The Effect Of Noise On Wildlife: A Literature Review

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Abstract: Noise pollution, as it effects humans, has been a recognized problem for decades, but the effect of noise on wildlife has only recently been considered a potential threat to animal health and long-term survival. Research into the effects of noise on wildlife, which has been growing rapidly since the 1970s, often presents conflicting results because of the variety of factors and variables that can effect and/or interfere with the determination of the actual effects that human-produced noise is having on any given creature. Both land and marine wildlife have been studied, especially in regards to noise in the National Parks System and the onslaught of human- made cacophony in the oceans from military, commercial and scientific endeavors.

Most researchers agree that noise can effect an animal's physiology and behavior, and if it becomes a chronic stress, noise can be injurious to an animal's energy budget, reproductive success and long-term survival. Armed with this understanding it should follow that humans would attempt to minimize the threat to wildlife by reducing the amount of noise that they are exposed to in natural areas; but this has not been the situation. Natural areas continue to be degraded by human-made noise, wildlife continues to suffer from these disturbances, and to date the majority of the debate revolves around the egocentric demands of people to either produce more noise in nature (through motorized recreation, scientific research, military exercises etc.) or experience natural areas in the absence of anthropogenic noise. Neither side has adequately addressed the issue from the biocentric view of wildlife and the known, or as yet undiscovered, damage that our increasingly noisy human-altered environment is inflicting upon them.

Table of Contents

INTRODUCTION

People are becoming increasingly aware of and disturbed by the cacophony of sounds in the environment. More often than not these sounds are loud, intrusive and unwelcome side-effects of our fast-paced, progress-motivated society. While tolerating noise in our urban and even suburban environment may seem like a necessary compromise for the services, improved construction and transportation we receive in return, noise in the natural

environment is much less palatable. As more and more people seek temporary escape from the confines and clamor of the built environment and seek solace in our National Parks and other land and water wilderness areas, they are noticing the absence of quiet, let alone natural silence that once predominated a wilderness experience.

As avid environmentalists and weekend naturalists alike rally a defense against the noise-makers in industrial tourism, the military, commercial airlines, and scientific research, a nagging question lurks in back of some minds: What about the animals in these noise-riddled environments? In many areas wildlife are being subjected to noise at a greater frequency and intensity than perhaps ever before in their evolutionary history. While noise has been considered a pollutant in the human environment for decades, noise in the natural environment has not been framed as such until quite recently.

Although we recognize that noise can affect humans psychologically and be physically injurious, little attention has been paid to the potential effects that noise may have on individual animals and populations within an area. This ignorance of the potential harm that could be caused by our own actions and the inertia with which research and concern about the issue has grown is symptomatic of the anthropocentric way in which we value and view the world. Wanting to reduce the human-produced din in natural areas for the sake of our solitude is not unjust, but failure to consider the effects on other life within those areas epitomizes the arrogance and egocentrism with which we typically approach and subsequently degrade the environment. We must ask ourselves, as the debate over man-made noise in natural areas becomes more heated, how much we value life beyond that which exists in the human form. Are we willing to protect wildlife from the onslaught of airplanes, helicopters, ships and scientific experiments that generate colossal noise at the expense of our traveling convenience, our military advancement, and scientific discovery? The verdict is yet undecided because to date we do not have conclusive evidence of the effects of noise on wildlife (which in and of itself may be indicative of our apathy and lack of inclination to discover the effects expediently).

The following discussion will introduce the problem of noise in natural areas, review both historical and more recent research into the effects that noise may inflict on wildlife, and disclose the current challenges and policies that are facing the American people today in choosing between natural quiet and other desirables of civilization.

DETERMINING THE EFFECTS OF NOISE ON WILDLIFE

The study of acoustic ecology began in the late 1970s, but it has just recently been recognized as a useful means for determining the health of both marine and terrestrial habitats (Krause, 1993). In his article "Niche Hypothesis", Bernard Krause suggests that every creature has an "aural niche" or its own particular voice and specific place in a habitat based on the relative frequency, amplitude, timbre and duration of the sound it produces. Taken together, the vocalizations of all the creatures in a given habitat zone produce a unique vocal fingerprint which Krause believes can be used to infer the biological integrity of the area. With increasing destruction and loss of habitat, many creatures are forced into different areas with consequently different aural zones in which they lack an established niche. The inability of creatures to successfully communicate or otherwise employ their auditory senses is detrimental to the long-term survival of these displaced creatures and the overall biological intergrity of the environment. Krause thus argues that in natural areas "...the sounds of each of these zones are so unique and important to creature life in a given location..." that disturbance to this soundscape could be detrimental to the future of the individuals, populations or entire species (Krause, 1993).

Determining the effect of noise on wildlife is complicated however because responses vary between species and between individuals of a single population. These variable responses are due to the characteristics of the noise and its duration, the life history characteristics of the species, habitat type, season, activity at the time of exposure, sex and age of the individual, level of previous exposure, and whether other physical stresses such as drought are occurring around the time of exposure (Busnel, 1978).

In determining the effects of aircraft stimuli on wildlife Congress issued a report that collaborated the complexity of determining the effects on wildlife due to the various factors that influence an individual's response. Chapter Five of the Report on the Effects of Aircraft Overflights on the National Park System discusses the differences in perception of stimuli based on the physical environment and the psychological attributes of the animal at the time of its exposure. The report states that: "Some habitats enhance stimuli associated with aircraft overflights. The sound and visual stimuli associated with aircraft have different effects in an open desert than in a forest where trees can obscure the sight and may reduce the sound of aircraft." In addition the report surmised that "One relationship between aircraft and animals is clear: the closer the aircraft, the greater the probability that an animal will respond...Unfortunately, there is no particular overflight altitude at which all animals are or are not disturbed." Thus determining the effects of noise on wildlife is not an easy endeavor. The following section will examine the historical studies that often support the findings of Congress and that helped direct the most recent research and discoveries.

RESEARCH INTO THE EFFECT OF NOISE ON TERRESTRIAL WILDLIFE DURING THE 1970s

The 1970s heralded an increase in scientific interest into the effects of noise on wildlife. In 1975 Dorrance et. al published an article that probed the issue of the effects of snowmobile noise on white tailed deer. Between 1973 and 1974 they studied the responses of a population of Odocoileus viginianus in Minnesota's St. Croix State Park that was exposed to up to 195 snowmobiles per day compared to the responses of a control population on Mille Laes Wildlife Management Area that had never been exposed to snowmobile noise. While the deer at St. Croix State Park seemed to have become habituated to the noise of the snowmobiles due to years of previous exposure, the deer at Mille Laes Wildlife Management Area appeared to increase their home range size and avoided the snowmobile trails as snowmobile activity increased. In Mille Laes "deer responded to very low intensities of intrusion by man and vehicles. Some deer were particularly sensitive to intrusion by man and vehicle and changed their home ranges to entirely different locations." The scientists acknowledged that this avoidance of snowmobiles and the extra movement that avoidance necessitates could change the Mille Laes deer's energy budgets such that they would be expending more energy than they were conserving. The resulting energy deficit would thus endanger the animals' health during the winter season.

Even though the St. Croix deer appear habituated to the stimuli of snowmobile's the researchers recommended that in both populations the snowmobilists should avoid areas of high deer concentration and avoid use of any one trail on consecutive days to minimize detected and possible undetected injurious effects.

Noise: The New Menace was published by Lucy Kavaler in 1975 and included various sections on the hazards of noise to wildlife. Kavaler reminded readers in the mid 1970s that the first determinants of the effect of noise on wildlife were conducted in laboratories rather than in the field. During these studies it was concluded that the most readily observable effect was harm to hearing and/or deafness due to damage to the sensory cells of the inner ear and

adjacent nerve endings and hair cells. Disorientation, nausea, and signs of alarm were also common responses. Kavaler also called attention to the study of the little cotton rat which "...however fragmentary, is one of the few that has been made anywhere to date that considers the possible effect of noise on the ecosystem of an area."

The study of the little cotton rat, Sigmodon hispidus , was conducted at Cape Kennedy Regional Airport in Melbourne, Florida and compared a population in a high noise corridor to a population a few hundred feet away. The density of the rats in the high noise corridor was 2.58 animals per acre while the population at a greater distance from the airport was as dense as 10.3 animals per acre. The study revealed that the little cotton rats closer to the airport were more timid and less social then their counterparts farther from the noise and researchers thus concluded that noise was the cause of "...general behavior differences between the two groups" (Kavaler, 1975).

Noise: The New Menace also reported on early research into the effects low flying supersonic aircraft on Dry Tortugas Sooty Terns. The population of Florida birds averaged 25,000-30,000 fledglings during their hatching seasons until 1969 during which a 99% failure rate in hatching occurred. In that same year low flying supersonic aircraft began repeated pass-overs of the nesting areas of the sooty terns. National Parks Service biologist Dr. W.B. Robertson Jr. blamed the sonic booms associated with these military flights because the noise presumably caused the mother birds to panic and fly from the nests. Sudden escape often ejected eggs from the nest or left the nest open to predation and neglect in the mothers' absence.

In addition to population decimation of birds through fledgling failures, Kavaler also noted the possible disruption to animal communication that would result as human-made noise encroached on the natural environment. She noted that "the bat, relying totally on echo location, is unable to find food when interference is produced by natural or mechanical means." A similar threat would also exist for marine mammals and others who depend on echo location for finding prey, mates or determining their migration routes. As Kavaler astutely observed, and as scientists continue to lament today, "no adequate answers are available to questions to the possible harm of such booms, known to be startling to man and animals, to life above and below the surface of the ocean."

In 1976 Calef et. al published "The Reaction of Barren Ground Caribou to Aircraft" at the conclusion of their studies of fixed winged aircraft and helicopters in Alaska and northern Yukon. In determining the possible effects of noise on the caribou populations they considered the effects of aircraft altitude, the type of aircraft, season, terrain, and the activity and size of the caribou that were exposed to the aircraft. The two year study (1973-1974) focused on the Porcupine Herd of Rangifer tarandus, which included 736 groups of caribou and four different types of aircraft. Calef and his associates grouped the responses of the caribou to the aircraft into five categories: panic response, strong escape response, mild escape response, stationary response and no visible response. They observed that panic reactions (animals out of control, colliding, stumbling etc.) and strong escape responses (trotting, running for long distances) were common in a high percentage of all groups when the aircraft flew at or below 60 meters. Thirty to 65% of all groups continued to exhibit these responses for altitudes up to 150 meters. However, they also noted that "the activity of caribou at the time of observation influenced their response to the aircraft." For example, when the caribou were traveling, feeding, and at river crossings their reactions were greater than when they were resting. During spring and fall migrations, while on calving grounds, in pre-rut conditions and during cold weather in early winter, the caribou were more likely to exhibit panic and strong escape responses. Calef et al. noted that neither the size of the group, the terrain, nor the vegetation contributed any significant effect on the caribou's response to the noise. In differentiating between the fixed winged aircraft and the helicopters, the researchers noted

the extra abilities of helicopters to hover and more closely pursue animals. According to their article "...following is the most dangerous from of harassment, and is possible only with a helicopter."

At the conclusion of their study, they determined that in panic responses the caribou were most in danger of injury through collisions with each other and stumbling on obstacles, whereas sustained running in the strong escape responses would create a less immediate, but equally great danger. Running in cold weather not only promotes pulmonary disorders, but it also creates a large depletion of energy reserves which is particularly harmful during the stresses of long winters and insect harassment when conservation of energy is critical to the animals' survival. While this study provided seemingly conclusive evidence that noise can indeed have a detrimental impact on wildlife, or at least caribou in particular, other studies have not concurred.

In the study, "Eastern Wild Turkey Responses Induced by Sonic Booms," Lynch and Speake placed 164 Megahertz transmitters in the habitat of twenty wild turkeys and exposed them to real and simulated sonic booms. The turkeys would generally stand at attention, and often run for four to eight meters when exposed to the sonic booms, but within thirty seconds they would return to their previous activity. According to Lynch and Speake "the results of this study indicate that sonic booms do not initiate abnormal behavior in wild turkey that would result in decreased productivity. The reaction is usually slight and they seem to adapt readily to further booms." The disparities between this and the aforementioned study of caribou is indicative of the difficulty in assessing the problem of noise pollution. One species may be more or less affected than another, different noises have correspondingly different effects, and even individuals within the same species may have dissimilar responses depending on any number of physiological and location differences. Reconciling these difficulties is but one of the challenges for scientists and policy makers.

Publication of the book The Effect of Noise on Wildlife alleviated some of this confusion by providing a thorough summary of the physiological and behavioral responses that wildlife generally experience when introduced to human-made noise (Busnel, 1978). Physiological responses to noise include an increased heart rate, and altering of metabolism and hormone balance. Behavioral reactions consist of head raising, body shifting, trotting short distances, flapping of wings (birds), and panic and escape behavior. According to the text, the coupling of these effects has the potential to cause bodily injury, energy loss, a decrease in food intake, habitat avoidance and abandonment, and reproductive losses. This text exemplifies how the historical research served to frame and direct subsequent research by providing various foci for later studies.

RESEARCH INTO THE EFFECTS OF NOISE ON TERRESTRIAL WILDLIFE DURING THE 1980's

Richard Knight exposed the problematic interaction between bald eagles and boating activity in 1984 with his study of wintering populations that are closely associated with open water used for motorized recreation. He noted that the rapid motion of boats allows them to impact large areas in short periods of time which increases the probability of negative repercussions on the eagles nesting along the shore lines. The boat noise disrupted feeding activity which reduced the eagles' energy intake, while avoidance flights simultaneously increased the energy expended by the eagles, thereby magnifying their energy deficit. With continued exposure to the motor noises the eagles had a decreased tendency to fly away, but Knight was unable to determine as to whether this was a result of habituation or a consequence of decreased food availability farther from shore. As with any other study on the effects of noise on wildlife, this study was complicated by the fact that it is impossible to isolate the noise

from other factors influencing the behavior and physiology of an animal.

The publication of "Elk Calf Responses to Simulated Mine Disturbances" added a new type of sound to the field of research into noise pollution in the natural environment (Hompland, 1985). This study assessed the calf movements, habitat selection patterns and survival of Cervus elaphus when exposed to sounds similar to those encountered in mining operations as compared to a control population. The researches found that calves exposed to the noise moved greater distances, used larger areas, and lacked selection for favorable physiographic parameters. Cow and calf pairs also readily abandoned their traditional calf rearing areas, but cows did not abandon calves in the noise-exposed population. Researchers worried that calves could imprint on the less favorable habitat and continue to use marginal areas even after the noise source was removed which would likely reduce their chances of long-term survival. In addition, the effects of exposure to mining disturbances "...are cumulative and could result in reduced calf survival or aborted fetuses in cows," thus endangering the survivorship of the entire population. In regards to mitigating the potential of long-term effects of mining noise on elk and other wildlife, the researchers intimated the need for federal and state involvement in the planning process of mining to prevent or minimize unnecessary exposure through fragmentation of critical elk habitat. Suggestions for eliminating or minimizing the impact of noise on wildlife, which was largely absent in earlier research, became more prevalent with the transition into the 1980s with the increasing awareness of the problem.

Krausman et. al presented a different view of the effect of noise on wildlife in their 1986 publication: "Desert Mule Deer Response to Aircraft." During May-September 1984 they studied twenty two Odocoileus heminonus crooki in the Picacho Mountains of South-central Arizona. Through the use of radio collars they hoped to determine whether these deer altered their habitat use in response to aircraft overflights between thirty and 300 meters in altitude. Krausman et al. determined that "whether a deer changed habitats as a result of overflights was independent of the average height of the aircraft." Ninety seven percent of the time "desert mule deer in South-central Arizona rarely responded to aerial overflights by changing habitat." They speculated that the deer had become habituated to noise because the Picacho Mountains border an interstate highway that serves Tucson and which is followed regularly by aircraft. Thus, we are again presented with a divergent view that refutes the concern for the injurious effects of noise on wildlife populations, but attests to the diversity of responses that researches continue to discover.

In order to address this conundrum, the U.S. Fish and Wildlife Service in cooperation with Ecological Services, field offices, refuges, hatcheries, research centers conducted a survey in January of 1987 that focused on the perceived effects of aircraft noise and sonic booms on fish and wildlife. The survey asked directors and supervisors of the aforementioned locations about the impact on species, populations, and habitat utilization as a result of aircraft induced impacts. They were to document the reaction of animals to the aircraft on a scale from no known adverse effect, to animals abandoning the area, to death (such as at a hatchery in response to intense sonic booms). In summarizing the results of the survey, the Fish and Wildlife Service concluded that helicopters engender a greater flight/fright response, waterfowl are most frequently disturbed by aircraft - especially colonial nesting species and that, impacts to all wildlife range from minor behavioral responses to severe changes in the use of an area.

From the data collected and the suggestions of directors and supervisors, the Fish and Wildlife Service made several recommendations including the need for better relations with the FAA, airport operators, and military bases such that discussions of the effects of aircraft operations on fish and wildlife could be openly and productively pursued. The directors and

supervisors also suggested that a clearing house be created to disseminate information about the actual and potential affects of aircraft on wildlife which would be gathered as a result of continued research. This survey served as a much needed impetus for further research and expanded interest in the problem of human-produced noise in natural areas.

RESEARCH INTO THE EFFECT OF NOISE ON TERRESTRIAL WILDLIFE DURING THE 1990s

Harrington and Veitch published "Short Term Impacts of Low-level Jet Fighter Training on Caribou in Labrador" in December of 1991 at the conclusion of their 1986-1988 studies of ten Rangifer tanrandus. Satellite telemetry, video tape, visual observations, and radio collars were used to determine the effects of exposure to noise by indirect measurement of the caribou's daily movements and activity levels. They observed that the usual response of the caribou to the jet overflights was a startle reflex (an activation of the sympathetic nervous system) which induced bolting and running. This reaction was intensified when the jets made a direct overpass. Because it is a reflex action, it is unlikely that the caribou would habituate to the noise. Harrington and Veitch noted that the startle response, although short-lived, did pose a threat during calving season by increasing the likelihood of: cow and calf separations, injuries to newborn calves (if the mother were to bolt) and stillbirths. Such panic during a thaw might also cause the caribou to become mired in wet snow.

The researchers also hypothesized that the stress caused by overflights may cause mother cows to produce less milk and calves to have reduced thyroid function which would slow their growth and thus increase their probability of death through predation. While the startle reaction had the greatest impact on the caribou, Harrington and Veitch did not find a significant increase in overall activity level in animals that were deliberately overflown on a daily basis. "Neither the twenty-four hour activity index nor the daily distance traveled was consistently related to the degree of exposure to low level flying aircraft," which they attributed to the short-lived nature of the caribou's reactions. The study concluded with a recommendation by the authors that in order to minimize actual and as yet undiscovered impacts, flightpaths should be monitored so that excessive exposure of specific areas could be avoided - especially during calving.

A study of the potential effects of helicopter noise on big horn sheep time budgets in the Grand Canyon by Berger et. al looked at if and/or how food intake might be impaired. They found that during the winter Ovis canadensis nelson were more sensitive to noise such that the sheep experienced a forty-three percent reduction in foraging efficiency. In the spring however, they found no significant effect in foraging efficiency. The disturbance threshold they calculated for big horn sheep in regards to helicopter altitude was 250-450 meters which lead them to hypothesize that the difference in disturbance between spring and winter was due to the migration to lower elevations in the spring which created a greater distance between them and the helicopter. Minimizing the effects to big horn sheep in the Grand Canyon would be achieved by limiting the helicopter flights to the spring and/or maintaining at least 450 meters between the helicopter and the animals. As with the previous studies, this study does not go so far as to propose the elimination of such flights, nor does it address the possible incompatibility of human-made noise in the natural environment. Later into the 1990s however, this recognition of dissonance between noise and nature became more apparent and publicized, but all too often the reports ignored the wildlife aspect and focused instead on the impact to our human wilderness experience.

A 1996 study "Effects of Simulated Jet Aircraft Noise on Heart Rate and Behavior of Desert Ungulates," questioned the management objectives of public lands and the congruity of allowing military airspace to be underlain by National Parks and other wildlife refuges given

the disturbances created by the noise of their engines. The purpose of the study was to determine the cardiac responses (immediate and long-term) of desert mule deer and bighorn sheep to simulated low level aircraft noise and to establish whether or not the animals become habituated to such exposure. The animals were implanted with heart rate monitors and studied over three twenty-eight day sessions during the summer, late summer and early spring during which overflight frequencies ranged from one per day to seven per day.

During the summer and late summer desert mule deer exhibited a significant increase in heart rate one minute before an aircraft passed overhead and during the overpass, but no significant increase was detected beyond two to three minutes after the overflight. During the spring their heart rates were significantly elevated before, during, and up to three minutes following the overflight. Big horn sheep had significantly elevated heart rates at the time of the overflights and for three minutes after the aircraft passed during the two summer seasons, but during the spring a significant increase in heart rate was only observed during the direct overpass. For both deer and sheep the intensity and frequency of alerted and alarmed responses to aircraft was greater in the summer than in other seasons. This finding was consistent with past studies as was the finding that aircraft that generated louder noise caused greater elevations in heart rate.

The researches concluded that "the animals in this study habituated rapidly and probably did not view this stimuli as a threat. The frequency and noise level were not detrimental to their well-being" nor did it inhibit their reproductive mechanisms. Direct, unexpected human harassment was deemed a greater threat to the animals' health than the noise produced by such things as aircraft and mining disturbances.

A different study in the desert, that of the kangaroo rat and the sidewinder rattlesnake, painted a rather contrary picture of the effects of noise in that habitat. Richard Immel's article "Shhhh...those `peculiar people' are listening" observed that in the desert "...man-made noise is the enemy - and it's more serious than a mere distraction" (Immel, 1995). In determining the effects of dune-buggy noise on the desert kangaroo rat the article stated: "the roar of a dune-buggy engine can temporarily disable a reflexive defense of the desert kangaroo rat against one of its archenemies, the sidewinder rattlesnake. The rat normally can hear the snake at 30 inches, which gives it time to kick sand in the snake's eyes and escape. But the engine noise deafens the rat and virtually eliminates its defensive hearing. Until the rat's normal hearing returns, several days later, the snake often wins in an encounter" (Immel, 1995). The dissimilarity between this and the aforementioned study of desert ungulates again demonstrates the diversity of effects that noise can have among and between species and the ensuing difficulty the scientific community has in presenting definitive evidence for wildlife as a whole. Issues of management and protection become a morass when each species could potentially have different thresholds of disturbance.

In accordance with the side that purports the maleficent effect of noise on wildlife was a February 1997 report that announced a pending agreement between federal wildlife and aviation officials concerning bald eagles near Denver Airport. Fish and Wildlife representatives charged that planes taking off west or landing east on runway 7125 were in violation of the Endangered Species Act because the noise of the aircraft was effectively driving up to thirty bald eagles from their roosting site in a grove of cottonwoods on the east side of the Rocky Mountain Arsenal. In escaping the noise the birds were forced into less secure roosting areas including trees amongst lakes and industrial areas that had been heavily polluted during four decades of pesticides and chemical weapons production.

In order to comply with the Endangered Species Act and return the eagles to their cottonwood sanctuary, federal aviation officials agreed to re-route planes away from this

sensitive winter habitat. Although not what many people would consider a `natural area' the habitat is crucial to the long-term survival of that bald eagle population and thus necessitate a reprieve from the hazards of human-produced noise. It is interesting however, that this decision was made in favor of wildlife while in other, more `natural' areas, the issue of wildlife and their right to a quiet environment is dismissed in deference to the rights of humans to either create noise or seek solitude from it. Perhaps the enforcement of the Endangered Species Act is what saved the eagles and not some revelation in regards to the perilous effects of unnatural noise and our duty to protect other creatures.

NOISE IN THE NATIONAL PARKS

"The first government official to note what air traffic might do to the National Parks was Secretary of the Interior Harold Ickes in 1934. He stated that he did not see any sense in looking at parks flying by at one hundred miles an hour" (Lee, 1994). Since Ickes' statement over sixty years ago the problem has worsened significantly for humans and wildlife alike, but looking at the media publications one would think this was only a problem that affected humans. However, somewhat surprisingly, Congress has periodically addressed the issue of human-made noise in our National Parks from the perspective of its effects on wildlife. In the 1994 Report to Congress entitled "Report on the Effects of Aircraft Overflights on the National Park System," Chapter Five was dedicated to detailing the effects of overflights on wildlife. The report discussed physiological and behavioral responses to overflights, indirect effects, accidental injury, reproductive losses, energy losses, habitat avoidance and abandonment, impact on Endangered Species, problems with detecting long-term effects of aircraft disturbance, and development of impact criteria.

In regards to the physiological responses of wildlife to aircraft overflights, the report stated that depending on the characteristics of the noise and the species, (its natural history, health at the time etc.) the reaction of a particular animal could range from mild annoyance to panic and escape behavior. Such responses are manifestations of stress, and while the effects of stress from overflights are not well documented, the report did warn that "...excessive stimulation of the nervous system can amount to chronic stress, and that continuous exposure to aircraft overflights can be harmful for the health, growth, and reproductive fitness of animals" (Fletcher, 1980, 1990). As with physiological responses, behavioral responses vary between species and within a species due to a variety of factors (such as age, sex, prior exposure etc.). While the report stated that "behavioral responses reflect a variety of states, from indifference to extreme panic," the aforementioned variability only allowed for anecdotal information on individuals which "...is not useful for drawing conclusions for that or any other species." The report only briefly discusses indirect losses, noting that it is difficult to assess such harm because "whether or not such indirect effects occur depends on other factors associated with the natural history of a species." Again, researchers were impeded in their attempts to secure decisive information due to the inherent variability of species and individual animals in their responses to noise.

In regards to accidental injury the report cited that "A common concern among biologists is that animals will occasionally fall, run into objects, or become trampled when they panic and run from aircraft." In addition they noted that young animals are more likely to be trampled in panic situations and that the topography of an area could increase the probability of injury, particularly if the population density is high. The reproductive losses discussed in the report included those caused by "...altered patterns of attendance to young," accidental breakage of eggs in a panic response, and malnourishment of young due to inhibited milk production. Energy losses, according to the document, resulted from a two pronged effect - energy expended in escape and panic responses, and a reduced energy intake due to missed feeding

opportunities. In reference to habitat avoidance and abandonment the report again noted that generalizations could not be made because different species and individuals within species have varying sensitivities, and thus have variable tendencies to leave a habitat. Of great concern however, is the possibility of habitat avoidance and abandonment by "...species whose high-quality habitat is already scarce" because this could jeopardize the future stability and success of the population. The overflight impacts on endangered species, at the time of the report were largely unknown. "Of all threatened and endangered species Federally listed in the United States, there is information regarding responses to overflights only for the grizzly bear, sonoran pronghorn, peregrine falcon, bald eagle, and everglades kite. None of these species have been studied enough to differentiate between aircraft activities that do and do not cause harm." The lack of knowledge is not limited to endangered species and is representative of the difficulty that scientists, the public, and policy makes have in drawing conclusions and making informed decisions about what should be done in regards to noise in the National Parks.

Adding to this predicament are the problems with detecting long-term effects of aircraft disturbance. According to the report "This is due both to the limitations of ecological research and to the nature of long-term responses." While speculation on the effects experienced by particular species was limited, the report did concede that "Long-term responses that might occur include permanent changes in habitat use, increased mortality of birds during migration (due to lower weight gains during staging), or population effects due to reduced reproductive success (due to egg loss, for example)." In spite of these dilemmas, the report did offer recommendations for developing impact criteria "...meant to help agencies in determining the severity of impacts." The report divided impacts into four categories: negligible, low, moderate, and high and proceeded to list examples of what each might include. While the report laid a decent foundation for addressing the issue of noise in our National Parks and the effect that the noise may be having on wildlife, much of the proceeding governmental discussions and media exposure, nevertheless remained focused on the impact to people.

At the center of the controversy over noise in our National Parks is Grand Canyon National Park. Approximately thirty years ago an airport opened in Tusayon, Arizona, a small town near the south rim of the Grand Canyon (Udall, 1997). Shortly thereafter pilots began selling sightseeing flights to interested tourists and the historic quiet of the Grand Canyon was eliminated. According to flight records, over 80,000 flights occur over the Grand Canyon per year, with as many as 10,000 flights per month during the summer season (Lee, 1994). During busier days at Tusayon Airport there are as many as one hundred take-offs and landings per hour. The FAA has named the Grand Canyon "...the air tour capital of the USA, if not the world" (Udall, 1997). In response to the excessive noise in the Grand Canyon, Transportation Secretary Federico Pena declared: "if we can't enjoy peace and quiet in our National Parks, where can we?" (Lee, 1994). Secretary of the Interior Bruce Babbit `s remark "It's an outrage," likewise expressed displeasure at the current cacophony in our National Parks (Udall, 1997). Congress, despite the sentiments of these top officials, and the demands of environmentalists, has been slow to enact legislation. Their reluctance is partially a response to the issue's other side - that of the industrial tourism industry and those tourists who believe that they have a right to view the National Parks by aircraft (automobile, snowmobile, etc.).

Air tourism exerts a considerable influence in Congress because of the revenue it creates in the nation's economy. The thirty-one tour operators at the Grand Canyon in 1996 served over 800,000 customers, thus grossing approximately 117 million dollars (Udall, 1997). Clearly the operators and the other businesses that they indirectly support have a vested interest in maintaining or increasing the number of flights over the Grand Canyon and other National Parks. Jack Thompson, flight operations manager for the National Transportation Association

deflected criticism of the air tour industry by asserting that they "...provide valuable service for the 1000s of visitors who want to see the Grand Canyon," many of whom would not be able to explore it by other means (Lee, 1994). Absent from much of this discussion and similarly neglected in Congress' discussions is the impact of these overflights on wildlife. Without detracting from the importance of a quiet wilderness experience for people, it is essential that values and issues beyond those ascribed by and important to humans be considered.

Senator John McCain, who introduced the "National Overflights Act of 1997" to Congress alluded to the importance of wildlife in instructing people to heed the lessons from the Grand Canyon: "We cannot wait until natural quiet has been lost before we take steps to prevent the impairment of natural resources" (1997). Contrary to this sentiment however, Senator McCain's version of the National Parks Overflights Act of 1997 did not contain any mention of wildlife per se. While two of the goals of the Act were "to protect the resources of any national park experiencing an adverse impact associated with noise from aircraft overflights;" and "to prevent resource impairment from noise associated with overflights at any national park," concern specific to wildlife was disregarded. The restrictions placed on aircraft such as limitations on the number, altitude and areas of flights will aid in the restoration of quiet, but the benefits to wildlife will be incidental. For as long as the rights and health of wildlife is not preeminent in the minds of people, the issue of the effects of noise on wildlife will remain unaddressed, thus risking irrevocable impairment to individuals, populations, and species as a whole.

RESEARCH INTO THE EFFECTS OF NOISE ON MARINE WILDLIFE

Land animals are not the only wildlife effected by human-produced noise; their brethren in the aquatic world are also subjected to noise, often at greater intensities. The recognition of noise as a pollutant in the hydrosphere was delayed longer than noise pollution in the atmosphere, perhaps because we are not as aware of or concerned about noise that we cannot readily hear. Noise, particularly in the oceans, is created by numerous sources including commercial and military ships, oil exploration, and military and scientific tests. The National Marine Fisheries Service, which enforces the Marine Mammal Protection Act of 1972 announced in 1994 that scientists, often in an effort to protect marine life through their research "...contribute to the harassment of these denizens of the deep" (Schulhof, 1994). In agreement with this declaration, the Acoustical Society of America announced in that same year that human-created noise was posing an ever greater threat to the health of marine mammals. To support their stance they cited the increasing tendency of whales to become caught in nets in New Foundland after blasting occurred in an effort to enlarge a channel for tanker travel. Entanglement in the nets suggested that the whales' ability to echolocate had been impaired. Dr. Darlene Ketten, a hearing specialist from Harvard University confirmed this suspicion after finding the ear bones of two whales killed in the blast shattered and the ear canals filled with blood and pus. The National Marine Fisheries Service, partly in response to Ketten's discovery, recommended that a 120 decibel cap be placed on underwater noise in order to minimize the injurious effect on whales and other aquatic life. Many researchers were outraged by this demand, asserting that dolphin calls have been recorded at levels of 130 decibels and that a decibel cap would undermine their ability to perform experiments. In addition they argued that enforceability would be veritably impossible, especially outside of United States waters. The cap was not enacted, but the debate over noise in the ocean and other waterways was far from over and to date remains unresolved.

The issue of noise in the ocean is not unlike the issue on land in that both solutions hinge on similar points - how much we value the rights of other animals to live a peaceful, healthy

existence (and what costs we are willing to incur to ensure this quiet), and how much effort we are willing to put forth in terms of research that will ideally unravel the diversity of varying effects that noise has on wildlife. The disagreements over and the uncertainty of what is currently known and the vast amount of undiscovered knowledge is a great impediment to our understanding and progress towards protection of wildlife.

Tom Norris' studies of "The Effects of Boat Noise on the Acoustic Behavior of Humpback Whales" exemplifies this obstacle of uncertainty. Dr. Norris studied the songs of Megaptera novaegliae as they were introduced to boat noise and discovered that "...boat noise level might affect humpback whale song structure at the most basic level by altering the rhythm or increasing the tempo of songs..." (Norris,1994). As Dr. Norris noted however, the significance of these effects, especially on the behavior of the whales, remains uncertain. Similarly, disagreements among scientists also engender a level of uncertainty. In the 1994 report "Low Frequency Sound and Marine Mammals," a committee appointed by the Ocean Studies Board of the National Academy of Sciences National Research Council scientists could not come to consensus (Holing, 1994). "While it acknowledged that the effects of loud, low frequency sound `could conceivably range between potential hearing damage and gradual deafness for the entire species - and eventual extinction - and practically no discernible impact' the report concluded that a dearth of scientific evidence makes it virtually impossible to predict what those effects will be" (Holing, 1994). While that particular committee made that conclusion, other scientists such as Sylvia Earle, former chief scientist at the National Oceanic and Atmospheric Association, are of a different opinion. Dr. Earle asserted that "each sound by itself is probably not a matter of much concern, but taken all together, it's creating a totally different environment than existed fifty years ago. The high level of noise is bound to have a hard, sweeping impact on life in the sea" (Holing, 1994). Disagreement among scientists and their inability to provide concrete proof on either side of the debate confuses the public and virtually paralyzes policy makers seeking to settle the issue. Taking this attitude however, is another manifestation of our anthropocentric view of the world, for if our view was biocentric we would intuitively understand that a cacophony of noise, even if not life threatening, cannot provide for a decent quality of life for any organism, land or marine. This knowledge would in turn serve as the basis for our decisions to mollify the situation and greatly reduce if not eliminate the impact of noise everywhere.

The decision of course is not that easy, for we have structured our society around noise-producing progress, and in order to deal in reality we must acknowledge and accept a certain level of noise. Agreeing upon an acceptable level of noise, especially in regards to the ocean and the sound sensitive life that resides there is a daunting challenge. Richard Pattock, in the article, "Cacophony of human-made noise pounds oceans," echoes this sentiment by posing the question "...how much noise is too much?" Pattock discusses the intensity of noise in the oceans, noting that supertankers, "....the largest human-made source of ocean noise... are so loud they can be heard under water a full day before they appear on the horizon." While the levels of sound are easily measured, the problem again lies in determining the effects of this noise on marine life because "...so little is known about these creatures that scientists cannot say for sure how they are affected by the noise of humans, particularly the cumulative effect of low frequency sound." This dearth of knowledge was evident to Peter Schiefele, a researcher at the National Undersea Research Center at the University of Connecticut, as recently as May 1997. Scheifele, who is trying to determine whether noise levels in the St. Lawrence and Saugenay Rivers in Quebec are damaging the hearing and capacity of survival for beluga whales was forced to admit that the extent of damage continues to remain unclear. (Chang, 1997).

In March of 1997 a forty foot sperm whale became trapped in the inshore waters of Firth of Forth near Edinburgh, Scotland (Quinn, 1997). Scientists attributed this to traffic noise from

the rail and road bridges that traverse the waterway. Although they could not confirm their suspicions, the scientists believed that the clamorous noise made the sperm whale reluctant to return to open waters which eventually caused it to become stranded in the shallows between the bridges. This incident, like many others of its kind provides anecdotal rather than definitive evidence and as such is often dismissed by researchers, policy makers and those responsible for generating the noise. As researcher Ronald Larkin asserted, "Research is hampered by a preponderance of small, disconnected, anecdotal or correctional studies as opposed to coherent programs of controlled experiments" (1996). This absence of concrete answers begets the question of whether, as a society, we are willing to risk waiting for undisputed proof, cognizant that, as we wait, we may be allowing a multitude of marine organisms to be deafened or otherwise injured in regards to the quality and length of their lives. The American Oceans Campaign, which monitors governmental and industrial sound generation, believes that "what marine mammals in the Pacific Ocean experience now is akin to living next to a freeway with the windows closed" (Preston, 1997). While this may not seem intolerable to humans, the American Oceans Campaign reminds us that we do not know what it means to them and their greater sensitivity to sound, and as such our failure to enact preventative measures could be causing irreparable damage to the marine ecosystem.

ACOUSTIC THERMOMETRY OF OCEAN CLIMATE

At the center of the debate over how much noise is too much and what effects noise pollution is having on marine life is the controversial Acoustic Thermometry of Ocean Climate (ATOC) project lead by Scripps Institution of Oceanography. ATOC, a thirty five million dollar program, is designed to measure the oceans' temperatures in an effort to predict climate change (Brown, 1995). Using low frequency sound waves, "underwater microphones in the Pacific Ocean will measure average deep-water temperatures by clocking the travel time of sound from submerged emitters off California and Hawaii." ATOC concerns many marine scientists, environmentalists and animal welfare advocates "...because the 195 decibel noise - a low rumble to be broadcaster six times daily for as long as 10 years - could affect as many as 677,000 marine mammals in the ocean off Big Sur, south of San Francisco" (LA Times). Congruous with the lack of understanding of the potential affects of noise in general, and ATOC noise specifically, a National Resource Defense Council senior attorney admonished, "We simply cannot afford to play Russian roulette with our global oceanic system" (Preston, 1997).

The opposition with which ATOC was met prompted public hearings which in turn persuaded Scripps Institution of Oceanography to use their Marine Mammal Research Program (MMRP) to study the effects of ATOC-like noise in the oceans. While Scripps Oceanographer David Hyde supported the public hearings, welcomed the suggested research and stated that "We're not out to harm a single animal and we will stop the project if there is any evidence of that," Christopher Clark, head of the ATOC marine mammal study was rankled by the controversy stating that "This is environmental activism gone completely astray" (Brown, 1995). Clark conducted the study none-the-less and published MMRP's report "Results From Over a Year of Acoustic Transmissions" on May 14, 1997. He and Adam S. Frankel concluded that "Presently there are no MMRP results indicating that any species shows any biologically significant adverse response to ATOC or ATOC-like sounds..." The finding of no ill effects to marine mammals allowed the ATOC program to commence, but the MMRP continues to monitor the acoustic transmissions and watches for adverse impacts on the aquatic ecosystem.

SUMMARY

R. Murray Schafer, composer and author of The Tuning of the World believes that "the general

acoustic environment of a society can be read as an indicator of social conditions which produce it and may tell us much about the trending and evolution of that society" (Giansante, 1979). Assuming Schaefer is correct, the issue of noise in our National Parks and other natural areas is very telling of the social conditions and trends of our society in regards to our encroachment on the last remaining wilds and degradation of natural quiet. In addition, our narcissistic focus on the right of humans to either generate noise or be free of human noise in nature, and consequent indifference to the effect that our noise is having on wildlife is likewise very poignant in revealing our values as a society. By allowing human-produced noise to destroy the historic quiet of natural areas we are valuing the consumptive desires of motorized tourists, exorbitant military practice flights, and research of questionable value over the inestimable worth of areas free of human cacophony. By remaining unconcerned or unaware of the potential harm that this unnecessary noise is having on wildlife we are valuing our anthropocentric wants over the very survival and future of other creatures. Nature recordist and Nature Sounds Society member Bernard Krause "...says there is now almost no place on Earth - including the North Pole, Antarctica and the dense forests of Indonesia and the Amazon - that is free of aircraft overflights, the buzz of chain saws and other human clatter. Krause remembers when it took 20 hours to get 15 minutes of usable recorded material. `Now it takes 200 hours,' he says" (Immel, 1995). If we remain on this course of introducing our sounds to every inch of the Earth, there will not be any escape from our clamorous, progress-oriented world and worse still there may be less wildlife, for many species may not be able to adapt to the changes in their once peaceful habitats. Ultimately the choice rests in our hands, but to choose quiet and protect the welfare of other animals in addition to ourselves, we must summon the courage to challenge those who would deny the rights of wildlife and leave neither us nor them respite from the human-altered world.

REFERENCES

Berger, Joel et al. 1991. "Conflict in National Parks: A Case Study of Helicopters and Bighorn Sheep Time Budgets as the Grand Canyon." Biological Conservation. 56(3):317-328.

Brown, Stuart F. "The Sound of Global Warming." Popular Science. July 1995: pp.59-63.

Busnel,R.G. and John Fletcher (eds.). 1978. Effects of Noise on Wildlife. New York: Academic Press.

Calef, George et al. 1976. "The Reaction of Barren Ground Caribou to Aircraft." Arctic. 29(4):210- 212.

Chang, Kenneth. "Researchers Study Beluga Whales' Response to Shipping Noise in Canadian Rivers." Newsday. May 6, 1997: p.B27.

Dorrance, Michael et al. 1975. "Effects of Snowmobiles on White-tailed Deer." Journal of Wildlife Management. 39(3):563-569.

Driscoll, Patrick. "Eagles Near Denver Airport Will Soon Get Noise Relief." The Denver Post. February 17,1997: p.B1.

"Effects of Simulated Jet Aircraft Noise on Heart Rate and Behavior of Desert Ungulates." Journal of Wildlife Management. 60(1):52-61.

Giansante, Louis. "The Soundscape." Media and Methods. November 1979:pp.43-48.

Harrington, Fred and Alasandair Veitch. 1991. "Short-term Impacts of Low Level Jet Fighter Training on Caribou in Labrador." Arctic. 44(4):318-327.

Holing, Dwight. 1994. "The Sound and The Fury: Debate Gets Louder Over Ocean Noise Pollution and Marine Mammals." The Amicus Journal. 16(3):19-25.

Hompland, Gary et al. 1985. "Elk Responses to Simulated Mine Disturbance in Southeast Idaho." Journal of Wildlife Management. 49(3)751-757.

Immel, Richard. 1995. "Shhh...Those Peculiar People Are Listening." Smithsonian. 26(1):151-160.

Kavaler, Lucy. 1975. Noise: The New Menace. New York: The John Day Company.

Knight, Richard. 1984. "Responses of Wintering Bald Eagles to Boating Activity." Journal of Wildlife Management. 48(3):999-1004.

Krause, Bernard. "The Niche Hypothesis." The Soundscape Newsletter. June 6, 1993.

Krausman, Paul et al. 1986. "Desert Mule Deer Response to Aircraft." Wildlife Society Bulletin. 14(1):68-70.

Larkin, Ronald. "Effects of Military Noise on Wildlife: A Literature Review." USA CERL Technical Report. January 1996.

Lee, David. "Increasing Air Tours Pollute Our National Parks." National Parks July 1994: p.25.

"Breaking the Sound Barrier." National Parks July 1994: p.24.

McCain, John. "Overflight Oversight." National Parks. September-October 1997. 71(9-10):41.

National Overflights Act of 1997. S268. 105th Congress. 1st Session.

Norris, Tom F. 1994. "The Effects of Boat Noise on the Acoustic Behavior of Humpback Whales." Proceedings of the Acoustic Society of America. (128th Meeting). 96(5):3251.

"Ocean Sound Testing Put on Hold." Los Angeles Times.

Paddock, Richard. "Cacophony of Human-Made Noise Pounds Oceans." Los Angeles Times. p.1A.

Preston, Todd. "The Unquiet Oceans." E Magazine. March-April 1997. 8(2):21-24.

Quinn, Joe. "Whale Trapped in Firth of Forth by Traffic Noise." Home News. March 21,1997.

Report on Effects Of Aircraft Overflights On The National Parks System. Chapter 5: Effects of Overflights on Wildlife. 5.1-5.27.

Schulhof, Julia. "Quiet Please." Sea Frontiers. March-April 1994. 40(2):10-11.

Scripps Institute of Oceanography. "ATOC Marine Mammal Research Program to Commence at Both Locations." UCSD News. October 30,1997.

"Marine Mammal Research Program: Results From Over a Year of Acoustic Transmissions." UCSD News. May 14, 1997.

Udall, James R. "Silence Under Siege." Sierra. March-April 1997. 82(2):28-30.

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