Conducting Masking Analysis for Marbled Murrelets & Pile Driving Projects

Presentation for WSDOT Biologists and Consultants

November 19, 2013

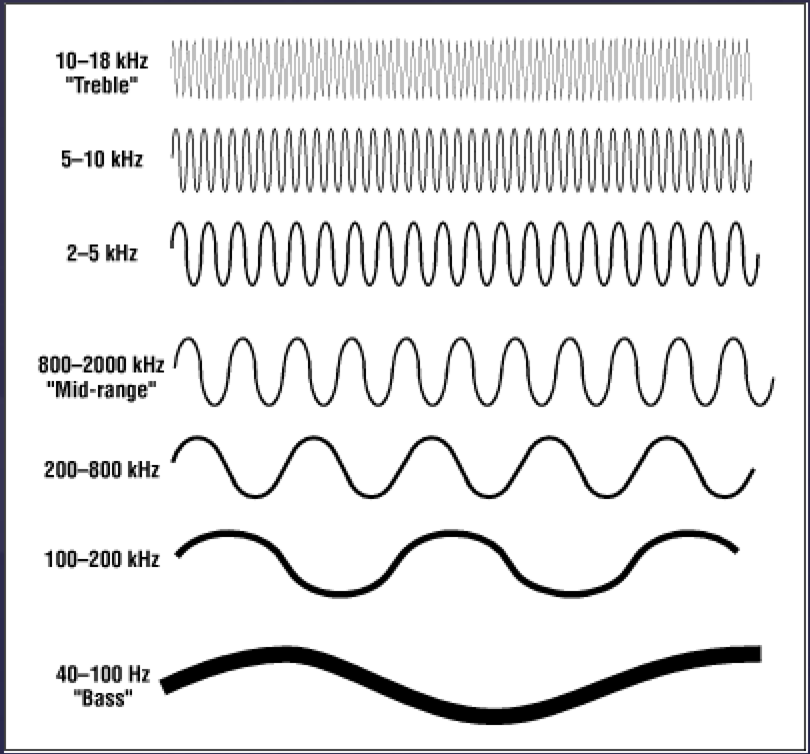
Presented by Emily Teachout, USFWS, WFWO

Overview

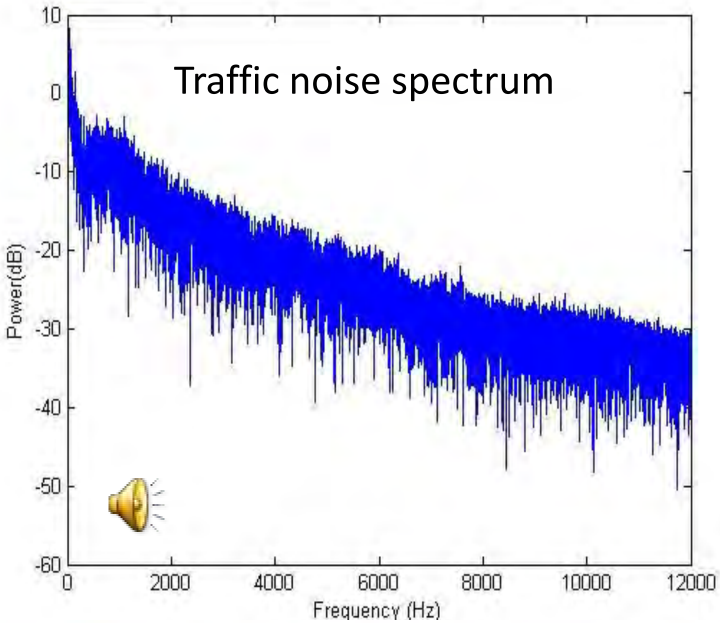
- What is Masking?
- Terms
- Panel II – Who and Why
- Nit Picking – What was NITS and where did it go?
- Can You Hear Me?! (Conspecific Communication)
- Masking Demonstration
- MAMU Vocalizations
- Role of Ambient
- When Does Masking Occur
- “Typical Pile Driving Projects”
- Minimization Measures
- Info Needs

What is Masking?

- Masking occurs when a loud sound drowns out a softer sound or when noise is at the same frequency as a sound signal.
  - Because of the widespread nature of anthropogenic activities, masking may be one of the most extensive and significant effects on the acoustic communication of marine organisms today.



Traffic Noise and Human Speech



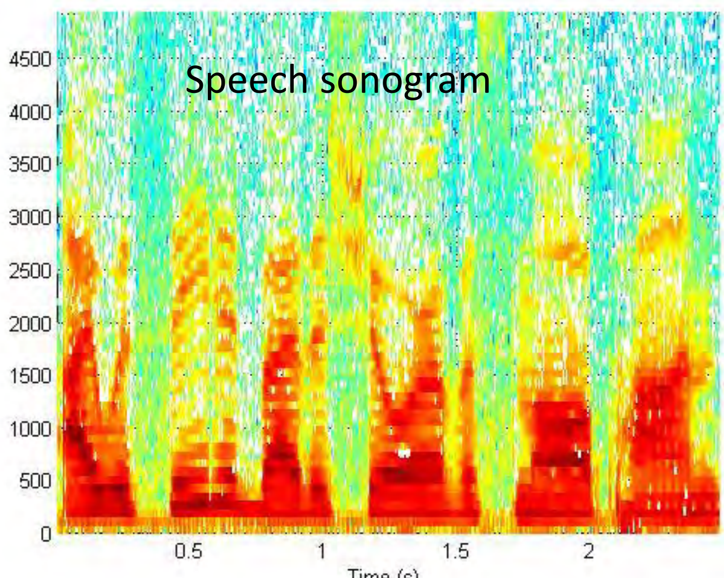
S/N Levels:

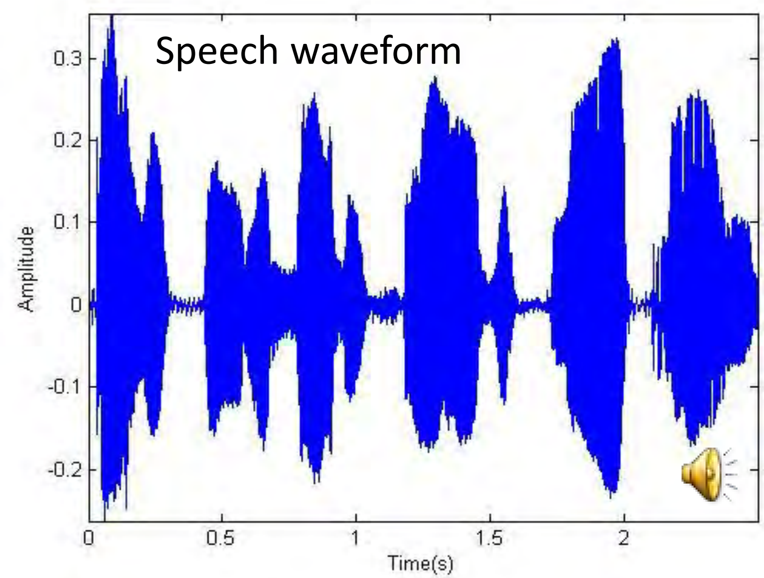
Comfortable Level(+15dB) - - -

Recognition Level(+4dB) - - - - -

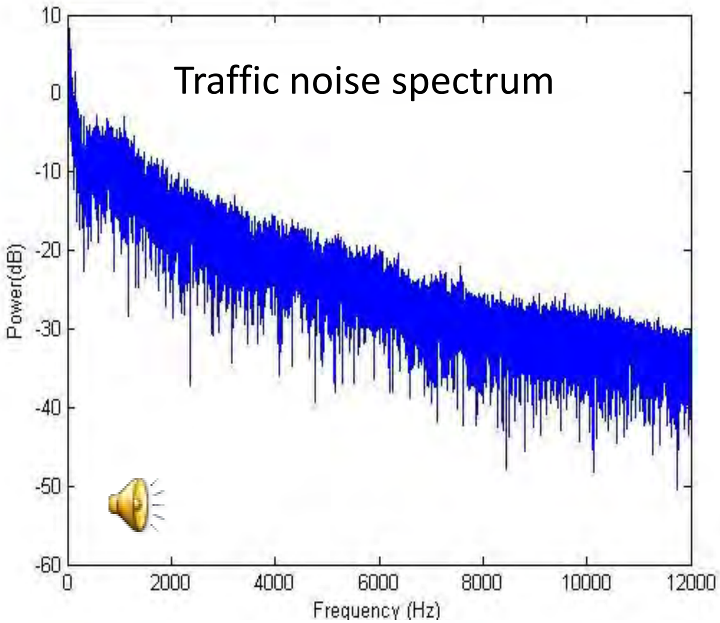
Discrimination Level(+2db)- - -

Detection Level - - - - - - - - - -- -



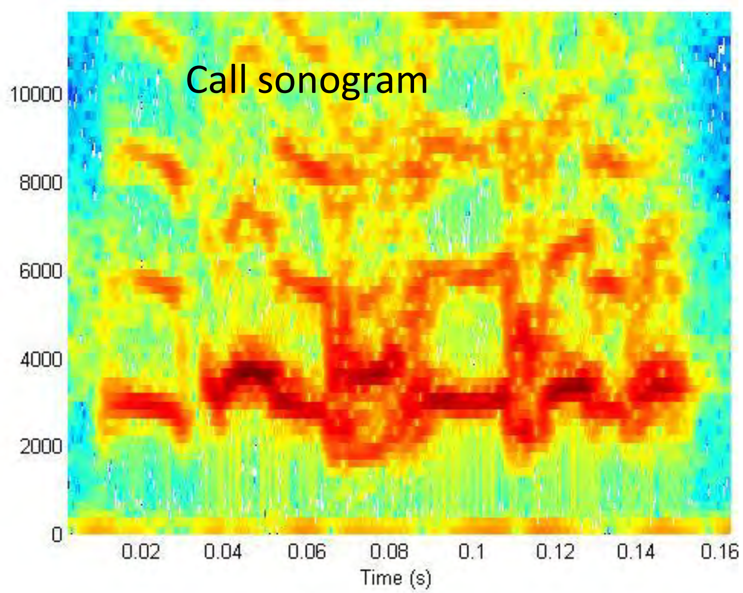


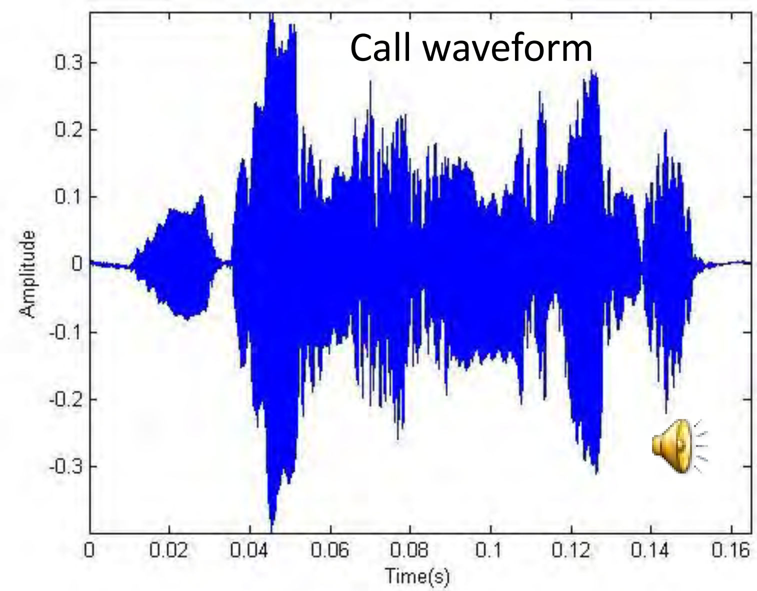
Traffic Noise and a Budgerigar Call



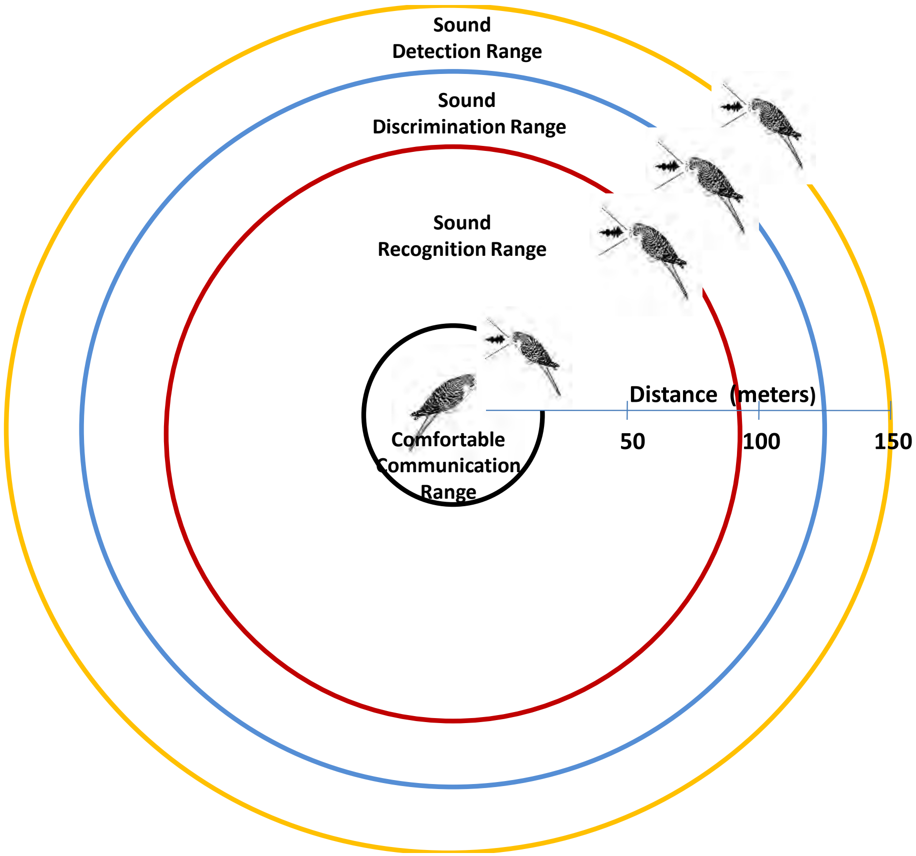
S/N Levels:

- Comfortable Level - - -
- Recognition Level - - - -
- Discrimination Level - -
- Detection Level - - - - -





Effects of Traffic Noise on Communication Distance



Dooling , Leek, West , 2009

Sound Metrics & Key Terms

Critical Ratio – difference (dB) between a hearing threshold and a masking noise; must be 25 dB above back ground to be detectable (Dooling et al. 2000)

Masking – interference with the detection of one sound by another (Dooling and Therrien 2012)

Masked Threshold – the quietest sound level that is detectable when combined with a specific masking noise

Received Level – the sound level at the location of the animal of interest

Sound Metrics & Key Terms cont.

Spectrum Level – amount of sound energy at a particular frequency (dB)

Threshold Shift– temporary or permanent changes in auditory sensitivity as a result of exposure to noise

(Saunders and Dooling 1974, p. 1962)

Panel I & Panel II

- Panel I focused on injury.
- Panel II focused on sound exposures would induce behavioral changes constituting “harassment”.

Criteria for Murrelet Harm (Injury)

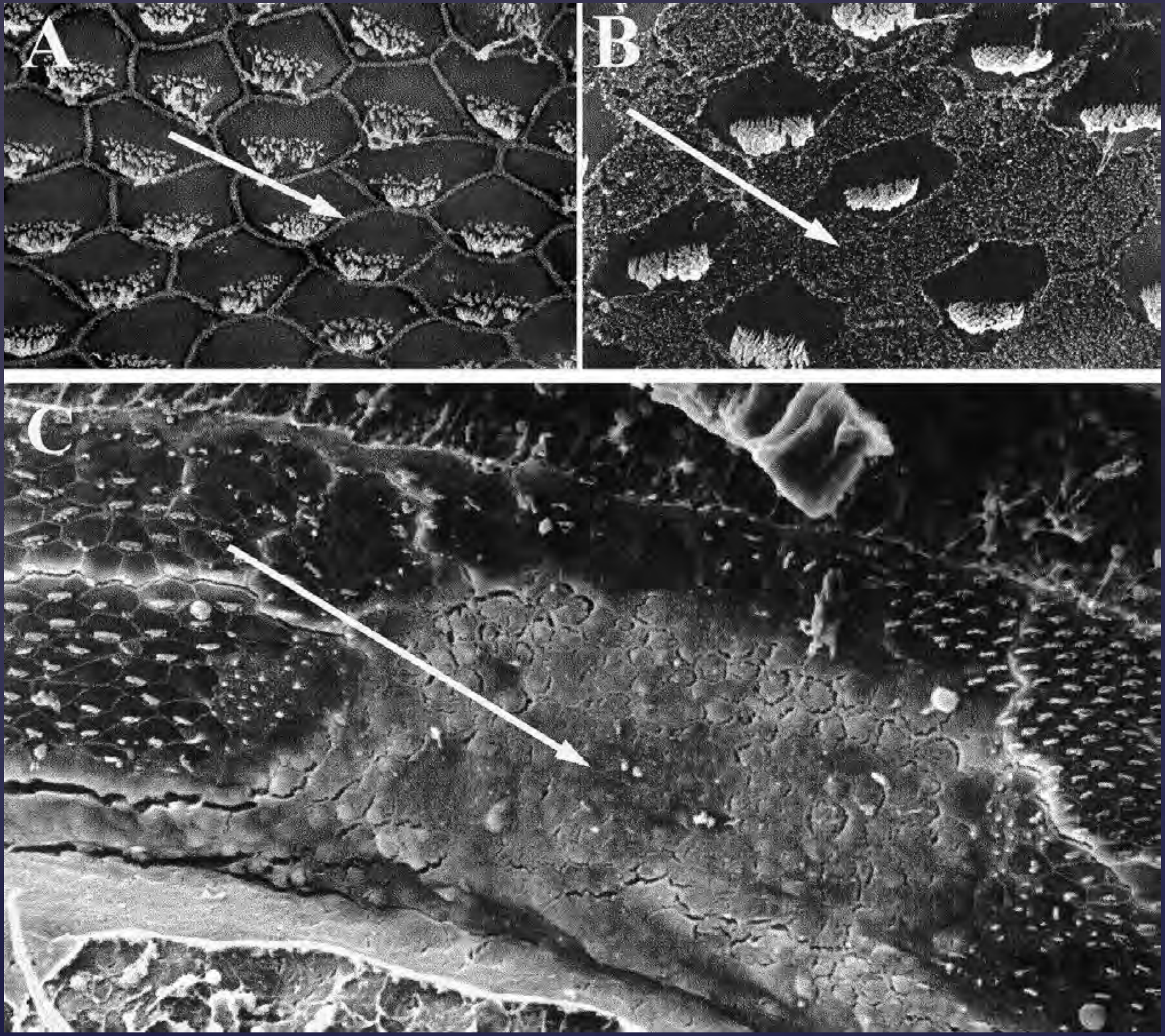
As of August 2011:

- Harm =

  202 dB SEL

  - Death, barotrauma, auditory damage
  - TS >40 dB

Continuum of Injurious Effects



Canary

A: hair cells in a control papilla are regularly spaced, similar in size and have a single stereocilia bundle.

B: immediately after exposure. Enlarged surface area of supporting cells. Hair cells normal in appearance.

C: 7 days after identical exposure. Arrow indicates area of complete hair cell loss.

Panel 2

- Danielle Buonantony, U.S. Navy, Biologist
- Dr. Robert Dooling, University of Maryland, Professor
- Deanna Lynch, USFWS, Biologist
- Kristine Petersen, NMFS, Biologist
- Dr. John Piatt, USGS, Research Biologist
- Dr. James Saunders, University of Pennsylvania, Professor
- Dr. Hans Slabbekoorn, Leiden University, the Netherlands
- Mike Slater, SAIC, Acoustician
- Dr. John Stadler, NOAA, Biologist
- Emily Teachout, USFWS, Biologist

- Assistance from Craig Johnson (NOAA), Dr. Zach Peery

Then

Metric	Form	Exposure	Effect
208 dB SEL	Barotrauma	Underwater	Tissue damage, more serious injuries, mortality
202 dB SEL	Injury	Underwater	Onset of inner ear damage (hair cell loss), and other sublethal injuries
183 dB SEL	Non-Injurious Threshold Shift	Underwater	Threshold shift (hearing damage) not associated with inner ear damage; impairs biologically important communication while foraging
150 dB rms	Behavioral Effects	Underwater	Potential for behavioral responses such as flushing and avoidance

Now

Metric	Form	Exposure	Effect
208 dB SEL	Barotrauma	Underwater	Tissue damage, more serious injuries, mortality
202 dB SEL	Injury	Underwater	Onset of inner ear damage (hair cell loss), and other sublethal injuries
29 dB SL	Masking	RL In-air	Impairs essential communication among foraging birds
150 dB rms	Behavioral Effects	Underwater	Potential for behavioral responses such as flushing and avoidance

Criteria for Harassment

- Navy Panel II = NITS (183 dB) not an issue
  - In the marine environment, TS <40 dB is usually masked by ambient sound and has no biological significance.
  - MAMU returning to terrestrial habitat will have some recovery and critical hearing demands not impeded.
- RL of in-air noise >29 dB (SL) = masking
  - Monitoring may be required.
  - Not an issue for “typical” projects.

Behavioral Responses Associated with Non-Injurious Threshold Shift

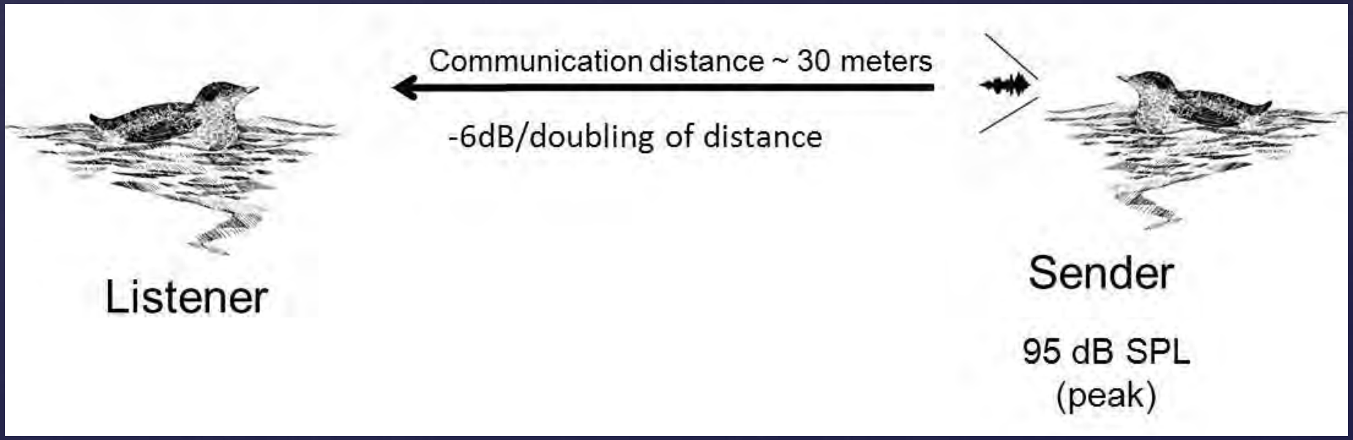
- Two *critical hearing demands* influenced by exposure to pile driving at-sea:
  - communication between conspecifics (at-sea, or in terrestrial habitat); and
  - detection of the presence of corvid predators in terrestrial habitat.

Communication Between Conspecifics

http://youtu.be/YcX1ZjzCuic

Communication Between Conspecifics

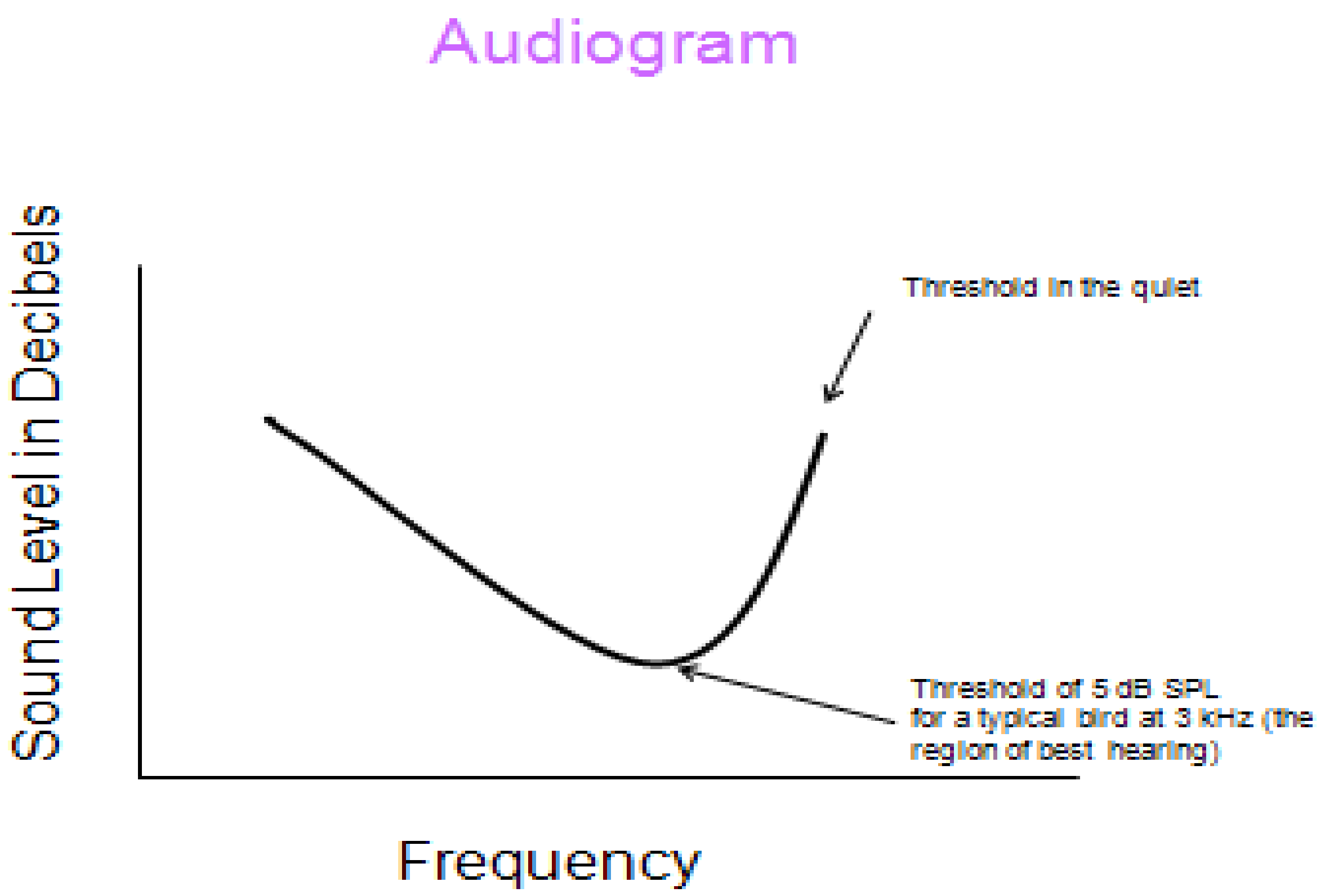
- Typically forage in groups of two+ and are highly vocal.
- Vocalization audibility has important role in foraging efficiency (SAIC 2012, p. 13).
- Panel estimated that the social foraging strategy employed by murrelets requires acoustic communication at the recognition level up to 30 m (SAIC 2012, p. 16).
- If TS limits recognition within 30 m, then foraging efficiency is expected to be impaired.



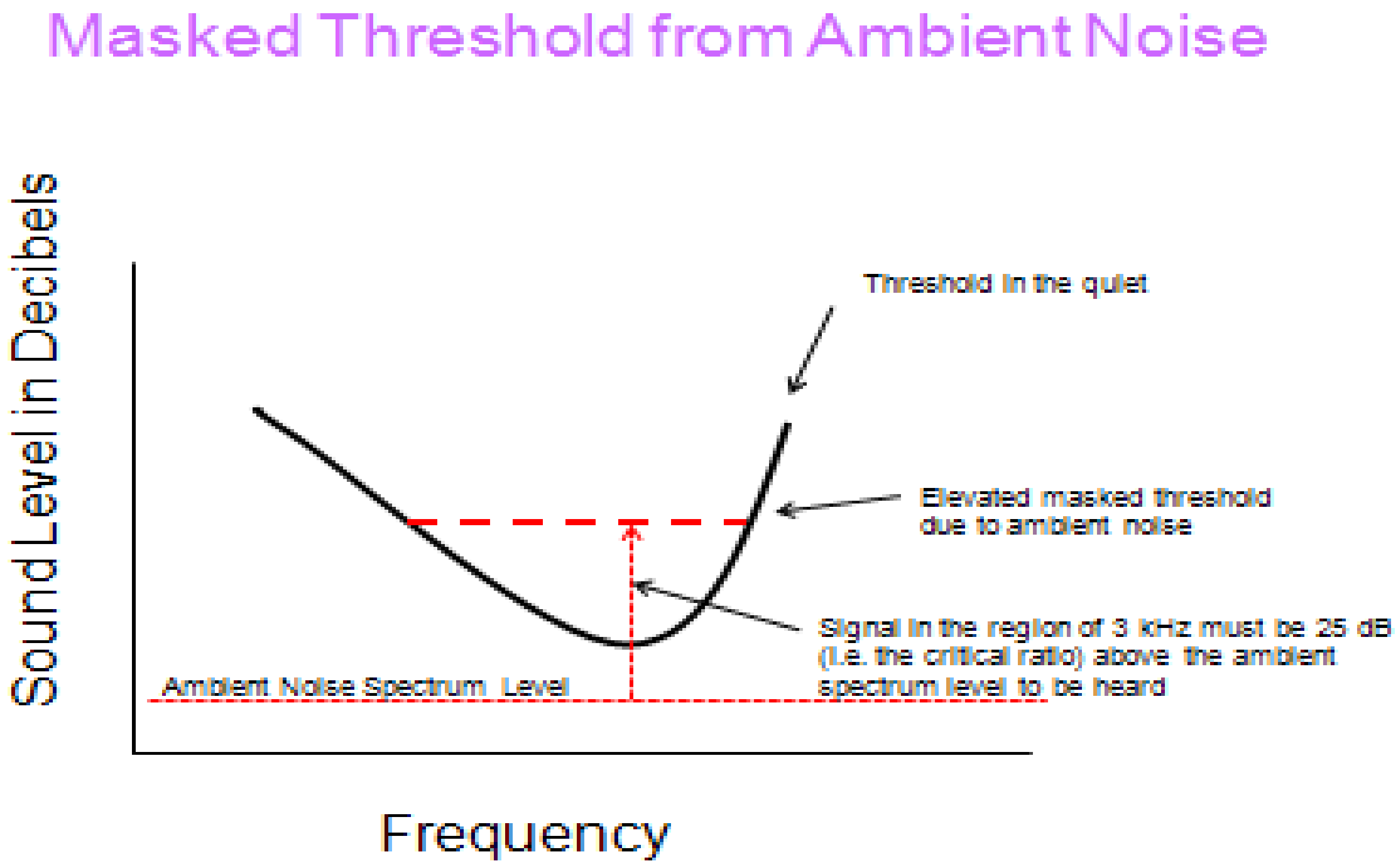
Communication Between Conspecifics cont.

- Small amounts of TS may not affect hearing in natural environments where ambient noise is already above the shifted threshold level (Figure 1).
- There is a certain amount of TS that is inconsequential because it is effectively truncated by the masking effect of ambient sound.
- If the TS is below the ambient sound, then the TS is inconsequential because it is then the ambient sound that may interfere with signal perception (Figure 2).
- If the reverse is true, and the TS level is greater than the ambient sound, then the TS may be relevant (Figure 2).

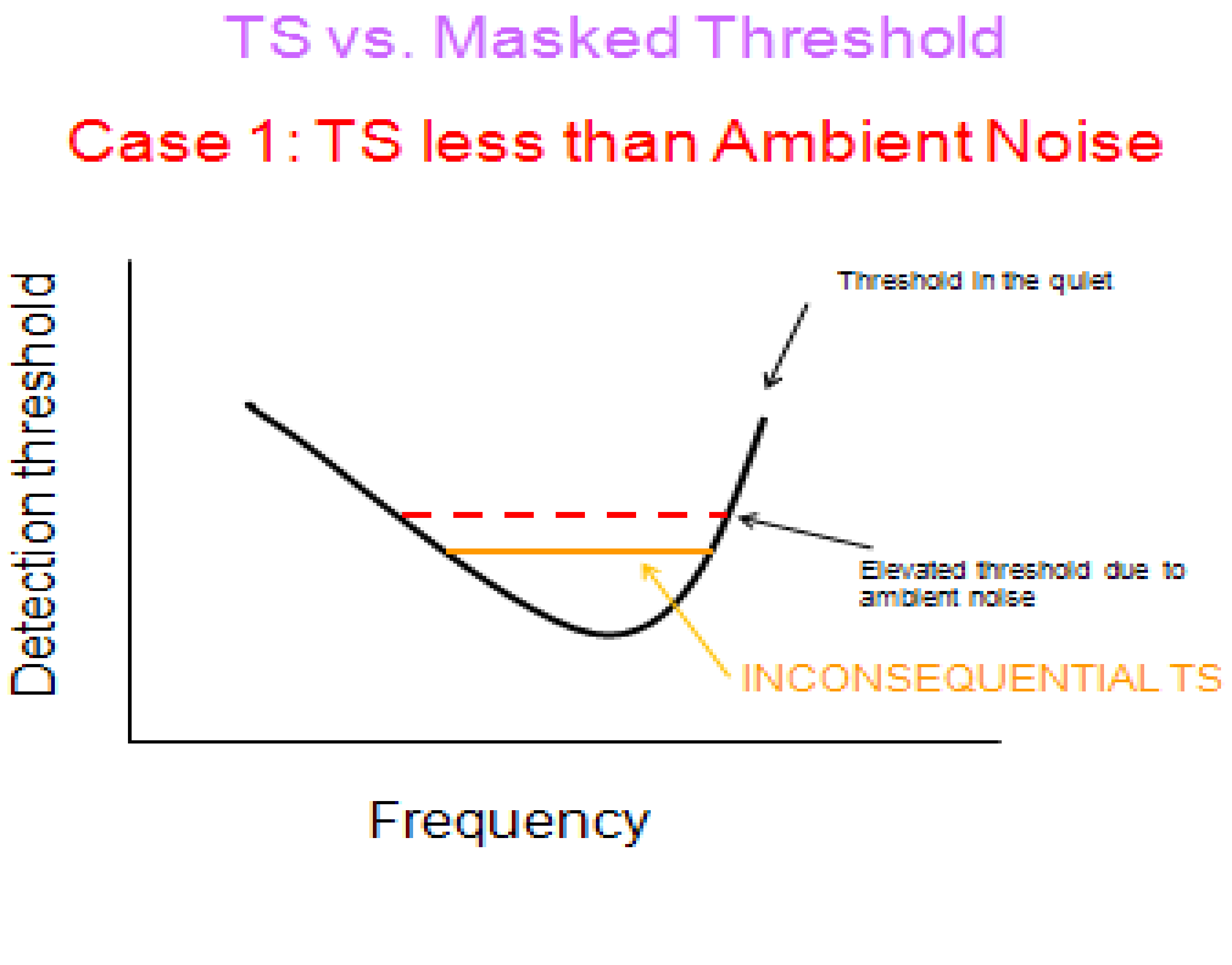
Generalized avian hearing audiogram: hearing thresholds in a lab setting



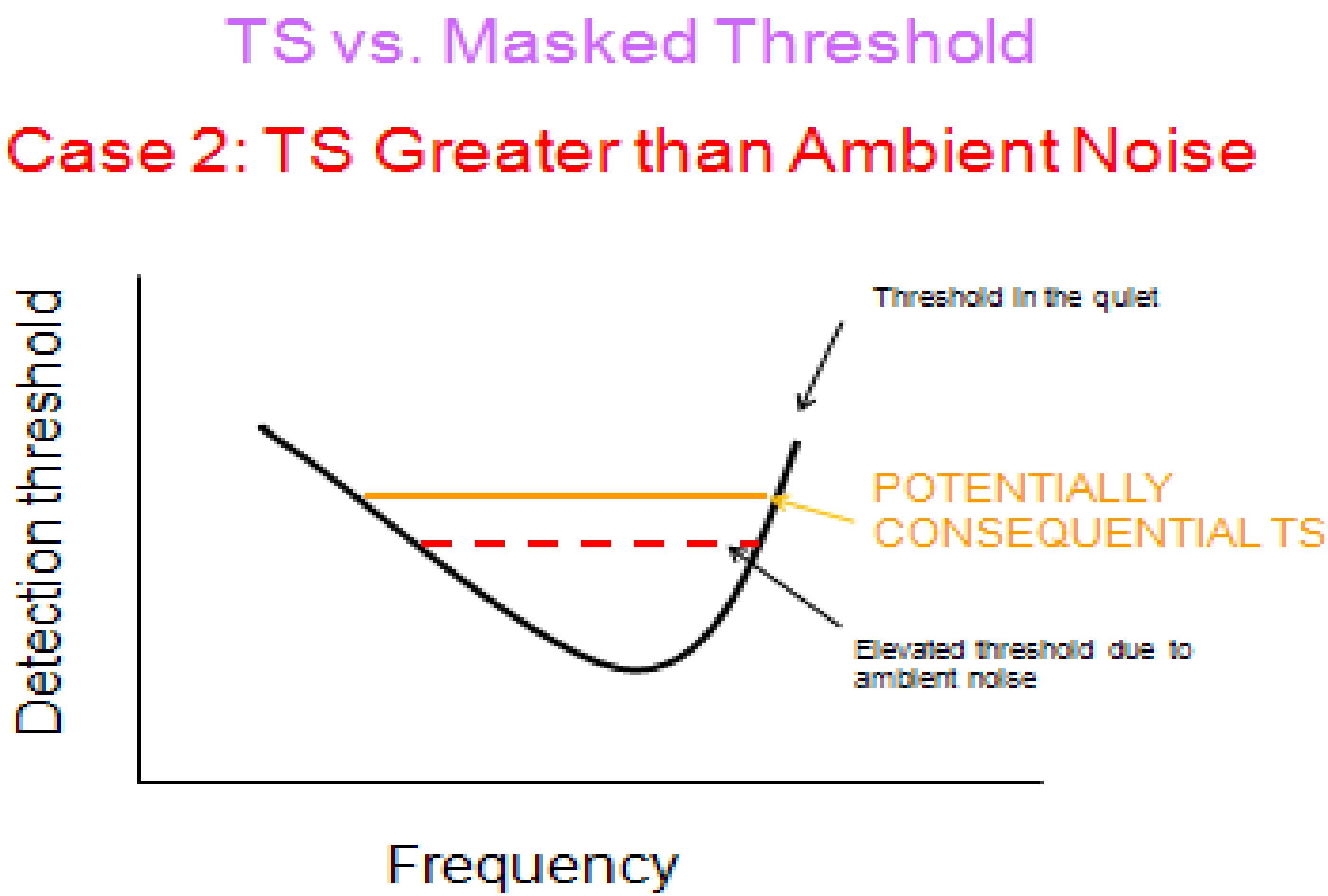
Generalized avian hearing audiogram: masked threshold from real-world setting



Threshold shift vs. Masked threshold: inconsequential threshold shift



Threshold shift vs. Masked threshold: consequential threshold shift



When does masking occur?

- When a sound interferes with the perception a signal of interest (i.e., trying to hear a quiet conversation in a noisy room).
- A way to quantify the amount is with a critical ratio (CR).
  - The CR is the difference, in dB, between a hearing threshold and the masking noise.
- Critical ratios (CRs) are documented for a number of bird species (Dooling et al. 2000).

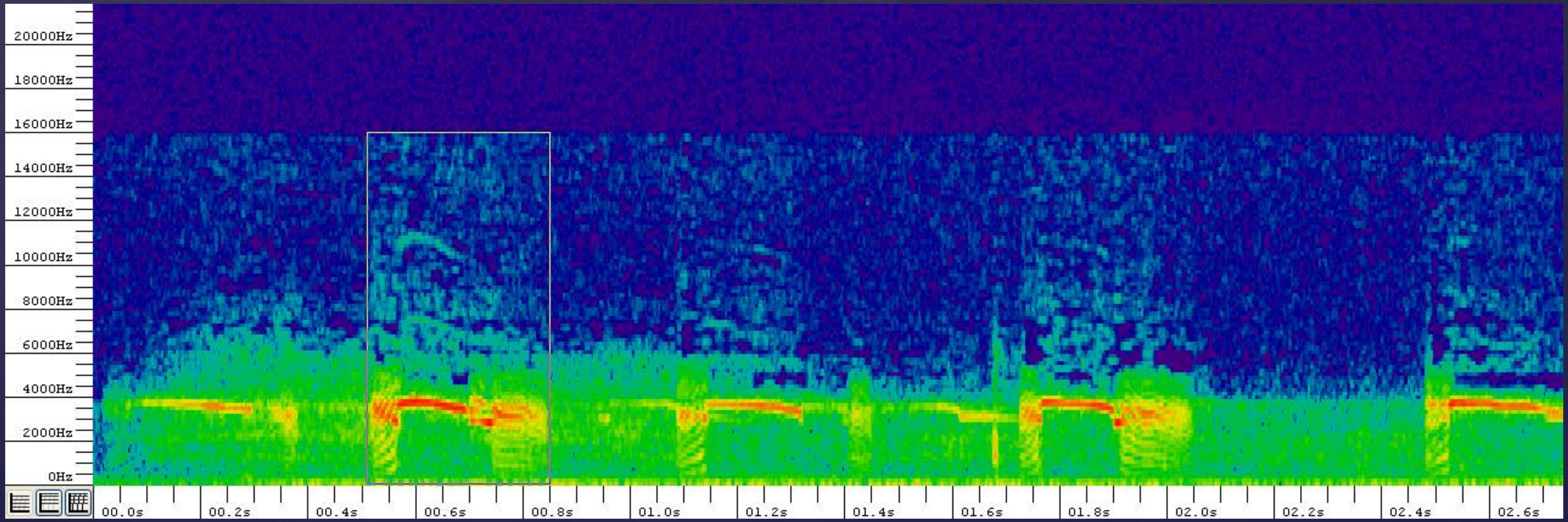
From Studies in Other Birds…

- Signal must be about 25 dB above ambient SL to be detected.
- From detection to recognition, the sound must be at least 6 dB above the CR, or at least 31 dB above background.
- If the ambient SL was 15 dB, the SL of the received signal would need to be at least 40 dB (15 + 25) to be audible.

Photo: E. Teachout

Murrelet call types

- Five primary types: the chirp, groan, keer, whistle and variant; keer is most common, at > 60%.
- Keer call of murrelet is relatively loud (95dBA $_{rms}$) w/most energy centered at 3 kHz (Sanborn et al. 2005 & Brackenbury 1979).



Characteristics of Murrelet Calls

- “Conspicuous” (Van Pelt et al. 1999), repetitive and relatively long duration.
- Whistle >600 ms and keer >400 ms (Sanborn et al. 2005).
- “Strident” and “Easily heard at sea” (Van Pelt et al. 1999).
- Kittlitz’s murrelet vocalizations are low amplitude and are difficult to record.
- MAMU are more often heard than seen (Paton 1995), vocalizations used to assess presence (Ralph et al. 1995).
- MAMU vocalizations are well-suited for transmitting well in the relatively noisy conditions at sea.

Role of Ambient

- Ambient in-air sound in industrialized marine shoreline areas were estimated to be 65 dBA_{rms}
- Quieter areas ambient would be 55 dBA_{rms}.
- The ambient SL is estimated from broadband levels by subtracting 40 dB resulting in 25 dB (SL) for industrialized areas, and 15 dB (SL) for quieter areas, and masked thresholds for the ambient sounds at 3 kHz were calculated.
- NITS (<40 dB) in the marine environment would not measurably effect murrelet behavior because the effect of ambient noise levels on signal perception would be greater than that of the TS.

NITS in Terrestrial Habitat?

- TS resulting in a missed cue from predators could limit silencing responses, and increase vulnerability of an egg or nestling.

NITS in Terrestrial Habitat? No…

- TS needed to impact detection of predator calls is ~40 dB (very close to injury).
- Significant effects might be expected with greater TS, but this would be categorized as injury.
- Some recovery occurs during travel from sea to terrestrial habitat (at a rate of 7-9 dB per hour), and TS is expected to be well below 40 dB when birds reach their nests.
- NITS from exposure to pile driving sound at-sea is not expected to result in significant effects to MAMU in terrestrial habitat.

Masking from In-Air Exposure to Impulsive Pile Driving Sound

- Masking could occur if in-air sound interfered with communication between foraging partners.
- In considering the role that sound perception may play in avoiding aerial predators at-sea, auditory cues for avoiding predation are less important than visual cues (SAIC 2012, p. 13).
- As such, we consider effective communication between foraging partners to be the *critical hearing demand* for murrelets at sea.

When does masking occur?

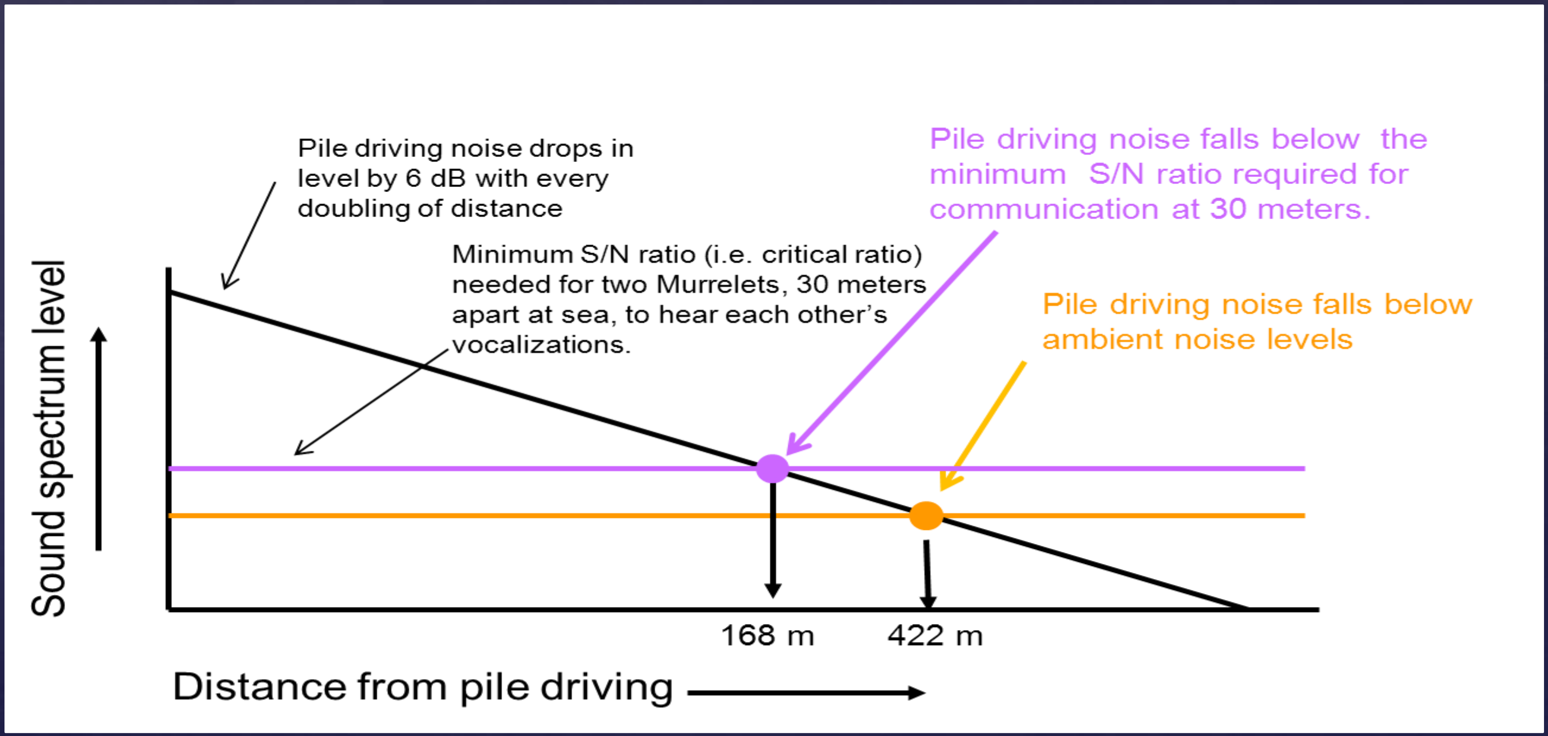
- When murrelets are 30 m apart, we estimate that the RL of the keer call is 60 dB (SL) (at 3 kHz).
- Subtracting* the 25 dB CR for detection and an additional 6 dB needed for recognition equates to 29 dB.
- Thus, pile driving sounds with a RL of 29 dB (SL) will mask communication.

Photo: Aaron Barna

*60 – 25 – 6 = 29 dB

Determining area affected by masking

- To determine the area affected by masking, solve for the transmission loss needed for the RL of the pile driving noise to reach 29 dB (SL).
- Used data from the Navy's test pile project in Bangor to estimate areas of effect.



Test Pile Data

- 36” diameter steel pile – area affected ~168 m
- 24” diameter steel pile – area affected ~42 m


Photo: E. Teachout

“Typical Pile Driving Project”

- 24” or 36” steel piles
- Installed with vibratory hammer
- Proofing only
- 2 hr. timing restriction (sunrise/sunset)

“Typical” Projects = Insignificant Masking

- “Typical” projects will not result in measureable effects
  - 2-hr. timing restriction
  - Proofing is short duration and intermittent
  - MAMU may employ behavioral strategies to overcome
  - MAMU vocalizations appear adapted to carry well at sea
  - MAMU vocalizations are long (~400 ms)

Photo: E. Teachout

Atypical Projects: Impact Only

- If impacting is constant, could impair communication. between foraging partners.
- Diurnal timing restriction can lessen severity.
- Will need project-specific analysis in coordination with USFWS.

Atypical Projects: Larger Piles

- Larger Piles
  - SL data unavailable.
  - Question is exposure.
  - Assumptions could be made to apply framework.


Photo: WSDOT

Atypical Projects: Other Pile Types

- Concrete is 2nd most common type.
- SL data are unavailable.
- Is the SL of a concrete pile similar to steel in frequency content and energy concentration?
  - One could assume that the SLs generated from concrete piles will pose the same risks for masking.
- Otherwise, project-specific analysis will be required.

Conclusions about Masking

- Masking is a demonstrated effect of anthropogenic noise and MAMU are exposed to the masking effect of in-air noise at sea.
- Masking is a potential effect in the marine environment because in-air pile driving noise can impinge upon important communication with conspecifics when the RL of the pile driving sound exceeds 29 dB (SL).
- For the typical project in Puget Sound the affected area will be between 42 and 168 m.

Overall Conclusions about Masking

- In the marine environment, NITS <40 dB is masked by ambient = no biological significance.
- No significant effects from NITS for MAMU that return to terrestrial habitat.
  - Critical hearing demands won't be impeded by non-injurious exposures
  - Some recovery is likely to occur during the time it takes an individual murrelet to transit to terrestrial habitat.

Overall Conclusions cont…..

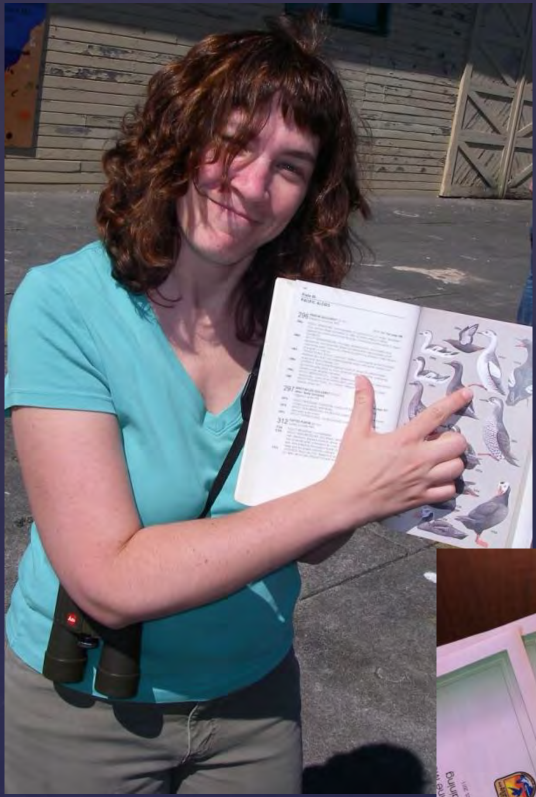
- At-sea, masking impinges communication within 30 m, concurrent with pile driving when the RL of the sound exceeds 29 dB (SL).
  - The area will vary depending on source levels and ambient conditions.
  - For atypical projects, 36” piles will result in a potential masking zone of 168 m and 24” diameter piles will result in a potential masking zone of 42 m.
  - Masking is not expected to result in measureable effects to individuals for typical impact pile driving projects.
  - Masking may result in measureable effects to individual murrelets for “atypical” projects.
  - Monitoring may be required in the masking zone (but…)

Murrelet Monitoring

- Monitoring for murrelets to avoid take from masking should only occur from shore based locations

Survey Protocol

- If monitoring is required, follow USFWS protocol and utilize certified observers



Information Needed for Masking Analysis

- Size of Piles (24” or smaller, vs. 36”)
- Impact installation or proofing?
- Project timing (Winter or summer? Or both?)
- Project location
- Number of piles
- Monitoring planned?


Photo: E. Teachout

Questions?

Western Yellow-Billed Cuckoo (*Coccyzus americanus*)

Proposed listing under the Endangered Species Act

DPS Proposed as Threatened

- Proposal in Federal Register on October 3, 2013
  - 78 FR 61621 61666
- Proposed as a Distinct Population Segment (DPS)
  - Distinct from populations in the east and has different habitat requirements
- Comments accepted through December 2, 2013
  - Can submit online at www.regulations.gov

Figure 2: Boundary of the Western Distinct Population Segment of the Yellow-billed Cuckoo

Critical Habitat?

- A proposed rule to designate critical habitat is scheduled to publish in the Federal Register later this year
  - Additional comment period

FEDERAL REGISTER

Range

- Neotropical Migrant
  - Winters in South America
- Occurs in western US in:
  - AZ, CA, CO, ID, NV, NM, TX, UT, WY, MT, OR, and WA
  - Also occurs in BC, Canada and MX
- DPS is delineated by Continental Divide

Canada
3 Bellingham Locations 1908 1915 1921
Friday Harbor
Mount Vernon
2 Tonasket Locations 1991 1992
2012 Sinlahekin State Wildlife Area
1990 Omak
Okanogan
Republic
1956 North of Coulee Dam
1991 Kettle Falls
Colville
2012 Little Pend Oreille NWR
Port Angeles
Port Townsend
Everett
1979 Sultan
2000 Mountainlake Terrace
2 Kirkland Locations 1909 1910
9 Seattle Locations 1894 1902 1907 1907 1909 1916 1923 1923 1997
1920 Lake Washington Vicinity
1974 Beaux Arts Lake Washington
1894 Seattle, South Park
Tacoma
1890 E. Fk. Humptulips River
1899 Willow Swamp, Puyallup Valley
Olympia
Montesano
1996 Vance Creek County Park
3 Tacoma Locations 1905 1940 1940
South Bend
Chehalis
Waterville
Wenatchee
Ephrata
Davenport
Spokane
Washington
1983 Turnbull NWR
Ritzville
1999 Moses Lake
Ellensburg
1978 George
2001 Lind
Colfax
Yakima
2012 Julia Butler Hansen National Wildlife Refuge
Cathlamet
Kelso
1999 Ft Simcoe State Park
Prosser
Pasco
1987 Sacajawea State Park
2007 Touchet River
2008 SE of Eureka
Pomeroy
Dayton
Asotin
Walla Walla
1990 Walla Walla County
1892 Ridgefield
1836 Vancouver
Stevenson
Goldendale
Oregon
N
0 15 30 60 Miles
For Internal Review Only
This map was produced by the Northern Idaho Field Office of the USFWS on 9/26/13.
No warranty is made by the U.S. Fish and Wildlife Service as to accuracy, reliability, or completeness of these data for individual or aggregate use with other data. Original data were compiled from various sources. Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.
Layers in this map include ESRI Basemap - USA Topo Maps, National Atlas of the United States data, and USFWS digitized project information.
Yellow-billed Cuckoo Location - Post-1993
Yellow-billed Cuckoo Location - Pre-1993
(WA Records, Teachout 2012)
Copyright:© 2013 National Geographic Society, i-cubed

Habitat

- Nest in low to moderation elevation riparian woodlands >50 acres
- Most nests are in willow (Salix spp.)
  - Also alder, cottonwood, and other species.
- Large home ranges
  - Most likely to be found in patches >200 acres

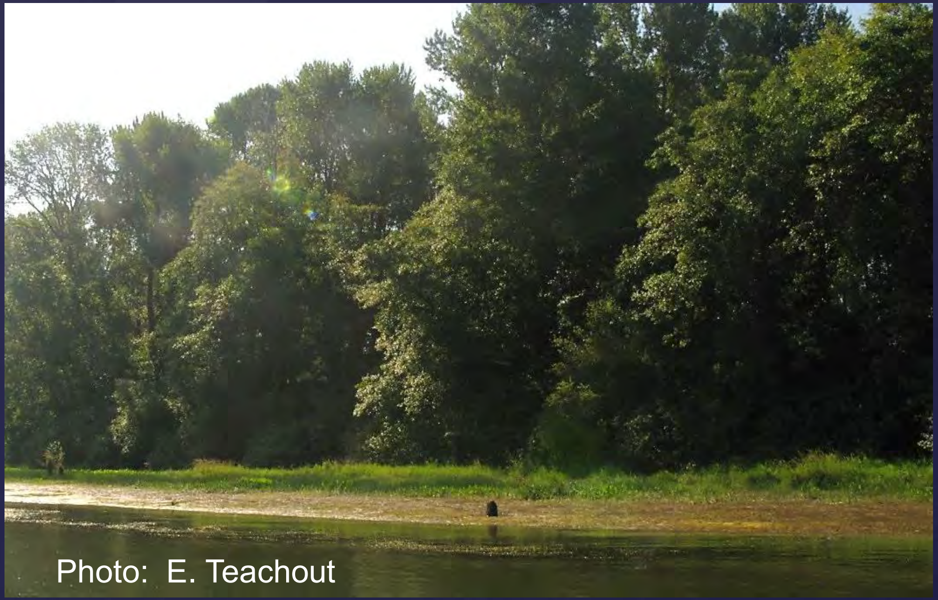


Photo: E. Teachout

Threats

- Destruction, modification, or curtailment of the species' habitat or range.
  - More than 90% lost or degraded
    - Dams
    - Water diversion
    - River flow management
    - Stream channelization/stabilization
    - Conversion to agriculture & grazing
    - Urbanization and transportation
    - Wildlife

Vocalizations

- Secretive, and hard to detect.
- Mated birds have a distinct “kowlp” call
- Unmated birds use soft cooing notes

http://macaulaylibrary.org/audio/180818

Breeding Season

- Arrive late
- Varies regionally based on prey availability
- Peaks Mid-June through August
- Up to three broods if prey are sufficient
- Incubation and nestling period is short
  - Incubation: 11-12 d
  - Fledging: 5-7 d

Considerations for Conferencing

- Proposed for listing wherever they occur in WA (statewide)
- All counties, no distinct pattern of occurrence
- Occur here during breeding season
- Suitable nesting habitat is willow/cottonwood forest >50 acres
- Preferred habitat is >200 acres
- Need abundant insect fauna to nest
- Survey protocol in existence but applicability in WA is currently undetermined

Photo: J. Bass

Contacts

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