2017 AEP State Conference

Hydroacoustics 101:

How It Works, Why It Matters, and What To Do With It In CEQA

WRA ENVIRONMENTAL CONSULTANTS

ILLINGWORTH & RODKIN, INC. Acoustics • Air Quality

Panelists

Keith Pommerenck, *Acoustical and Air Quality Scientist with Illingworth & Rodkin, Inc.*

Daniel Chase, *Fisheries Biologist with WRA, Inc.*

Justin Semion, *Aquatic Ecologist with WRA, Inc.*

Panelist Change - Keith Pommerenck

Mr. Pommerenck provides consulting services in the area environmental noise and air quality issues with over 33 years of professional experience (21 years with Caltrans and 12 years with Illingworth and Rodkin) in preparing technical air, noise, and vibration reports for inclusion in CEQA and NEPA environmental documents for transportation projects. Mr. Pommerenck led numerous hydroacoustic field investigations for bridge construction projects. He was the field leader for the Ten Mile River Bridge project that included several months of acoustic measurements and compliance reporting. Mr. Pommerenck's expertise was routinely relied upon for solutions to reduce underwater sound when construction activities were in jeopardy of exceeding permit underwater noise conditions. Mr. Pommerenck also led Illingworth & Rodkin's hydroacoustic monitoring efforts on other notable projects that included the Humboldt Bay Bridges Seismic Retrofit, Mad River Bridge replacement, the Klamath River Bridge emergency repair (during salmon migration), Test Pile portion and the construction portion of the Explosive Handling Wharf 2 project for the navy and several other smaller projects in California, Oregon, and Washington. Mr. Pommerenck has also assisted transportation agencies in assessing sound impacts to wildlife in marine environments (both airborne and underwater).

Panel Overview

History of Hydroacoustic Analysis

Technical Specification of Underwater Sound

Biological Effects of Underwater Sound

Regulatory Application of Hydroacoustic Impacts

CEQA Application of Hydroacoustic Impact Evaluation

Questions

Hydroacoustics – Anthropogenic Sounds

Keith Pommerenck

and James Reyff

Illingworth & Rodkin, Inc.

Petaluma * Marysville * Denver

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Acoustics • Air Quality

Hydroacoustic Impacts - History

- Pile Driving
- Explosives
- Other construction sounds

SFOBB Pile Installation Demonstration Project - conducted in 2000

- Driving 8ft diameter steel piles
- Over 300 feet long
- Tested two sound attenuation systems
- Fish harmed

Test Piles

New Benicia-Martinez Bridge

- Driving 8ft diameter steel piles
- Some hard substrates
- Fish harmed
- Construction stopped

- Successfully attenuated sound to resume

Fisheries Hydroacoustic Working Group

- Developed to improve and coordinate information on fishery impacts due to underwater sound pressure caused by in-water pile driving
- Developed known information on sound effects on fish
- Identified interim sound thresholds
- Developed guidance

Technical Specification of Underwater Sound

- Fundamentals of hydroacoustics
- Anthropogenic sounds
- Underwater sound control
- Underwater sound measurement systems
- Technical guidance

Fundamentals -
Basic Sound Descriptors

- Peak Pressure (**Peak**)
  - Over/under pressure
- Root Mean Square (**RMS**)
  - Pulse
  - Continuous time averaged
- Sound Exposure Level (**SEL**)
  - Pulse, pile driving event, workday

Decibel to Describe Sound

“A logarithmic measure of the sound strength”

Or in mathematical terms:

The base 10 Logarithmic function of the ratio of the pressure fluctuation to a reference pressure

Calculation of Sound Pressure Level

$$SPL = 10 \log (p/p_{ref})^2, dB$$

or

$$SPL = 20 \log (p/p_{ref}), \text{dB}$$

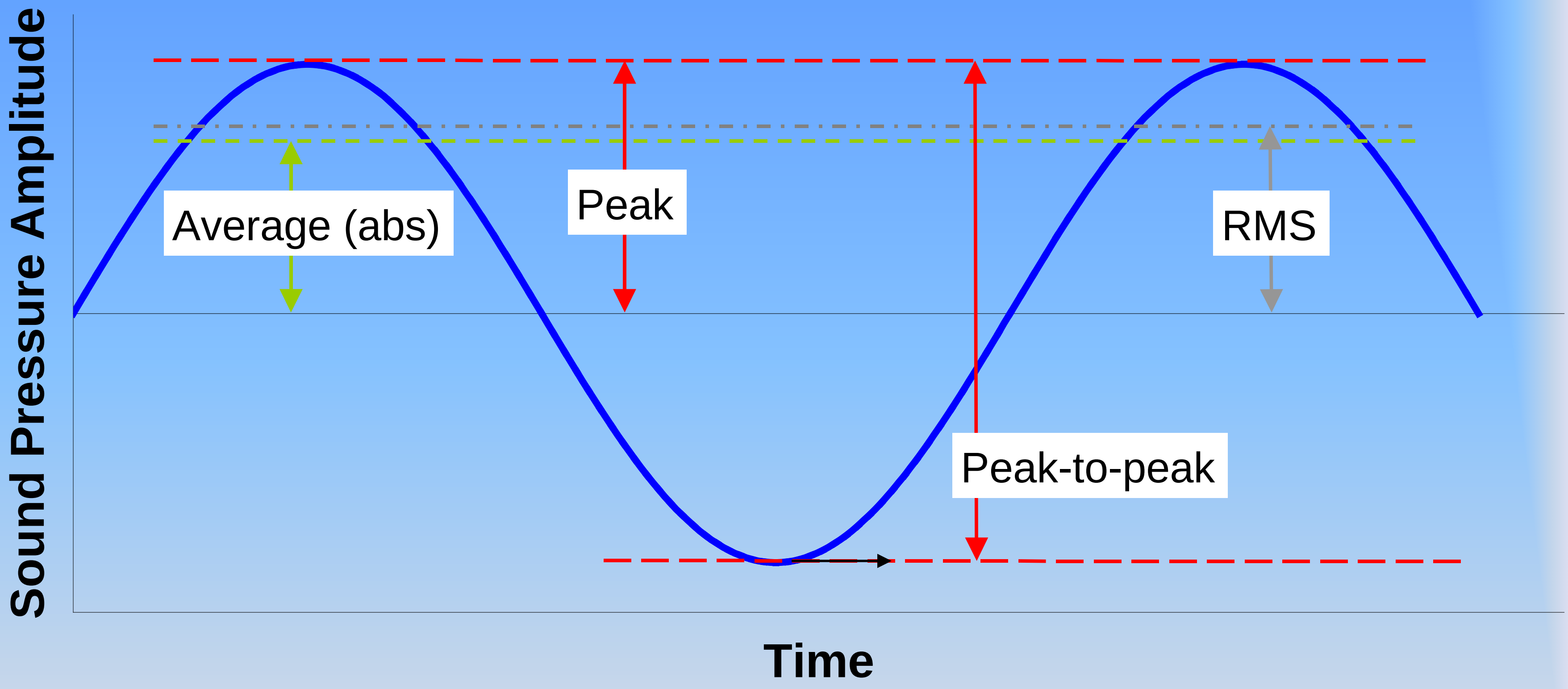
where p_{ref} is the reference pressure:

- For air, $p_{ref} = 20\ \mu$ Pa
- For water, $p_{ref} = 1\ \mu$ Pa
- As a result:

  $SPL_{water} = SPL_{air} + 26\ dB$

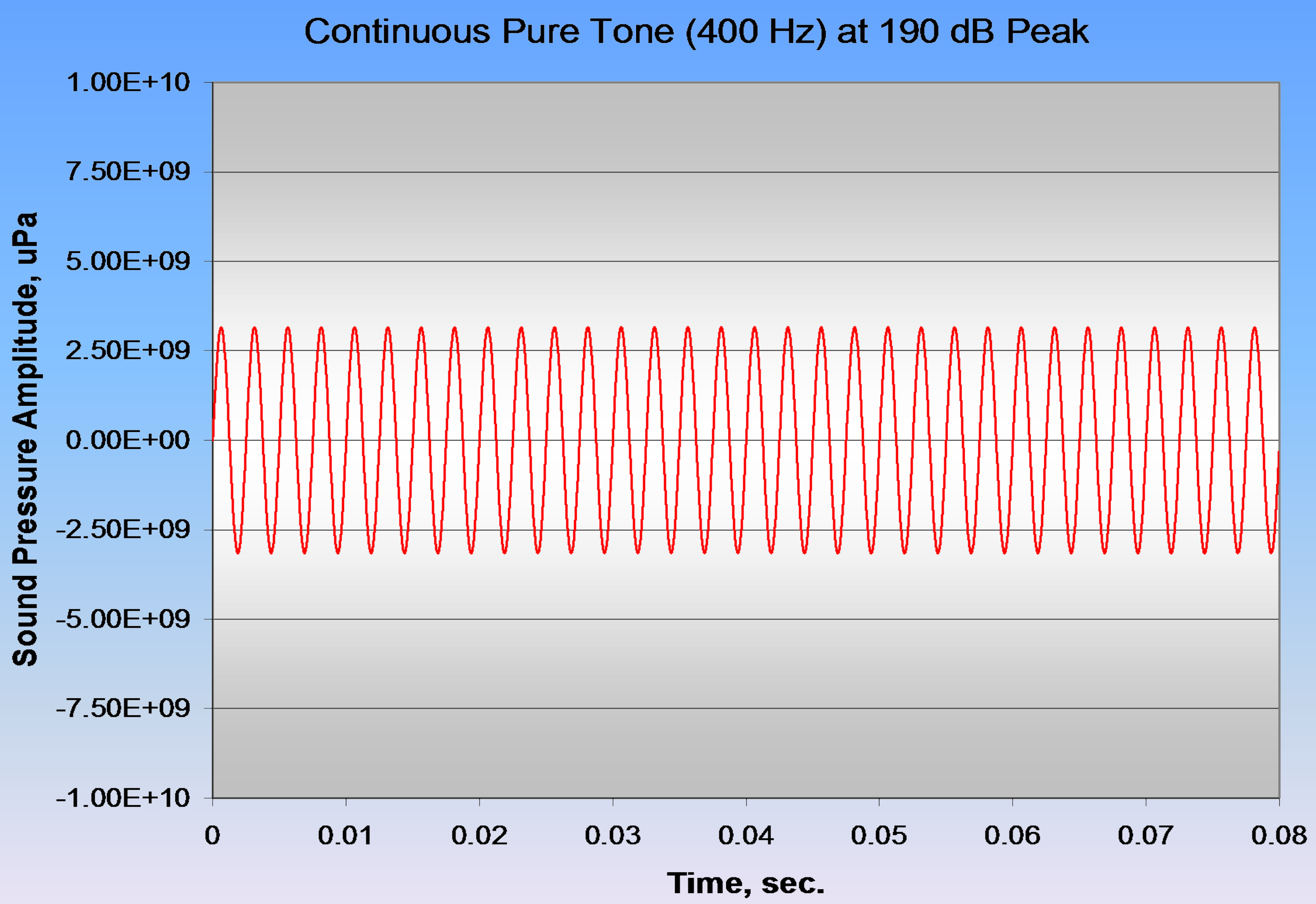
1 *PSI* = 6,895 *Pascals* = 197 *dB re 1μPa*

Sound Level Metrics

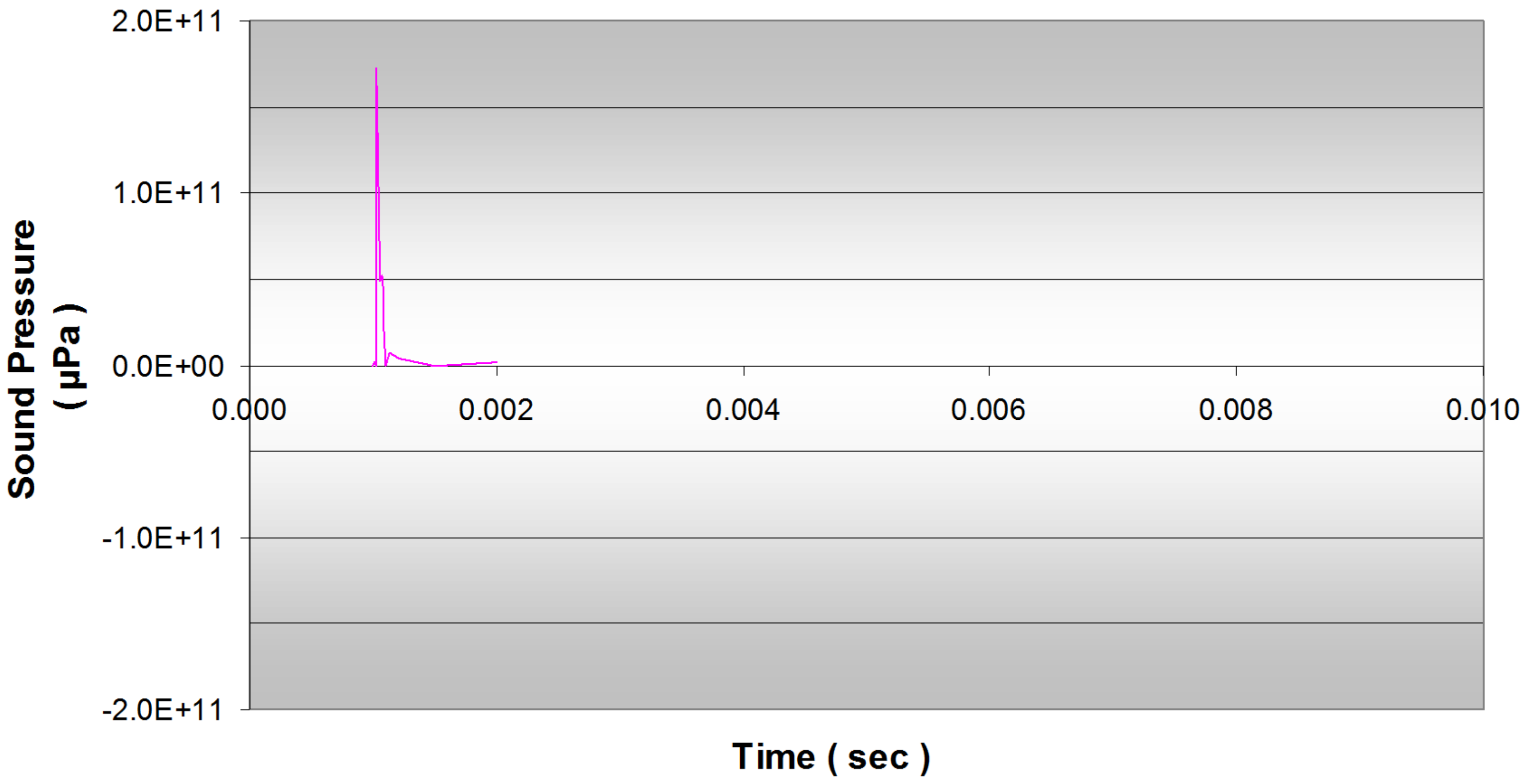


Typical Sound Levels

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

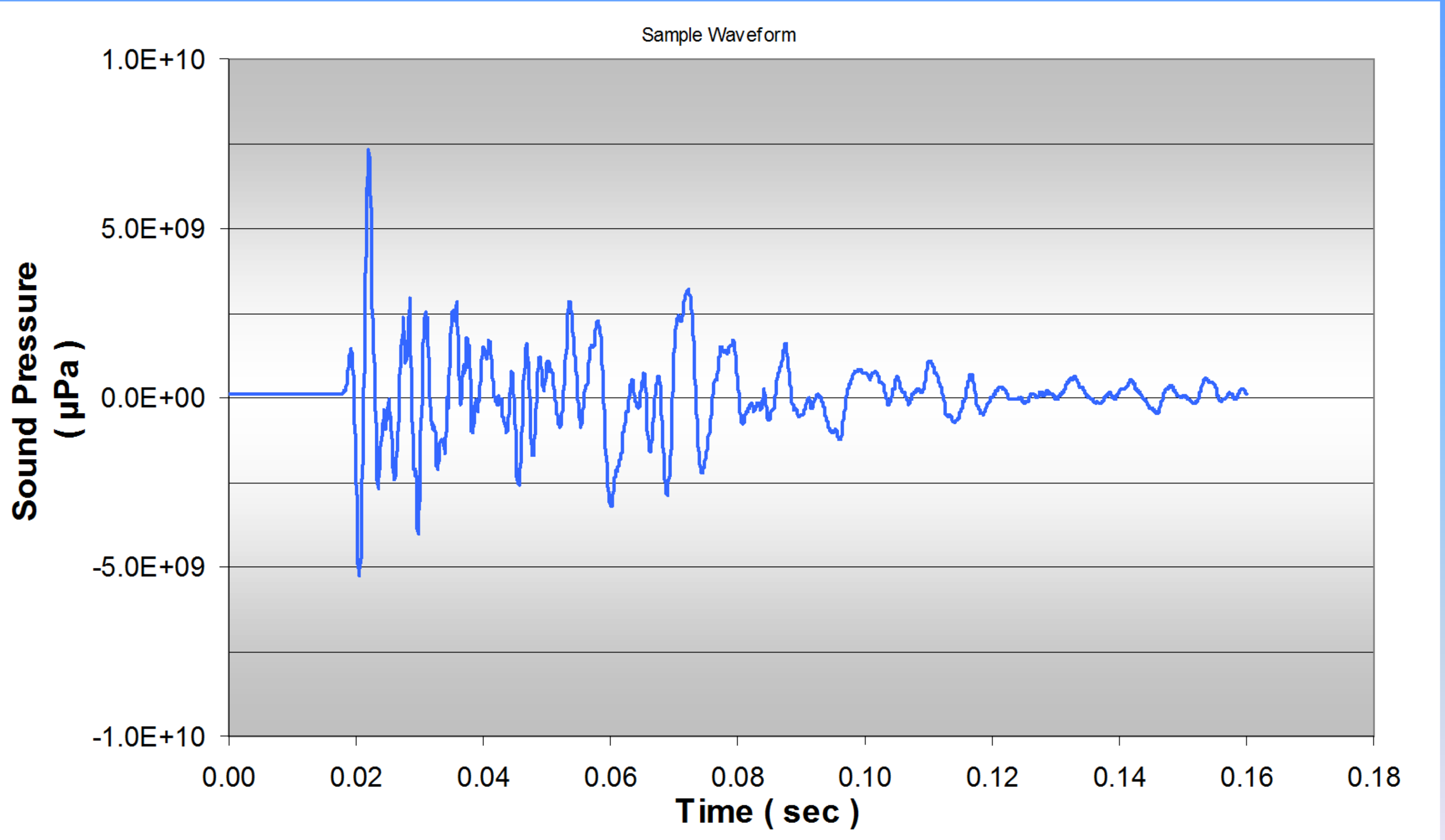

Continuous Pure Tone (400 Hz) at 190 dB Peak
Sound Pressure Amplitude, uPa
1.00E+10
7.50E+09
5.00E+09
2.50E+09
0.00E+00
-2.50E+09
-5.00E+09
-7.50E+09
-1.00E+10
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
Time, sec.

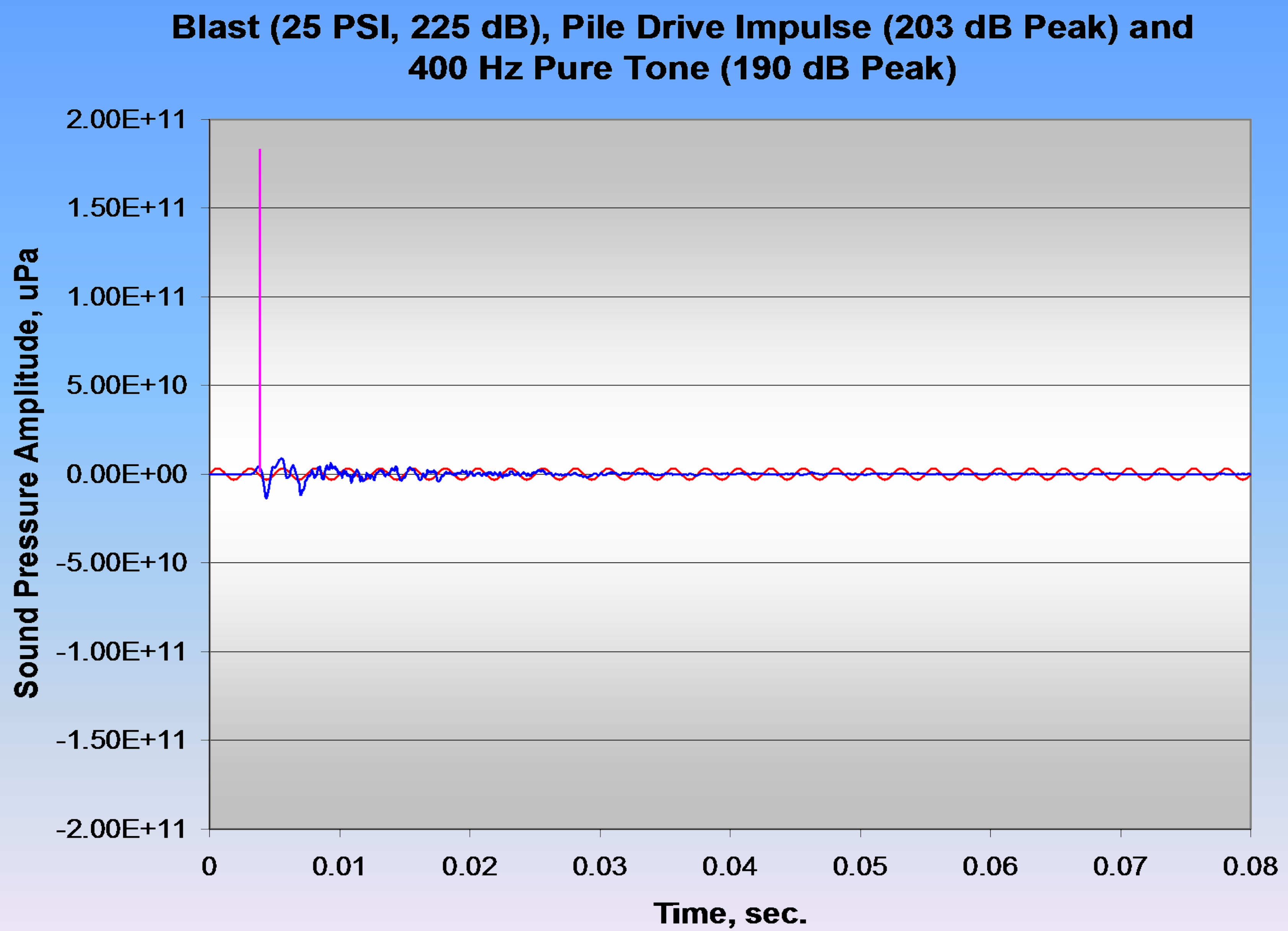
Explosive – Underwater Blast



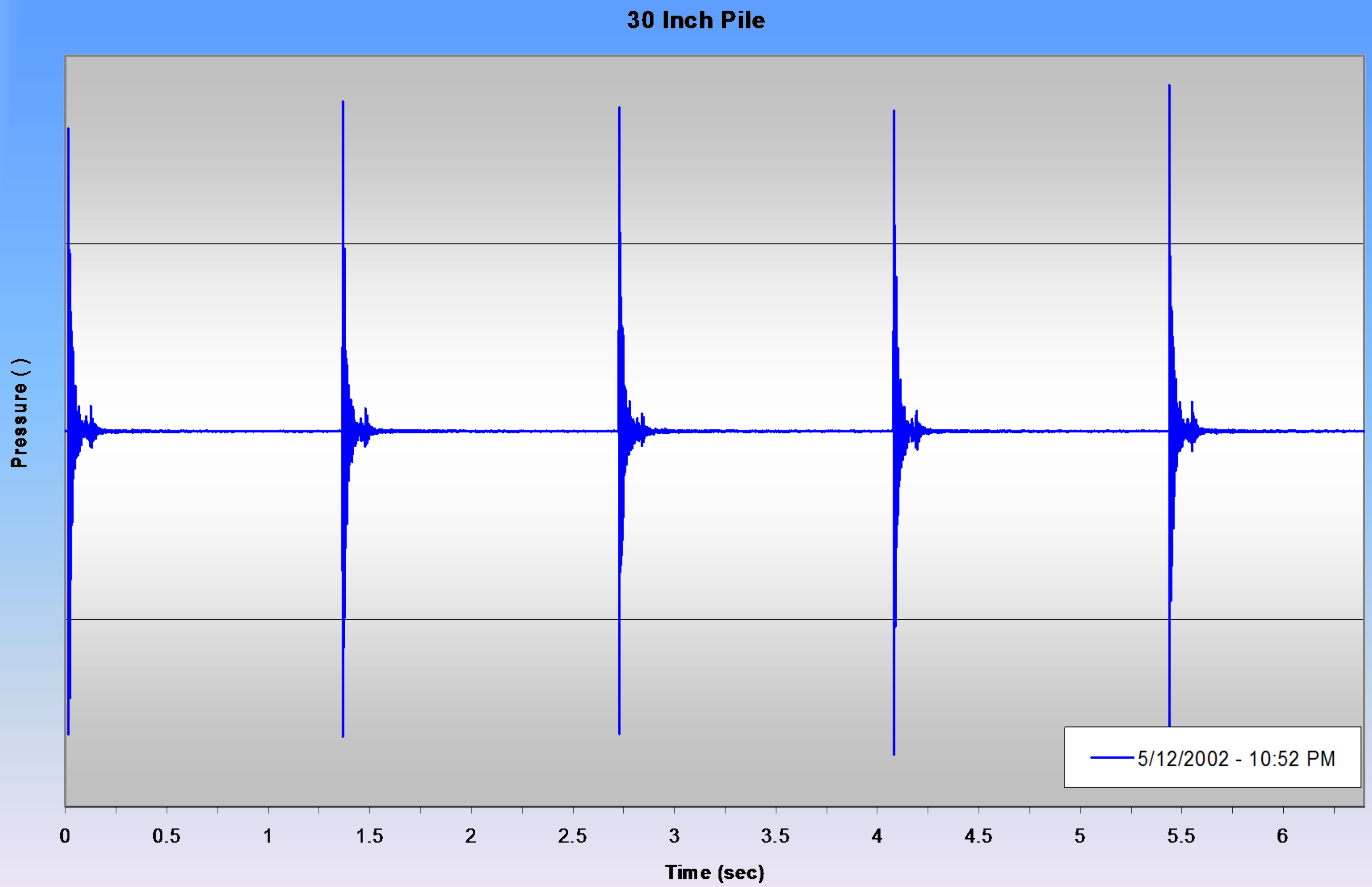
Single Pile Driving Impulse

From SFOBB

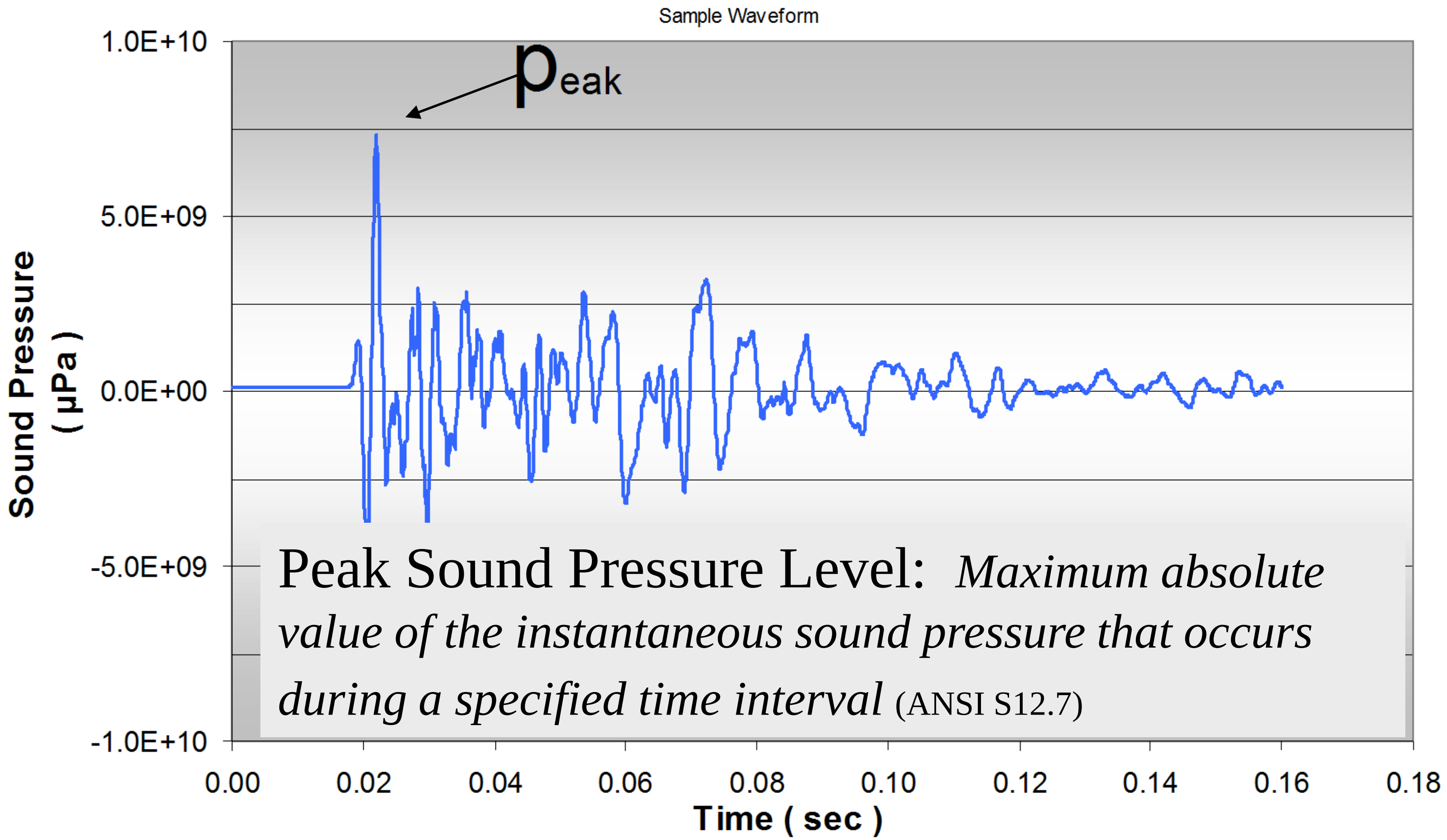



Blast (25 PSI, 225 dB), Pile Drive Impulse (203 dB Peak) and
400 Hz Pure Tone (190 dB Peak)
Sound Pressure Amplitude, uPa
2.00E+11
1.50E+11
1.00E+11
5.00E+10
0.00E+00
-5.00E+10
-1.00E+11
-1.50E+11
-2.00E+11
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
Time, sec.

Impact Pile Driving Sounds

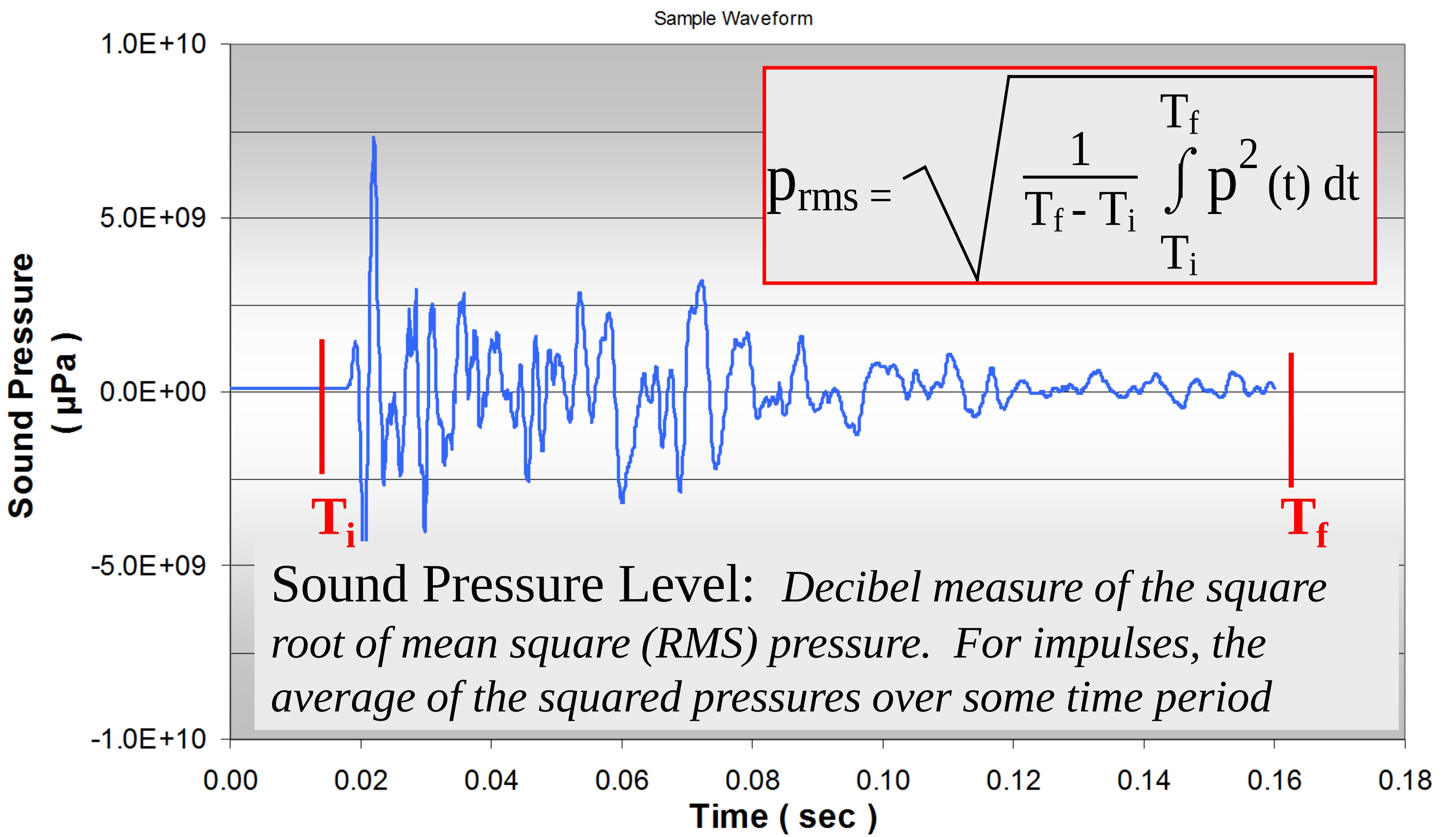


Single Pile Driving Pulse



Peak Sound Pressure Level: *Maximum absolute value of the instantaneous sound pressure that occurs during a specified time interval* (ANSI S12.7)

RMS Sound Pressure Level



$$p_{rms} = \sqrt{\frac{1}{T_f - T_i} \int_{T_i}^{T_f} p^2(t)\, dt}$$

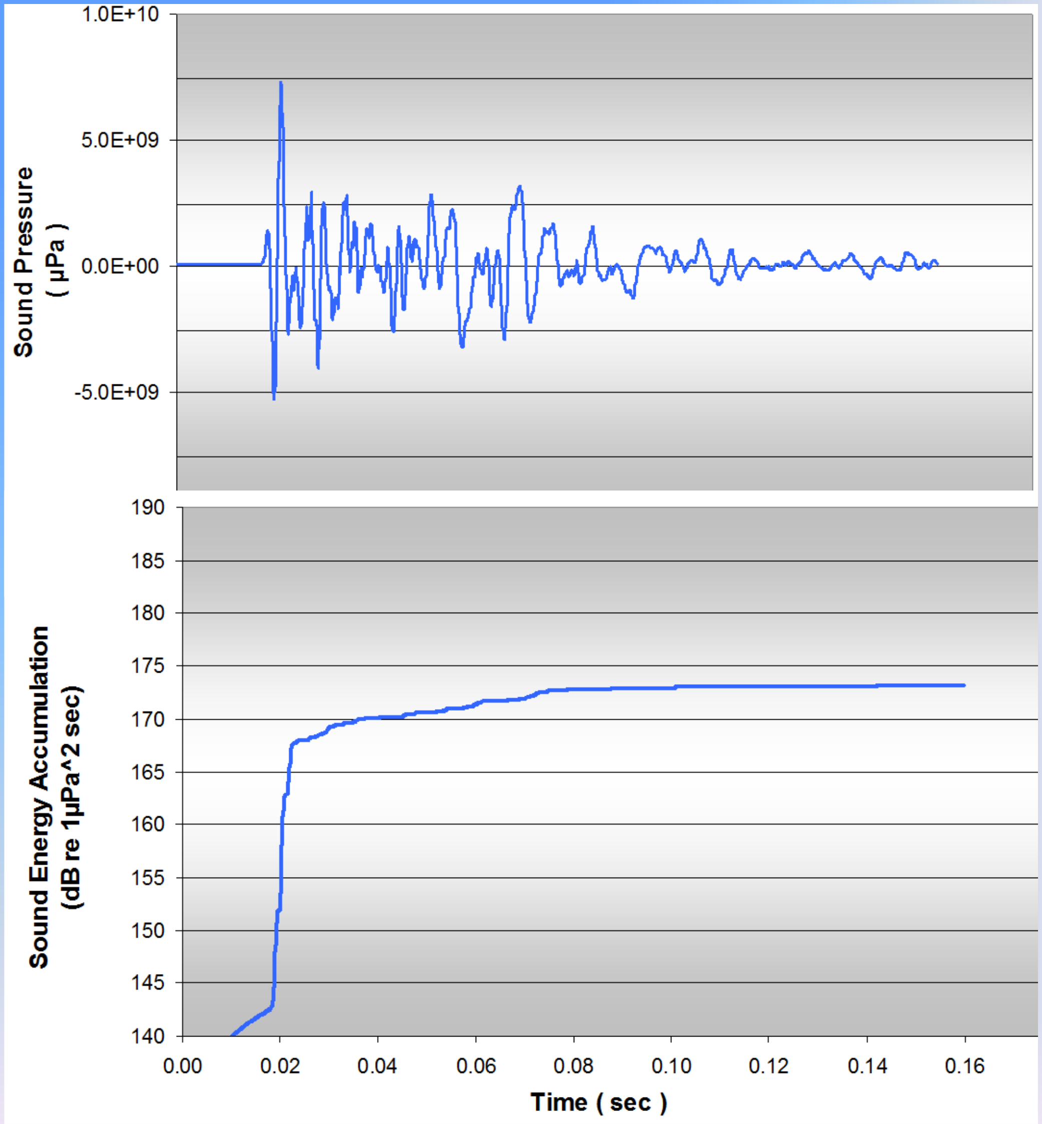
Sound Pressure Level: *Decibel measure of the square root of mean square (RMS) pressure. For impulses, the average of the squared pressures over some time period*

Sound Exposure Level
SEL

Sound Exposure: *time integral of frequency weighted squared instantaneous sound pressure* (ANSI S12.7).

Proportional to Acoustic Energy

(Richardson, et al. 1995).



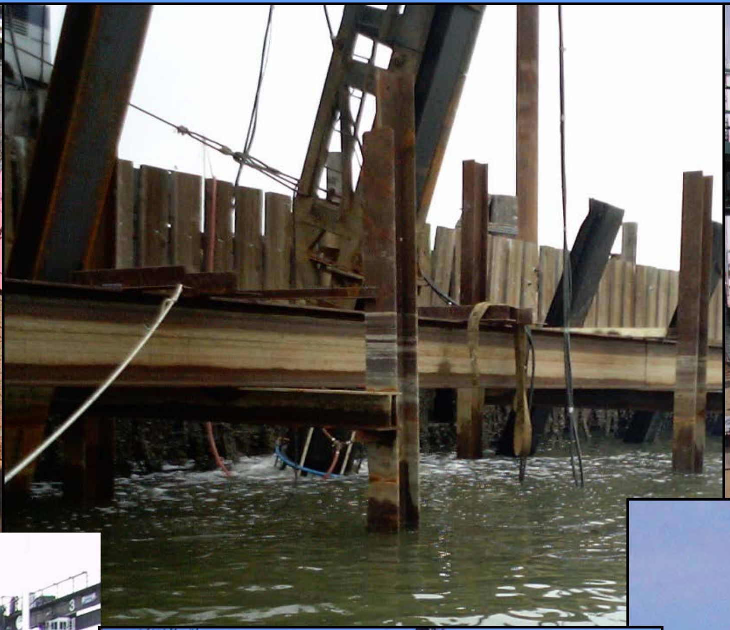
Sound Propagation

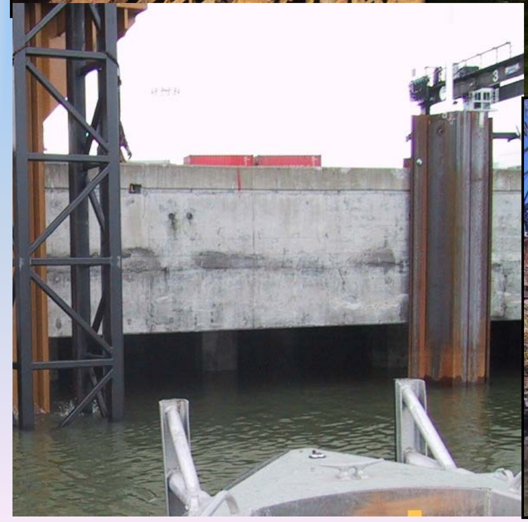
- Complicated problem
  - Well bounded environment
  - Extended source
  - Ground borne sound
  - Sound propagating through saturated soils
- Use of 15 Log drop off (4.5 dB/dd)
- Measured drop off rates
  - 10 Log to 30 Log – considerable range

Anthropogenic Sound Sources

- Pile driving
  - Impact driving (loudest)
  - Vibratory driving
  - Impact near water
- Demolition/explosives
- Continuous sources

Impact Pile Driving





Different Types of Conditions

On Land Near Water

Vibratory Pile Driving

- Much lower amplitude sounds than impact pile driving (20 to 30 dB lower)
- Sounds tend to be more continuous
- Higher Frequency sounds

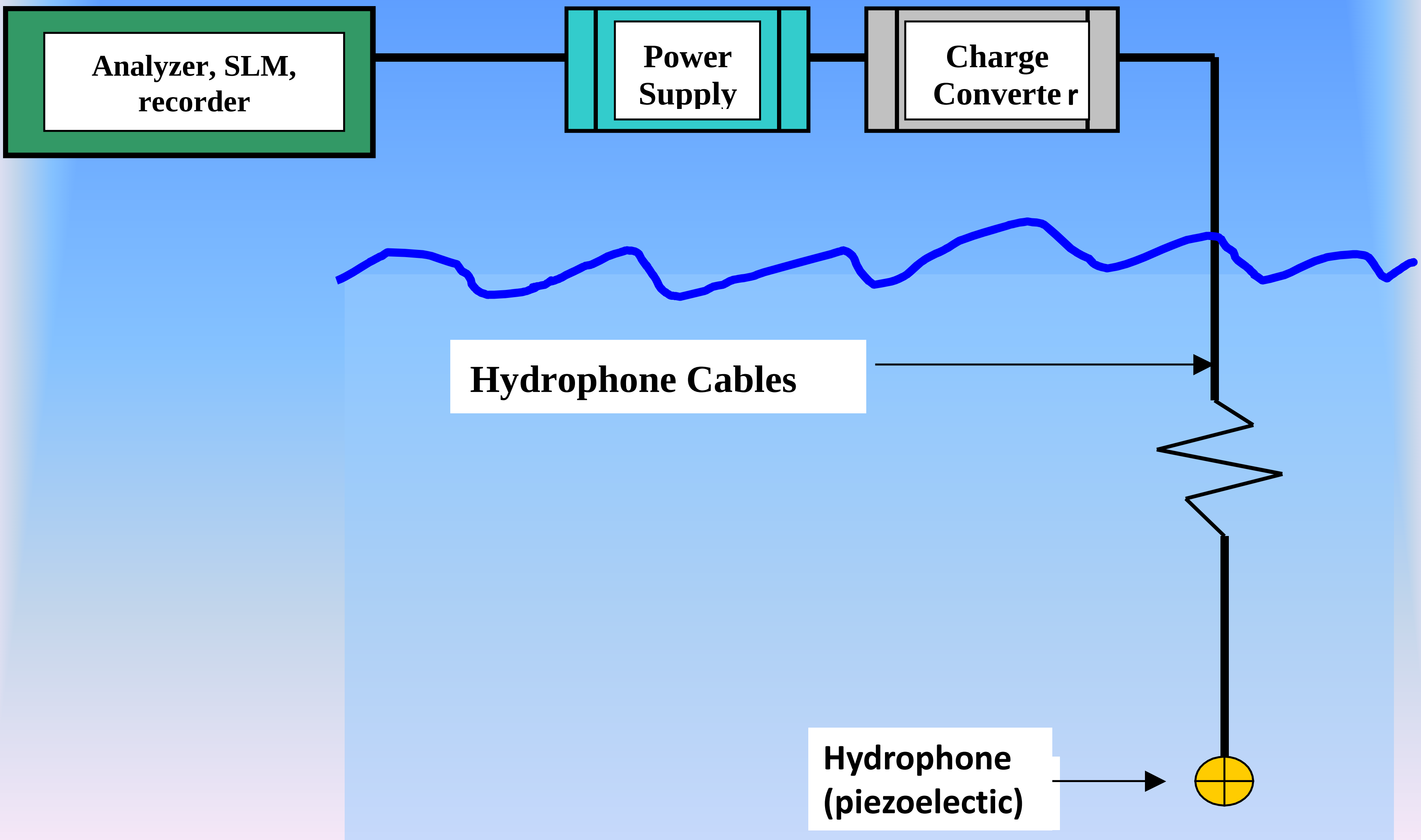
Minimization Measures

- Air bubble curtains
  - Confined / unconfined
- Dewatered cofferdams
- Avoid in water driving
  - Move footings out of water
- Construction windows
  - Avoid times when species are preser

Measurement Systems

- Hydrophones
- Signal conditioning
- Signal processing
- Recording
- Descriptors

Basic Hydrophone System



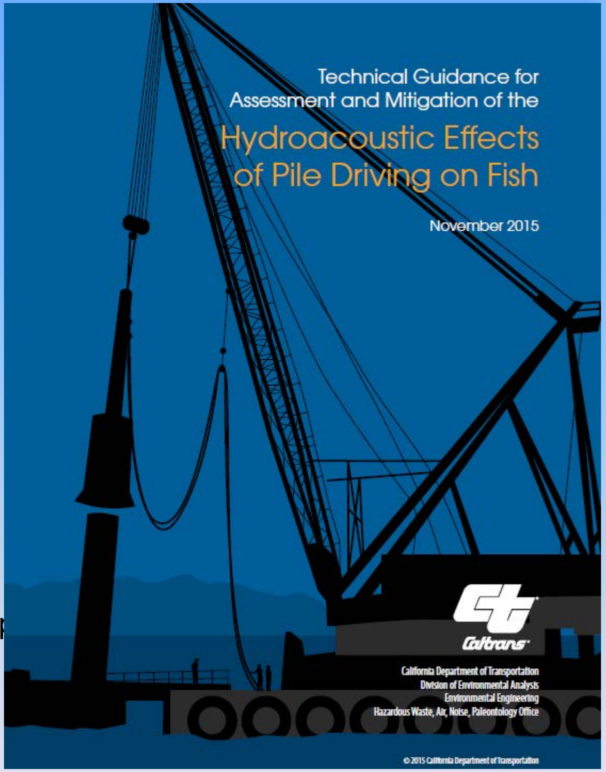
Pressure Sensors

Caltrans Guidance Manual

Provides biologists, engineers and consultants guidance related to environmental permitting of pile driving projects in or near water

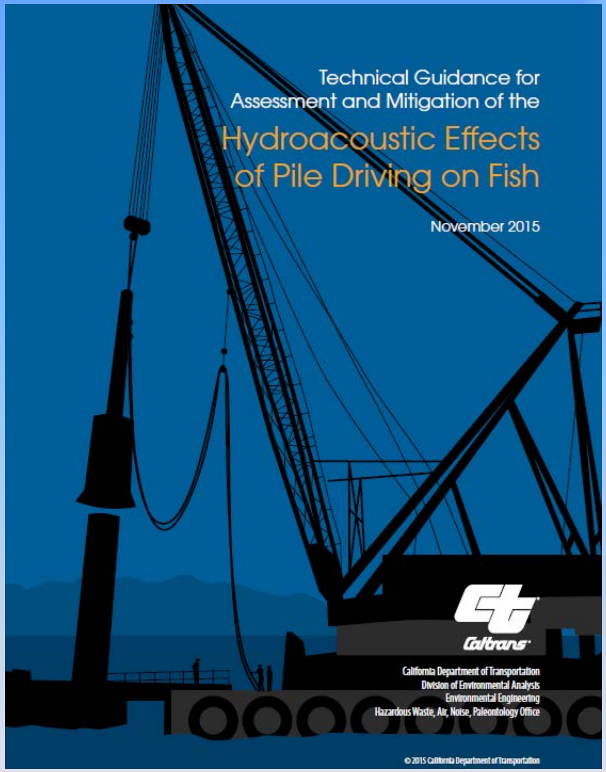
- Fundamentals of hydroacoustics
- Fundamentals of noise effects to fish
- Guidance to assess pile driving impacts to fish (hydroacoustic)
- Appendices

http://www.dot.ca.gov/hq/env/bio/files/bio_tech_guidance_hydroacoustic_effects_110215.p



Caltrans Guidance Manual appendices

- Compendium of Pile Driving Sound Data
- Procedures for Measuring Pile Driving Sound
  - Hydrophone and equipment selection
  - Data analysis/Quality control
  - Reporting



http://www.dot.ca.gov/hq/env/bio/files/bio_tech_guidance_hydroacoustic_effects_110215.pdf

2017 AEP State Conference

Biological Effects of Underwater Sound:

Overview for Fish and Marine Mammals

Presented By:
Daniel Chase, MS
Fisheries Biologist
WRA, Inc.

Talk Outline

Fish

- What and how sound is perceived
- Two Hearing Groups
- Hydroacoustic Effects

Marine Mammals

- What sound is used for
- Five Hearing Groups
- Hydroacoustic Effects

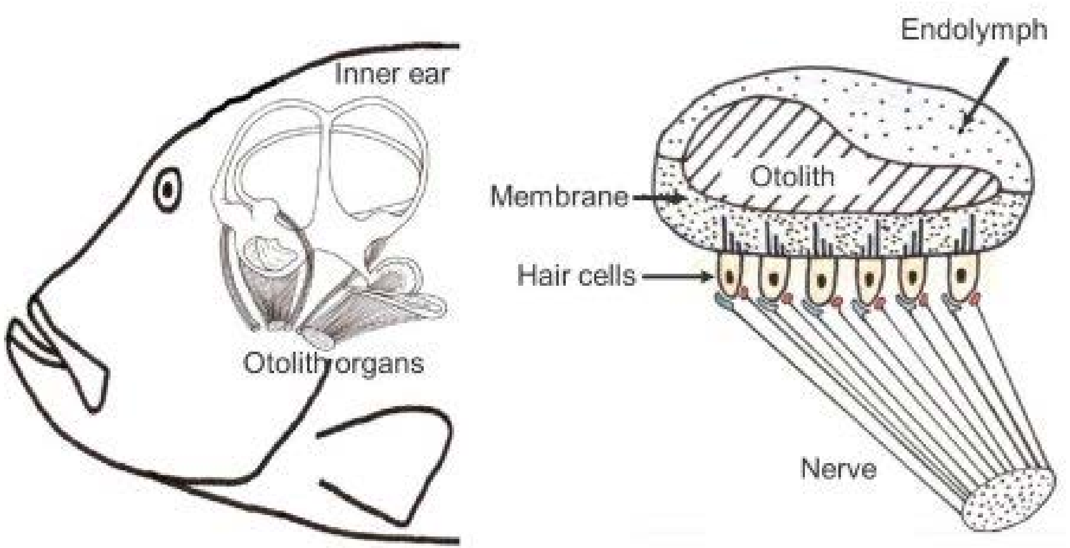
What do fish use sound for?

Determine the direction of a sound source

- Communicate
- Locate prey
- Avoid predators
- Perceive their environment

Monterey Bay Aquarium; James Perdue

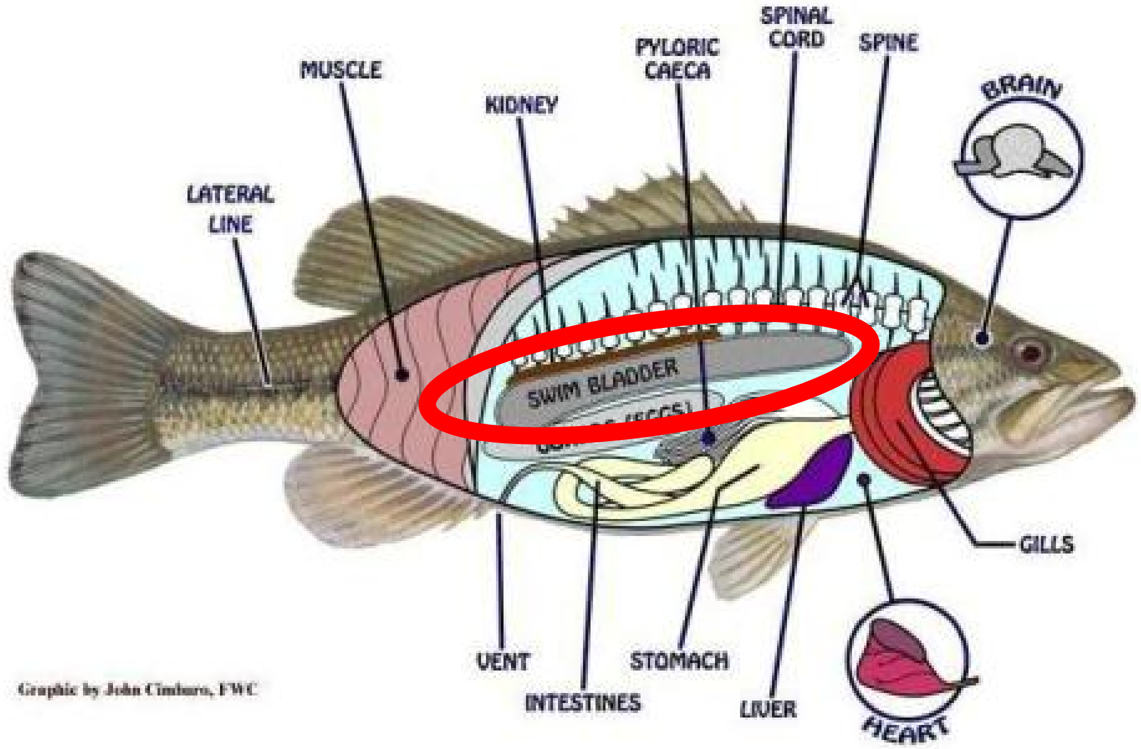
Fish Anatomy– How Fish Perceive Sound



Source: thefisheriesblog.com

1. Otoliths - inner ear structure

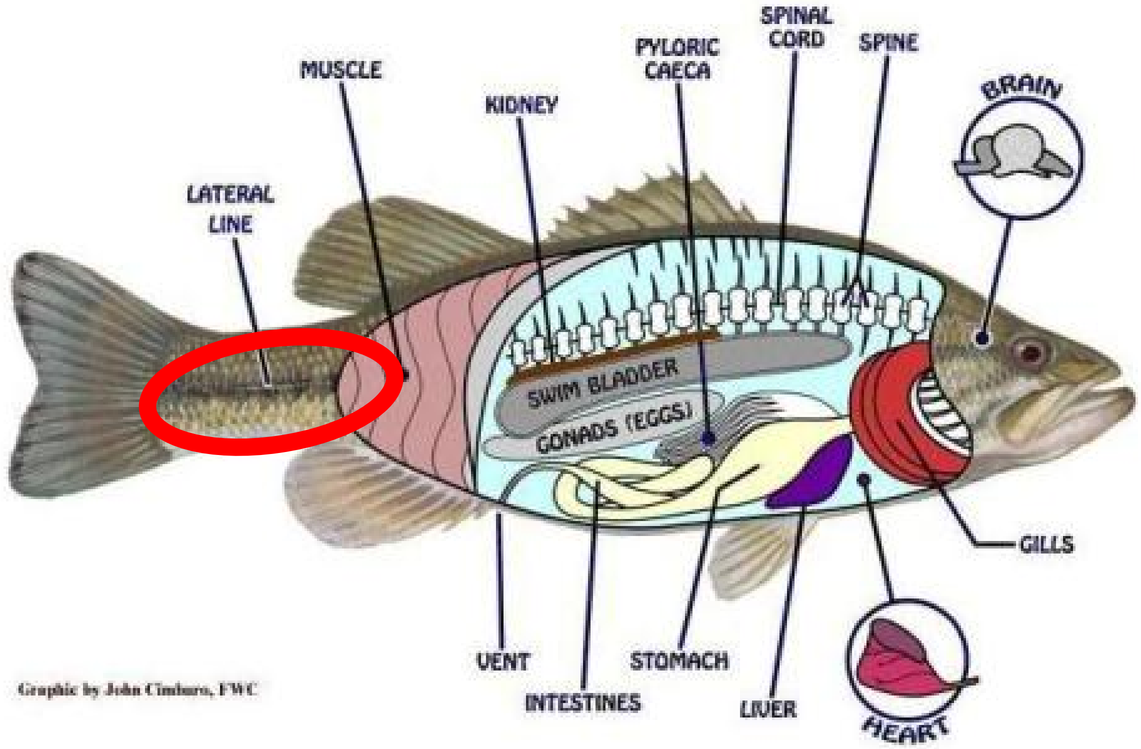
Fish Anatomy– How Fish Perceive Sound



1. Otoliths - inner ear structure

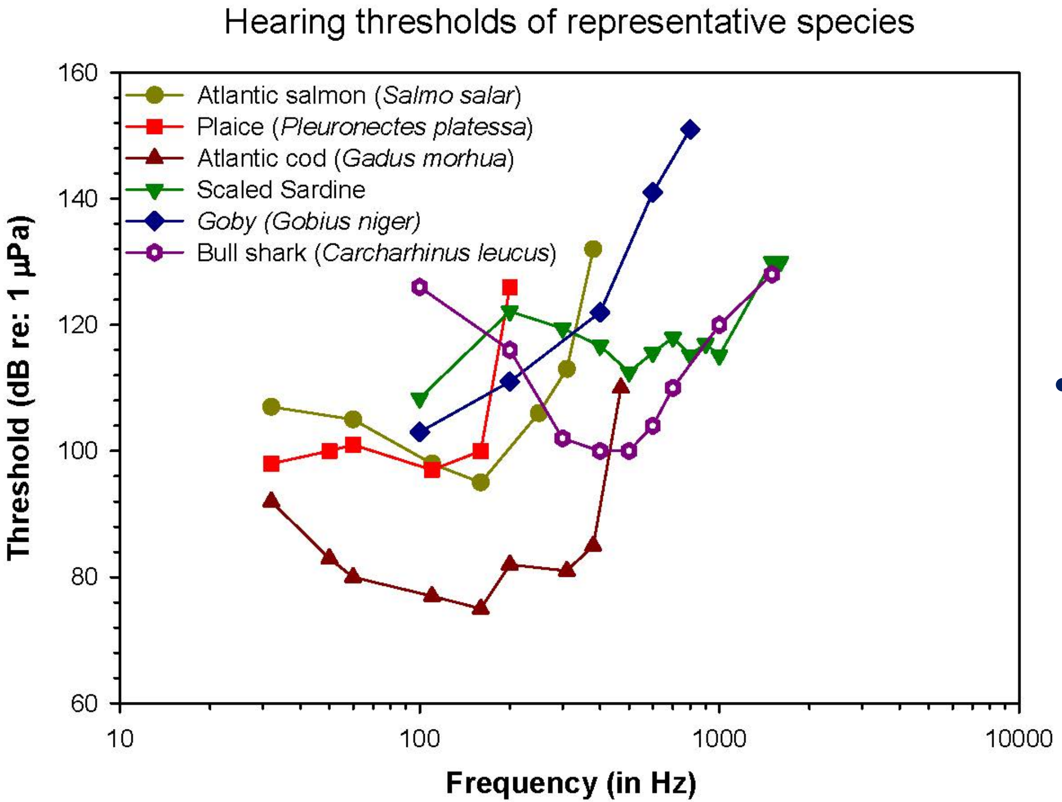
2. Swim bladder

Fish Anatomy– How Fish Perceive Sound



1. Otoliths - inner ear structure
2. Swim bladder
3. Lateral Line

Fish Hearing Groups



Fish species have different hearing thresholds

Source: Hastings & Popper 2005 *Effects of Sound on Fish*

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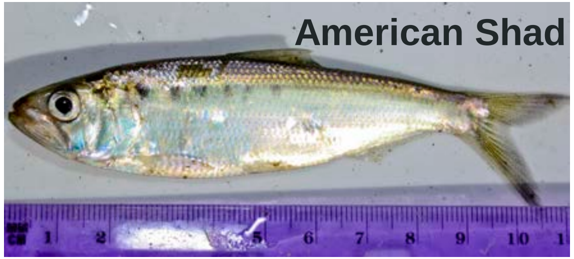
Fish Hearing Groups

Hearing Specialists

Connection between ear and swim bladder
Capable of hearing over a wide range of frequencies

Example Species



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Fish Hearing Groups

Hearing Generalists

No connection between ear and swim bladder
Narrower range of frequencies

Example Species

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How Hydroacoustics Can Effect Fish

Behavioral Effects

Examples:

- Causing fish to vacate or leave an area,
- Move or leave cover or territories,
- Exposure to predators,
- Interfere with foraging and prey capture,
- Elevated stress response

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How Hydroacoustics Can Effect Fish

Behavioral Effects

Injury

Examples:

- Temporary threshold shifts (TTS)
- Permanent threshold shifts (PTS)
- Auditory tissue damage
- Capillary ruptures
- Reduces individuals fitness

How Hydroacoustics Can Effect Fish

Behavioral Effects

Injury

Mortality

Examples:

- Barotrauma
  - Swim bladder and tissue rupture
  - Traumatic brain injury
  - Neurotrauma

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Marine Mammals use sound for:

- Communication
- Perceive their environment
- Locate prey
- Avoid predators/protection

Marine Mammal Hearing Groups

Because not all marine mammals use sound or hear the same…

Five basic **hearing groups** have been established

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Marine Mammal Hearing Groups

3 Cetacean Groups

Low-Frequency 

[humpback whale, blue whale]

Marine Mammal Hearing Groups

3 Cetacean Groups

Low-Frequency

[humpback whale, blue whale]

Mid-Frequency

[killer whale, bottlenose dolphin]

Marine Mammal Hearing Groups

3 Cetacean Groups

Low-Frequency

[humpback whale, blue whale]

Mid-Frequency

[killer whale, bottlenose dolphin]

High-Frequency

[harbor porpoise]

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Marine Mammal Hearing Groups

3 Cetacean Groups: Low-Frequency; Mid-Frequency; High-Frequency

2 Pinniped Groups:

Phocids 

[elephant seal, harbor seal]

Marine Mammal Hearing Groups

3 Cetacean Groups: Low-Frequency; Mid-Frequency; High-Frequency

2 Pinniped Groups:

Phocids 

[elephant seal, harbor seal]

Otariids 

[sea lions, sea otters]

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How Hydroacoustics Can Effect Marine Mammals

Behavioral Effects

Examples:

- Vacate or leave an area – haul out locations
- Auditory masking,
- Interfere with communication,
- Distress and elevated stress response,
- Interfere with foraging and prey capture

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How Hydroacoustics Can Effect Marine Mammals

Behavioral Effects

Injury

Examples:

- Temporary threshold shifts (TTS)
- Permanent threshold shifts (PTS)
- Auditory tissue damage
- Lung or gastrointestinal tract injury
- Reduces individuals fitness

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How Hydroacoustics Can Effect Marine Mammals

Behavioral Effects

Injury

Mortality

Examples:

- Stranding
- Barotrauma
  - Traumatic brain injury
  - Neurotrauma

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Summary

Fish and Marine Mammals

- Underwater sound important for perceiving and interacting with the environment
- Species hear and use sound different – hearing group categories
- Elevated hydroacoustic levels can cause harmful effects – behavioral, injurious, and/or potentially fatal

Thank you!

Contact:

Dan Chase
Fisheries Biologist
WRA, Inc.
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Phone: 415-454-8868

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Regulatory Application of Hydroacoustic Impacts

Keith Pommerenck

and James Reyff

Illingworth & Rodkin, Inc.

Petaluma * Marysville * Denver

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Thresholds for Fish

Interim acoustic criteria – 2008

- Onset of injury expected:
  - Peak pressure $\geq$206 dB
  - SEL_{12hr} = 187 dB (fish $\geq$2grams)*
  - SEL_{12hr} = 183 dB (fish <2grams)*

    *150dB SEL_{strike} = effective quiet

- Effect area = >150 dB RMS (Behavioral)

Except for very short events, SEL is dominant threshold

Assessing Effect Areas - Fish

- Determine near source sound levels
  - Use compendium – type, size, environment, etc…
- Estimate sound propagation rate (use 15 Log if unknown)
- Identify amount of activity
  - #piles, pile strikes, locations
- Effect of sound control measures

NMFS Fish Calculator

- Simple model relying on available data
- Uniform spreading loss
- Applies effective quiet to SEL levels
- **Spreadsheet inputs in Green Cells**

Project Title	AEP Project
Pile information (size, type, number, pile strikes, etc.)	36-inch diameter steel shell pile, 1 hour pile driving 1 strike every 1.5 seconds = 2,400 strikes

Fill in green cells: estimated sound levels and distances at which they were measured, estimated number of pile strikes per day, and transmision loss constant.

	Acoustic Metric			
	Peak	SEL	RMS	Effective Quiet
Measured single strike level (dB)	**211**	**184**	**192**	**150**
Distance (m)	**10**	**10**	**10**	
Estimated number of strikes	**2400**			
Cumulative SEL at measured distance				
217.80				

	Distance (m) to threshold			
	Onset of Physical Injury			Behavior
	Peak	Cumulative SEL dB**		RMS
	dB	Fish ≥ 2 g	Fish < 2 g	dB
Transmission loss constant (15 if unknown)	206	187	183	150
15	**22**	**1131**	**1848**	**6310**

** This calculation assumes that single strike SELs < 150 dB do not accumulate to cause injury (Effective Quiet)

Notes (source for estimates, etc.)

NMFS Fish Calculator

- **Same as previous**
- **Air Bubble Curtain**

  -8 dB

Project Title	AEP Project			
Pile information (size, type, number, pile strikes, etc.)	36-inch diameter steel shell pile, 1 hour pile driving 1 strike every 1.5 seconds = 2,400 strikes			
Fill in green cells: estimated sound levels and distances at which they were measured, estimated number of pile strikes per day, and transmision loss constant.				
	Acoustic Metric			
	Peak	SEL	RMS	Effective Quiet
Measured single strike level (dB)	**203**	**176**	**184**	**150**
Distance (m)	**10**	**10**	**10**	
Estimated number of strikes	**2400**			
Cumulative SEL at measured distance				
209.80				
	Distance (m) to threshold			
	Onset of Physical Injury			Behavior
	Peak	Cumulative SEL dB**		RMS
	dB	Fish ≥ 2 g	Fish < 2 g	dB
Transmission loss constant (15 if unknown)	206	187	183	150
15	**6**	**331**	**541**	**1848**
** This calculation assumes that single strike SELs < 150 dB do not accumulate to cause injury (Effective Quiet)				
Notes (source for estimates, etc.)				

Sensitivity of Transmission Loss Constant

	Acoustic Metric			
	Peak	SEL	RMS	Effective Quiet
Measured single strike level (dB)	211	184	192	150
Distance (m)	10	10	10	
Estimated number of strikes	2400			
Cumulative SEL at measured distance				
218				
	Distance (m) to threshold			
	Peak	Cumulative SEL**		RMS
Transmission loss constant (15 if unknown)	208 dB	187 dB	183 dB	150 dB
15	22	1131	1848	6310

	Acoustic Metric			
	Peak	SEL	RMS	Effective Quiet
Measured single strike level (dB)	211	184	192	150
Distance (m)	10	10	10	
Estimated number of strikes	2400			
Cumulative SEL at measured distance				
218				
	Distance (m) to threshold			
	Peak	Cumulative SEL**		RMS
Transmission loss constant (15 if unknown)	208 dB	187 dB	183 dB	150 dB
17	20	648	1000	2955

Thresholds for Marine Mammals

PTS Onset Criteria (used for Level A)

- Continuous and impulsive thresholds
- Peak and SEL thresholds
- Functional hearing groups
  - Low-frequency cetaceans (7 Hz to 35 kHz)
  - Mid-frequency cetaceans (150 Hz to 160 kHz)
  - High-frequency cetaceans (275 Hz to 160 kHz)
  - Phocid pinnipeds (e.g., harbor seals) (50 Hz to 86 kHz)
  - Otariid pinnipeds (e.g., sea lions) (60 Hz to 39 kHz)

Thresholds for Marine Mammals

	PTS Onset Acoustic Thresholds* (Received Level)	
Hearing Group	**Impulsive**	**Non-impulsive**
Low-Frequency (LF) Cetaceans	*Cell 1* $L_{pk,flat}$: 219 dB $L_{E,LF,24h}$: 183 dB	*Cell 2* $L_{E,LF,24h}$: 199 dB
Mid-Frequency (MF) Cetaceans	*Cell 3* $L_{pk,flat}$: 230 dB $L_{E,MF,24h}$: 185 dB	*Cell 4* $L_{E,MF,24h}$: 198 dB
High-Frequency (HF) Cetaceans	*Cell 5* $L_{pk,flat}$: 202 dB $L_{E,HF,24h}$: 155 dB	*Cell 6* $L_{E,HF,24h}$: 173 dB
Phocid Pinnipeds (PW) (Underwater)	*Cell 7* $L_{pk,flat}$: 218 dB $L_{E,PW,24h}$: 185 dB	*Cell 8* $L_{E,PW,24h}$: 201 dB
Otariid Pinnipeds (OW) (Underwater)	*Cell 9* $L_{pk,flat}$: 232 dB $L_{E,OW,24h}$: 203 dB	*Cell 10* $L_{E,OW,24h}$: 219 dB

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

Point of this slide is that these are complex!

Dual thresholds, different types of sounds and frequency weightings

Thresholds for Marine Mammals

Behaivoral Criteria (used for Level B)

- Continuous and impulsive thresholds
- RMS thresholds
  - Time averaged for continuous
  - Pulse averaged for impulses
- No applicable frequency weightings
  - next step for NMFS??

Continuous Sounds (e.g., vibratory driving)	= 120 dB (time avg)
Impulsive Sounds (e.g., impact driving)	= 160 dB (pulse avg)

Thresholds for Marine Mammals

In Air Disturbance (used for Level B)

- RMS thresholds (time averaged)
  - 90 dB phocid pinnipeds (harbor seals)
  - 100 dB otariid pinnipeds (sea lions)
- Typically applied at haul outs

Explosives (Level A)

- Several types for injury

NMFS User Spreadsheet

- Simple model relying on available data
- Uniform spreading loss
- Computes duty cycle for SEL computations
- ***NO*** effective quiet applied to SEL levels
- ***Frequency adjustments are key inputs***

E.1: IMPACT PILE DRIVING (STATIONARY SOURCE: Impulsive, Intermittent)

VERSION: 1.1 (Aug-16)

KEY	
(green)	Action Proponent Provided Information
(pink)	NMFS Provided Information (Acoustic Guidance)
(blue)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	
PROJECT/SOURCE INFORMATION Please include any assumptions	
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	2

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 64), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

* BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either E1-1 OR E.1-2 method to calculate isopleths (not required to fill in sage boxes for both)

E.1-1: METHOD USING RMS SPL SOURCE LEVEL

Source Level (RMS SPL)	
Activity Duration (h) within 24-h period OR Number of piles per day	
Pulse Duration[Δ] (seconds)	
Number of strikes in 1 h OR Number of strikes per pile	
Activity Duration (seconds)	0
10 Log (duration)	#NUM!
Propagation (xLogR)	
Distance of source level measurement (meters)[+]	

[Δ]Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005

[+]Unless otherwise specified, source levels are referenced 1 m from the source.

Marine Mammal Hearing Group
Low-frequency (LF) cetaceans: baleen whales
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales
High-frequency (HF) cetaceans: true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* & *L. australis*
Phocid pinnipeds (PW): true seals
Otariid pinnipeds (OW): sea lions and fur seals

RESULTANT ISOPLETHS*

*Note: For impulsive sounds, action proponent must also consider isopleths peak sound pressure level (PK) thresholds (dual thresholds).

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

E.1-2: ALTERNATIVE METHOD (SINGLE STRIKE EQUIVALENT)

Unweighted $SEL_{cum\ (at\ measured\ distance)} = SEL_{ss}$ + 10 Log (# strikes)	#NUM!

Source Level (Single Strike/shot SEL)	
Number of strikes in 1 h OR Number of strikes per pile	
Activity Duration (h) within 24-h period OR Number of piles per day	
Propagation (xLogR)	
Distance of single strike SEL measurement (meters)[+]	

[+]Unless otherwise specified, source levels are referenced 1 m from the source.

Marine Mammal Hearing Group
Low-frequency (LF) cetaceans: baleen whales
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales
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SEL_{cum} Threshold	183	185	155	185	203
PTS Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (dB)†	-0.01	-19.74	-26.87	-2.08	-1.15

NMFS User Spreadsheet
5 different types

- Non-impulsive stationary continuous
- Non-impulsive stationary intermittent
- Non-impulsive mobile continuous
- Non-impulsive mobile intermittent
- Impulsive – Stationary
- Impact Pile Driving
- Impulsive mobile

- WFA – Weighting Factor Adjustments
  - Default single factors
  - Develop factors or weighted levels using guidance weighting functions applied to signal

CEQA and Permitting Impacts Analysis

Hydroacoustic Effects

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Overview Hydroacoustics Impacts Analysis

- CEQA and Permitting Thresholds
- Factors and Uncertainties Affecting Thresholds
- Impacts Analysis
- Mitigation Approach

CEQA Significance Thresholds

Appendix G Biological Resources

- a) Have a **substantial adverse effect**, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?
- d) **Interfere substantially** with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?

CEQA Significance Thresholds

Substantial Adverse Effect

- substantially reduce the habitat of a fish or wildlife species
- cause a fish or wildlife population to drop below self-sustaining levels
- threaten to eliminate a plant or animal community
- **reduce the number or restrict the range of a rare or endangered plant or animal**

Regulatory Background

Endangered Species Act

Federal	
No effect	No consultation
Not likely to adversely affect	Letter of concurrence, no “take” coverage
Likely to adversely affect	Biological Opinion, “take” coverage
State	
Pursue, injure or harm to individuals, or attempt to	2081 Incidental Take Permit

Regulatory Background

Marine Mammal Protection Act

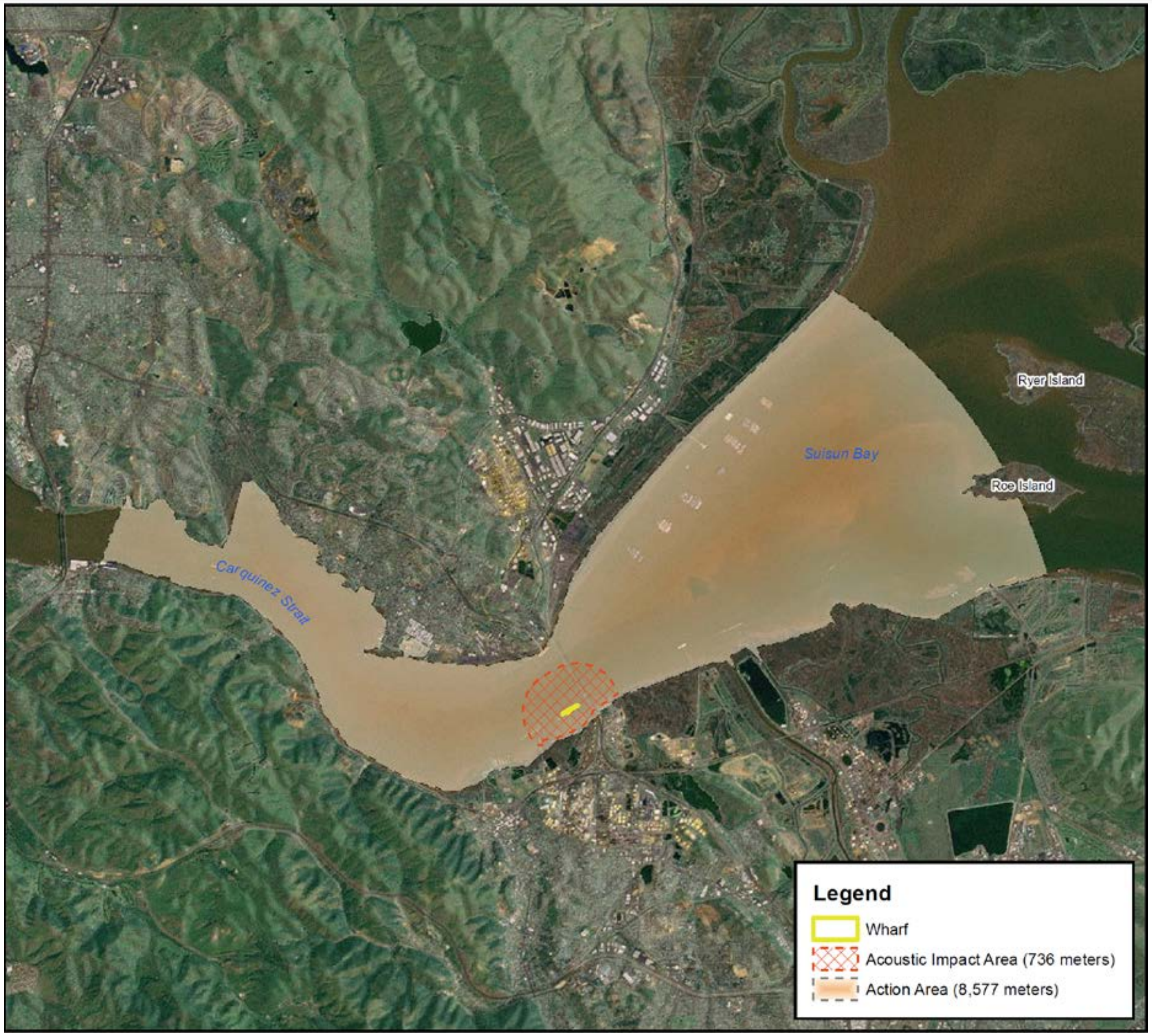
Federal	
Level A Harassment, “serious” injury or mortality	Letter of Authorization (federal rulemaking process)
Level B Harassment, non-serious injury and/or disturbance	Letter of concurrence, no “take” coverage
State	
Fish and Game Code, no permit process except for listed marine mammal species	

Hydroacoustic Thresholds

- Fish
  - Peak pressure ≥ 206 dB (re: 1μPa)
  - SEL
    - > 2 grams = 187 dB (re: 1μPa2 • sec)
    - < 2 grams = 183 dB (re: 1μPa2 • sec)

- Marine Mammals
  - Level A Harassment (e.g., "Permanent Threshold Shift")
  - Level B Harassment
  - Temporary Threshold Shift

Hydroacoustic Thresholds



- Model output: distance at which specific decibel levels are reached

Hydroacoustic Impacts

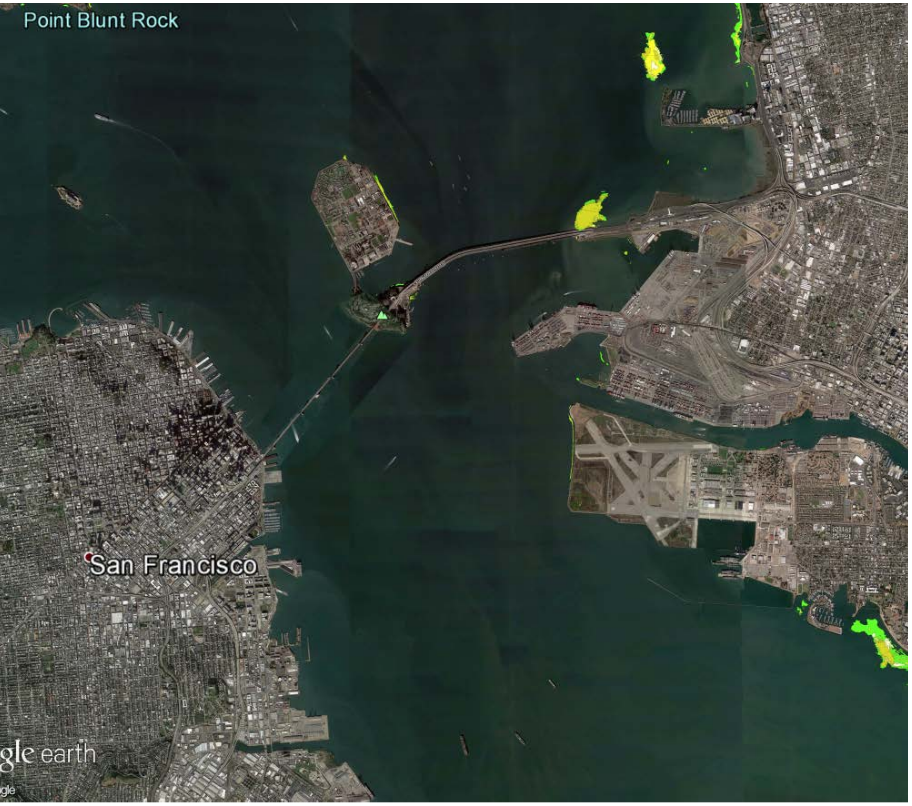
Interpreting hydroacoustic effects modeling:

- "All models are wrong, some models are useful"
- At a distance of 1 foot from the sound source, all thresholds are exceeded in most (but not all) cases
- Decibel level dissipates over distance, fish and marine mammals can be thought of as mobile "sensitive receptors"
- CEQA assumptions for hydroacoustic models are usually wrong, and change, often substantially, as the project progresses toward final design

Factors and Uncertainties

- Context/environmental setting
- Pile size and type
- Number of piles per day
- Number of strikes per pile
- Frequency shift
- Other and unstudied sound sources
  - Different types of sound can affect aquatic resources in different ways
  - Pile driving is relatively well studied
- Gaps in scientific knowledge
- Modeling imperfections

Context/Environmental Setting



San Francisco Bay

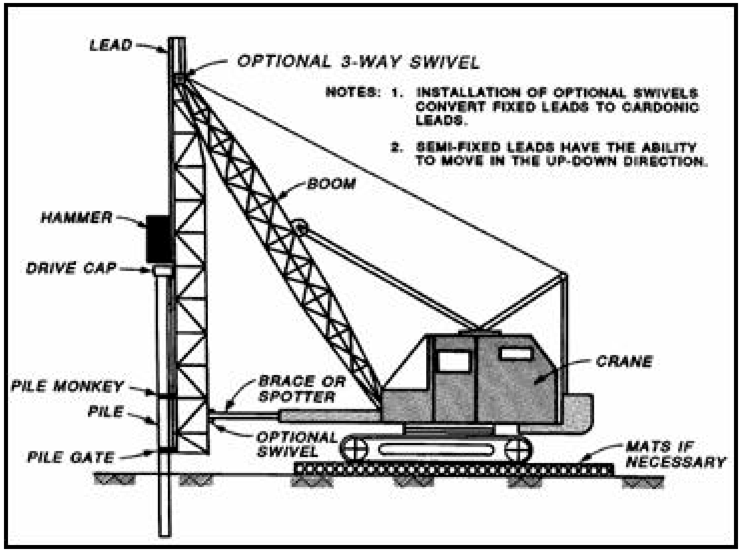
Moss Landing

Context/Environmental Setting

- Background noise
- Habituation
- Haul outs
- Migratory corridors
- Spawning and pupping
- Presence of ESA/CESA listed species

Factors Affecting Observed Hydroacoustics

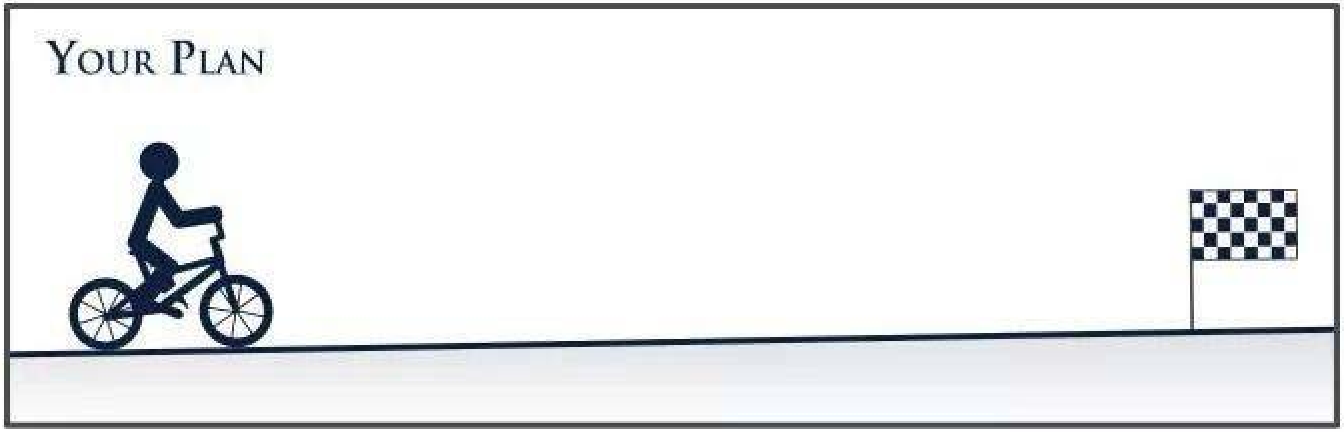
- Sound source
- Physical dynamics of a site
- Background noise
- Type of piles
- Number of piles per day
- Number of strikes per pile
- Currents
- Soil/substrate type
- Distance of measurement
- Attenuation methods
- Type of pile driving equipment (down to model #)
- Other things we may not even be looking for…

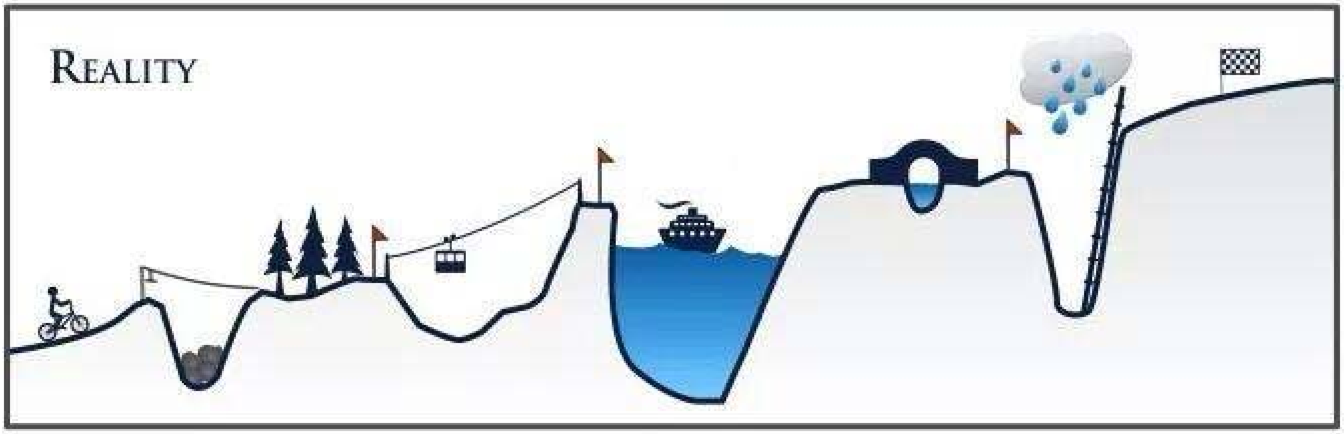


Design Factors Affecting Pile Driving Assumptions and Models

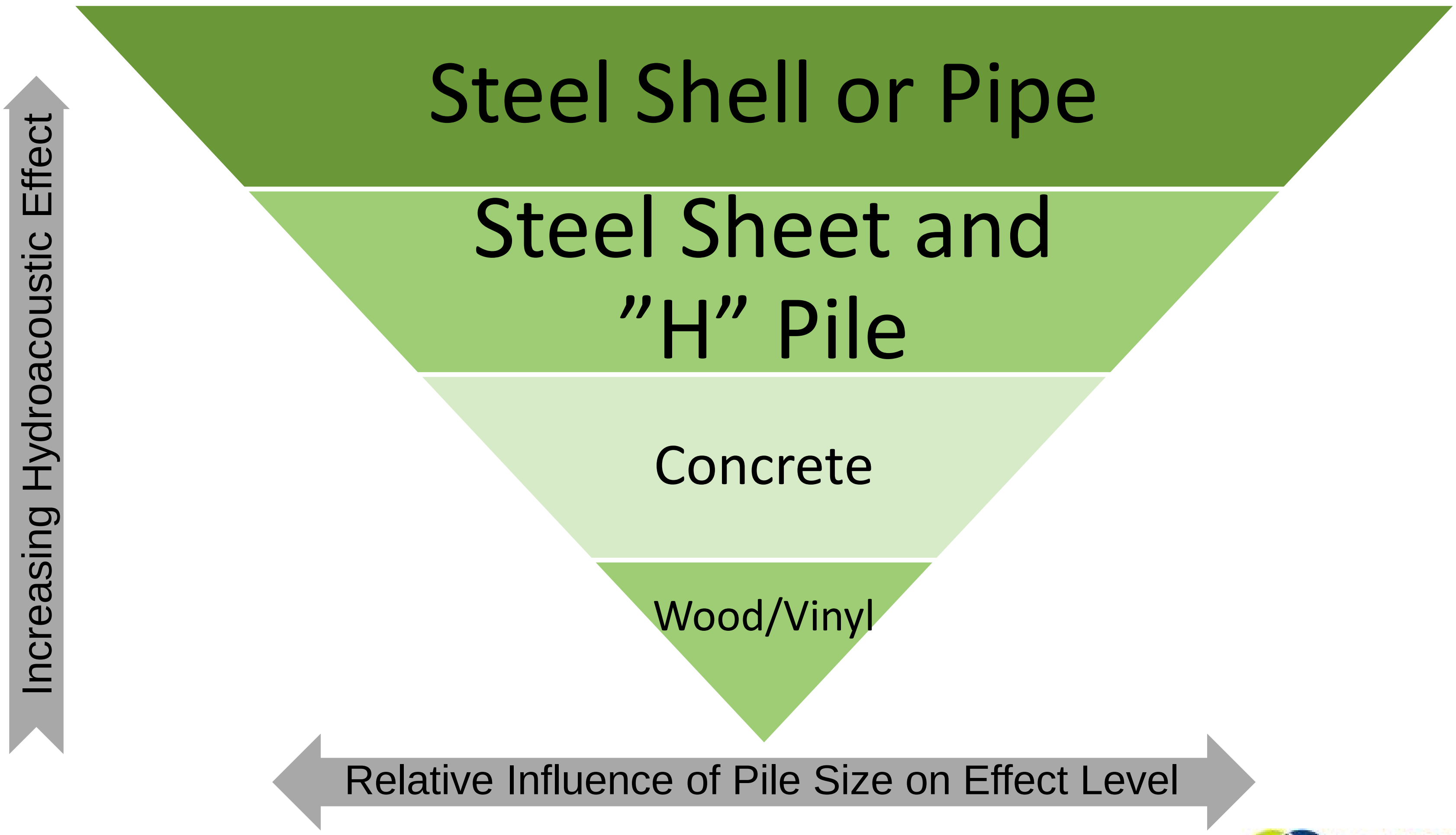
- Anticipated use
- Structural load
- Geotechnical factors
- Skill of construction contractor
- Equipment availability
- Site access and maneuverability
- Physical conditions coefficients
- Unknown submerged objects

Factors and Uncertainties





Generalized Hierarchy of Pile Types



Hydroacoustic Impacts Analysis

- Individuals' residence time within the affected area
- Incidental occurrence vs. core habitat
- Species' status
- Modeling uncertainties
- Background noise and habituation
- Speculative or discountable effects standards

- substantially reduce the habitat of a fish or wildlife species
- cause a fish or wildlife population to drop below self-sustaining levels
- threaten to eliminate a plant or animal community
- reduce the number or restrict the range of a rare or endangered plant or animal

Mitigation Measures

- Very few cases where a technical solution can avoid all risk to individuals

- Minimization and avoidance

- Similar to many CEQA technical areas: noise, GHG, water quality, traffic

Developing Mitigation Measures

- Avoid deferral
- Avoid being overly prescriptive
  - Not every BMP is feasible for all construction conditions
- Allow for the regulatory process to run its course
- Do not assume that modeling assumptions will hold true for construction

Developing Mitigation Measures

- Implementation of some BMPs can extend the duration that resources are subject to disturbance
- Practicability of field biological monitoring and assigning source of stress or injury
- Consider the level of risk to the resource

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Developing Mitigation Measures

- Consider use of an “if…then” framing
- Standard mitigation measures for developing a SWPPP may provide a good conceptual model
  - Develop a hydroacoustic effects analysis for review by NMFS
  - Include list of BMPs “such as…”
- Field measurement of underwater sound can be appropriate to refine and inform modeling results
  - Field hydroacoustic measurement is not a mitigation measure in and of itself
  - Consider the cost in relation to the resource risk
- Biological monitoring is typically effective for marine mammals, less so for fish
  - Site conditions influence efficacy of biological monitoring

Developing Mitigation Measures

Maintain flexibility

There is a physical universe that we cannot always control

Questions?