Source levels and spectral characteristics of sound produced during pile driving at US East Coast Navy Installations

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Introduction

- Pile installation and extraction is a major source of underwater noise along coastlines.
- Acoustic impacts often overlap the ranges of marine and aquatic species that may be vulnerable to underwater sound.
- Few measurements of pile driving source levels exist for the bathymetric and geological conditions along the US east coast.
- This project measured source levels and spectra during pile installation and extraction at Naval installations along the US east coast.

Methods

- Underwater and airborne measurements were taken from a variety of pile types, including steel pipe, steel sheet, concrete, and timber pilings during installation and/or extraction .
- Measurements were conducted at 3 distances – 10m, ~ 100m, and ~250m from the pilings with sound level meters, calibrated hydrophones, and archival recorders.

Fig. 1. Locations of pile driving measurements at naval installations along the US coast. Top: Philadelphia Naval Shipyard, Philadelphia, Pennsylvania. Middle (clockwise): Craney Island, Naval Station Norfolk, and Joint Expeditionary Base Little Creek (Cofferdam and ELCAS locations); Norfolk, Virginia. Bottom: Naval Station Mayport, Mayport Florida.

- Average broadband and spectral data (1/3 octave bands) were analyzed for all pile types.

Results

- Broadband (10 Hz – 20 kHz) source levels varied with installation method, location, and pile type.

Method	Pile Type	Project Location	Source Level	
			Peak [dB re 1µPa]	**SEL** [dB re 1µPa^{2}s]
Impact	24” Steel pipe	JEBLC ELCAS	208	182
	36” Steel pipe	PNSY	200.0	173.2
	48” Steel pipe	PNSY	200.6	174.5
	24” Concrete	Craney Island	180.4	162.3
		NS Norfolk	185.1	181.8
			RMS [dB re 1µPa]	
Vibratory	Steel sheet pile	NS Mayport	151	
		JEBLC Cofferdam	161.4	
	Steel king pile	NS Mayport	148	
	12 – 16” Timber	NS Norfolk	160.4	
	24” Steel pipe (extraction)	JEBLC ELCAS	146	
	36” Steel pipe	PNSY	152.5	
	48” Steel pipe	PNSY	158.9	

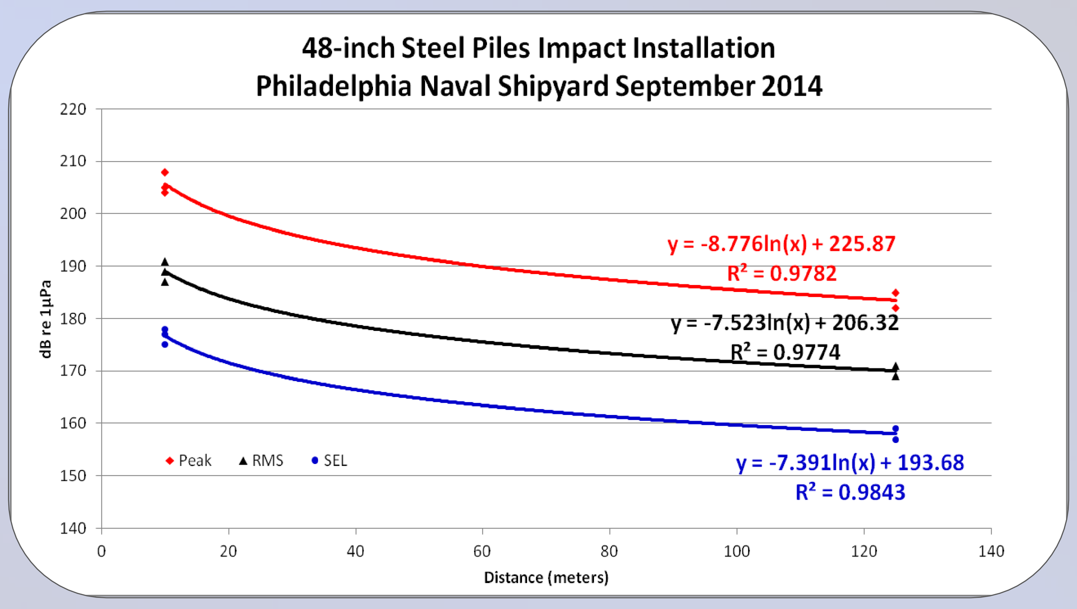

Fig. 2. Example propagation equations generated for impact driving of 48” steel pipe piles at Philadelphia Naval Shipyard.

- Measurements at longer ranges (100 - 200m) allowed for estimation of site-specific propagation equations at project locations (Fig. 2).

Results

- Energy is concentrated below 500 Hz, but sound from pile driving can be detected up to at least 20 kHz in most instances.

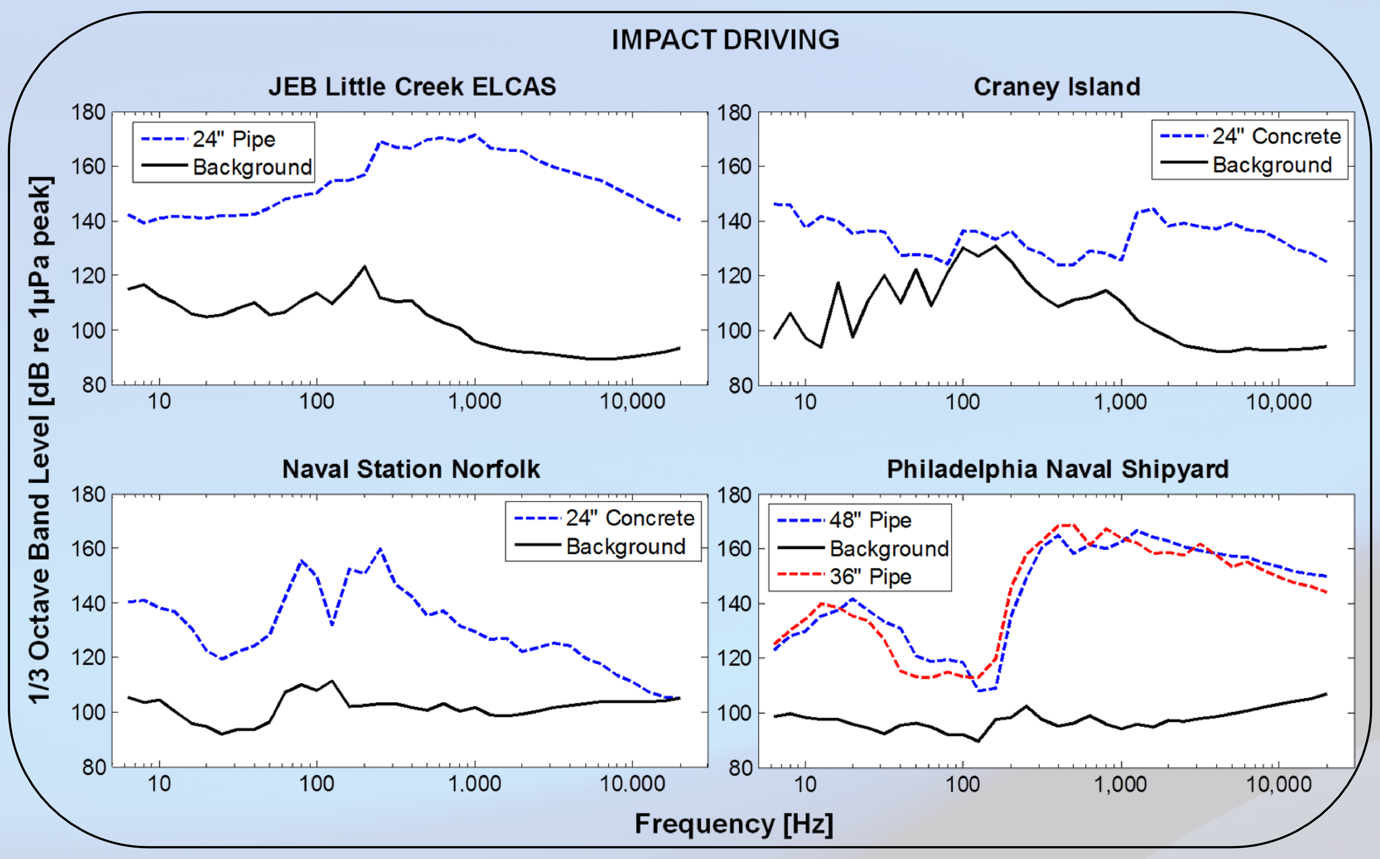

Fig. 3. 1/3 octave band levels of impact pile driving by location and pile type. Note that background noise levels at Craney Island were affected by shipping traffic in the area during measurements.

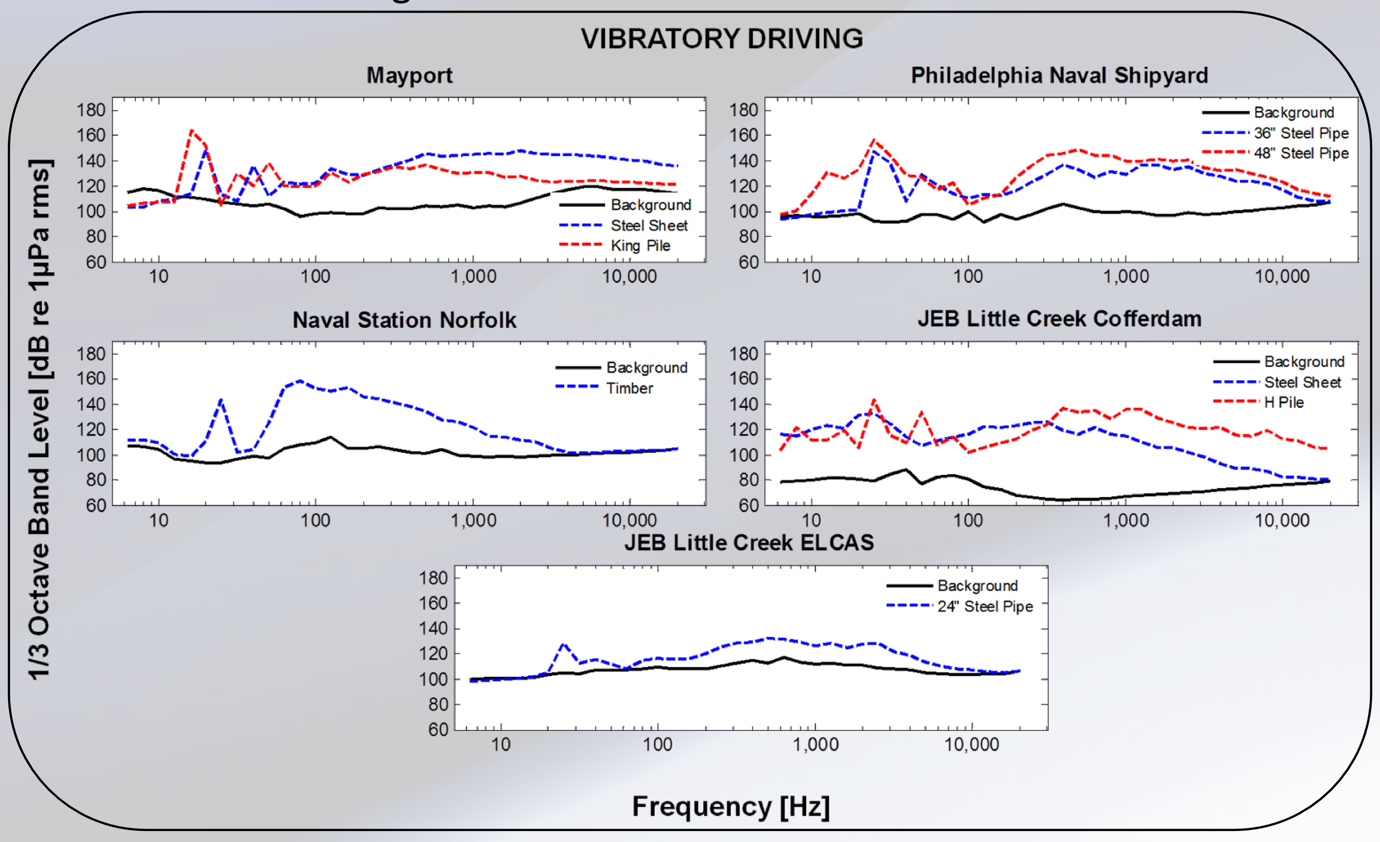

Fig. 4. 1/3 octave band levels of vibratory pile driving by location and pile type. The JEB Little Creek ELCAS project involved vibratory extraction of 24” pipe piles; all other projects involved vibratory pile installation. Background levels at the JEB Little Creek Cofferdam project were low because of the sheltered location of the basin (Fig. 1).

Conclusions

- Measured source levels from the US east coast are comparable to west coast measurements for impact driving and significantly quieter for vibratory driving.
- Source levels, spectral data, and measurements of time required to install and extract piles will be applied to US Navy compliance efforts to reduce the potential impacts from pile driving on marine species.
- Changes to regulatory criteria for addressing potential effects of underwater sound to marine mammals put forth by the US National Marine Fisheries Service require collection of spectral data from additional pile types and sizes.

Fig. 5. Marine mammals (*Tursiops truncatus*) sighted during vibratory extraction of 24” steel pipe piles at JEB Little Creek.

- Future work should include examination of responses of marine species to pile installation and extraction, with reference to hearing abilities and behavioral and social contexts.

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