Overview of Pile Driving Impacts on Fish, Current Interim Impact Criteria, and The Caltrans Guidance Manual

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Transportation Research Board Annual Meeting 2010

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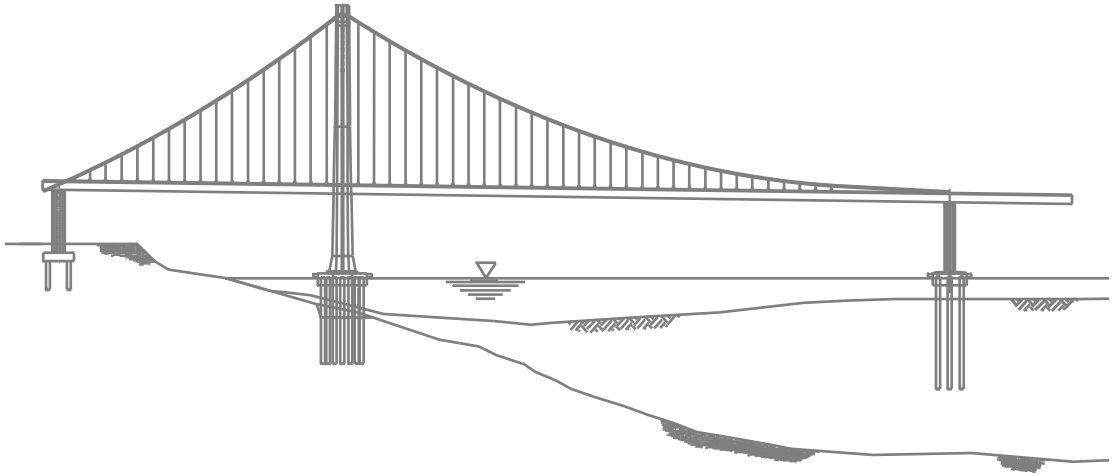


Overview on Pile Driving Noise Issue

In 2000, the California Department of Transportation (Caltrans) began preliminary work on the new San Francisco Bay Bridge.

Overview on Pile Driving Noise Issue

As part of preliminary work, 8-foot diameter steel test piles over 300 feet long were installed.

Overview on Pile Driving Noise Issue

In-water pile driving work on the test piles triggered interest by resource agencies (primarily NOAA Fisheries and USFWS) on the issue of pile driving noise impacts on fish protected by the Endangered Species Act.

Overview on Pile Driving Noise Issue

- Several on-going Caltrans bridge projects were delayed as a result of concerns about effects on protected fish.
- This led to substantial costs for Caltrans associated with project delays and created challenges in the permit approval process.
- Good information on the effects of pile driving on fish was lacking.
- There was substantial uncertainty as to what level of underwater sound causes injury to fish.

Overview on Pile Driving Noise Issue

- Caltrans led an effort understand the issue, to develop impact criteria, and to arrange agreements with the resource agencies.
- Caltrans retained Dr. Arthur Popper (University of Maryland) and Dr. Mardi Hastings (Georgia Tech) to review available information and to recommend further research for developing interim impact criteria.

Overview on Pile Driving Noise Issue

Caltrans published the report entitled “Effects of Sound on Fish” in January 2005.

[Popper and Hastings subsequently published “The Effects on Fish of Human-generated (Anthropogenic) Sound.” Integrative Zoology 2009.]

Overview on Pile Driving Noise Issue

- Caltrans formed the Fisheries Hydroacoustic Working Group (FHWG) to develop interim impact criteria and a multi-agency agreement.
- The FHWG included participants from:
  - Federal Highway Administration
  - NOAA Fisheries
  - U.S. Fish and Wildlife Service
  - Oregon Department of Transportation
  - Washington State Department of Transportation

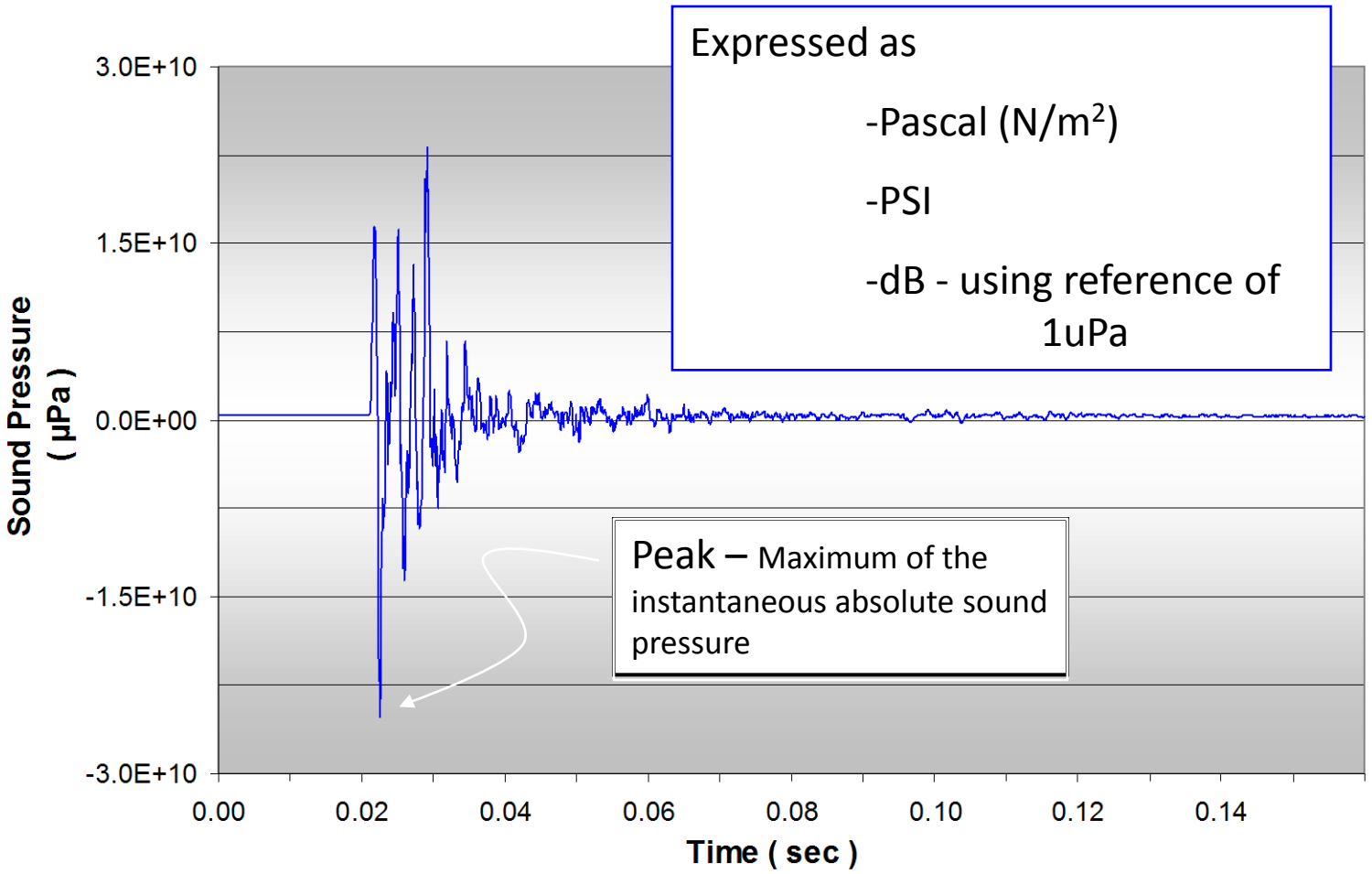
Overview on Pile Driving Noise Issue

- The FHWG met several times between 2004 and 2008.
- Additional analyses were conducted by Drs. Popper and Hastings and Dr. Tom Carlson (Pacific Northwest National Laboratory) during this time.

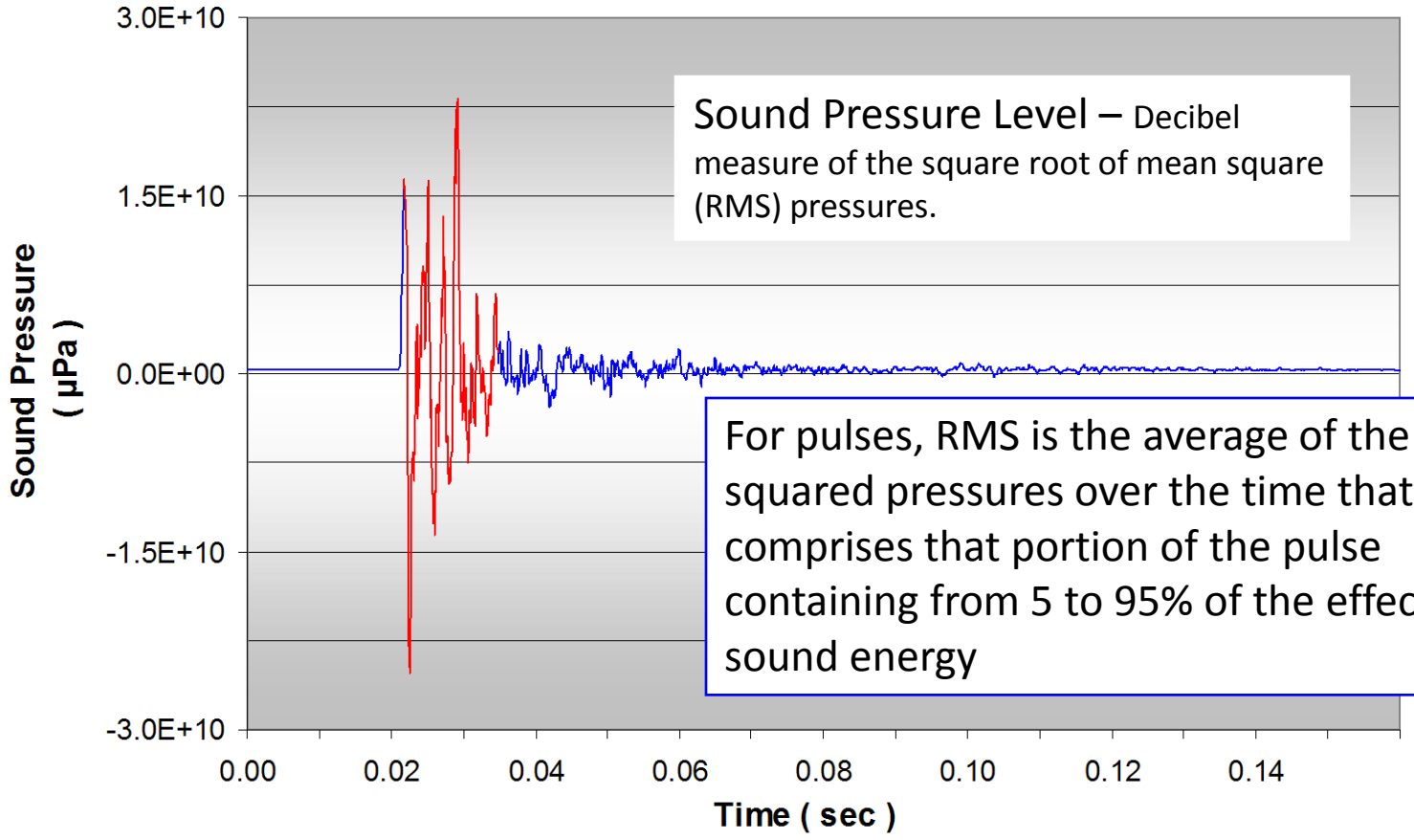
Agreement in Principal

In June 2008, the “Agreement in Principal for Interim Criteria for Injury to Fish from Pile Driving Activities” was signed by all of the participating agencies in the FHWG.

Pile Driving Sound Pressure



RMS Sound Pressure



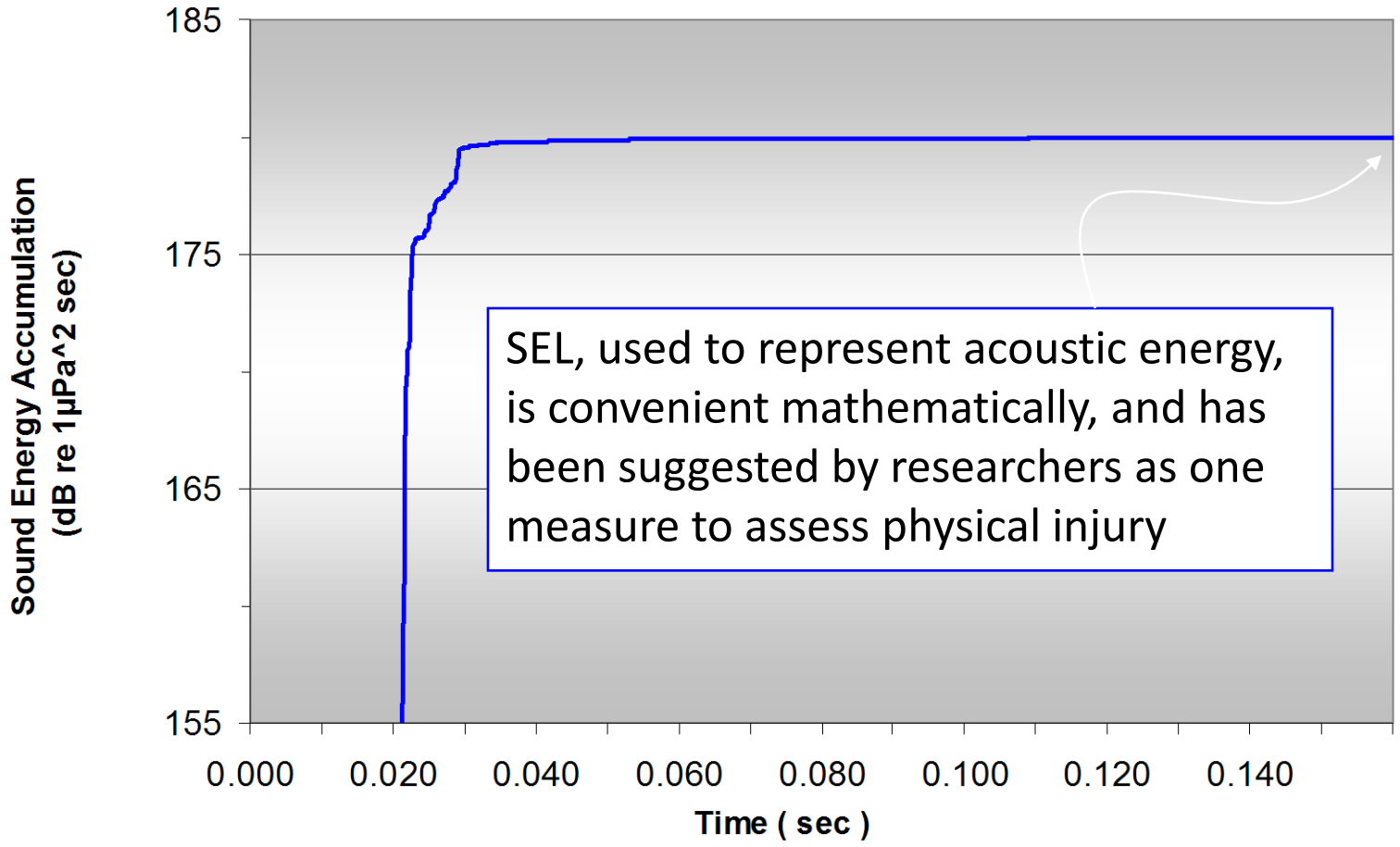
Sound Pressure Level – Decibel measure of the square root of mean square (RMS) pressures.

For pulses, RMS is the average of the squared pressures over the time that comprises that portion of the pulse containing from 5 to 95% of the effective sound energy

Typical Underwater Sound Levels

Sound Source	Sound Pressure Level	
	dB	Pascals
High explosive at 100m	220	100,000
Airgun array at 100m Unattenuated Pile Strike at 100m (SFOBB, Benicia)	200	10,000
	180	1,000
Large ship at 100m	160	100
Fish Trawler passby (low speed) at 20m	140	10
	120	1
Background with boat traffic	100	0.1
	80	0.01
	60	0.001

Sound Exposure Level (SEL)



$SEL_{cumulative}$

$$SEL_{cumulative} = 10 \log (\text{no. of strikes}) + SEL_{single\ strike}$$

Example:

$$SEL_{single\ strike} = 165\ dB$$

1,000 strikes

$$SEL_{cumulative} = 165\ dB + 30\ dB = 195\ dB$$

Interim Criteria

- Interim impact criteria for fish
  - 208 dB-peak
  - 187 dB-$SEL_{cumulative}$
  - 183 dB-$SEL_{cumulative}$ for fish less than 2 g
- These interim criteria are currently being used on projects on the West Coast.

Guidance Manual

- Caltrans retained ICF Jones & Stokes and Illingworth & Rodkin to develop a technical guidance manual
- The purpose is to provide Caltrans engineers, biologists, planners, and consultants with guidance related to the environmental permitting of in-water pile driving projects.

Guidance Manual

- Fundamentals of hydroacoustics.
- Fish hearing and hydroacoustic impacts on fish.
- Environmental documentation and permit applications required for pile driving projects.
- Assessment of potential impacts on fish and their habitat from sound generated from pile driving.
- Measures to avoid or minimize pile driving impacts.
- Methods to assess impacts, mitigation, and compensation for pile driving impacts on fish.

Appendix I. Compendium of Pile Driving Sound Data

- A large collection of measured underwater sound level data in a variety of construction configurations.
- Potential impacts from proposed projects are evaluated using data from similar situations.

Appendix II. Procedures for Measuring Pile Driving Sound

Detailed guidance on how to measure underwater pile driving sound.

Guidance Manual

- The guidance manual was posted on the Caltrans website on March 5, 2009.
- http://www.dot.ca.gov/hq/env/bio/fisheries_bioacoustics.htm

Current Research

- Development of alternative criterion for vibratory pile driving Dr. Mardi Hastings.
- Laboratory research being conducted at the University of Maryland by Dr. Popper using pile driving signals in a controlled tank environment (funding through Minerals Management Service, Caltrans, and NCHRP).
- Detailed evaluation of measured data from projects under construction.

Questions?

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