Sonic Booms and their Effects on Wildlife

Past, Present, and Future

by

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PARSONS

Agenda

- Explain my background
- The past: overview & assessment of past SB research on animals
- The present: brief review of SB research
  - Ungulates
  - Domestic animals
  - Bird eggs
  - Birds
  - Raptors and a raptor model
  - Tortoises
  - Marine mammals
- The future: research areas to consider and NOT to consider (in my opinion)

My Background

- Retired US Air Force Officer
- Biologist, with MS degree from University of North Carolina
- Assistant Professor at Air Force Academy
- Asked to write a literature review on noise and sonic boom effects on animals (1986)
- Program manager for USAF research on noise & sonic booms (NSBIT) 1989-1994

More background.....

- Started first USAF program on noise effects on wildlife in 1989
- Chair the International Commission on Biological Effects of Noise, Team 7 (Noise & Animals)
- Presently work for Parsons

The Past……..

- Reviewed literature in 1986
  - There were more reviews than actual research
  - Main concern was for domestic animals
  - Main source was jet aircraft and helicopter noise
  - Main problem was that the research focused on the behavior of animals or physics of noise, but never on both
  - Mostly anecdotal information
  - No standards for effects or for the stimuli
  - Noise usually based on A-weighted sound levels

The Past……

- Initial studies were mainly in the laboratory
  - Relate noise to hearing effects in humans
  - Equipment didn't allow precise field work
- Wildlife studies did not measure the levels of the stimuli the animals experienced

Difficulties in studying noise effects on animals

- Observing the animals in the wild
- Difficult to measure noise exposures
- Species of concern are usually low in population size and laws restrict work
- Thousands of species
- Can’t interview animals
- Animals seem to habituate quickly
- Terrestrial animals usually not exposed for long periods or high levels

What has promoted the research?

- General environmental concerns by public and regulators
- Supersonic Transport (SST)
- Better understanding of acoustics
- Research on noise effects on humans
- Technology: computers, SLM, other electronics
- Global Positioning Systems (GPS)
- US Air Force in 1980s -1990s
- US Navy 1995- present for marine mammals
- Surface transportation industry

How to Identify Greatest Concerns

- Estes Park Colorado Conference- 1988
  - Invited researchers, environmental regulators, environmentalists invited to a conference
  - Asked: What species are at greatest risk?

    During what life stage does risk occur?
  - Developed a ranking process to achieve the Top 10 list
  - Tried to get consensus within the group

Possible acute effects of noise or sonic booms

- Startle effects causing adverse reaction
  - Run/trip resulting in injury to self or others
  - Run/trample young or injured
  - Increased heart rate, corticosteroids
  - Abortion or premature birth
  - Adult eating/destroying young
  - Adult birds cracking eggs
  - Abandoning young
  - Reveal presence when hiding or camouflaged
  - Expend energy fleeing during flight/fight response
  - Bleeding ears
  - Void water, critical during drought conditions
- Change in migration direction

Possible chronic effects of noise or sonic booms

- Physiological response causes lowered immune system, resulting in illness
- Unfitness may prohibit breeding
- Chronic noise may make habitats unsuitable
- Mask calls/communications to mates or members of same species
- Abandoning critical habitat

The Present.....

- Studies designed to show acute effects that will lead to chronic ones
  - Dose-response curves
    - Behavioral response
    - Physiological response
- Relating studies of similar animal types
  - Dose-response models based on similar species
    - Raptors, ungulates, waterfowl, etc
  - Must be accepted by environmental regulators

Sonic boom effects on ungulates

Sonic boom effects on ungulates

- Espmark (1972): Observed 24 reindeer during 3 days of sonic booms (0.35-7.0 mb, .73-1.46 psf) in enclosure; no injurious effects
- Workman et. al. (1992) studied the effects of noise & sonic booms on elk, pronghorn and bighorn sheep
  - Gandy range, Utah
  - Penned and free-roaming animals
  - Used a variety of stimuli
  - Measured heart rate and body temperature as indicators of physiological response
  - Also looked at behavioral responses

Sonic boom effects on ungulates

- Workman's study:
  - Tests only looked at acute effects; not able to connect to long term effects
  - Too small sample size used for detection of subtle effect
  - Were not able to discern actual level of stimuli
  - Used too many different stimuli
  - Stimuli were too close together (30 mins.) , so that possible effects were confounded

Sonic boom effects on domestic animals

Sonic boom effects on domestic animals

- Casady & Lehmann (1967): observed behaviors of domestic mammals and birds exposed to sonic booms (unkn levels); horses & cattle adapted quickly; poultry reacted stronger and less adaptation over time
- Espmark et. al. (1974): exposed cattle and sheep to sonic booms; momentary “strong” reactions occurred in both, but no injurious effects observed
- Travis et. al. (1974): tested kit survival of farm-raised mink; no adverse effect from three real 6 psf booms or three simulated 3.5 psf booms
- Reinis (1976): exposed lab mice to 1-5 psf booms; found blood clots in scala tympani with booms 3.3 or higher
- Reinis (1987): exposed guinea pigs to 100 booms (4 psf) at 1 sec intervals; observed 44 dB threshold shifts

Sonic boom effects on domestic animals

- Boutelier (1967): Observed Army dogs in training reacted to booms
  - heart rate: rate increased 0-20 beats/min for 20-30 secs
  - behavior: some dogs showed aggression; some adapted to disturbance

Sonic boom effects on bird eggs

Sonic boom effects on bird eggs

- Sooty Tern incident in the Dry Tortugas- 1969
  - Oliver Austin et. al. reported nesting failure of 50,000 Sooty Terns in Dry Tortugas
  - Researchers had considered and rejected many possible explanations for the failure
    - Predators, food shortage, pesticides, human intervention, abnormal weather
    - Could rule out everything except sonic booms caused by recent supersonic overflights in early May
    - Couldn't explain successful nesting Noody Terns
  - Abstract cited in numerous environmental documents as "evidence" of sonic boom damage

Sonic boom effects on bird eggs

- In my 1986 paper I recommended testing the hypothesis
- Ann Bowles designed a simple shock wave test as a worst scenario
  - Used a class-C explosive to create 170 dB re 20μPa (138-144 dB CSEL)
  - High onset time (100-400 μsecs)
  - Used fertilized and unfertilized chicken and quail eggs
  - Did not observe any significant effects

Sonic boom effects on bird eggs

- Criticism with the type of stimulus used, we designed a more realistic study in a sonic boom chamber
  - Exposed chicken eggs to 3, 20 and 30 psf booms
  - Exposures occurred throughout incubation
  - None of the exposed eggs cracked
  - All chicks hatched were normal
  - Resonance egg frequencies 6-7 octaves above peak energy of simulated sonic booms
  - Higher hatch rate in groups exposed to 20-30 psf booms; this is not an abnormal phenomenon

Sonic boom effects on bird eggs

- Ting, Garrelick and Bowles (2002)
  - Performed mathematical analysis of the response of avian eggs to sonic boom overpressures.
  - Determined that it would take a 250 psf boom to crack an egg
  - The highest documented sonic boom was by an F-4 at Mach 1.26, 95ft AGL; boom was 144 psf

Sonic boom effects on bird eggs

- Teer and Truett (1973)
  - tested quail eggs to 2, 4, & 5.5 psf booms in lab; no adverse effects
- Keller (1971)
  - exposed chicken eggs to 2 and 10 psf booms; no adverse effects; higher booms unrealistic
- Heinemann (1965)
  - exposed >3,400 chicken eggs to 3-18 psf booms; no adverse effects

Sonic boom effects on birds

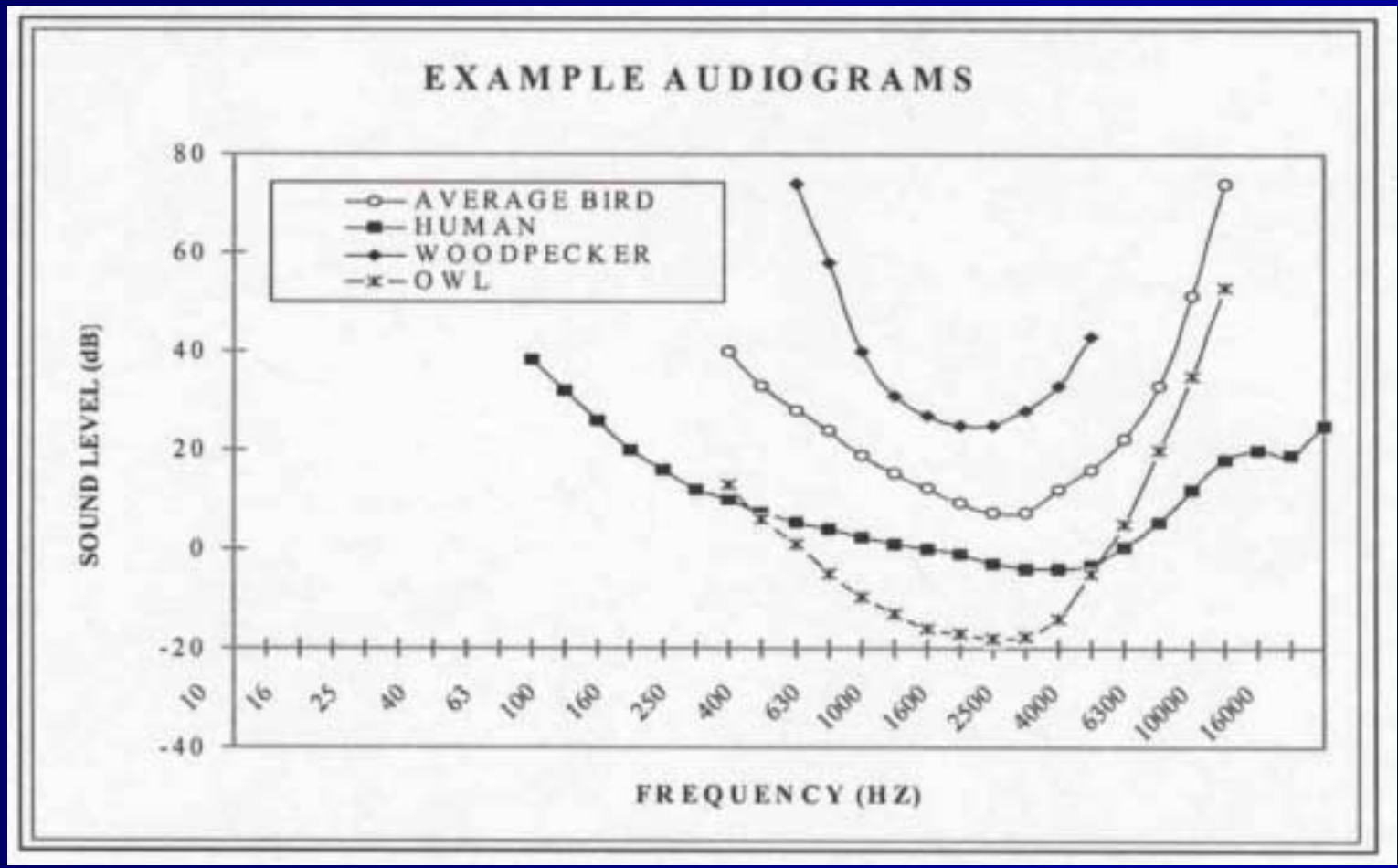
Sonic boom effects on birds

- Teer and Truett (1973):
  - Examined reproductive success in 4 species of wild birds of 1 psf or greater booms; no adverse effect
- Higgins (1974):
  - Observed songbirds sensed seismic signal through ground and stopped singing 4-8 secs prior to audible boom
- Schreiber & Schreiber (1980):
  - Cormorant and Western Gull reacted to shotgun blasts and carbide cannons; some nesting birds stand and walk 4-5 steps; head-jerk motions in many; seem to habituate quickly; non-nesting birds may react by flight reaction

Red-Cockaded Woodpecker Study

- Delaney et al. (2000)
  - Tested RCW response to .50 caliber blank fire and artillery simulators
  - Monitored RCW response to helicopter noise, military vehicle disturbance, and large caliber weapons
  - Noise levels 58-119dB
  - 53-91dB RCW Weighting

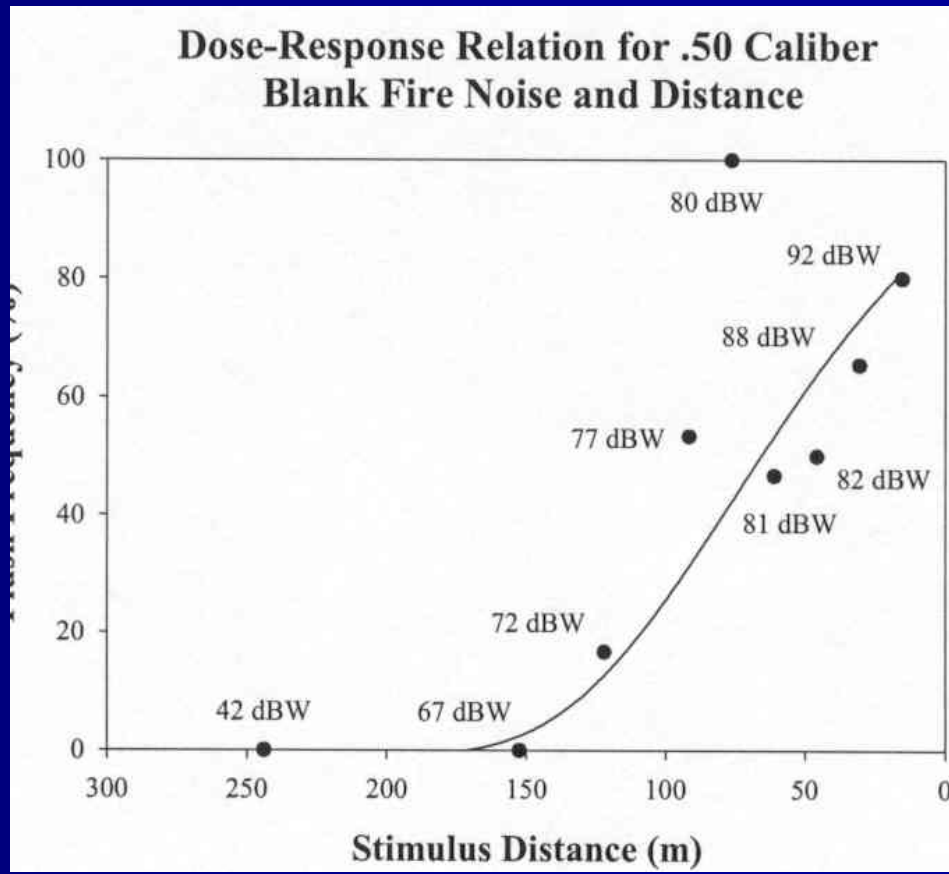
Red-Cockaded Woodpecker Study



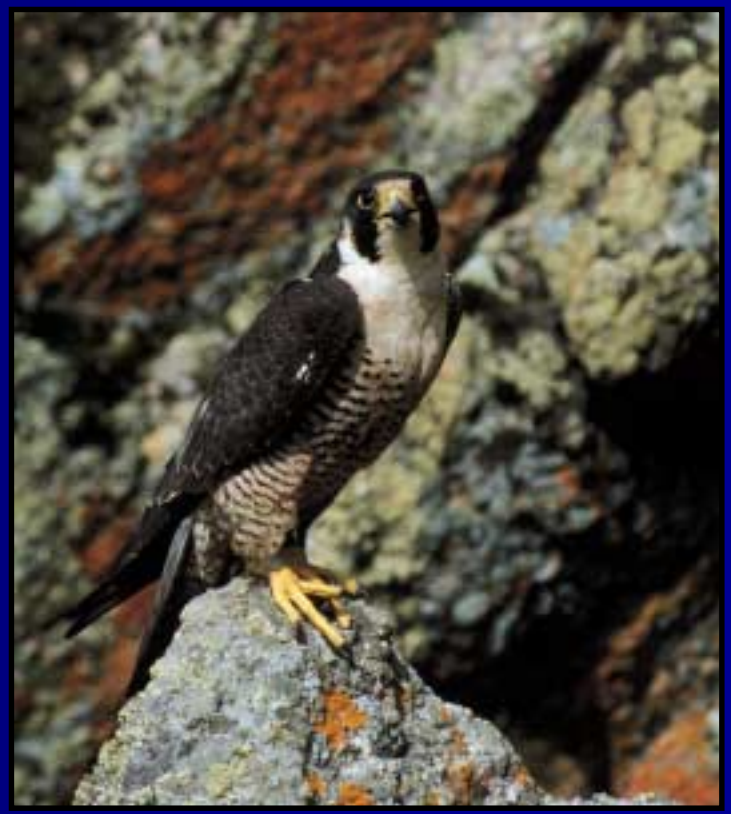
Red-Cockaded Woodpecker Study

RCW Study Findings:

- Disturbance did not affect
  - nesting success
  - productivity
- Flush response increased as stimulus distance decreased
- Unweighted noise levels in cavities considerably higher than at tree base



Sonic boom effects on raptors



Sonic boom during Peregrine feeding nestlings

Peregrine disturbed by gunshot

Feeding nestling Peregrine alerted during sonic boom

Peregrine watching low-flying jet aircraft

Sonic boom effects on raptors

- Literature synthesis by Awbrey and Bowles (1990)
  - Physical effects on raptor hearing
    - Most are not particularly sensitive
    - Damaged hair cells regenerate
    - Exposures are intermittent and not intense
    - Some raptor calls are most likely quite high in amplitude without effects
  - Effects on raptor reproduction
    - Disturbance causing site abandonment- raptors abandon sites regularly, so difficult to test

Sonic boom effects on raptors

- Abandonment: direct evidence is weak
- Effects of sonic booms on hatchability: no evidence to support theory
- Effects of disturbance on hatchability: some observations, but most used human disturbance as criteria; perched birds more prone to fly (78%) than incubating birds (36%) or brooding birds (18%)
- Time spent off nest after startle: Holthuijzen reported 6.5 mins mean time for recovery; hunting flights longer than 30 mins

Sonic boom effects on raptors

- Parents knock eggs out of nest: losses are rare; many times perching bird flushes while incubating bird is alerted
- Exposure of eggs or nestlings to unfavorable weather: raptors are more resistant to flushing in inclement weather
- Exposure to predators: is possible, but not tested
- Premature fledging: caused by human disturbance, but never reported as a result of noise disturbance

Ellis (1981)

- Exposed 8 species of raptors; 40 nests

>1000 aircraft overflights; 100 simulated sonic booms

- No naïve birds tested; controls were also exposed to aircraft overflights to lesser degree
- Observed high variability in responses, but no observable negative effects
- Good anecdotal information; little conclusive evidence

Preliminary Raptor Model

- Bowles & Awbrey (1990)
- Straw-man model developed to predict noise effects on raptors
- 0.005 eggs per overflight (10% eggs lost w/ 50 eggs exposed to 100 overflights <150m or >95dB)

Sonic boom effects on Tortoises

Sonic boom effects on Desert Tortoises

- Bowles, Eckert, Starke, Berg and Wolski (1999)
- Concern from F-22 supersonic flights
  - Carpet booms up to 8 psf, 100ms duration
  - F-22 testing at Edwards AFB, CA and Nellis AFB, NV
- Two successive 6 psf booms in sonic boom test facility showed no significant TTS
- Ten successive 4 psf booms caused 5-20dB TTS in 5 of 9 tortoises; 4 recovered within 1 hr; 1 recovered within 48 hrs
- Simulated overflights caused freezing in 30% of initial tests (up to 113 mins); habituation was rapid
- Heart rate, metabolic rate and body temperature were measured, but inconclusive regarding effects

Sonic boom effects on marine mammals

Sonic boom effects on Marine Mammals

- Pinnipeds (seals and sea lions)
  - Stewart (1993): 129 peak, flat spl caused hauled harbor seals to enter water
  - Stewart (1981): Northern elephant seals and California Sea Lions exposed to simulated sonic booms of 125-147dB (flat) caused no adverse reactions
  - Bowles & Stewart (1980): observed major disturbances from sonic booms to harbor seals, Northern fur seals, California sea lions; elephant seals less likely to be disturbed
  - Perry et. al. (2002): Observed gray seals and harbor seals during breeding season prior to, during and after sonic booms from SST; average overpressure 0.9 psf. Harbor seal males more vigilant; heart rates and behaviors were not significantly different in all other cases

Sonic boom effects on Marine Mammals

- Pinnipeds continued:
  - Stewart et. al. (1993) California sea lions stampeded into water during sonic booms; elephant seals unaffected

Sonic Boom Research NOT Worth Considering

- SB effects on bird eggs or their hatchlings- no evidence of any effects
- SB effects on marine mammals underwater- SB levels too low compared to sound levels animals generate

Sonic Boom Research to Consider

- Waterfowl: virtually no research has been done on SB effects; only anecdotal observations
- Colonial nesting birds: anecdotal information and responses to aircraft noise give some indications that research maybe warranted
- Caribou: considerable amount of work done on disturbance; physiological and behavioral responses to SB would be worthwhile

Sonic Boom Research to Consider

- Nestling birds at critical stages: startle effect when nestling passerines are at a critical stage and flushing would be detrimental

Additional Information Requested

- Most recent compendium: IBON, 1999
- Flares and chaff: See next slide
- Names in USFWS and others: need more information

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