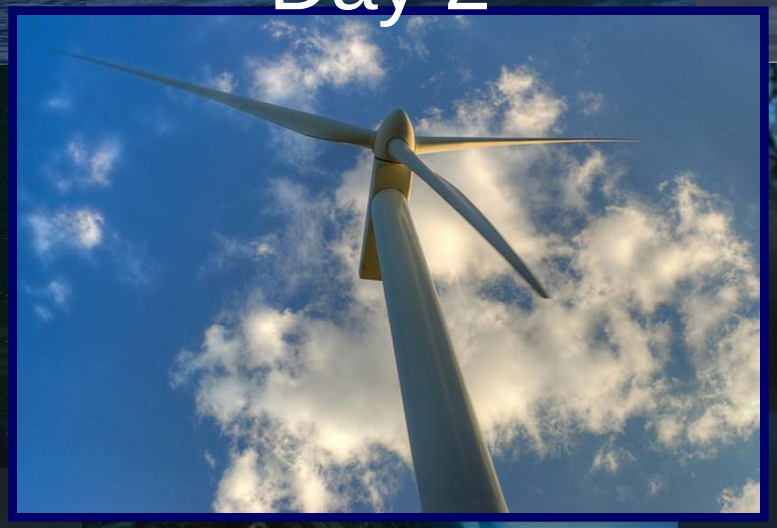
Workshop on Best Management Practices for Atlantic Offshore Wind Facilities

Day 2



& Marine Protected Species

March 7-9, 2017

National Oceanic and Atmospheric Administration
NOAA
U.S. Department of Commerce

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Pile Driving

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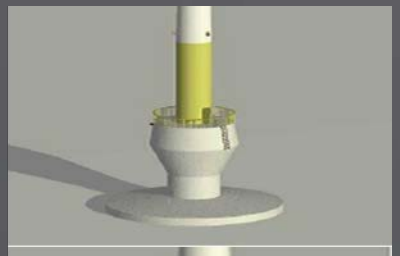
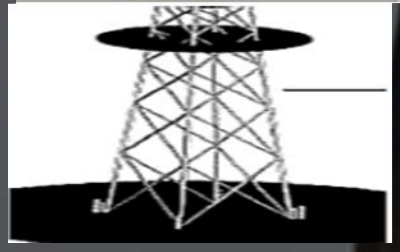
Pile Driving





Gravity foundations have no piles

Monopile foundations have 1 pile/foundation

Tri-pod/multi-pod foundations have 3-4 piles/foundation

Jacket foundations have 4 piles/foundation

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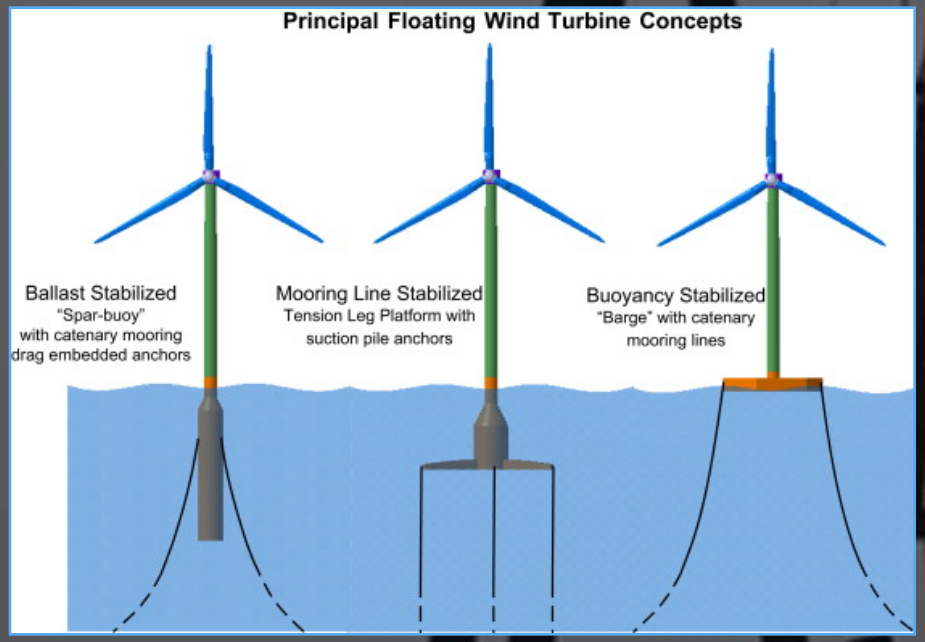
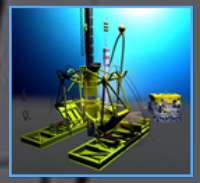
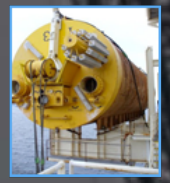
Floating Foundations

Depths >50-60 m




Driven pile anchor


Suction anchor


Gravity anchor


Drag anchor


Drilled and grouted pile


Driven anchor plate (usually vibratory)


Torpedo anchor

Effects of Noise Exposure

- Permanent hearing loss (PTS)
- TTS
- Stress
- Behavioral Effects
  - Avoidance
  - Attraction
  - No effect
  - Foraging
  - Energetics
  - Reproduction
  - Migration

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Pile Driving Noise

- Pile diameter and the bottom type are most influential factors
- Pile diameter affects the loudness and tones produced
- Bottom type effects the energy propagation
- Other project-specific factors include:
  - drive depth
  - pile angle
  - hammer energy
  - water temperature
  - water depth

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Representative Source Levels for a Met Tower

Pile Diameter	Source Level (dB re 1 µPa)		
	Peak	RMS	SEL
1 m (40 in)	228	215	200
1.2 m (48 in)	208	215	200
1.4 m (54 in)	229	214	205
1.7 m (66 in)	230	215	206 (est)
2.4 m (96 in)	240	225	214

*Data from Deepwater Wind (2016), Illingworth and Rodkin, Compendium of Pile Driving Data (Version October 1, 2012), and Genesis (2011). In some cases, we have back-calculated using 20 LogR spreading loss to obtain estimated source levels dB re 1 µPa at 1 m.

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Pile Driving Cumulative PTS Distances for a Met Tower

Example for 3-8 hr of Cumulative Exposure without a Sound Reduction System (SRS)

Pile Diameter	Cumulative Exposure Distance for Each Hearing Group (meters)			
	LF	MF	HF	Seals
1.4 m	859-1,403	70-115	980-1,560	538-878
2.4 m	2,421-3,954	198-324	2,761-4,508	1,515-2,474

*Distances are conservative estimates using the NOAA spreadsheet tool for cumulative sound exposure

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Example Reduction in PTS Distance for Pile Driving with an SRS

Example for 3-8 hr of Cumulative Exposure with a Sound Reduction System (SRS)

	Cumulative Exposure Distance for Each Hearing Group (Reduction in meters)			
Diameter	**LF**	**MF**	**HF**	**Seals**
1.4 m	216-352 **(-643-1,051)**	18-29 **(-62-86)**	246-402 **(-734-1,158)**	135-221 **(-403-657)**
2.4 (m)	608-993 **(-1,813-2,961 m)**	50-81 **(-148-243)**	693-1,132 **(-2,068-3,376)**	381-621 **(-1,134-1,853)**

*Sound reduction >12 dB can be achieved!

*Distance estimates are based on an average 12 dB reduction in source level using the NOAA spreadsheet tool

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Pile Driving Exposure

- Source level (pile size)
- Frequencies (pile size)
- Hearing ability
- Duration of exposure/day (number of piles, time, and strikes/pile)
- Number of days
- Time of year
- Site characteristics affecting propagation

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Pile Driving

OBJECTIVES

- What are the major effects of concern?
- Identify any regional-specific concerns
- Identify or species-specific concerns
- Exclusion zone criteria
  - Effects to avoid
  - Effects to monitor
  - How to predict (NOAA spreadsheet and other modeling)

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Pile Driving

OBJECTIVES

- Mitigation and methods/technologies for 24/7 operations
  - Sound source verification
  - Survey platforms
  - Protected species observers
  - Real-time and remote monitoring methods
  - Noise reduction
- Standard monitoring methods and data collection
- Identify any financial, logistical, or regulatory mechanisms and constraints

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