Review of Studies Related To Aircraft Noise Disturbance of Waterfowl

A Technical Report in Support of The Supplemental Environmental Impact Statement (SEIS) For Introduction of F/A-18 E/F (Super Hornet) Aircraft To the East Coast of the United States

Prepared For

U.S. Department of the Navy
Naval Facilities Engineering Command Atlantic
Norfolk, Virginia

Prepared By

David Plumpton, Ph.D.
Ecology and Environment, Inc.
San Francisco, CA

Technical Review:

Susan Sheaffer, Ph.D., Cornell University
Don Hunsaker, II, Ph.D., Hubbs Sea World Research Institute
Scott Petrie, Ph.D., Long Point Waterfowl and Wetlands Research Fund

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1 Introduction

This literature review was based on a survey of peer-reviewed studies published in scientific journals and unpublished technical reports related to the response of waterfowl to aircraft noise. Each of these studies was reviewed to determine its scientific rigor and the applicability of its conclusions to the assessment of impacts from construction and operation of an Outlying Landing Field (OLF) near waterfowl concentration areas in northeastern North Carolina. Results of these studies will be used as applicable in the development of the *Supplemental Environmental Impact Statement (SEIS) for the Introduction of F/A-18 E/F (Super Hornet) Aircraft to the East Coast of the United States.*

The Navy is considering five alternative sites in northeast North Carolina for construction of an OLF, which would support the Field Carrier Landing Practice (FCLP) operations of Super Hornet squadrons based at Naval Air Station (NAS) Oceana, Virginia, and Marine Corps Air Station (MCAS) Cherry Point, North Carolina. The Super Hornet is a single- and two-seat, twin-engine, multi-mission fighter/attack aircraft that can operate from either aircraft carriers or land bases. Super Hornet squadrons perform FCLP operations as part of the pilot training process. An FCLP operation is a “touch-and-go” training operation for pilots to practice “carrier” landings on a land-based airstrip before their deployment to an aircraft carrier.

Approximately 31,652 FCLP operations are projected to occur annually at the OLF. Aircraft would generally transit between the air station and the OLF at altitudes between 15,000 and 25,000 feet. Once in the local vicinity of the OLF, aircraft would descend to an altitude of 800 feet above ground level (AGL) for the overhead arrival into the FCLP pattern. The actual FCLP pattern is flown at 600 ft AGL.

The region being studied for construction and operation of an OLF also supports a seasonally abundant population of waterfowl. Numerous species of ducks, snow geese, and tundra swans overwinter in several National Wildlife Refuges (NWRs) in the area and benefit from the availability of agricultural forage crops. Specifically, alternative OLF Sites C and D are located within 10 miles of NWRs. In contrast, alternative OLF Sites A, B, and E are located farther from NWRs and have comparably lower populations of migratory waterfowl nearby. However, conclusions made in the literature on potential impacts of aircraft operations on waterfowl will be applied to all OLF sites, as appropriate.

The purpose of this task was to review the literature on aircraft noise effects on overwintering and migrating populations of snow geese, tundra swans, and other waterfowl to determine what conclusions from the literature can be used to support the impact assessment of the construction and operation of an OLF in northeastern North Carolina. Tundra swans and snow geese were the primary subjects of the literature search, although inferences from other waterfowl studies may also provide analytical support.

The applicability of the literature is limited by the subjects that have been studied. For example, much of the peer-reviewed literature has focused on breeding grounds in Alaska and the effect of aircraft operations largely associated with oil and gas exploration activities there. Primary species studied in that area include snow geese and brant. A large body of work has also been conducted in North Carolina associated with military training activities at Piney Island (the Marine Corps bombing range). Primary species studied in that area include ducks. As with all studies, a multitude of factors can influence the results. Therefore, the conclusions that can be drawn from the literature will of necessity be conditional.

A summary of each study is provided in this report and includes (1) salient conclusions from the study; (2) areas of scientific uncertainty and the characterization of these uncertainties; and (3) the relevance of the study to the relationship of aircraft operations and the waterfowl/wildlife populations in the vicinity of alternative OLF sites in northeastern North Carolina.

2 Methodology

This literature review was a collaborative effort between GeoMarine, Inc. (GMI), and Ecology and Environment, Inc. (E & E). GMI conducted the literature search for peer-reviewed studies and unpublished reports related to the response of waterfowl to aircraft noise, and E & E conducted the review of those studies identified through the literature search. In addition, those studies cited in the *Final Environment Impact Statement (Final EIS) for the Introduction of F/A-18 E/F to the East Coast of the United States* that are related to waterfowl response to aircraft noise have been obtained and reviewed as well.

GMI initiated the literature search using Internet search engines, such as Yahoo and Google. In addition, publicly accessible databases maintained by the College of William and Mary were searched. These included *AGRICOLA (U.S. Department of Agriculture [USDA] National Agriculture Library)*, *Dissertation Abstracts*, *INSPEC (combined database of the Institution of Electrical Engineers and Institution of Incorporated Engineers)*, *MedLine*, *Science Citation Index*, *JSTOR (Journal STORage)*, *ASFA (Aquatic Sciences and Fisheries Abstracts)*, *Biology Digest*, and *Bio One.*

The search terms used to identify relevant studies were “snow geese,” “tundra swan,” and “waterfowl,” plus “North Carolina,” “noise,” “habitat,” “distribution,” “disturbance,” “human disturbance,” “aircraft disturbance,” “military disturbance,” and “jet.” GMI also searched the databases for names of researchers in the relevant fields obtained from the studies and literature cited.

GMI conducted an initial review of the literature to determine whether the study was relevant for inclusion in the literature review. The study was retained for inclusion in the literature review if it was found to have addressed noise-related impacts to waterfowl use of breeding, staging, and/or overwintering habitats; waterfowl responses to noise (e.g., habituation, energy budgets, exposure to predators, etc.); or waterfowl responses to different aircraft types, including fixed-wing (both propeller-driven and jet) and rotor-winged (helicopter).

GMI obtained 53 studies during the literature search, as well as symposia proceedings and other information. Full copies of the relevant studies were provided to E & E.

Upon receipt, these studies were read by E & E and summarized using a standard format. Included in the literature review was (1) salient conclusions from the study; (2) areas of scientific uncertainty and the characterization of these uncertainties; and (3) relevance of the study to the relationship of aircraft operations to the waterfowl/wildlife populations in the vicinity of the alternative OLF sites in northeastern North Carolina.

The scientific rigor of each paper was rated “high,” “medium,” or “low” using subjective criteria that included the scope and duration of the study; the validity of the experimental design, data collection, analyses, and interpretation; and whether the conclusions were supported by the data (Table 2-1).

Table 2-1 Characteristics Used to Assess Scientific Rigor

High	Study was a well-controlled, manipulative, or valid mensurative experiment of adequate scope and duration to provide meaningful results; results were rigorously tested, and conclusions were supported by hypothesis tests.
Moderate	Study used a reasonable approach, sample size, scope, and/or duration; results were interpreted correctly from well-designed studies.
Low	Study was of small scope, short duration, or lacked scientific control. Study used a faulty experimental design, incorrect statistical procedures for the questions asked, or provided no test outcomes, data analyses, or observed significance levels. Or, the study was otherwise flawed in interpretation or made unsupported conclusions.

The relevance of a study to the SEIS was rated "high," "medium," or "low," using criteria such as species, potential effects (e.g., type of disturbance), locality, season, and other similarities or differences (Table 2-2), and the relevance to the SEIS was also weighed against the scientific rigor of the study (Table 2-1).

Table 2-2 Characteristics Used to Assess Relevance to the SEIS

High	Study addresses similar species, location, and aircraft type to those found at alternative OLF site or otherwise provided data on effects likely to be considered in the SEIS.
Moderate	Study had at least some similarities of species, location, and/or aircraft type to those found at alternative OLF site.
Low	Study had few or no similarities of species, location, or aircraft type to those found at alternative OLF site.

Also included for each study are key words that will be used to identify those studies that presented similar topics when using the studies as supporting references for the assessment of potential impacts of construction and operation of an OLF in the SEIS.

Table 2-3 provides a list of the studies included in this literature review and relate to assessing aircraft noise disturbance to waterfowl. A summary of each of the studies listed in Table 2-3 follows a summary of the conclusions of the literature.

Table 2-3 List of References Included in Literature Review

Article	Reference	Relevance to SEIS
1	Bateman, M. C., A. H. Hicks, and S. M. Bowes, 1999, *Environmental Mitigation Program Supporting Military Flying Activity in Goose Bay, Labrador: Waterfowl Behavior in Response to Jet Overflights at Snemagook* [sic] *Lake, Labrador*, Report to National Defence Headquarters, Goose Bay Office, Ottawa, Canada, 139 pp.	Moderate
2	Bélanger, L., and J. Bédard, 1989, "Responses of Staging Greater Snow Geese to Human Disturbance," *Journal of Wildlife Management,* 53: pp. 713-719.	High
3	Bélanger, L., and J. Bédard, 1990, "Energetic Cost of Man-Induced disturbance to Staging Snow Geese," Journal of Wildlife Management, 54: pp. 36-41.	High
4	Black, B. B., M. W. Collopy, H. F. Percival, A. A. Tiller, and P. G. Bonhall, 1984, *Effects of Low Level Military Training Flights on Wading Bird Colonies in Florida*, Florida Cooperative Fish and Wildlife Research Unit, School of Forest Resources and Conservation, University of Florida, Technical Report No. 7.	Moderate
5	Burger, J., 1983, "Jet Aircraft Noise and Bird Strikes: Why More Birds Are Being Hit," *Environmental Pollution* 30: pp. 143-152.	Moderate

Table 2-3 List of References Included in Literature Review

Article	Reference	Relevance to SEIS
6	Burger, J., 1981, "Behavioral Responses of Herring Gulls (*Larus Argentatus*) to Aircraft Noise," *Environmental Pollution* (Series A) 24: pp. 177-184.	Moderate
7	Burger, J., 1981, "The Effect of Human Activity on Birds at a Coastal Bay," *Biological Conservation*, 21: pp. 231-241.	Moderate
8	Conomy, J. T., 1993, *Habitat Use by, and Effects of Aircraft Noise on the Behavior and Energetics of, Wintering Dabbling Ducks in Piney and Cedar Islands, North Carolina*, master's thesis, North Carolina State University.	High
9	Conomy, J. T., J. A. Collazo, J. A. Dubovsky, and W. J. Fleming, 1998, "Dabbling Duck Behavior and Aircraft Activity in Coastal North Carolina," *Journal of Wildlife Management*, 62: pp. 1127-1134.	High
10	Conomy, J. T., J. A. Collazo, and W. J. Fleming, 1996, "Behavioral Responses of Wintering Waterfowl to Military Aircraft Activity in Pamlico Sound, North Carolina," in *An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina*, Final Report to U.S. Marine Corps, Cherry Point Marine Corps Air Station.	High
11	Conomy, J. T., J. A. Dubovsky, J. A. Collazo, and W. J. Fleming, 1996, "Habituation of Black and Wood Ducks to Aircraft Noise," Chapter E in W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, editors, *An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina*, Final Report to U.S. Marine Corps, Cherry Point Marine Corps Air Station.	High
12	Davis, R. A., and A. N. Wiseley, 1974, "Normal Behavior of Snow Geese on the Yukon-Alaska North Slope and the Effects of Aircraft-Induced Disturbance on this Behaviour, September, 1973," Chapter II (unpaginated) in W. W. H. Gunn, W. J. Richardson, R. E. Schweinsburg, and T. D. Wright, editors, *Studies on Snow Geese and Waterfowl in the Northwest Territories, Yukon Territory and Alaska, 1973*, Biological Report Series, Volume 27, September 1974, 85 pp.	Low/ Moderate
13	Derksen, D. V., K. S. Bollinger, D. Esler, K. C. Jensen, E. J. Taylor, M. W. Miller, and M. W. Weller, 1991, *Effects of Aircraft on Behavior and Ecology of Molting Brant Near Teshekpuk Lake, Alaska*, U. S. Fish and Wildlife Service, Report to U.S. Bureau of Land Management and U.S. Minerals Management Service, 129 pp.	Low
14	Dooling, R. J., 1980, "Behavior and Psychophysics of Hearing in Birds," Chapter 9 in A. N. Popper and R. R. Fay, editors, *Comparative Studies of Hearing in Vertebrates*, Springer-Verlag, New York, New York.	Moderate
15	Dooling, R. J., B. Lohr, and M. L. Dent, 2000, "Hearing in Birds and Reptiles," Chapter 7 in R. J. Dooling, R. R. Fay, and A. N. Popper, editors, *Comparative Hearing: Birds and Reptiles*, Springer-Verlag, New York, New York.	Low/ Moderate
16	Dooling, R., 2002, *Avian Hearing and the Avoidance of Wind Turbines*, Technical Report NREL/TP-500-30844, June 2002, National Renewable Energy Laboratory, Golden Colorado, 84 pp.	Moderate

Table 2-3 List of References Included in Literature Review

Article	Reference	Relevance to SEIS
17	Dubovsky, J. A., J. T. Conomy, J. A. Collazo, and W. J. Fleming, 1996, "Wintering Waterfowl Numbers and Behaviors in a Military Aircraft Training Facility in Pamlico Sound, North Carolina," Chapter C in W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, editors, *An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina*, Final Report to U.S. Marine Corps, Cherry Point Marine Corps Air Station.	High
18	Dubovsky, J. A., and W. J. Fleming, 1996, "Population Trends of Wintering Waterfowl in Military Aircraft Operating Areas in Pamlico Sound, North Carolina," Chapter B in W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, editors, *An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina*, Final Report to U.S. Marine Corps, Cherry Point Marine Corps Air Station.	High
19	Dubovsky, J. A., W. J. Fleming, R. Lien, and G. S. Davis, 1996, "Body Mass, Behaviors, and Physiological Responses of Black Ducks Maintained in a Military Aircraft Operating Area in Pamlico Sound, North Carolina," Chapter G in W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, editors, *An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina*, Final Report to U.S. Marine Corps, Cherry Point Marine Corps Air Station.	High
20	Dunnet, G. M., 1977, "Observations on the Effects of Low-Flying Aircraft at Seabird Colonies on the Coast of Aberdeenshire, Scotland," *Biological Conservation*, 12: pp. 55-63.	Low
21	Fleming, W. J., G. S. Davis, and V. M. Graham, 1996, "Response of Mallard Ducklings to Recordings of Jet Aircraft Noise," Chapter I in W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, editors, *An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina*, Final Report to U.S. Marine Corps, Cherry Point Marine Corps Air Station.	High/ Moderate
22	Fleming, W. J., J. A. Dubovsky, and J. A. Collazo, 1996, editors, *An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina*, Final Report to U.S. Marine Corps, Cherry Point Marine Corps Air Station.	High
23	Gladwin, D. N., D. A. Asherin, and K. M. Manci, 1988, "Effects of Aircraft Noise and Sonic Booms on Fish and Wildlife: Results of a Survey of U.S. Fish and Wildlife Service Endangered Species and Ecological Services Field Offices, Refuges, Hatcheries, and Research Centers," *Bibliographic Abstracts*, U.S. Fish and Wildlife Service, National Ecology Research Center, Ft. Collins, CO., NERC-88/32.	Moderate
24	Harms, C. A., W. J. Fleming, and M. K. Stoskopf, 1996, "Heart Rate Biotelemetry in Black Ducks: Response to Simulated Aircraft Noise," Chapter F in W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, editors, *An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina*, Final Report to U.S. Marine Corps, Cherry Point Marine Corps Air Station.	High
25	Henson, P., and T. A. Grant, 1991, "The Effects of Human Disturbance on Trumpeter Swan Breeding Behavior," *Wildlife Society Bulletin*, 19: pp. 248-257.	Low

Table 2-3 List of References Included in Literature Review

Article	Reference	Relevance to SEIS
26	Jensen, K. C., 1990, *Responses of Molting Pacific Black Brant to Experimental Aircraft Disturbance in the Teshekpuk Lake Special Area, Alaska*, Ph.D. thesis, Texas A&M University.	Moderate
27	Klump, G. M., 2000, "Sound Localization in Birds," Chapter 6 in R. J. Dooling, R. R. Fay, and A. N. Popper, Editors, *Comparative Hearing: Birds and Reptiles.*	Low
28	Komenda-Zehnder, S., M. Cevallos, and B. Bruderer, 2003, *Effects of Disturbance by Aircraft Overflight on Waterbirds: An Experimental Approach,* International Bird Strike Committee, Report No. IBSC26/WP-LE2.	Moderate
29	Kushlan, J. A., 1979, "Effects of Helicopter Censuses on Wading Bird Colonies," *Journal of Wildlife Management*, 43: pp. 756-760.	Low
30	Lamp, R. E., 1989, *Monitoring the Effects of Military Air Operations at Naval Air Station Fallon on the Biota of Nevada*, Nevada Department of Wildlife, 90 pp.	Moderate/ High
31	McKechnie, A. M., and D. N. Gladwin, 1993, "National Park Service Aircraft Overflight Study: Aircraft Overflight Effects on Wildlife Resources," *NPOA Report Number 93-8*.	Moderate
32	Miller, M. W., 1994, "Route Selection to Minimize Helicopter Disturbance of Molting Pacific Black Brant: A Simulation," *Arctic* 47: pp. 341-349.	Low
33	Miller, M. W., K. C. Jensen, W. E. Grant, and M. W. Weller, 1994, "A Simulation Model of Helicopter Disturbance of Molting Pacific Brant," *Ecological Modeling*, 73: pp. 293-309.	Low
34	Murphy, S. M., and B. A. Anderson, 1993, *Lisburne Terrestrial Monitoring Program: the Effects of the Lisburne Development Project on Geese and Swans, 1985-1989*, Final Synthesis Report, Alaska Biological Research, Inc., 202 pp.	Moderate
35	Owens, N. W., 1977, "Responses of Wintering Brant Geese to Human Disturbance," *Wildfowl*, 28: pp. 5-14.	Low
36	Salter, R., and R. A. Davis, 1974, "Snow Geese Disturbance by Aircraft in the North Slope, September, 1972," Chapter VII in W. W. H. Gunn and J. A. Livingston, editors, *Disturbance to Birds by Gas Compressor Noise Simulators, Aircraft and Human Activity in the Mackenzie Valley and the North Slope, 1972*, Biological Report Series, Volume 14, February 1974, pp. 258-280.	Low
37	Schweinsburg, R., 1974, "Disturbance Effects of Aircraft to Waterfowl on North Slope Lakes, June, 1972," Chapter I in W. W. H. Gunn and J. A. Livingston, editors, *Disturbance to Birds by Gas Compressor Noise Simulators, Aircraft and Human Activity in the Mackenzie Valley and the North Slope, 1972*, Biological Report Series, Volume 14, February 1974, pp. 1-49.	Low
38	Temple, E. R., W. J. Fleming, and J. A. Dubovsky, 1996, "Reproduction, Growth and Survival of Captive Black Ducks Maintained in a Military Aircraft Operating Area," Chapter H in W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, editors, *An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina*, Final Report to U.S. Marine Corps, Cherry Point Marine Corps Air Station.	High

Table 2-3 List of References Included in Literature Review

Article	Reference	Relevance to SEIS
39	Ward, D. H., E. J. Taylor, M. A. Wotawa, R. A. Stehn, D. V. Derksen, and C. J. Lensink, 1987, "1986 Annual Report: Behavior of Pacific Black Brant and Other Geese in Response to Aircraft Disturbances and Other Disturbances at Izembek Lagoon, Alaska," *1986 Annual Report*, U. S. Fish and Wildlife Service, Alaska Wildlife Research Center.	Low/ Moderate
40	Ward, D. H., R. A. Stehn, M. A. Wotawa, M. R. North, P. Brooks-Blenden, C. J. Lensink, and D. V. Derksen, 1988, "Response of Pacific Black Brant and Other Geese to Aircraft Overflights at Izembek Lagoon, Alaska," *1987 Annual Report,* U. S. Fish and Wildlife Service, Alaska Fish and Wildlife Research Center.	Low/ Moderate
41	Ward, D. H., R. A. Stehn, W. P. Erickson, and D. V. Derksen, 1999, "Response of Fall-Staging Brant and Canada Geese to Aircraft Overflights in Southeastern Alaska," *Journal of Wildlife Management*, 63: pp. 373-381	High
42	Ward, D. H., R. A. Stehn, and D. V. Derksen, 1994, "Response of Staging Brant to Disturbance at the Izembek Lagoon, Alaska," *Alaska Wildlife Society Bulletin*, 22: pp. 220-228.	Low/ Moderate

Based on the literature review, some of the studies initially identified by GMI were determined not to be relevant to assessing aircraft noise disturbance to waterfowl (Table 2-4). However, in some cases, these studies were considered relevant to the SEIS in terms of population and distribution, waterfowl behavior, migratory patterns, or other aspects and are therefore discussed in other contexts related to the SEIS.

Table 2-4 List of References Not Included in Literature Review

Article	Reference
1	Awbrey, F. T., and A. E. Bowles, 1990, *The Effects of Aircraft Noise and Sonic Booms on Raptors: A Preliminary Model and a Synthesis of the Literature on Disturbance*, Technical Operating Report No. 12 to Noise and Sonic Boom Impact Technology (NSBIT), Advanced Development Program Office, Wright-Patterson Air Force Base, Ohio.
2	Bélanger, L., and J. Bédard, 1992, "Flock Composition and Foraging Behavior of Greater Snow Geese," Canadian Journal of Zoology, 70: pp. 2410-2415.
3	Bortner, J. B., 1985, *Bioenergetics of Wintering Tundra Swans in the Mattamuskeet Region of North Carolina,* master's thesis, University of Maryland, College Park, Maryland.
4	Brame, R. M., 1983, *The Winter Movements and Activity Budgets of Greater Snow Geese along Pea and Bodie Islands, North Carolina,* master's thesis, North Carolina State University, Raleigh, North Carolina.
5	Burton, B. A., and R. J. Hudson, 1978, "Activity Budgets of Lesser Snow Geese Wintering on the Fraser River Estuary, British Columbia," *Wildfowl,* 29: pp. 111-117.
6	Cooke, F., and K. F. Abraham, 1980, "Habitat and Locality Selection in Lesser Snow Geese: the Role of Previous Experience," *Proceedings of the International Ornithological Congress*, 17: pp. 998-1004.
7	Crawley, D. R., Jr., and E. G. Bolen, 2002, "Effect of Tundra Swan Grazing on Winter Wheat in North Carolina," *Waterbirds* 25 (Special Publication 1): pp. 162-167.

Table 2-4 List of References Not Included in Literature Review

Article	Reference
8	Efromyson, R. A., W. H. Rose, S. Nemeth, and G. W. Suter, II, No Date, *Ecological Risk Assessment Framework for Low-Altitude Overflights by Fixed-Wing and Rotary-Wing Military Aircraft*, ORNL/TM-2000/289, Oak Ridge National Laboratory, Tennessee.
9	Frederick, R. B., W. R. Clark, and E. E. Klaas, 1987, "Behavior, Energetics, and Management of Refuging Waterfowl: A Simulation Model," *Wildlife Monographs*, 96: pp. 1-35.
10	Gauthier, G., J. Bédard, and Y. Bédard, 1984, "Comparison of Daily Energy Expenditure of Greater Snow Geese between Two Habitats," *Canadian Journal of Zoology*, 62: pp. 1304-1307.
11	Giroux, J. F., and J. Bédard, 1990, "Activity Budget of Greater Snow Geese in Fall," *Canadian Journal of Zoology*, 68: pp. 2700-2702.
12	Gold, A., 1973, "Energy Expenditure in Animal Locomotion," *Science*, 181: pp. 275-276.
13	Henry, W. G., 1980, *Populations and Behavior of Black Brant at Humboldt Bay, California*, master's thesis, Humboldt State University.
14	Hepp, G. R., 1982, *Behavioral Ecology of Waterfowl* (Anatini) *Wintering in Coastal North Carolina*, Ph.D. Thesis, North Carolina State University, Raleigh, North Carolina.
15	Hill, M. R., and R. B. Frederick, 1997, "Winter Movements and Habitat Use by Greater Snow Geese," *Journal of Wildlife Management*, 61: pp. 1213-1221.
16	King, J. R., 1974, "Seasonal Allocation of Time and Energy Resources in Birds," in R. A. Paynter, editor, *Avian Energetics*, Nuttall Ornithological Club, Cambridge, Massachusetts, pp. 4-85.
17	Luszcz, D., and C. Betsill, 1988, "Evaluation of a Tundra Swan Season in North Carolina," *Proceedings of the Annual Conference of the Southeast Association of Fish and Wildlife Agencies*, 42: pp. 388-395.
18	Paulus, S., 1988, "Time-Activity Budgets of Nonbreeding *Anatidae*: A Review," Chapter 10 in Milton W. Weller, Editor, *Waterfowl in Winter*, University of Minnesota Press.
19	Prevett, J. P., and C. D. MacInnes, 1980, "Family and Other Social Groups in Snow Geese," *Wildlife Monographs 71*, 46 pp.
20	Robertson, D. G., 1991, *Movements and Habitat Use of Lesser Snow Geese Wintering on the Upper Texas Coast*, master's thesis, Texas A&M University.
21	Serie, J. R., D. Luszcz, and R. V. Raftovich, 2002, "Population Trends, Productivity, and Harvest of Eastern Population Tundra Swans," *Waterbirds 25* (Special Publication 1): pp. 32-36.
22	Spindler, M. A., 1983, *Distribution, Abundance, and Productivity of Fall Staging Lesser Snow Geese on Coastal Habitats of Northwest Alaska and Northwest Canada, 1983*, U. S. Fish and Wildlife Service ANWR Progress Report Number FY84-2.
23	Williams, J. E., and S. C. Kendeigh, 1982, "Energetics of the Canada Goose," *Journal of Wildlife Management*, 46: pp. 588-600.

The literature review was provided to a Technical Review Panel (TRP) of three waterfowl experts for review and comment. Some additional literature was identified by this TRP for inclusion in the literature review.

3 Summary

Researchers have measured behavior using a variety of metrics (e.g., variously defining disturbance response), methods, and levels of field data collection (e.g., from a 1-day study of unmarked and non-independent populations to multi-year studies using marked or captive birds). Some studies were observational or mensurative (i.e., they observed and recorded responses to unscheduled, non-experimentally imposed disturbances), and some studies were experimental or manipulative (they experimentally imposed controlled disturbances to quantify results). Manipulative studies allow greater control and more rigorous and specific interpretation. However, caution is warranted when extrapolating results from one study, study area, habitat type, effect, season, or species to another. In fact, many authors cautioned against making inferences from their study to different situations.

Most studies of avian responses to aircraft activity have concluded that birds (and specifically waterfowl) may respond more to disturbance from helicopters than to that from fixed-wing aircraft, and more to disturbance from slower fixed-wing aircraft (e.g., propeller-driven planes) than to that from fast fixed-wing aircraft (i.e., jets; Henry 1980; Davis and Wiseley [1974] in Spindler [1983]; Gladwin et al. 1987; Ward et al. 1987, 1988; Fleming et al. 1996a).

Increasing horizontal distance between the flock and the aircraft, and not aircraft altitude, has generally been found to result in lower incidence and duration of disturbance response (Ward et al. 1988, Jensen 1990, Derksen et al. 1991). However, this finding has not always been consistent; Ward et al. (1987:11) found no direct relationship between the distance from flock to aircraft and the proportion of birds reacting to the disturbance. Also, while Ward et al. (1987) found that bird disturbance was greatest in response to aircraft at low altitudes, some studies found that disturbance increased with exposure to aircraft at higher altitude (Spindler 1983, Jensen 1990, Derksen et al. 1991, Miller 1994). This may occur because sound may increase with increasing altitude (Ward et al. 1988) for some aircraft, partially because more horizontal spread of sound is achieved when flying above low levels, and possibly because visibility may be obscured and noise attenuated by topography or trees (Derksen et al. 1991). Noise may be the variable that most determines the intensity of disturbance response exhibited by waterfowl (Ward et al. 1988).

Studies of Pacific black brant have demonstrated that large flocks are more likely to respond to a disturbance than are small flocks (Owens 1977, Jensen 1990, Derksen et al. 1991), but Ward et al. (1987, 1988) found that flock size for black brant did not influence disturbance response. Flocks tended to flush in response to the first-flushing member (Owens 1977). This may be adaptive, as flocking facilitates early detection and avoidance of predators (Derksen et al. 1991:99). Regardless, levels of response to aircraft disturbance varied among brant and goose species (Ward et al. 1987).

Many authors did not observe any instances of what they categorized as their most severe disturbance response behavior (e.g., Kushlan 1979). An exception was Lamp (1989), who monitored waterfowl while staging, feeding, and nesting. Snow geese that were migrating showed no response to 33 (41%) of the observed aircraft disturbances. Minor reactions were seen for 22 (27%) of the events, and major flushing reactions occurred during 26 (32%) of the events. These reactions were in response to helicopters, propeller-driven planes, and jets, at altitudes from 100 feet to 10,000 feet.

Several studies documented that natural disturbances such as passing eagles or other predators were more frequent - and resulted in greater responses - than did human-induced disturbances (Murphy and Anderson 1993), including disturbances caused by experimentally-imposed aircraft overflights (Ward et al. 1987).

Several studies have been included that address the work completed on avian hearing. By considering the diversity of birds and the range of vocalizations bird use, one can understand the hearing acuity required for nocturnal hunting, echolocation, pair bonding, territorial protection, social interactions, predator detection, and other aspects of the behavioral ecology of birds. In general, birds hear about as well as humans and other vertebrates (Dooling 1980; Dooling et al. 2000; Dooling 2002). They cannot hear any noises outside the range of normal human hearing, in spite of the anecdotal information to the contrary. Birds use the complex acoustic signals in conjunction with sight for communication on many levels of social interaction and ecological behavior. Birds use their hearing to detect potential predators, to locate prey, and to receive alarm signals for other birds; they probably use hearing to a greater extent for their day-to-day survival than humans.

The audibility curve (i.e., the minimum sound that can be detected at frequencies throughout the animal's range of hearing) of a typical bird shows that they are more sensitive to slightly lower frequencies than humans, and their sensitivity to both the very high and very low frequencies is less than that of humans. Forty-nine bird species have had audibility curves measured (Dooling 2002). Most hear best at 2 to 5 kHz, which is the frequency of most communication signals that birds use. At the higher frequency of 10 kHz, the average bird can only hear that frequency at 100 dB sound pressure level (SPL), while humans can hear (on average) that tone at 20 dB SPL.

4 Summaries of Studies of Noise Effects on Waterfowl

Article 1

Author/Year:	**Title:**
Bateman, M. C., A. H. Hicks, and S. M. Bowes 1999	*Environmental Mitigation Program Supporting Military Flying Activity in Goose Bay, Labrador: Waterfowl Behavior in Response to Jet Overflights at Snemagook* [sic] *Lake, Labrador.*
Author's Affiliation:	**Published In:**
Canadian Wildlife Service	Report to National Defence Headquarters, Goose Bay Office, Ottawa, Canada.

Summary of Findings:

This report was commissioned by the Canadian military to explore possible effects of low-level jet training flights on molting and staging waterfowl in Labrador, mostly black ducks and Canada geese. Military flights had occurred in the region since the Second World War, and intensive low-level jet flights had occurred in a military training area that encompassed Snegamook Lake since 1981. Molting and staging waterfowl normally spend considerable time resting and feeding, and they could be particularly sensitive to disturbance effects, as this interval is characterized by energetic stress associated with premigratory habits and feather replacement.

The study was designed to examine immediate effects of overflights on behaviors of molting and staging waterfowl. The null hypothesis tested was that there was no difference between the behavior of birds during periods of no disturbance and periods with low-level jet overflights. Two-week trips were made to the study area during July and August. Two trips were made in 1995, three in 1996, and one in 1997. During those trips, eight jet aircraft events were observed in 1995 (in 1995 the area was closed to military flying except when observers were present), 58 in 1996, and 62 in 1997.

Behavioral observations were taken throughout the day in one of three daily periods. Scan sampling of flocks was used to record the percentage of each flock engaged in different behaviors. Every 15 minutes, the species of ducks and geese within view of the observer, and their numbers, locations, and behaviors, were recorded. Behavioral activities included feeding, loafing, preening, and flying. Data were used only when more than 10 birds were within view. Data were included in the control group only if no overflight had occurred during the prior day, and data were included in the experimental group up to one hour after an overflight. Sound levels were recorded only during 1996.

Fifteen percent of flights were at or below 30 m (98 ft), 45% were between 30 and 75 m (98'-246'), 30% were between 75 and 150 m (246' – 492'), and 10% were above 150 m (492'). Thus, over 50% of all events were at or below 75m (246 ft.) AGL. Waterfowl were present for 110 (85%) of the aircraft events. Of these, observable changes in waterfowl behavior in response to jets were observed two times. Responses observed included brief startle responses, fast swimming, or a cessation of feeding. With minor exceptions attributed to small sample sizes, no significant differences were found between black duck swimming and feeding before and during jet events. With minor exceptions attributed to small sample sizes, no significant changes in Canada goose activities as a result of jet events were recorded.

The 24-hour Single Event Noise (SEL) level ranged from 90.28 dBA to 122.4 dBA, with an average of 104.95 dBA. The 24-hour Equivalent Sound Level (L_{eq}) ranged from 40.96 to 73.30 dBA, and averaged 55.92 dBA. However, the author determined that although the noise levels of the jets are high, the overall contribution of jet noise to the background noise at Snegamook Lake is low. The noise monitors recorded 3,101 noise events (e.g., wind) above 75 dBA that were not related to aircraft activity and contributed to the high overall noise levels at Snegamook Lake.

Annual differences in the data were attributed to varying lake levels and other phenomena unrelated to aircraft. There were few significant differences in the proportions of black ducks and Canada geese exhibiting selected behaviors before and after jet overflights. Results suggested that the current program of low-level jet training was having a negligible effect on the behavior of molting and staging waterfowl.

Scientific Rigor:

Moderate. This was an observational study and did not use experimentally-imposed aircraft disturbances. There was no control over the level of treatment effects (i.e., when multiple aircraft were encountered, they were treated as a single aircraft). Because successive observations were made at 15-min intervals, it is not readily apparent that observations were made at uniform times before and after exposure to aircraft, or whether they occurred at different intervals relative to exposure to the aircraft.

E & E Reviewer Comments (Including Limitations of Study):

In response to a review of Bateman 1999 by the Labrador Institute for Environmental Monitoring and Research, a re-assessment of the data was completed that and included a comparison of paired observation periods before and after each overflight, which would function to eliminate behavioral variation in the data due to time of day, time of year, and year so that the results focus on the effect of overflights only (in Chardine, J.W., 2002, A Re-assessment of Data on Waterfowl Behavior in Response to Jet Overflights at Snegamook Lake, Labrador"). This reassessment supported the findings of Bateman 1999.

Relevance to SEIS:

Moderate. Analysis addressed military jet aircraft overflights. The species most represented (black ducks and Canada geese) are not the focus of the SEIS, and birds were observed in mid-late summer.

Keywords:

Low-level, jet flight, military, training, molting, staging, scan sampling, black duck, Canada goose, Labrador, Canada

Article 2

Author/Year:	Title:
Bélanger, L., and J. Bédard 1989.	"Responses of Staging Greater Snow Geese to Human Disturbance"
Author's Affiliation:	**Published In:**
Department de Biologie, Universite Laval, Sainte-Foy, Quebec, Canada.	*Journal of Wildlife Management* 53:713-719.

Summary of Findings:

The authors studied the non-experimental effects of human disturbance on staging in greater snow geese in spring and fall in the Montmagny Bird Sanctuary, along the St. Lawrence River in Quebec. The cause of the disturbance was classified as human-related, natural, or unidentified. Human-related disturbance was subdivided as hunting activities, non-hunting activities, agricultural or urban activities (e.g., cars, trucks, or agricultural implements), and transport activities related to aircraft overflights or passage of boats (e.g., ferries, small yachts, or motorboats). Of disturbance events causing some or all of the geese to take flight, the entire flock flushed in 20% of cases. Low-flying aircraft caused >45% of disturbances, and the time spent in flight after aircraft disturbance averaged 65 seconds in fall and 109 seconds in the spring. In 40% of cases, geese stopped feeding following a disturbance, and the mean time to resume feeding was 726 seconds in the fall and 122 seconds in the spring. When they resumed feeding, they fed at the same site used prior to the disturbance in 83% and 75% of the time in fall and spring, respectively.

Hunting and transportation disturbances combined resulted in the greatest loss of feeding time in fall (>15 minutes per disturbance). The level of disturbance during fall influenced goose use of the area; when disturbances exceeded two per hour, 50% fewer geese occupied the sanctuary the next day. The authors found that the amplitude of the disturbance response varied, depending upon the disturbance, and that the impact of the disturbance was related to the disturbance frequency and type. Aircraft disturbance generally affected the entire flock and resulted in the greatest duration of response.

The time to resume feeding was shorter in spring than in fall. This suggests that time to resume pre-disturbance activities is likely also influenced by nutritional need--i.e., the necessity to deposit fat during spring as the birds prepare for migration and breeding.

Authors concluded that disturbance of greater snow geese affects their feeding activities and their subsequent use of the Montmagny sanctuary, particularly in fall. Authors recommend that flights over the sanctuary be prohibited below 500 meters.

Scientific Rigor:

High. Data and statistical analysis appear to support conclusions.

E & E Reviewer Comments (Including Limitations of Study):

Authors recorded only moderate to strong disturbances that caused a part or all of the observed flock to take flight. When slightly disturbed, snow geese stretch their necks, may give alarm calls, and may exhibit flight intention movements. These types of responses were not recorded. Aircraft type, altitude, and sound level associated with aircraft disturbance were not reported.

Relevance to SEIS:

High. Similar species (greater snow geese) and similar habitat (sanctuary surrounded by agriculture).

Keywords:

Greater snow goose, aircraft disturbance, response (flight, resumption of feeding, avoidance of feeding area), Quebec.

Article 3

Author/Year:	**Title:**
Bélanger, L., and J. Bédard 1990.	"Energetic Cost of Man-Induced Disturbance to Staging Snow Geese"
Author's Affiliation:	**Published In:**
Department de Biologie, Universite Laval, Sainte-Foy, Quebec, Canada	*Journal of Wildlife Management* 54:36-41.

Summary of Findings:

The authors estimated the energetic cost of human-induced disturbance to fall-staging greater snow geese based on a study in the Montmagny Bird Sanctuary, along the St. Lawrence River in Quebec (see Belanger and Bedard 1989). Two types of responses by birds to disturbance were considered: 1) birds fly away but promptly resume feeding following the disturbance (Response A); and 2) birds interrupt feeding altogether (Response B). Authors also modeled and compared two consequences of Response B: 1) a net loss of foraging time as disturbed birds simply increase resting, preening time, or both (passive reaction); and 2) birds compensate for lost foraging time by reducing time normally allocated to resting (e.g., increased night feeding, increased daytime ingestion rate (compensatory reaction), or a combination of both. The time spent in flight and the interval before resuming feeding following a disturbance did not differ among days with different levels of disturbance. However, the frequency of disturbance had a direct impact on the total time spent in flight. On days when the frequency of disturbance was five times higher than low-disturbance days, there was a corresponding five-fold increase in flight movements. The authors concluded that human disturbance can have significant energetic consequences for fall-staging snow geese. In fact, at the mean disturbance rate during their study, they estimated that geese incurred an hourly energy loss, the magnitude of which was dependent on whether they immediately resumed feeding or stopped feeding. The authors also suggested that geese needed to increase their time spent feeding (nighttime) by 4% (Response A) to 32% (Response B) to account for these energy losses.

The authors concluded that no increase in feeding rates was observed between days with different disturbance levels. Therefore, geese did not compensate for loss of feeding time by increasing their daily foraging behavior to maximize food intake during undisturbed periods. More than two disturbances per hour may cause an energy deficit that no behavioral compensatory mechanism, such as night feeding, can overcome.

The authors conclude that high levels of disturbance may have harmful energetic consequences on fall-staging snow geese in Quebec. Authors recommend reducing human disturbance, particularly aircraft overflights, and that the sanctuary should be large enough (>200 ha) so that geese could fly away but promptly return to the foraging site and resume feeding (Response A rather than Response B).

Scientific Rigor:

High. Data and statistical analysis appear to support conclusions.

E & E Reviewer Comments (Including Limitations of Study):

Aircraft type, altitude, and sound level associated with aircraft disturbance were not reported.

Relevance to SEIS:

High. Similar species (greater snow goose) and similar habitat (sanctuary surrounded by agriculture).

Keywords:

Aircraft disturbance, energetic cost, greater snow goose.

Article 4

Author/Year:	**Title:**
Black, B. B., M. W. Collopy, H. F. Percival, A. A. Tiller, and P. G. Bonhall 1984.	*Effects of Low Level Military Training Flights on Wading Bird Colonies in Florida*
Author's Affiliation:	**Published By:**
University of Florida.	Florida Cooperative Fish and Wildlife Research Unit, School of Forest Resources and Conservation, University of Florida, Technical Report No. 7.

Summary of Findings:

This is a report of a two-year study on the effect of low-altitude military aircraft training flights on establishment, size, and reproductive success of wading bird nesting colonies in Florida.

During two breeding seasons, the behavioral responses and reproductive success of selected species were monitored in a non-habituated treatment colony (military overflights) and a control colony (no overflights). Breeding wading birds were exposed to F-16 overflights at 420 knots indicated airspeed, 82% to 84% maximum rpm, at 500 ft above ground level, producing noise levels ranging from 55 to100 dBA. Birds exposed to overflights responded in several ways (by exhibiting no response, by looking up, or by in-place body movement) as compared with control groups not subjected to overflights. The responses were significantly different from the control group, but the levels of responses were not severe; no walking or flushing from nests was observed. No productivity-limiting responses were observed. In fact, overall nest success of species studied in both years was greater at the treatment site than at the control site (p. 85). No differences in adult attendance, aggression, or chick feeding rates resulted from F-16 overflights. Some species-specific differences were seen: great egrets that nested high in trees responded more, and nestling great and cattle egrets responded more than adults of these species. However, the authors indicated no evidence of habituation to aircraft overflights. Adults responded less during incubation and chick-rearing than at other times.

Humans entering the colony or airboats in the vicinity elicited a greater response (flushing) than did aircraft. Reproductive parameters were independent of aircraft training flights and responded to environmental influences (climate, colony location, etc.).

Colony turnover rate (i.e., the percentage of colonies changing use each year) was nearly identical in overflight and control colonies; turnover rate was within 2% between MOA and non-MOA areas. Turnover was inversely proportional to colony size; larger colonies experienced lower rates of turnover. Turnover was also a function of species composition; colonies in which great blue herons were most numerous had the highest turnover rates. For some species, colony turnover rate was higher in non-MOA areas than in MOA areas subjected to overflights.

The authors caution against extrapolating these results to other aircraft, lower altitudes, or greater noise levels.

Scientific Rigor:

High. Data and statistical analysis appear to support conclusions. Large sample sizes were used over a large area and involving multiple species, and contrasts were made to unaffected control groups.

E & E Reviewer Comments (Including Limitations of Study):

Authors cite the varying response by nesting adults--dependent upon the stage of the nesting cycle--as evidence that habituation did not occur. However, because almost no differences were observed based upon F-16 disturbances, it could be that these birds either did not need to habituate (i.e., their tolerance was sufficiently high) or already had habituated. It could be argued that the mere presence of these birds, and their ability to successfully nest in areas underlying MOAs, indicates that they had already habituated to aircraft noise.

Relevance to SEIS:

Moderate. Different species (wading birds).

Keywords:

Low level training, wading birds, military aircraft disturbance, behavioral response

Article 5

Author/Year: Burger, J. 1983	**Title:** "Jet Aircraft Noise and Bird Strikes: Why More Birds Are Being Hit"
Author's Affiliation: Department of Biological Sciences, Rutgers University	**Published In:** *Environmental Pollution* 30:143-152.

Summary of Findings:

This study compared the noise generated by narrow-bodied aircraft (e.g., Boeing 707 and 727) and wide-bodied aircraft (e.g., Boeing 747, L1011, DC10) at John F. Kennedy International Airport, in New York, to correlate noise levels with risk of a bird strike. Thousands of ducks, gulls, and shorebirds use the Jamaica Bay Wildlife Refuge adjacent to Kennedy International Airport; 70% of the bird strikes are attributable to gulls. The author's premise is that birds are struck because they do not perceive the threat or cannot avoid the plane once they perceive it.

For tests on the noisy runway, noise levels of the approaching and departing planes did not go above pre-departure noise levels (mean ambient noise level: 85.6 dB) until the plane was within 800 meters of the test site, while on the quiet runway (mean ambient noise level: 66.2 dB) the noise levels went above these levels just prior to 600 meters. Birds would therefore perceive an increase in sound when the plane was only 600 to 800 feet, or 9 to 14 seconds, away. The wide-bodied planes traverse this distance in less time, giving the birds less opportunity to react.

Narrow-bodied planes were significantly louder at touchdown (111.5 dB after 5 seconds compared to 107.0 dB), but wide-bodied planes struck significantly more birds. The author implied that reduced noise from landing wide-bodied aircraft (as it is related to ambient noise) as compared to landing narrow-bodied aircraft was the source of increased strike risk to birds because birds have less warning of an approaching wide-bodied aircraft.

Scientific Rigor:

Moderate.

E & E Reviewer Comments (Including Limitations of Study):

No additional comments.

Relevance to SEIS:

Moderate.

Keywords:

Aircraft body width, speed, noise, JFK Airport, flight behavior risk.

Article 6

Author/Year:	**Title:**
Burger, J. 1981.	"Behavioral Responses of Herring Gulls (*Larus argentatus)* to Aircraft Noise"
Author's Affiliation:	**Published In:**
Biology Department, Center for Coastal and Environmental Studies, Rutgers University.	*Environmental Pollution* (Series A) 24:177-184.

Summary of Findings:

The author studied the effects of airplane noise on incubating and brooding herring gulls nesting at Jamaica Bay National Recreation Area within 2 km of Kennedy International Airport in New York. The author points out that prior to the 1981 publication date of the paper, little other than anecdotal observation existed on bird responses to noise. Furthermore, to support the assertion that noise has little effect, some non-quantitative observations that free-ranging birds have nested in noisy environments (e.g., gulls on airfields) had been offered. In response, the author measured responses of nesting herring gulls to supersonic transport (SST) aircraft, such as the Concorde, and non-SST (i.e., subsonic aircraft, such as the Boeing 707, 727, and 747).

The author recorded the noise level (dBA), the number of birds flying over the area, and the number of fights--both in a control environment and whenever a plane flew overhead. The noise levels during non-SST flights ranged between 88 and 101 dBA; the noise levels during SST flights ranged between 101 and 116 dBA.

The number of nesting gulls in flight over the colony increased significantly during SST overflights but not during non-SST flights. Significantly more gull fights were recorded following SST flights than following other conditions; the incidence of fighting following an SST overflight was 60 times greater than normal. Fights were longer, and eggs were broken after SST overflights as compared with normal conditions.

Solitary-nesting birds (i.e., those away from the colony) had larger surviving clutches, possibly because there were fewer nearby birds to cause egg loss during post-SST fighting. Similarly, loafing gulls flew in response to SST overflights but not for subsonic aircraft overflights. Sounds produced by subsonic jets were of two kinds: those resulting from turbulence between the aircraft and the atmosphere, and those from the engine itself. SSTs also produced a sonic boom in addition to the two noises produced by subsonic aircraft. The responses may have been due to the noise levels, frequency levels of the sounds, or to vibrations from SSTs.

Scientific Rigor:

High. Sound levels were measured, valid sample sizes were used, and the experiment was replicated.

E & E Reviewer Comments (Including Limitations of Study):

Since the SST only lands once or twice daily, whereas non-SST aircraft land every two or three minutes, the frequency of exposure to SST noise levels may not be sufficient for habituation

Relevance to SEIS:

Moderate. Nesting gulls may have different sensitivities to aircraft disturbance than wintering waterfowl, and nesting aggression would not be a factor for OLF geese and swans.

Keywords:

Subsonic and supersonic aircraft disturbance, behavioral response, gulls.

Article 7

Author/Year:	Title:
Burger, J. 1981	"The Effect of Human Activity on Birds at a Coastal Bay"
Author's Affiliation:	**Published In:**
Center for Coastal and Environmental Studies, Rutgers University.	*Biological Conservation* 21:231-241.

Summary of Findings:

This study focused on evaluating the effects of human activity (non-investigator; e.g., horseback riding, jogging, walking, swimming, working [cutting grass], aircraft overflights) on non-nesting birds--mostly gulls, terns, and other colonial waterbirds, including ducks, herons, and egrets. Presumably, non-breeding birds, which are not required to defend their territory or nest, or to care for eggs or chicks, can more easily vacate an area to avoid disturbance compared to nesting birds. The study was conducted in the Jamaica Bay Wildlife Refuge, located within the boundaries of New York City and adjacent to Kennedy International Airport. Responses included no disturbance (birds remained where they were) or disturbed (birds flew). Whenever a plane disturbed birds, the species, their response, and the type of aircraft were recorded.

The author found that birds did not generally respond to subsonic jets. However, SSTs [supersonic transports that produced noise that averaged 108 $\pm$ 3.8 dBA and ranged as high as 116 dBA] (see Burger 1981a) were always observed to disturb birds whenever they passed directly overhead. Birds responded to the SST noise by flushing, although many returned to where they had been.

The author determined that close and fast-moving human activities, such as jogging or grass mowing, usually caused birds to flush. The study also found that proximity to water seemed to lessen the disturbance response. Further, disturbance response varied by location, bird species, and type of disturbance. Gulls did not often flush in the presence of disturbance including aircraft, and shorebirds exhibited the greatest disturbance avoidance response, often vacating the area upon disturbance. In this study, ducks and brant exhibited a response to several kinds of disturbances that was intermediate, flying some distance and not immediately returning.

Scientific Rigor:

Moderate.

E & E Reviewer Comments (Including Limitations of Study):

The observation that supersonic transports were always observed to disturb birds whenever they passed directly overhead contrasts sharply with Fleming et al. (1996), and apparently with Salter and Davis (1972).

Relevance to SEIS:

Moderate. Noise response was studied in different groups of birds. Disturbance response generalized for aircraft; most discussion focused on disturbance from other human activities.

Keywords:

Human disturbance, behavioral response, duck, heron, egret, shorebird.

Article 8

Author/Year:	**Title:**
Conomy, J. T. 1993.	*Habitat Use by, and Effects of Aircraft Noise on the Behavior and Energetics of, Wintering Dabbling Ducks in Piney and Cedar Islands, North Carolina.*
Author's Affiliation:	**Published As:**
Department of Zoology, North Carolina State University, Raleigh.	Master's Thesis, North Carolina State University.

Summary of Findings:

The author studied black ducks, American wigeon, green-winged teal, and gadwall to determine how ducks used various habitats in Piney and Cedar Islands, North Carolina; to quantify time budgets and responses to aircraft disturbance; and to evaluate whether black ducks habituated to aircraft disturbance. Piney Island is used as a bombing and training range (BT-11), and Cedar Island, although not used for military training activity, is close to Piney Island. An average of six disturbance events occurred per hour (80-109 dB), predominantly by fixed-wing military jet aircraft (e.g., F-14, F/A-18, F-16).

All four species spent >90% of their time in four behaviors: feeding, resting, locomotion, and comfort. All species except green-winged teal spend most of their time feeding (range = 18% to 49%) or resting (range = 22% to 36%); activities such as feeding and locomotion were more prevalent during the morning and evening hours than during midday. Resting generally occupied a large portion of the time budget during afternoon hours for most species.

Waterfowl spent ≤1.5% of their time responding to aircraft, and responses included flying, swimming, and alert behaviors, with flying being the most common (0.46%). Mean duration of response for all species was 10 to 40 seconds, and corresponding estimates of energy expenditure were low (0.04 to 2.23 kcal/hour). The low reaction rates suggest that waterfowl were able to behaviorally tolerate aircraft noise across the range of sound levels recorded in the study (mean = 85.7 dB; range = 80 to 109 dB).

Ducks exhibited a low response rate to aircraft noise, and time budgets were not significantly altered in response to aircraft activity. No relationship was found between the number and intensity of disturbance events >80 dB and response rates. For black ducks, only four of 149 (2.6%) and four of 162 (2.4%) responded in 1991 and 1992, respectively (p. 38). Time budgets of black ducks disturbed by aircraft were comparable to the time budgets found in data collected nearby by different researchers from undisturbed ducks. Black duck responses to disturbances other than aircraft were also low, with about <1% of time budgets spent in response to boats and predators. The ducks exhibited no response to hunting activities (but no indication is given of the frequency of such disturbances). Like black ducks, wigeon, gadwall, and green-winged teal exhibited almost no response to aircraft activity.

The ability of black ducks to habituate to aircraft noise was tested by simulating aircraft sounds and measuring responses by captive ducks. Captive ducks allocated >8% of their time budget to swimming and alert behavior in response to simulated aircraft noise, and ducks reduced the time spent reacting to noise during successive days, but reactions never ceased entirely. Captive black ducks began habituating to aircraft noise on the first day of exposure.

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

Author indicated a possibility that black ducks have greater response to sounds with a sharp onset rate than sounds with slower onset rates.

Relevance to SEIS:

High. Behavioral response to military aircraft overflights. Study provides estimated energetic costs to waterfowl attributable to aircraft disturbance in kcal/hour. However, different species were studied than those present near OLF sites.

Keywords:

Aircraft noise disturbance, ducks, time budget, activity budget, Piney Island, Cedar Island, North Carolina.

Article 9

Author/Year:	**Title:**
Conomy, J. T., J. A. Collazo, J. A. Dubovsky, and W. J. Fleming 1998.	"Dabbling Duck Behavior and Aircraft Activity in Coastal North Carolina"
Author's Affiliation:	**Published In:**
U.S. Geological Survey, Biological Resources Division, North Carolina Cooperative Fish and Wildlife Research Unit, North Carolina State University.	*Journal of Wildlife Management* 62:1127-1134.

Summary of Findings:

Summary is related to study and findings in Conomy 1993. The authors studied black ducks, American wigeon, green-winged teal, and gadwall to determine how ducks used various habitats in Piney and Cedar Islands, North Carolina, to quantify time budgets and responses to aircraft disturbance. Piney Island is used as a bombing and training range (BT-11), and Cedar Island, although not used for military training activity, is close to Piney Island. See also: Conomy 1993.

An overflight occurred when an aircraft passed directly over focal individuals near or at 152 meters altitude, the minimum allowed on the range. To eliminate noises caused by sources other than aircraft, the threshold level of 80 dB or higher was deemed an exceedance. The number of exceedances per hour attributable to airplanes ranged from 1 to 44. Sound levels averaged 85.1 dB, +/- 0.9 dB, and ranged from 80 to 109 dB. Mean duration of exceedances (sec) during 1-hour observation periods was 5.1, +/- 0.3 (maximum = 10.0)

There was no relation between the number of disturbance events and the number of responses by black ducks, American wigeon, gadwall, or green-winged teal. Resting was the only activity inversely related to sound variables and most interrupted for all species combined (9/14 occasions). Because resting is an energy-conserving activity, the authors postulate that frequent interruptions could translate to energetic losses. In addition, disruption of one activity (e.g., resting, foraging) for another (e.g., locomotion, aggression) could increase energetic costs.

However, the authors conclude that the energetic costs to the population were deemed low because such a small proportion of the population responded (13/672; 2%), their responses were brief (10 to 40 seconds), and the waterfowl were highly likely to resume their pre-disturbance behavior (64%).

The authors caution against extrapolating these results to other species or locations and also caution that the effects should be re-examined if the type of aircraft in use is changed.

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

No additional comments.

Relevance to SEIS:

High. Study evaluated behavioral response to military aircraft overflights. However, species were different from those present near OLF sites. Note that decibel levels were A-scale. weighted because it most closely represents the sensitivity of the avian ear (p.1128).

Keywords:

Aircraft disturbance, black duck, wigeon, gadwall, green-winged teal, energy budget, North Carolina, winter.

Article 10

Author/Year:	**Title:**
Conomy, J. T., J. A. Collazo, and W. J. Fleming 1996.	"Behavioral Responses of Wintering Waterfowl to Military Aircraft Activity in Pamlico Sound, North Carolina"
Author's Affiliation:	**Published In:**
National Biological Service, Cooperative Fish and Wildlife Research Unit, North Carolina State University.	Chapter D *in* W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, Editors, *An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina, Final Report to U.S. Marine Corps, Cherry Point Marine Air Station.*

Summary of Findings:

Summary is related to study and findings in Conomy 1993. The authors studied black ducks, American wigeon, green-winged teal, and gadwall to determine how ducks used various habitats in Piney and Cedar Islands, North Carolina; to quantify time budgets and responses to aircraft disturbance; and to evaluate whether black ducks habituated to aircraft disturbance. Piney Island is used as a bombing and training range (BT-11), and Cedar Island, although not used for military training activity, is close to Piney Island. An average of six disturbance events occurred per hour (80 to 109 dB), predominantly by fixed-wing military jet aircraft (e.g., F-14, F/A-18, F-16).

Wintering black ducks, wigeon, gadwall, and green-winged teal spent < 1.4% of their time responding to aircraft. The mean duration of responses was 10 to 40 seconds, and energetic costs to waterfowl represented 1% to 3% of their estimated diurnal energy budget and about 1% of their daily budget. About 2.6% of the population reacted to aircraft disturbance, and the likelihood of resuming the same behavior after the disturbance reaction was 65% (9/14). In the remaining cases (mostly gadwall and green-winged teal), individuals initiated activities that were more energetically costly, such as locomotion, comfort movements, and aggression (p. D-14).

The authors suggested that aircraft disturbance was not adversely impacting the energy budgets of waterfowl or that aircraft disturbance did not diminish the quality of habitat on Piney and Cedar Islands. Waterfowl were free to distribute themselves where obtaining a balanced or positive energy budget was maximized, and authors noted that waterfowl numbers increased as the winter progressed See further discussion of conclusions in Conomy 1993.

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

The authors acknowledged that other aircraft or levels of intensity may affect different species differently and cautioned against making inferences to other locations or species. In addition, authors state that conclusions are based on observable behaviors. Others have reported that even when behavior does not change, black ducks may exhibit increased heart rates when aircraft fly over, or when other birds approach. However, these other researchers also stated that heart rate quickly subsides and that the increase is probably of no significance (p. D-15).

Relevance to SEIS:

High. Behavioral response to military aircraft overflights. However, different species than those present near OLF sites.

Keywords:

North Carolina, Pamlico Sound, military, aircraft, behavior, disturbance response, population.

Article 11

Author/Year:	**Title:**
Conomy, J. T., J. A. Dubovsky, J. A. Collazo, and W. J. Fleming 1996.	"Habituation of Black and Wood Ducks to Aircraft Noise"
Author's Affiliation:	**Published In:**
National Biological Service, Cooperative Fish and Wildlife Research Unit, North Carolina State University.	Chapter E *in* W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, Editors, *An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina, Final Report to U.S. Marine Corps, Cherry Point Marine Air Station.*

Summary of Findings:

Summary is related to study and findings in Conomy 1993. In this study, two experiments were conducted to test captive, wild-strain black ducks and wood ducks to actual or simulated jet aircraft activities. In the first experiment, black ducks were placed in an enclosure near the center of aircraft activities on Piney Island, a military aircraft bombing-target range (see Conomy 1993 for further discussion of range). The proportion of the experimental population of black ducks exhibiting reaction to visual and auditory aircraft activity decreased from 38% to 7.47% in the first 15 days of confinement, and the duration of the response per bird also decreased with time, suggesting that habituation did occur for black ducks. Response rates remained stable after 15 days.

In the second experiment, captive black and wood ducks were subjected to six different aircraft recordings of jet noise, played at randomly selected times, for a total of 36 noise events per day for 4 days (which approximated the mean of the overflights that occurred at Piney Island during the study period [1991-1992]) (see Conomy 1993). Black ducks spent >87% of their time in four behaviors: feeding, resting, locomotion (not due to noise), and comfort. Behaviors elicited by aircraft noise (swimming and alert) accounted for slightly over 8% of the ducks' time budget. The proportion of black ducks reacting to the noise decreased significantly from day 1 (25%) to day 6 (8%).

Over 90% of wood duck activity was spent on feeding, resting, locomotion (not due to noise), and comfort. Response to simulated noise accounted for about 9% of the total budget. Unlike the black ducks, which exhibited similar response patterns, two groups of wood ducks exhibited increased reactions (spending 18% and 11% of their time responding to aircraft noise, respectively). Because wood ducks did not demonstrate habituation to simulated aircraft noise and some became sensitized, demonstrating increased reactions in some days after initial exposure, the authors suggest that the ability of waterfowl to habituate to aircraft noise may be species-specific.

The authors indicated that sounds can elicit response both with and without visual cues, and that responses vary by species. They added that sounds with "sharp" (i.e., rapid) onset times (e.g., those of a fast-approaching jet) did not result in habituation to the same degree that sounds with longer onset times (e.g., those of slowly approaching aircraft) did.

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

No additional comments.

Relevance to SEIS:

High.

Keywords:

Black duck, habituation, sensitization, experimental disturbance.

Article 12

Author/Year:	**Title:**
Davis, R. A., and A. N. Wiseley 1974.	"Normal Behavior of Snow Geese on the Yukon-Alaska North Slope and the Effects of Aircraft-Induced Disturbance on this Behaviour, September, 1973"
Author's Affiliation:	**Published In:**
L.G.L., Limited, a private consultancy under contract to Canadian Arctic Gas Study, Limited, and to Alaska Arctic Gas Study Company.	Chapter II *in* W. W. H. Gunn, W. J. Richardson, R. E. Schweinsburg, and T. D. Wright, Editors, *Studies on Snow Geese and Waterfowl in the Northwest Territories, Yukon Territory and Alaska, 1973,* Biological Report Series, Volume 27, September 1974, pp. 1-85.

Summary of Findings:

This study was designed to document normal (i.e., undisturbed) behavior of snow geese during staging and evaluate the effects of aircraft overflights by various types of aircraft upon this behavior. The first phase of the study quantified the normal behavioral patterns of undisturbed snow geese. The second phase imposed an experimental disturbance (fixed wing [Cessna 185] and helicopter [Bell 206-B] overflights) of flocks of snow geese at two intervals of disturbance (one-half-hour and two-hour intervals). Finally, the effects of unscheduled aircraft and natural (bird and mammal) disturbances were evaluated.

The most important activity in the context of the study was the amount of time spent feeding. Each September, up to 400,000 snow geese occupy Alaska's North Slope, where they feed to build energy reserves in preparation for fall migration. The frequency of feeding determines the energy intake and the resultant increase in fat reserves for the fall migration.

Undisturbed geese were found to spend 57% of the daylight interval feeding. Juveniles spent between 65% and 70% of the daylight interval feeding. The percentage of birds feeding in a given flock was constant throughout the day, with a slight decline in mid-afternoon. Feeding was not continuous but instead occurred in periods of from one to four hours. The percentage of the flock that was in alert behavior, similarly, varied little through the day. Diurnal sleeping occurred, and generally, the percentage of flocks observed sleeping was lowest at midday and increased and leveled thereafter. On average, undisturbed geese spent time flying (5%), alert (18%), feeding (57%), sleeping (14%), and in other activities (6%). This baseline was used to evaluate disturbance effects.

Experimental aircraft disturbances were made on two days in mid-September, at 2-hour and one-half-hour intervals, using Cessna 185 fixed-wing aircraft and Bell 206-B helicopters. Authors sought to document 1) response of snow geese to aircraft disturbance; 2) comparative response of snow geese to small fixed-wing aircraft and helicopters, and 3) whether flocks of snow geese showed "accommodation" to the more frequent flights at one-half-hour intervals.

Not all flocks responded to aircraft (i.e., $\geq$10% of the flock took flight).

The authors found no difference between the percentage of flocks that flushed in response to nearby disturbances (<2 mi.) and those more distant (2 to 4 mi). Geese were equally prone to flushing in response to fixed-wing aircraft and helicopters. Geese flushed at greater distances in response to helicopters but flew for a longer time and exhibited longer overall interruption of normal behavior in response to fixed-wing aircraft disturbances. A lower proportion of flocks flushed in response to overflights by a Cessna at one-half-hour intervals than at two-hour intervals. Those flocks that flushed did so at greater distances from the aircraft during overflights at one-half-hour intervals, but they did not fly as far as during overflights at two-hour intervals.

Goose response was monitored during 73 natural disturbances and 163 non-experimental aircraft flights. For non-experimental aircraft disturbances, observers attempted to estimate the source, horizontal distance between aircraft and geese, altitude of aircraft, and flock behavior before, during, and after each overflight. Upon approach by aircraft or predator, the proportion of geese in each flock that was alert increased, but this phase was reversible; if the aircraft or predator did not approach closely, alert response waned to normal, and the flock resumed its pre-disturbance activity. If the disturbance continued to approach, geese formed tighter groups and called until the source left the area. If the disturbance source continued to approach, geese took flight as a group and maintained a tight formation--a flight pattern unique to disturbance aversion. If the aircraft or predator flew over at low altitude, flocks occasionally split and flew in different directions. If flocks returned to the ground, a large proportion remained alert. Level of behavior recorded included alert, mass, rise, circle, and flew from area.

With the exception of massed behavior (which was largely a response to raptors), there were no clear-cut qualitative differences in the behavior patterns of geese in response to the various sources of disturbance. However, flocks of geese flushed to greater distances when disturbed by aircraft of any type than by natural sources of disturbance and flew farther when flushed by large aircraft than by small or medium aircraft. Responses to aircraft related to size of aircraft, not to altitude or noise level.

Unscheduled aircraft disturbances occurred at a rate of 0.25 per hour and were mostly attributable to small, fixed-wing aircraft. These casual disturbances resulted in an average interruption of 6.3 minutes and goose flights that averaged 2.2 minutes. The energetic impact of a hypothetical rate of 0.5 disturbance per hour was estimated to be a 20.4% decline in energy stored (or 47.7 grams of fat).

Non-experimental aircraft disturbance at a rate of 0.25 per hour resulted in a potential decrease of 2.6% of time spent feeding. Experimental fixed-wing aircraft disturbance at 2-hour intervals caused a decrease in feeding time of 8.5% and could cause a reduction of 20.4% (or 47.7 grams of fat) in the energy reserves of juvenile geese. For small helicopter overflights, the reduction in feeding time was 9.5%.

Scientific Rigor:

Low. Conclusions are conflicting, and minimal statistical hypothesis testing was included.

E & E Reviewer Comments (Including Limitations of Study):

Authors acknowledge that response to unscheduled disturbances could be biased toward positive results because a source of disturbance was only detected when the geese reacted. Although the study indicated some level of accommodation did occur to aircraft disturbance, estimate of loss of energy reserves does not account for any accommodation. Also, as noted by authors, estimate of loss of energy reserves assumes that no compensatory increases in the time spent feeding occur following a disturbance.

Relevance to SEIS:

Low/Moderate. Small fixed-wing aircraft and helicopters were used, so inference is limited. There may be some worthwhile anecdotal information, but conclusions drawn from limited data analyses are questionable.

Keywords:

Snow goose, fall migration, Alaska, North Slope, Bell 206 helicopter, Cessna 185, feeding.

Article 13

Author/Year:	**Title:**
Derksen, D. V., K. S. Bollinger, D. Esler, K. C. Jensen, E. J. Taylor, M. W. Miller, and M. W. Weller 1991.	*Effects of Aircraft on Behavior and Ecology of Molting Brant Near Teshekpuk Lake, Alaska*
Author's Affiliation:	**Published In:**
DVD, KSB, and DE: U. S. Fish and Wildlife Service, Alaska Fish and Wildlife Research Center; KCJ, EJT, MWM, and MWW: Department of Wildlife and Fisheries Sciences, Texas A&M University.	U. S. Fish Wildlife Service Report to U. S. Bureau of Land Management and U. S. Minerals Management Service.

Summary of Findings:

This study was designed to 1) determine the effect of aircraft overflights and other human-induced activities on brant behavior, distribution, and habitat use in the Teshekpuk Lake Special Area (TLSA), and 2) examine nutritional and energetic requirements for completion of molt as these relate to habitat use and potential disruption by incidental and controlled disturbance events. The authors contend that undisturbed foraging is critical to completing the molt and acquiring the necessary lipid reserves for migration. Molting brant and geese are sensitive to disturbance and have been known to discontinue use of areas subject to human disturbance. Decreased time spent foraging, increased metabolism due to high numbers of energy-demanding behaviors (such as running and wing flapping), and dispersal to poorer quality habitat may result in an inadequate accumulation of body reserves.

Time-activity budgets for molting brant were recorded by observers, hidden in blinds, of an undisturbed population, so that effects from helicopters could be evaluated. Molting brant behavior included feeding (53%), resting (25%), maintenance (11%), walking (5%), swimming (4%), acting alert (0.9%), (running)0.6%, and aggression (0.4%).

Bell 206 helicopters were used to induce experimental disturbance during 140 flights. These flights were between 150 and 1,525 m altitude, at a speed of 100 knots, along predetermined flight lines. Observers were stationed in ground blinds and onboard helicopters. Non-experimental flights in the area were also monitored. Recorded disturbances were alert, walking, running, swimming, massing, and flightless flapping. Duration of disturbance response varied with helicopter altitude and lateral distance to the flock. Response duration was greatest at helicopter altitudes of <1,070 m. Mid-altitude flights (215 to 360 m) were the most disturbing to brant, more so than even low-altitude flights, possibly because visibility was obscured. Greater horizontal distances resulted in lower disturbance responses. Flock size influenced disturbance response; the duration of disturbance response increased with flock size. Brant did not habituate to aircraft on a daily basis, or during the study interval. The duration of response increased with flock size. Telemetry-equipped brant that were subjected to overflights moved more than five times the rate at which control birds did, and disturbed birds also moved more during than after disturbances. Disturbances could affect movement rate and habitat use in successive days.

The authors developed a simulation model to test the effect of helicopter disturbance on molting brant. Body mass loss was the only response variable tested, and response categories were generated from different flight parameters. Up to 16% of this population could suffer heavy weight loss if subjected to up to 50 flights per day; it was doubtful that birds experiencing this mass loss would survive.

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

No additional comments.

Relevance to SEIS:

Low. Helicopter flights elicit different responses than fixed-wing aircraft. Different species than species studied in SEIS.

Keywords:

Teshekpuk Lake, Alaska, Pacific black brant, molt, helicopter disturbance, Bell 206, simulation model.

Article 14

Author/Year:	**Title:**
Dooling, R. J. 1980	"Behavior and Psychophysics of Hearing in Birds."
Author's Affiliation:	**Published In:**
Rockefeller University	Chapter 9 *in* A. N. Popper and R. R. Fay, Editors, *Comparative Studies of Hearing in Vertebrates*, Springer-Verlag, New York, New York.

Summary of Findings:

Bird hearing is thought to be generally intermediate between that of reptiles and mammals, but birds have undergone significant adaptive radiation and vary considerably. Until the time of this book, anatomical and psychophysical techniques had not been available to determine parameters of bird hearing capability. Behavioral audibility curves were available for only 16 species. These species were similar in terms of absolute threshold curve; lowest thresholds were at 2 kHz and 4 kHz, the region of maximum sensitivity was narrow (1 to 2 octaves), and high-frequency sensitivity (>10 kHz) for these birds was very poor. Night hunting owls have a high absolute sensitivity. Bird hearing sensitivity falls within the range for humans, particularly at the avian upper and lower frequency limits. Within birds, passerines tend to have better high-frequency sensitivity, and poorer low-frequency sensitivity, than non-passerines. One reason, but not the only reason, for the difference in high-frequency sensitivity between birds and mammals is the performance of the middle ear. Low-frequency sensitivity is limited by middle ear impedance, which is affected by the small spaces in the ears of birds.

Although pigeon hearing spans 200 Hz down to 0.05 Hz, between 1 to 10 Hz, pigeon hearing is 50 dB more sensitive than man's. This is very low frequency, but whether other birds or even other vertebrates possess this ability is unknown.

There is no difference between birds and mammals in intensity or temporal resolving power, but there are differences in frequency resolving power.

At least one species, parakeets, showed much less threshold shift than that found in mammalian ears, supporting the idea that birds are relatively immune to acoustic trauma from loud noises (p. 275). For parakeets, no sensory cell loss was shown, even at the highest levels of experimental sound exposure.

Scientific Rigor:

Moderate.

E & E Reviewer Comments (Including Limitations of Study):

The chapter displays specialized and limited analytical results for few species of birds in a level of detail and with terminology laypersons cannot generally use. It discusses the theoretical influence of ambient noise on absolute hearing sensitivity (p. 268) and that birds are relatively immune to acoustic trauma from loud noises (p. 275). This chapter was written for a specialized audience that is highly knowledgeable about measures of hearing, research methods, anatomical structures, and other terminology associated with acoustic measurement. No data were presented for waterfowl hearing, and laypersons reading this chapter would benefit from a glossary, as the terminology is specialized and not understandable to non-specialists.

Relevance to SEIS:

Moderate. Some research to support noise impact assessment.

Keywords:

Bird hearing, behavior audibility curves

Article 15

Author/Year:	**Title:**
Dooling, R. J., B. Lohr, and M. L. Dent 2000.	"Hearing in Birds and Reptiles"
Author's Affiliation:	**Published In:**
RJD: Department of Psychology, University of Maryland; BL and MLD: affiliation not provided.	Chapter 7 *in* R. J. Dooling, R. R. Fay, and A. N. Popper, Editors, *Comparative Hearing: Birds and Reptiles.*

Summary of Findings:

This study reviewed the limits of auditory detection and resolving power of birds and reptiles. There is considerable similarity between anatomical structures of some birds and reptiles (particularly crocodilians) and seeming similarity in hearing performance between birds and humans (thresholds for detecting amplitude modulated [AM] and frequency modulated [FM] sounds are similar between budgerigars and humans). Hearing in animals can be studied using anatomical, physiological, and behavioral approaches, and there is seeming correspondence among measures made by each method. The minimum audible sound pressure at frequencies throughout an animal's range of hearing defines its audibility curve. Behavioral audibility curves are available for only 38 species of birds, and physiological recordings are available for another 10 species (*note*: the only member of *Anatidae* listed among the 48 species was the mallard duck).

Birds hear best at frequencies between 1 and 5 kHz, with absolute sensitivity around 0 to10 dB at the most sensitive frequency, usually around 2 to 3 kHz. Nocturnal predators hear better than songbirds; songbirds hear better at high frequencies than non-songbirds; non-songbirds hear better at low frequencies than songbirds. There tends to be a correlation between hearing sensitivity at high frequencies and the highest frequencies contained in a species' vocalizations. There may also be a strong correlation between body size and sensitivity such that larger birds hear better at low frequencies and poorer at high frequencies than small birds. But, variation and exceptions do occur. Pigeons, for example, have unusual auditory sensitivity to very low frequencies, possibly 50 dB more sensitive than humans in the range of 1 to 10 Hz.

Critical ratios (the ratio between the power in tone at threshold and the power per Hz of the background noise) have implications for interfering with acoustic communication. Critical ratios are available for 13 species of birds (no *Anatidae* were included). Typically, there was a 3 dB increase in critical ratio with each doubling of frequency over a frequency range of two to three octaves. Critical masking ratios are also known: the great tit produces an aerial predator alarm call that is pure tone, in the range of 8 kHz. Presumably, this is inaudible to the sparrow hawk, the tit's chief predator.

Birds are very sensitive to changes in the frequencies of acoustic signals and can probably hear a 1% change in frequency (humans can detect slightly better). Intensity discrimination is probably no more sensitive than that of humans, based on tests of five species of birds, and is probably within the range of 1 to 4 dB, similar to that of other nonhuman vertebrates.

Because birds produce, learn, and respond to complex acoustic signals, much is known about limits of auditory detection and resolution. Masking release, the ability to discriminate pure tone masked by noise, is similar in birds and humans. And, masking release increases with increasing masker bandwidths, also as is the case with humans. Where budgerigars and humans differ is in recognition of rising and falling pitch patterns. Budgerigars are sensitive to frequency range but insensitive to pitch contour (i.e., they were insensitive to whether successive tones rose in frequency, stayed constant, or fell); this was exactly the opposite of human capability. When humans and budgerigars were subjected to trials for ability to detect changes in frequency, and they knew when changes would occur (low uncertainty trials), discrimination was as good as for single tones in isolation. However, when the instant of frequency change was unknown to them (high uncertainty trials), discrimination thresholds were much worse for humans but not for budgerigars.

For many vertebrates and humans, the ability to detect a sound improves as the duration of the sound increases, to about 200 milliseconds (ms). This is called the time constant, and it is similar for birds and humans. Gap detection is the measure of the minimum detectable interval between two sounds. For humans, this measure falls within the range of 2 to 4 ms. For birds, the range is similar; 2 to 3 ms. At low sound pressure levels, birds are much more sensitive than humans and other mammals at detecting gaps in noise. And, when the frequency of the post-gap sinusoid was varied, human performance dropped dramatically, while budgerigar performance did not. For birds, discriminatory sensitivity of the auditory system begins to fail when trying to resolve acoustic events happening faster than once every 1 to 2 ms, whereas for humans, sensitivity is lost for events occurring faster than every 4 to 5 ms. But, humans are more sensitive to intensive changes than birds are. Birds are not unusually sensitive to changes in duration of acoustic signals presented in isolation. While noise can affect a bird's ability to detect important sounds, birds can gain a significant advantage in signal-to-noise ratio simply by turning their heads.

Behavioral tests of bird hearing have provided the first critical evidence of the extent to which hearing is regained following hair-cell regeneration in the peripheral auditory system for birds. As for humans, noise can damage the hair cells in the basal papilla, resulting in temporary and permanent threshold shifts. Hair cell regeneration appears to result in almost complete recovery of absolute thresholds.

Scientific Rigor:

Not Applicable

E & E Reviewer Comments (Including Limitations of Study):

This study provides no new experimental data and no waterfowl data. However, it does provide experimental evaluation of bird hearing relative to human capability. This paper was written for a specialized audience that is highly knowledgeable about measures of hearing, research methods, anatomical structures, and other terminology associated with acoustic measurement. No data were presented for waterfowl hearing.

Relevance to SEIS:

Low/Moderate. Some research to support noise impact assessment.

Keywords:

Bird hearing relative to humans

Article 16

Author/Year:	**Title:**
Dooling, R. J., 2002.	*Avian Hearing and the Avoidance of Wind Turbines*
Author's Affiliation:	**Published By:**
Department of Psychology, University of Maryland.	Technical Report, National Renewable Energy Laboratory, NREL/TO-500-30844, June 2002.

Summary of Findings:

This report was contracted by the National Renewable Energy Laboratory and summarized available information on bird hearing relative to noise generated by wind turbines. The report provides general information, with specific reference to the Altamont Pass Wind Resource Area, a wind energy operation with high numbers of bird mortalities that result from collisions with wind-turbine generator blades. The report describes hearing measurement, then the relationship of bird hearing to environmental noise, and is followed by four appendices: 1) a bibliography on bird hearing in quiet environments; 2) plots of audiograms (audibility curves) for 49 species; 3) a bibliography on bird hearing in noise (i.e., "masked thresholds") and; 4) plots of masked auditory thresholds.

Bird hearing is studied using anatomical, physiological, and behavioral methods. Behavioral or psychoacoustic approaches are the most direct and appropriate methods to assess animal hearing capability. The minimum audible sound pressure level that can be detected at frequencies across the animal's range of hearing defines the audibility curve. Behavioral audibility curves are available for 39 species, and 10 additional species can be added, with data that resulted from physiological measurements. Dissimilar orders of birds were tested to evaluate the variability in hearing capability. There was less variation in hearing sensitivity among birds than among members of other vertebrate groups. Among vertebrates, birds are unusual in their high consistency of auditory structures among species and in their hearing capabilities.

Birds hear best between 1 and 5 kHz, with absolute sensitivity approaching 0-10 dB at the most sensitive frequency, which is usually in the range of 2-3 kHz. Some exceptions exist that demonstrate that all birds do not hear equally well. Pigeons, for example, have unusual sensitivity to sounds at very low frequency and may be 50 dB more sensitive than humans in the frequency range of 1-10 kHz. As another example, nocturnal predators such as owls have absolute auditory thresholds that are unusually low. In contrast to humans and most other vertebrates, birds do not hear well at either low or high frequencies, and there are no birds known that can hear above 15 kHz. Acoustic bird deterrents are not effective over the long term for two reasons. First, birds generally habituate to and disregard them after a short period. Second, devices that purport to deter birds without being annoying to humans (e.g., by using sound frequencies outside the range of human hearing) are inaudible to birds as well, given that they possess a more narrow range of hearing than do humans.

The "A" weighting of SPLs is useful for evaluating bird hearing, as it is similar to that used for humans. A-weighting is generally recognized because it is a filter shaped roughly like the human audiogram.

Scientific Rigor:

High. The review provides audibility curves for more and different bird species than available previously.

E & E Reviewer Comments (Including Limitations of Study):

The paper is more understandable to laypersons than other works by Dooling included in this review. Audibility curves for most of the species included are of little relevance to the SEIS; neither tundra swans nor snow geese are presented. However, an audiogram is available for mallard duck; the only waterfowl data provided.

Relevance to SEIS:

Moderate. The document was prepared to address bird vulnerability to wind turbines, with a case study of the Altamont Pass Wind Resource Area. As such, it provides considerable discussion relative to the topic of whether it is possible to lessen wind energy mortality to birds by incorporating audible (and visual) cues. But, the paper provides general discussion of bird hearing capability that may be of interest relative to the SEIS.

Keywords:

Wind turbine generator, Altamont Pass Wind Resource Area, bird hearing capability, audibility curve, mallard duck

Article 17

Author/Year:	**Title**:
Dubovsky, J. A., J. T. Conomy, J. A. Collazo, and W. J. Fleming 1996.	"Wintering Waterfowl Numbers and Behaviors in a Military Aircraft Training Facility in Pamlico Sound, North Carolina"
Author's Affiliation:	**Published In:**
National Biological Service, Cooperative Fish and Wildlife Research Unit, North Carolina State University.	Chapter C in W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, Editors, An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina, Final Report to U.S. Marine Corps, Cherry Point Marine Air Station.

Summary of Findings:

As part of a comprehensive project designed to assess the potential effects of aircraft activity on waterfowl, the authors determined the species composition, numbers, and distribution of wintering waterfowl at Piney and Cedar Islands during 1990-1991 and 1991-1992. The authors evaluated whether military training activity, conducted primarily during weekdays within the training range of Piney Island, influenced bird abundance and distribution around the islands (e.g., seasonal reduction in numbers).

Waterfowl numbers (American black duck, gadwall, wigeon, and green-winged teal) were higher in aerial survey counts conducted during weekdays than in those conducted on weekends, despite higher levels of military aircraft activity during the weekday. Mean numbers of waterfowl for weekday and weekend surveys were 4,258 and 5,689, respectively. If large (> 4,700 flocks of transient diving ducks) are removed from survey numbers, mean counts are 1,908 and 1,739 for weekday and weekend totals, respectively. More than 73% of waterfowl at Piney Island were concentrated in a few sites that are within the primary flight lines associated with the most frequently used targets on Piney Island (BT-11). Seasonally, black ducks and wigeons increased as winter progressed on both Cedar Island and Piney Island both years. Gadwall and green-winged teal fluctuated during the seasons at lower population numbers, but peak counts could be detected both during late fall and late winter. Trend analyses indicated that waterfowl numbers have not declined since the 1960s.

Waterfowl in areas with higher levels of military aircraft activity did not apportion time budgets differently to most activities than waterfowl that were monitored in areas where aircraft activity was minimal. All species except green-winged teal spent most of their time feeding (range of 18% to 49%) or resting (range of 22% to 36%). Teal spent most of their time resting (38% to 49%) and locomoting (37% to 40%), while only 7% to 9% of their time was spent feeding. Additionally, energetic costs due to disturbance from aircraft and other sources were close to those obtained by other waterfowl in areas of low or no aircraft disturbance.

See also Conomy 1993; Conomy et al. 1996, 1998.

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

Because of low sample sizes, statistical comparisons between weekdays and weekends were not made. This study did not conduct control surveys in replicate areas, so no true comparisons to areas not subjected to military aircraft were made.

Relevance to SEIS:

High.

Keywords:

North Carolina, Pamlico Sound, military, aircraft, behavior, population.

Article 18

Author/Year:	**Title:**
Dubovsky, J. A., and W. J. Fleming 1996.	"Population Trends of Wintering Waterfowl in Military Aircraft Operating Areas in Pamlico Sound, North Carolina"
Author's Affiliation:	**Published In:**
National Biological Service, Cooperative Fish and Wildlife Research Unit, North Carolina State University.	Chapter B in W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, Editors, An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina, Final Report to U.S. Marine Corps, Cherry Point Marine Air Station.

Summary of Findings:

As part of a comprehensive project designed to assess the potential effects of aircraft activity on waterfowl, the authors evaluated waterfowl population trends (growth rates and species composition) within the Military Operating Areas (MOAs) in comparison to population trends within North Carolina and the Atlantic Flyway. Midwinter Waterfowl Inventory (MWI) data from 1961-1991 were reviewed for 25 species of waterfowl. If military aircraft operations were affecting waterfowl within the MOAs, it would be expected that population declines would be greater there than those found for the State of North Carolina and for the Atlantic Flyway overall, where military aircraft activity was less intense. To analyze population numbers, waterfowl numbers for all MWI areas in North Carolina were compared against those for all survey areas overlapping in MOAs at Piney Island (which includes several MOAs and BT-11, a practice bombing range for military aircraft).

Population analysis indicated that, unlike declines found for North Carolina and the Atlantic Flyway overall, the Piney Island population was decreasing at a lower rate, and some species, paradoxically, were increasing. Likewise, the number of species in survey areas encompassing MOAs were not reduced, but actually increased (p. B-7).

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

Results were not a product of an experimental study. No cause-and-effect relationship is inferred. Also, this study demonstrated the potential for interspecific differences in population response to military aircraft activity levels. Authors suggest that the absence of declines could indicate that the species inhabiting Piney Island can habituate to noise. Also, habitat changes elsewhere could potentially influence the number of waterfowl inhabiting Piney Island.

Relevance to SEIS

High.

Keywords:

North Carolina, military, aircraft, population.

Article 19

Author/Year:	**Title:**
Dubovsky, J. A., W. J. Fleming, R. Lien, and G. S. Davis 1996.	"Body Mass, Behaviors, and Physiological Responses of Black Ducks Maintained in a Military Aircraft Operating Area in Pamlico Sound, North Carolina"
Author's Affiliation:	**Published In:**
National Biological Service, Cooperative Fish and Wildlife Research Unit, North Carolina State University.	Chapter G in W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, Editors, An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina, Final Report to U.S. Marine Corps, Cherry Point Marine Air Station.

Summary of Findings:

As part of a comprehensive project designed to assess the potential effects of aircraft activity on waterfowl at Piney Island, North Carolina, this study evaluated the winter physiology of captive black ducks to determine whether physiological changes resulted from repeated exposure to military-aircraft disturbance. Body mass, progression of the female prebasic molt, and plasma concentrations of hormones associated with the control of metabolic rate and initiation of reproductive development were compared between black ducks exposed and those unexposed to military aircraft noise.

The experimental stock was composed of 38 (19 male and 19 female) immature (i.e., less than 1 year of age), wild-strain black ducks hatched from eggs in 1990 at North Carolina State University. The birds had no prior exposure to military aircraft activity. Half of the experimental stock was transported to an aviary located on Piney Island and housed communally between November 1991 and March 1992.

Body masses of both males and females generally were lower at Piney Island than at the control site, although masses increased during the breeding season. Authors suggest that based on contradictory evidence in other studies, adults may be better able than immature ducks to tolerate disturbances caused by aircraft activity. The initiation date of the molt for Piney Island female ducks was later than that for control birds. However, median molt-termination dates were similar between Piney Island and control birds.

The authors suggest that unless body-mass decreases and delayed molt initiation negatively impact important life-cycle events (e.g., feather production, reproduction), the short-term effects may be negligible.

The authors could not determine whether differences would present long-term consequences for captive birds or if they would also be found in free-ranging waterfowl (p. G-25).

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

The small body-mass loss observed in captive birds--birds accustomed to being provided with *ad libitum* feed—in this study may have only a limited relevance to the magnitude of the body-mass loss that would result in wild birds not provided with unlimited food.

Relevance to SEIS:

High. Body mass is an important index of overwintering waterfowl biology and is a direct measure, as compared with behavioral responses, which are often interpreted as having the ability to influence indirect measures such as foraging efficiency.

Keywords:

Aircraft disturbance, black duck, captive study, physiological responses.

Article 20

Author/Year:	**Title:**
Dunnet, G. M. 1977.	"Observations on the Effects of Low-Flying Aircraft at Seabird Colonies on the Coast of Aberdeenshire, Scotland"
Author's Affiliation:	**Published In:**
Zoology Department, University of Aberdeen, Scotland.	*Biological Conservation* 12:55-63.

Summary of Findings:

The greatly increased use of helicopters and fixed-wing aircraft to support the exploration and exploitation of oilfields in the North Sea gave rise to concern about possible disturbance to seabirds breeding in the aircraft flight paths. Cliff-nesting fulmars, shags, herring gulls, kittiwakes, guillemots, razorbills, and puffins were observed during non-experimental flyovers to monitor disturbance response. Birds were observed for two days in egg-laying (mid-May) and early chick-rearing (mid-June). Nest attendance was recorded before, during, and after flyovers of a Sikorsky S61 and an Aztec Piper (twin-engine monoplane). The presence and response of both the adults was observed because the adult from each nesting pair that was not incubating or brooding chicks at the time of the aircraft flyover could presumably exhibit a different sensitivity than the parent involved with care of the young.

The authors recorded the number of nests and the nests with 0, 1, or 2 adults before and after flyovers. There was no evidence that aircraft overflights above 100 m (above the cliff-top) affected nest attendance. There was only a slight indication that, for kittiwakes, the non-incubating adults flew in response, but the effect on breeding was negligible. Because the study area was on the route used by existing aircraft to and from drilling platforms in the North Sea, the subject birds may have been habituated prior to this study. The author indicates that no inference is warranted to other species or to different conditions from those of this study.

Scientific Rigor:

Low. Data were collected over only 2 days, and there was little indication given that the researchers controlled for the effect of background disturbances at the colony

E & E Reviewer Comments (Including Limitations of Study):

No additional comments.

Relevance to SEIS:

Low. A cliff-nesting, mixed-species colony was studied over a very brief interval and responded to very few aircraft, all of which were very dissimilar to the F/A-18. Little inference can be made from the setting, season, species, or aircraft.

Keywords:

Airplane, helicopter, aircraft disturbance, fulmar, shag, herring gull, kittiwake, guillemot, razorbill, puffin, nesting, nest attendance, incubating, brooding.

Article 21

Author/Year:	**Title:**
Fleming, W. J., G. S. Davis, and V. M. Graham 1996.	"Response of Mallard Ducklings to Recordings of Jet Aircraft Noise"
Author's Affiliation:	**Published In:**
National Biological Service, Cooperative Fish and Wildlife Research Unit, North Carolina State University.	Chapter I *in* W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, Editors, *An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina, Final Report to U.S. Marine Corps, Cherry Point Marine Air Station.*

Summary of Findings:

The objective of the study was to determine the effects of aircraft noise, either alone or in combination with saline stress, on the growth and survival of mallard ducklings Two-day-old mallard ducklings were raised in a high (24 hour Leq = 80 dBA) and a low (24 hour Leq = 67 dBA) noise environments for 4 weeks. Ducks in the high-noise environment were played digitally recorded military jet noise for 16 hours per day, three events per hour (48 aircraft simulations per day). The total time birds were exposed to the noise stimuli was 24.8 minutes. Noise events had an onset time of 53.9 dB/sec, an average duration of 31 seconds, and a peak amplitude of 100-120 dBA. At four weeks old, ducklings in the noise study weighed 4.6% less than did control group ducklings and exhibited lower growth rates in some morphometric measurements (bill and *tibiotarsi)*. Salt regimen had no effect on biomass growth rates. The authors concluded that simulated aircraft noise at this level was stressful to mallard ducklings but stated that the biological significance of reduce growth rate of this magnitude was unknown.

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

Authors state that differences in biomass approached significance for all sampling periods following onset of noise; however, the weekly biomass differed significantly between the treatment and control groups in only one weekly period.

Relevance to SEIS:

High/Moderate. Simulated aircraft noise in a controlled environment, and different species.

Keywords:

Aircraft disturbance, mallard duck, simulated noise, growth rate.

Article 22

Author/Year:	**Title:**
Fleming, W. J., J. A. Dubovsky, and J. Collazo 1996.	*An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina*
Author's Affiliation:	**Published In:**
National Biological Service, Cooperative Fish and Wildlife Research Unit, North Carolina State University.	Final Report to U.S. Marine Corps, Cherry Point Marine Air Station.

Summary of Findings:

In the period from 1954 through1956, wintering waterfowl populations in Atlantic coastal bays and sounds were found to number about 2 million. By the period from 1982 through1984, waterfowl populations had declined to 1.2 million. Human-made changes (e.g., agricultural intensification, urbanization) likely have contributed to the decline. However, concern has also been expressed over the growth in military aircraft training activities and its effect on waterfowl.

The study area includes Piney Island and Cedar Island, located in coastal North Carolina. Piney Island is the site of BT-11, a military aircraft practice bombing range. The winter waterfowl at Piney and Cedar Islands include the black duck, wigeon, gadwall, scaup, and bufflehead. In addition, several species of rail, shorebirds, wading birds, gulls, and terns inhabit the area.

This report covers several studies conducted to investigate the responses of waterfowl to military training activities. The studies have been described in Conomy 1996a (Chapter D), Conomy 1996b (Chapter E), Dubovsky 1996a (Chapter C), Dubovsky 1996b (Chapter B), Dubovsky 1996c (Chapter G), Fleming (1996a) (Chapter I), Harms 1996 (Chapter F), and Temple 1996 (Chapter H).

The authors determined that despite the long-term use of the USMC Atlantic coastal training bombing range at Piney Island, the population of wintering waterfowl (in terms of both the number of species and their abundance) in the study area of Fleming et al. (1996), was found to not have declined in proportion to the waterfowl declines identified for North Carolina or the Atlantic Flyway overall (see also Dubovsky 1996b).

Aircraft flights are at low altitudes (approximately 170 meters above ground level) and at speeds of 250 knots or higher, but not supersonic. Approximately 95% of aircraft-related noise events exceeded 80 dB for 2 to 12 minutes.

The results of the studies found that waterfowl at Piney Island were more likely not to respond rather than to respond to the presence of aircraft. Waterfowl spent only <1% of their time reacting to aircraft activities, and the proportion of birds responding to aircraft activities was low (2.6% of black ducks displayed discernible reactions). Fleming et al. (1996), expected that the daily energetic cost of responding to aircraft activities would be less than 1% of the daily energy expenditure of free-ranging waterfowl (see also Conomy 1996a). Waterfowl were more abundant at the Fleming et al. (1996) study site on weekdays than on weekends, despite the fact that aircraft use in Military Operations Areas was also highest during weekdays. The highest numbers of free-ranging, wild waterfowl were observed in approach and exit vectors for training aircraft, suggesting that these activities, at these levels, did not discourage waterfowl from using preferred bays (see also Dubovsky1996a).

According to Fleming et al. (1996), the low response rate to the presence of aircraft suggested that waterfowl either did not perceive the aircraft as stressors or that they quickly habituated to the presence of aircraft due to repeated exposures. However, results suggested that inter-specific differences existed in behavioral responses and habituation rates. Fleming et al. (1996) found that waterfowl were more likely to respond, (e.g., alert behaviors or taking flight, at the approach of a propeller-driven aircraft or helicopter than they were at the approach of military jet aircraft.

Nest chronology, the number of eggs laid, the number of eggs hatched, nest success rates, and nest desertion rates by captive black ducks were similar in treatment (i.e., noise) and control sites. However, females in the bombing practice range removed more of their own eggs from the nest, and young had significantly lower growth and survivorship rates than did control group birds. A cause-and-effect relationship was detected between aircraft noise and duckling growth and survival, and this relationship was attributed to stress-related disorders (see also Fleming 1996a).

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

Prior to Fleming et al. (1996), the effects of aircraft activity in Military Operations Areas on waterfowl had not been extensively researched.

These studies partially included captive birds. Moreover, some of these ducks were nesting, not overwintering, and therefore had different sensitivities and metabolic stressors. Presumably, non-breeding birds can more easily vacate an area to avoid disturbance than can nesting birds because the former are not required to defend their territory or nest, or to care for eggs or chicks (Burger 1981). Also, many species of birds are more sensitive to anthropogenic stressors, including disturbance, while nesting. Another implication of captivity is that free-ranging waterfowl would have had the option of departing the area of the disturbance as a means of *avoiding* the very stressors that could have caused the negative effects measured in the experiment. So, avoidance of aircraft activity may be viewed as adaptive and beneficial.

Relevance to SEIS:

High. Various studies imposed simulated aircraft disturbances experimentally, but authors also observed and measured effects from non-experimental aircraft, in both wild and captive settings.

Keywords:

Pamlico Sound, Piney Island, North Carolina, black duck, population, behavior, military, aircraft, habituation, sensitization, physiology, reproduction, mortality, condition, military operations area.

Article 23

Author/Year:	**Title:**
Gladwin, D. N., D. A. Asherin, and K. M. Manci 1988.	*Effects of Aircraft Noise and Sonic Booms on Fish and Wildlife: Results of a Survey of U.S. Fish and Wildlife Service Endangered Species and Ecological Services Field Offices, Refuges, Hatcheries, and Research Centers*
Author's Affiliation:	**Published By:**
DNG and DAA: U. S. Fish and Wildlife Service, National Ecology Research Center, Ft. Collins, CO; KMM: TGS Technology, Inc., Ft. Collins, CO	NERC-88/30, U.S. Fish and Wildlife Service, National Ecology Research Center, Fort Collins, CO, 24 pp.

Summary of Findings:

This report was prepared in cooperation with the National Ecology Research Center and USAF Engineering and Services Center. The objective was to determine the nature and extent of aircraft impacts on fish and wildlife populations and on habitat use within the USFWS installation. A survey was sent to all USFWS regional directors, research center directors, ecological services and endangered species field offices supervisors, refuge managers, and hatchery managers requesting information or data on fish and wildlife reactions to low-altitude aircraft disturbances. Responses to a survey questionnaire (N=132) came from 30 states. Aircraft disturbances were classified as military (60%), private (44%), and commercial (37%). Helicopter disturbance was reported at 70% of the USFWS installations, small jets at 59%, propeller-driven aircraft at 50%, and large jets at 31%.

Installations also reported those animal groups that were being potentially disturbed by low-altitude aircraft activity. The percentage of installations reporting impacts to the following classes of wildlife were waterfowl (63%), raptors (17%), shorebirds (11%), and colony-nesting birds (10%). Birds overall were thought to be disturbed by low-altitude aircraft at 90% of installations responding. Common issues by respondents citing bird impacts included flushing and disturbance of waterfowl, waterfowl departing refuges for the duration of aircraft noise, violation of the 2,000' AGL minimum flight altitude, and disturbances making waterfowl more disease susceptible. Mammals as a group were thought to be disturbed by low-altitude aircraft at 20% of installations responding, and ungulates were rated highest (17%). All other wildlife classes (other birds, other mammals, bats, and fish) were below 10%. Clearly, helicopters were the aircraft most suspected, and the wildlife group thought waterfowl were the most affected. Responses from North Carolina (four) all mentioned military aircraft (military/large jet/small jet/helicopter), all affecting birds (three of the four mentioned waterfowl), and all mentioned low-altitude aircraft activity causing flushing or other startle responses.

Scientific Rigor:

Moderate. Results were based on respondent observations. Experimental approaches were not used to draw conclusions. Survey could be biased toward respondents who observe disturbances.

E & E Reviewer Comments (Including Limitations of Study):

No additional comments.

Relevance to SEIS:

Moderate. Inferences difficult to determine. No information on sound levels or aircraft altitudes. Summary statistics of types of responses not provided.

Keywords:

Helicopter, aircraft, jet, disturbance, military, civilian, fish, bird, mammal.

Article 24

Author/Year:	**Title:**
Harms, C. A., W. J. Fleming, and M. K. Stoskopf 1996.	"Heart Rate Biotelemetry in Black Ducks: Response to Simulated Aircraft Noise"
Author's Affiliation:	**Published In:**
National Biological Service, Cooperative Fish and Wildlife Research Unit, North Carolina State University.	Chapter F in W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, Editors, An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina, Final Report to U.S. Marine Corps, Cherry Point Marine Air Station.

Summary of Findings:

This study was designed to assess the physiologic impact of aircraft noise on black ducks by monitoring heart rate. Authors used heart rate biotelemetry transmitters to monitor heart-rate fluctuations in black ducks exposed to simulated aircraft noise (replicating an FB 111 jet flying 70 meters above ground level). Undisturbed baseline heart rates and normal variation were established to study instantaneous (reflecting arousal) and sustained (reflecting metabolic rate) changes in response to aircraft noise and to evaluate heart-rate accommodation to aircraft noise.

Forty-eight noise events occurred each day, a rate of three events per hour. All noise events were 35.76 seconds long, with an approach crescendo, a peak of 110 dB, and a departing decrescendo. Sound energy and number of events per day were designed to approximate actual military aircraft noise exposures near the center of a military operating area in coastal North Carolina.

Daily mean heart rates did not increase in response to the simulated aircraft noise. Also, both behavioral and acute heart-rate responses to aircraft noises diminished rapidly.

The authors asserted that this supported an undetectable energetic cost associated with noise broadcasts and the ability of black ducks to habituate to the sound of low-altitude aircraft overflights. But, the authors also speculate that the small acute response, coupled with the rapid apparent habituation, may have been the result of using acoustic stimulation without accompanying visual stimulus. This is further supported by the observation that a small, single-engine plane elicited a greater response from the study ducks.

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

Energetic costs are to be expected whenever uncaged ducks expend energy fleeing noise stimuli that caged ducks cannot escape. The nature of the experiment (caged animals that cannot flee) may have caused a floor-effect in the data (and thus the inability to measure the true response) that might have been found in free-ranging birds. This is in contrast to other studies (e.g., in which birds that flee an aircraft or simulation are somehow "affected" by it). Perhaps the fact that they fled means that they escaped being affected by it.

Relevance to SEIS:

High. Provides rare experimental data and results from physiological, as opposed to strictly behavioral, responses of waterfowl to aircraft disturbance.

Keywords:

Aircraft noise disturbance, acute response, habituation, energetic cost.

Article 25

Author/Year:	**Title:**
Henson, P., and T. A. Grant 1991.	"The Effects of Human Disturbance on Trumpeter Swan Breeding Behavior"
Author's Affiliation:	**Published In:**
Department of Fisheries and Wildlife, University of Minnesota, St. Paul, MN	*Wildlife Society Bulletin* 19:248-257.

Summary of Findings:

Breeding trumpeter swans in the Copper River Delta of Alaska were visually monitored and studied by time-lapse cameras to document their behavioral response to several kinds of human disturbance, including aircraft overflights, vehicular road traffic, pedestrian activity on roads and lands adjacent to nesting wetlands, and researcher presence and activity. Time-budget observations were conducted from the prelaying through the brood-rearing phases of reproduction. Authors also studied nesting recesses, both "normal" and from disturbance (disturbance recesses).

Swan reactions to aircraft flying below 615 m (2,017 ft) were also recorded. Swans reacted to 19 of 21 overflights (four commercial airliner, 10 fixed-wing, five helicopter). Simple head-up posture was adopted for an average of 54 seconds. No differences were seen in responses to different kinds of aircraft. In two instances, incubating female swans took disturbance recesses from incubation in response to observer aircraft circling overhead at 60 m (196 ft), although they did not take disturbance recesses from other aircraft disturbance.

Overall, responses to routine, non-experimental aircraft were of short duration and caused no changes in incubation constancy or cygnet (i.e., young swan) behavior. One pair of swans nested within 1.3 km (0.8 mi) of a commercial runway and was exposed to landing and takeoff noise, with no apparent effect. Responses of swans to disturbance from pedestrian activity exceeded that observed in response to aircraft. Disturbance recesses were longer (mean = 39.4 minutes), and composed of different activities, than were normal incubation recesses (mean = 26.3 minutes). Swans generally responded to loud noise the most (e.g., motorcycles and airboats), and visual screening reduced the effect, except in the case of pedestrians.

Scientific Rigor:

Moderate.

E & E Reviewer Comments (Including Limitations of Study):

Non-experimental disturbances were monitored, and a small sample size was used.

Relevance to SEIS:

Low. Aircraft types, habitat, and species are all different from the aircraft type, habitat, and species in SEIS. Responses of swans to disturbance from pedestrian activity exceeded those observed in responses to aircraft.

Keywords:

Trumpeter swan, human disturbance, aircraft, pedestrian, vehicle, nesting, productivity, Copper River Delta, Alaska.

Article 26

Author/Year:	**Title:**
Jensen, K. C. 1990.	*Responses of Molting Pacific Black Brant to Experimental Aircraft Disturbance in the Teshekpuk Lake Special Area, Alaska*
Author's Affiliation:	**Published As:**
Texas A&M University.	Ph.D. Dissertation, Texas A&M University.

Summary of Findings:

The objectives of the study were to 1) determine the behavioral responses of molting brant to helicopter overflights, and 2) determine the effects of helicopter disturbances on movement rates of brant. Feather molt (i.e., the annual 3- to 5-week-long loss and replacement of all flight feathers) is energetically costly and can be compensated for by increasing feeding, decreasing other energy-requiring activities, or catabolizing body tissues. Molting brant spent a total of 89% of their time feeding (52.8%), resting (24.6%), and in maintenance (11.2%) behaviors and have the potential to be disrupted by aircraft during feeding and resting. Disturbance during molt can put birds into nutritional stress and affect the quality of emerging flight feathers; both effects can jeopardize individuals. Brant are at their lowest body mass when in molt, and feeding peaked between 0400 and 0800. Gut capacity and forage digestibility may limit the duration of feeding. Brant selected areas with abundant forage, in floristically nondiverse habitats, with high visibility on shorelines.

Experimental overflights of helicopters were imposed to measure disturbance response. Bell 206 helicopters were used, and, for flights directly over flocks, disturbance responses varied with altitude and horizontal distance to the helicopter. Recorded responses to disturbances were alert, walking, running, swimming, massing, and flightless flapping.

Increased horizontal distance resulted in decreased response duration for flights at 1,500 ft (460 m) altitude and for flights at all altitudes from 1,000 to 2,500 ft (300 to 760 m). Bell 206 helicopters would have to fly at 1,070 m (3,510 ft) to have no significant affect, and disturbance response declined beyond 4 km horizontal distance from the helicopter. Overflights at altitudes of 215 to 360 m were the most disturbing to geese. As flock size increased, so did the duration of disturbance response. Disturbance response did not vary depending upon the behavior of brant prior to disturbance. Molting brant did not appear able to habituate to overflights, either on a daily basis or during the interval in which experimental overflights were conducted. Rather, they became sensitized upon successive disturbances. Brant disturbed by helicopters moved at over five times the rate of non-disturbed brant.

See also Derksen 1991.

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

Molting brant have different metabolic pressures and sensitivities, but the report does provide evidence of threshold disturbance levels to experimentally imposed disturbances. Experimental disturbances, as used in this study, allow more concrete statements about cause-and-effect responses. This contrasts with mensurative studies, in which observers simply measure response to “normal” (non-experimentally imposed) disturbances. Increased sensitivity is likely influenced by the fact that birds are incapable of avoiding the disturbance via relocation as they are flightless.

Relevance to SEIS:

Moderate. Black brant is a species related to snow geese. However, aircraft type and location not relevant to SEIS study area.

Keywords:

Helicopter disturbance, habituation, molt, energy, brant, Alaska.

Article 27

Author/Year: Klump, G. M. 2000.	**Title:** "Sound Localization in Birds"
Author's Affiliation: Affiliation not provided.	**Published In:** Chapter 6 *in* R. J. Dooling, R. R. Fay, and A. N. Popper, Editors, *Comparative Hearing: Birds and Reptiles.*

Summary of Findings:

This was a highly specialized chapter in an edited volume for sound and hearing specialists.

Scientific Rigor:

N/A.

E & E Reviewer Comments (Including Limitations of Study):

This chapter was written for a specialized audience that is highly knowledgeable about measures of hearing, research methods, anatomical structures, and other terminology associated with acoustic measurement. No data were presented for waterfowl hearing, and laypersons reading this chapter would benefit from a glossary, as the terminology is specialized and not understandable to non-specialists.

Relevance to SEIS:

Low.

Keywords:

None.

Article 28

Author/Year:	**Title:**
Komenda-Zehnder, S., M. Cevallos, and B. Bruderer 2003.	*Effects of Disturbance by Aircraft Overflight on Waterbirds--An Experimental Approach*
Author's Affiliation:	**Published By:**
Swiss Ornithological Institute	International Bird Strike Committee, Report No. IBSC26/WP-LE2.

Summary of Findings:

The study was conducted to determine a minimum altitude at which waterbirds do not show any visible reaction to overflying aircraft and was conducted in support of a government proposal to protect sensitive areas from aircraft disturbance in Switzerland.

During 2001 and 2002, the authors made 326 experimental overflights above lakes in the Swiss lowlands on 29 days to study potential effects to overwintering waterbirds before, during, and after overflights. Thirty-two species of ducks, geese, swans, coots, grebes, cormorants, herons, gulls, and terns were included, but tefted duck, coot, and pochard were the most represented. Airplanes included: 1) Bonanza F33 A (Beechcraft, 4-seat, single-engine, propeller-driven); 2) Bonanza A 36 (Beechcraft, six-seat, propeller-driven); 3) Robin DR 400/500; and Robin DR 400-180 R (both are also light, five-to-six-seat, single-engine, propeller-driven). Helicopters tested included: 1) Ecureuil AS-350B2 (Australian Aerospace, a light single-engine helicopter that carries five or six passengers in addition to the pilot), and; 2) Alouette 3 SA-316B (Aerospatiale, a heavier, medium-duty, eight-seat, general-use helicopter).

Aircraft conducted four to six overflights, at 15-minute intervals, at either successively decreasing altitudes (series 1; 600, 450, 300, 150, and 80 m [1,969 ft., 1,476 ft., 984 ft., 492 ft., and 262 ft., respectively]), fixed altitude (series 2; 150 or 80 m [492 ft. or 262 ft., respectively]), or varying altitudes (series 3; 450, 300, 150, 80 m [1,476 ft., 1,476 ft., 492 ft., and 262 ft.]). Only one series per day was conducted. Bird abundance was estimated before the first and after the last overflight, and observers estimated the percentage of the flock engaged in stress responses (including alarm posture, swimming, diving, and flying) or relaxed behavior (including resting, preening, and feeding). Observations began 5 minutes before the first overflight and were repeated at 5-minute intervals; every third observation coincided with an overflight. One sound level meter was used to record peak sound levels in dB.

For all aircraft and series, the number of birds present before and after overflights did not differ. Sensitization was deemed not to have occurred when the proportion of birds exhibiting stress responses remained constant throughout nine plane overflights at 80 m and 10 overflights at 150 m. The proportion of birds with stressed behaviors 5 minutes before and 5 minutes after an overflight did not differ for either airplane or helicopter overflights. Return to normal behaviors, such as resting, preening, and feeding, occurred within 5 minutes of overflights. No habituation or sensitization was observed.

The proportion of birds showing stress differed significantly dependent upon aircraft type (airplane vs. helicopter) and altitude. Disturbance from helicopters was greater than that from airplanes, and it increased at decreasing altitudes. Bird behavior was not significantly influenced when airplanes flew above 300 meters (984 ft.) or when helicopters flew above 450 meters (1,476 ft.) AGL. Peak noise levels ranged from approximately 56 to70 dB for airplanes at 600 m down to 80 m, and approximately 65 to 82 dB for helicopters at similar altitudes. Birds showed greater stress in response to the faster airplanes but showed no difference in stress response to helicopters of different speeds.

Authors opined that “disturbance by aircraft can be reduced significantly if minimum flight altitudes of 450 m AGL are implemented.” This altitude minimized the probability of inducing flocks to flush, which in turn decreased the bird strike hazard. However, they do not attempt to distinguish the separate effects that noise and visual stimuli may have elicited.

Scientific Rigor:

High. Study used experimentally imposed disturbance from several types of aircraft, controlled for several variables of interest, and used good replication and control-data collection.

E & E Reviewer Comments (Including limitations of study):

There is some confusion in the discussion of the effect of airplane speed on bird response. The table on page 10 and the discussion on page 11 state that the larger, slower airplane (the “Bonanza”) induced a larger stress response. This was used as corroboration of the fact that faster military jets often induce a lower response compared to that generated by slower airplanes. However, the discussion preceding the table on page 10 (Table 6) states the reverse, that the smaller, faster “Robin” resulted in a higher proportion of birds responding.

Relevance to SEIS:

Moderate. Overwintering birds were studied, but potentially none of the species included in the SEIS was involved. Additionally, experimental aircraft did not include jets of any kind.

Keywords:

Switzerland, duck, goose, swan, coot, cormorant, heron, gull, tern, airplane disturbance, helicopter disturbance, flight altitude, wintering waterfowl.

Article 29

Author/Year:	**Title:**
Kushlan, J. A. 1979.	“Effects of Helicopter Censuses on Wading Bird Colonies”
Author’s Affiliation:	**Published In:**
U. S. National Park Service, South Florida Research Center, Everglades National Park.	*Journal of Wildlife Management* 43:756-760.

Summary of Findings:

While aircraft are ideal for surveying or conducting a census of large colonies of birds, the effects of airplane and helicopter censuses on those birds are rarely quantified or evaluated. This study was done to quantify the effects of helicopter censuses on wading-bird nesting colonies and to evaluate the accuracy and economy of helicopter censuses. The authors assumed that airplane surveys had habituated birds to this disturbance and used airplane disturbances as a control. A Bell 47G-2 helicopter was tested against the effect from a Lake single-engine amphibious plane. The plane approached the colony at 120 m above ground level (AGL) and circled for 2 to 3 minutes, three to five times, counting the nesting colony. This was repeated after 10 minutes, at a height of 60 m AGL. The helicopter then repeated the pattern of two surveys after a delay of 1.5 to 2 hours (aircraft order was reversed on successive trials). Observers monitored incubating and brooding adults and classified it as a “drastic disturbance” response if an incubating or brooding adult flushed from the nest and did not return for 5 minutes (p. 757).

Lesser responses, given a score of from 1 to 5, respectively, consisted of (1) no reaction, (2) looking up, (3) standing up, (4) walking from the nest but returning within 5 minutes, and (5) flying from the nest but returning within 5 minutes. Data were collected mostly on great egrets, snowy egrets, and Louisiana herons. Even when airplanes and helicopters flew at 60 m, no bird ever failed to return within 5 minutes, so the drastic disturbance response was never observed. There was “no reaction” in nearly 75% of 220 observations, and in 90% of the observations, birds exhibited either no response or merely looked up.

Great egrets responded less to the helicopter at 60 m AGL than they did to the airplane at the same altitude, and in 11 of 12 comparisons, birds responded less to helicopters than to airplanes, or the response was no different; in only one comparison did the helicopter elicit a greater response than the airplane. The helicopter surveys were more accurate than airplane surveys for white birds and for dark birds that nest in tree tops. Both aircraft types were inaccurate for counting small, darker birds that nest in the canopy. Compared with ground-based surveys, the use of helicopters reduced the effort required to achieve the same survey result as--and did so at a lower cost. However, helicopters are less economical than airplanes for locating colonies over large areas. When highly accurate counts are needed, ground-based surveys should be used. Regardless of method, there are ways to minimize disruption and improve survey estimation for each of the techniques.

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

No additional comments.

Relevance to SEIS:

Low. Different species were tested for impacts by different aircraft, making different maneuvers, during a different season than those addressed by the SEIS.

Keywords:

Wading bird nesting colony, helicopter, disturbance, airplane, great egret, snowy egret, Louisiana heron.

Article 30

Author/Year:	Title:
Lamp, R. E. 1989.	*Monitoring the Effects of Military Air Operations at Naval Air Station Fallon on the Biota of Nevada*
Author's Affiliation:	**Published By:**
Nevada Department of Wildlife.	Nevada Department of Wildlife.

Summary of Findings:

This was the final report for a study of the effects of low-altitude subsonic and supersonic aircraft disturbance on wildlife near NAS Fallon. The study was initiated under a Memorandum of Agreement between the U.S. Navy and the State of Nevada. Aircraft disturbance was correlated to behavioral and population impacts on bighorn sheep, mule deer, sage grouse, chukar, raptors, waterfowl, and shorebirds.

Habitat for wintering and migrating waterfowl is used by many species of geese, ducks, and other waterfowl and shorebirds. Snow geese migrate through the Lahontan Valley (which provides overwintering habitat for 75% of the ducks, 65% of the tundra swans, and 50% of the Canada geese in Nevada), and 95% of the snow geese that migrate through Nevada stage at Carson Lake (south of NAS Fallon) during fall (October through December) and spring (mid-January through March). Canada geese nested (March and April) as well as staged in the area. Because recreation was an important local land use, a questionnaire was used to assess the effects of military training on attitudes of recreationists.

Aircraft disturbance was classified as: (1) sonic boom; (2) low-level [below 3,000 ft], and; (3) high-level [above 3,000 ft]. Reactions by wildlife were classified as: (1) no reaction [no observable change in behavior]; (2) minor reactions [slight change in body position, indication of awareness, or slight change in behavior], and;(3) major reactions [gross changes in behavior or body location, posture, adoption of defensive position, or exhibition of panic or stress, such as flushing or running]. All observations were made during each species' critical or sensitive intervals. All observations consisted of locating individuals during their presumed sensitive intervals and in locations where military flights could be expected, then monitoring those animals until the animals departed, behavior ceased, or daylight failed, with the objective of opportunistically observing animal reactions to non-experimental overflights.

Waterfowl were monitored while staging, feeding, and nesting. Snow geese that were migrating and staging showed no response to 33 (41%) of the observed aircraft disturbances. Minor reactions were seen for 22 (27%) of the events, and major flushing reactions occurred during 26 (32%) of the events. These reactions were in response to helicopters, propeller-driven planes, and jets, at altitudes of 100 ft to 10,000 ft. Major responses included flushing from the water and circling before landing, or departing the valley entirely. Some flocks flushed in apparent response to aircraft that were unseen by observers (p. 31). The average time required for disturbed snow geese to return to normal behavior was 235 seconds following a low-level aircraft disturbance and 150 seconds following a high-level aircraft disturbance.

The sound ranges of these events averaged 78 db for low-altitude and 84 db for high-altitude overflights. Feeding Canada geese were observed during one sonic boom, and they did not respond. Similarly, Canada geese did not respond to 66 (73%) of observed aircraft disturbances; geese reacted to 25 (27%) of observed low-altitude flights (91 db average) with minor reactions and had no major responses. Canada goose nesting may have been negatively impacted by a large amount of extremely low-altitude flights (p. 33), but other factors could also have been responsible (e.g., increased predation due to low water levels in reservoirs).

Migratory ducks exhibited no reaction to 233 (71%) aircraft disturbances, minor reaction to 53 (16%) aircraft disturbances, and major reactions to 41 (13%) aircraft disturbances. Major reactions included flushing and either circling and re-landing or landing a short distance away, or leaving the area. The average duration of response was 48 seconds for low-altitude (average 92 db) and 10 seconds for high-altitude aircraft (average 82 db). Sensitive duck species included wigeon, pintail, and green-winged teal; less sensitive species were cinnamon teal, gadwall, and mallard.

Questionnaires indicated that upland bird hunters (more than half), followed by deer hunters (over one-third), responded the most negatively about aircraft operations. Less than one-third of the waterfowl hunters are annoyed by aircraft activity.

Scientific Rigor:

Moderate/High.

E & E Reviewer Comments (Including Limitations of Study):

Aircraft observations were non-experimental (i.e., they were opportunistically collected, not experimentally controlled). However, biologists identified sensitive periods for wildlife and observed reactions to ambient aircraft activity of the type that would result in a Supersonic Operating Area. This report provides observed response data and summary statistics for migrating and staging snow geese (and other wildlife). However, the exact aircraft that induced the response was not always provided.

Relevance to SEIS:

Moderate/High.

Keywords:

NEPA, EIS, Navy, NAS, supersonic aircraft, sonic boom, sound meter, wildlife, snow goose.

Article 31

Author/Year:	**Title:**
McKechnie, A. M., and D. N. Gladwin 1993.	*National Park Service Aircraft Overflight Study: Aircraft Overflight Effects on Wildlife Resources*
Author's Affiliation:	**Published As:**
Harris Miller Miller & Hanson, Inc., Lexington, MA, and Sterna Fuscata, Inc., Ft. Collins, CO	NPOA Report Number 93-8.

Summary of Findings:

This report is a literature review, compiled for the National Park Service, from about 200 references on the nature and extent of low-altitude aircraft effects on wildlife. Overall, dose/response relationships are variable among species, populations, and, sometimes, between differing habitats. There is little information to relate behavioral responses to physiological and reproductive (and ultimately, population, or long-term) impacts.

Included in the literature review is a general discussion of the nature and extent of effects of aircraft overflights and factors that influence animal responses to aircraft. Studies on waterfowl referenced in the literature review include Schweinsburg 1974, Lamp 1989, Conomy et al. 1993, Salter and Davis 1974, Davis and Wisely 1974, and Henson and Grant 1991, all of which have been reviewed here.

Scientific Rigor:

Not Applicable.

E & E Reviewer Comments (Including Limitations of Study):

No additional comments.

Relevance to SEIS:

Moderate. Studies reviewed have also been included in more detail here.

Keywords:

Literature review, National Park Service

Article 32

Author/Year:	Title:
Miller, M. W. 1994.	"Route Selection to Minimize Helicopter Disturbance of Molting Pacific Black Brant: A Simulation"
Author's Affiliation:	**Published In:**
Department of Wildlife and Fisheries, Texas A&M University, and Department of Zoology, University of Guelph.	*Arctic* 47:341-349.

Summary of Findings:

Molt is energetically demanding, and brant typically lose body mass while regrowing flight feathers. Additionally, brant are known to be sensitive to human disturbance and particularly vulnerable to loud, low-flying aircraft; brant have been known to vacate traditionally used areas in favor of sites less affected by human disturbance. Up to 23% of the entire Pacific black brant population molts its primary flight feathers near Teshekpuk Lake, Alaska, and during this time remain flightless. Helicopter disturbance was recognized as having the potential to disrupt normal energy budgets. The author used an existing simulation model (Miller et al. 1994, "A Simulation Model of Helicopter Disturbance of Molting Pacific Brant," *Ecological Modeling* 73:293-309, summarized elsewhere in this review) to test for effects of Bell 206 and Bell 412 helicopters on molting Pacific brant at Teshekpuk Lake, Alaska. Two submodels were developed: one for flight lines and one for behavior and energetics. The two submodels were based upon field data on distribution and abundance of molting brant, and on actual responses from experimental overflights. Six flight paths at various altitudes and frequencies were simulated, and body condition after the molt was used to quantify impacts.

Helicopter altitude strongly affected both the number of birds disturbed and their final body weight. At lower altitudes, the Bell 412 caused greater weight loss than did the Bell 206 but did not result in disturbance to a greater number of birds. However, at higher altitudes, the Bell 412 increased both the number of birds disturbed and their mass loss. Flights at an altitude of >1,830 m for the Bell 412, and >1,220 m for the Bell 206 caused no weight loss. At typical flight altitudes (~460 m), the Bell 412 caused 3% to 15% more weight loss than did the Bell 206. Increasing the frequency of overflights, particularly with the larger Bell 412, increased both the number of affected birds and the amount of weight loss they suffered.

The author tested various flight routes relevant to the study area and affected population. The number of geese suffering heavy mass loss could be reduced 91% by altering the route taken. The simulation determined that flying around the molting grounds caused the least disturbance, and flying parallel to the coast, 1.6 km inland, caused the most. The authors concluded that flying at altitudes above 1,065 m, flying after brant were in their second week of molt, minimizing the frequency of flights, and use of the smaller helicopter would lessen weight loss. Also, the author stated that the model had not been validated by examining actual weight loss at flight exposures tested in the model and comparing these results against predicted results.

See also Derksen 1991, Jensen 1990, and Miller et al. 1994.

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

No additional comments.

Relevance to SEIS:

Low. A different species and aircraft type reduce the value of this study to the SEIS. The model was developed for a different area and used by a different species for a different purpose, so model performance and output were therefore specific to these parameters.

Keywords:

Computer simulation model, helicopter disturbance, molt, Pacific black brant, Alaska.

Article 33

Author/Year:	**Title:**
Miller, M. W., K. C. Jensen, W. E. Grant, and M. W. Weller 1994.	"A Simulation Model of Helicopter Disturbance of Molting Pacific Brant"
Author's Affiliation:	**Published In:**
Department of Wildlife and Fisheries Science, Texas A&M University, College Station, TX	*Ecological Modeling* 73:293-309.

Summary of Findings:

This article describes the simulation model designed to study the effects of helicopter disturbance on molting Pacific black brant near Teshekpuk Lake, Alaska. Two submodels were developed: one for flight lines, and one for behavior and energetics. The two submodels were based upon field data on distribution and abundance of molting brant and on actual responses from experimental overflights. Six flight paths at various altitudes and frequencies were simulated, and body condition after the molt was used to quantify results.

The submodel for flight lines simulates a helicopter flying over the molting ground in any direction while recording the number, size, and location of all flocks encountered along individual flight lines. The behavior and energetics model determines proximity of the aircraft to each flock recorded by the flight lines submodel and describes the reaction of these flocks to overflights of various altitudes. It determines the amount of energy brant expend in response to overflights and then calculates their weight at the end of molt. The magnitude of disturbance is a function of aircraft type and proximity as well as flock size.

Results indicated that simulation models could be used to identify flight path adjustments that would significantly decrease disturbance. Theoretical mass loss under different scenarios of flight frequency and altitude are presented, as are potential implications of predicted impacts.

See also Derksen 1991, Jensen 1990, and Miller et al. 1994.

Scientific Rigor:

Moderate.

E & E Reviewer Comments (Including Limitations of Study):

No additional comments.

Relevance to SEIS:

Low. A different species and aircraft type reduce the value of this study to the SEIS. The model was developed for a different area and used by a different species for a different purpose, so model performance and output were specific to these parameters.

Keywords:

Pacific black brant, molting, disturbance, simulation modeling.

Article 34

Author/Year:	**Title:**
Murphy, S. M., and B. A. Anderson 1993.	*Lisburne Terrestrial Monitoring Program: the Effects of the Lisburne Development Project on Geese and Swans, 1985-1989*
Author's Affiliation:	**Published By:**
Alaska Biological Research, Inc.	Final Synthesis Report, Alaska Biological Research, Inc.

Summary of Findings:

The Lisburne Terrestrial Monitoring Program was conducted to determine effects of oilfield-development-related disturbance and habitat loss on nesting and staging geese and swans (Canada geese, tundra swans, snow geese, white-fronted geese, and brant). This oilfield was in an area already developed within Prudhoe Bay, Alaska, so the Lisburne development represented an incremental increase as opposed to wholly new construction in a pristine area. The study looked at: (1) seasonal abundance, distribution, and habitat use; (2) nesting success, and; (3) activity budgets and reactions to disturbances. The minimum reaction for what was termed a disturbance event was for >50% of the adults in a group to become alert or for any member of the group to engage in any type of locomotion. Geese and swans were studied during pre-construction (1983 to1984), construction (1985 to1986), and post-construction (1987 to1989) phases, and observations were contrasted with a control site. Specifically, authors looked for differences in nesting and behavioral parameters throughout the different phases that could be attributed to development or disturbance, after controlling for environmental influences such as climate and predators.

All three lines of study (seasonal abundance, distribution, and habitat use; nesting success; and activity budgets and disturbance response) indicated that construction and the first three years of operation of the Lisburne oil field did not change the nature or extent of site use by geese and swans.

Seasonal Abundance, Distribution, and Habitat Use, by Species.
Differences in site use during and after construction by various waterfowl species were inconsistent.

Canada geese. More pre-nesting and nesting Canada geese used the site after construction than during construction; there were no differences in the mean number of adult, young, or fall staging geese on the site between construction and post-construction years (p. 33).

White-fronted geese. More pre-nesting white-fronted geese used the site after construction than during construction, but there was no difference during nesting. There was no difference in the number of adults on the site during construction than after construction during brood-rearing, but there were more young seen on the site during construction than after construction. There was no difference in fall staging during and after construction (p. 39).

Brant Pre-nesting brant abundance did not differ between construction and post-construction periods when other variables were controlled. Nesting brant were more abundant during construction than after construction. During brood-rearing, more adults were seen after construction than during construction, but no difference was found for young, and there was no difference in brant numbers during fall staging (p. 45).

Snow geese. The abundance of pre-nesting snow geese did not differ between construction and post-construction, and there were no observations of snow geese during nesting, so analyses could not be done. There were no differences in the numbers of adults and young on the site during brood rearing in construction and after construction, and there was no difference in the fall staging population during and after construction (p. 51).

Tundra swan. More pre-nesting, nesting, and brood-rearing adult tundra swans used the site after construction than during construction. There were no differences in the number of young during brood rearing, or in the number of swans during fall staging during and after construction (p. 55).

Nesting Success.
Canada geese. T he number of nesting Canada geese pairs seemed to be weather-dependent, as the coldest, snowiest spring coincided with the biggest decline in nesting pairs. However, nest success seemed to be independent of weather (p. 73). The study was not designed to determine the cause of nest failure. Mean nest densities differed little between pre-construction and construction but increased during post-construction. Construction did not significantly influence nest success: 22% of nests were successful during construction, and 28% of nests were successful during post-construction. Successful nests were significantly closer to roads, pads, pipelines, and power lines than were failed nests. Also, within the Lisburne Development Area, distances of successful and failed nests to roads, pads, etc., did not differ. During construction, Canada geese nested farther from pipelines than after construction.

White-fronted geese. Nesting white-fronted geese did not appear to respond to climate as Canada geese did. Nest densities were low and did not fluctuate significantly when compared either among pre-construction, construction, and post-construction seasons or between Lisburne and control sites. Successful nests of white-fronted geese were closer to roads and pads than were failed nests, and nest distances to oil field structures did not differ during and after construction.

Snow geese. For snow geese, the probability that a location would be used during pre-nesting increased as distance to roads decreased and traffic rate increased (p. 66).

Brant. For pre-nesting brant, in three of four years, the probability that a location would be used increased as distance to roads decreased and traffic rate increased. Brant were the most abundant nesting species and had variable annual success. Nest density was highest during pre-construction, medium during construction, and lowest during post-construction, but it was not indicated whether significant differences existed. During construction, 47% of brant nests succeeded, but during post-construction, only 27% succeeded (p. 80).

Tundra swans. For tundra swans, relationships were not as apparent, and distance to roads and traffic volume were apparently not as important determinants of habitat use as they were for some other species. Tundra swans nested at a density that varied little among pre-construction, construction, and post-construction years. Although nest success was apparently lower during post-construction, small sample size made valid analysis impossible. Successful tundra swan nests were significantly farther from pipelines than were failed nests.

There was no difference in the distances between successful and failed nests and oil field structures.

Activity Budgets and Disturbance Response.
Time budgets for Canada geese, white-fronted geese, brant, and snow geese were provided by gender for pre-nesting, nesting, brood-rearing, and fall staging intervals. Multiple regression was used to test for effects of disturbances (roads and pads), wind chill, and group size. The variance explained by the models was uniformly low among species, sexes, and nesting/staging interval. Likewise, gender showed no differences in the models. The proportion of time budgets spent by geese in various activities was tested for differences during and after construction phases, and this was a poor predictor of Canada, snow, and white-fronted goose and brant behavior. Seemingly unexpected, inconsistent, and variable responses resulted by gender, season, and construction phase with respect to distances to roads or pads (p. 97-98). For white-fronted geese, some behavior disruption occurred during construction.

Twenty-eight sources of natural and human-made disturbances were recorded, and these were ranked according to mean index values for all species of geese and swans, combined and separately. The differences between species were small, and, generally, natural disturbances were more disruptive than most human-made disturbances except for humans on foot (p.105). Aircraft was ranked at the low end of the index for disturbance responses, although little information on aircraft type, altitude, or sound level was provided.

For Canada geese, the three most disruptive disturbances were moving drill rigs, humans on foot, and foxes. Humans on foot were the most disruptive, and reaction severity did not diminish with distance during brood rearing or fall staging. For white-fronted geese, humans on foot were the most disturbing, followed by foxes and vehicles. During nesting, brood rearing, and fall staging, reactions to humans on foot occurred even when the disturbance occurred more than 200 m away. Brant were disturbed most by interspecific, non-predator interactions (e.g., with caribou, other waterfowl, etc.), humans on foot, and foxes. Humans on foot disturbed brant even beyond 300 m away. For snow geese, foxes, humans on foot, and non-predator interactions caused the most disturbances. Foxes elicited responses at distances up to 200 m, but reactions occurred beyond 300 m distance. Humans on foot caused disturbance during the flightless period at up to 300 m. However, non-predator interactions caused reactions at more than 300 m. Humans on foot also caused the greatest disturbance to tundra swans, but sample sizes were inadequate for rigorous analysis.

Activity budgets were not related to oil field development disturbance (p. 145). However, it was thought that geese simply spaced themselves sufficiently distant from disturbances to avoid altering their time budgets. However, results were not uniform; in some cases, geese appeared tolerant of predictable, steady-state disturbances (or merely moved to avoid them), whereas for some species in some stages of nesting, behaviors were modified. Nesting birds were less able to avoid disturbance unless they abandoned nests, so unpredictable disturbances (e.g., intermittent or non-routine activity at pads that were near incubating geese) close to nesting birds had the greatest potential effect. The response of geese and swans to passing vehicles was the lowest of any disturbance category recorded. Vehicles were also the most frequent disturbance. However, authors concluded that geese and swans using the oil fields during the breeding season habituated to traffic (p. 149). During some seasons only, geese and swans also selected for some human-altered habitats (e.g., peat roads) but generally selected native habitats.

Scientific Rigor:

High. Authors chose direct, relevant metrics (nest density and productivity, time budgets) and evaluated these variables before, during, and after construction. The authors also contrasted observations with a control site not associated with the Lisburne development. Environmental influences were controlled for in analyses, and statistical analysis was conservative, thorough, and clearly described. Study included 5 years of monitoring.

E & E Reviewer Comments (Including Limitations of Study):

Authors note that the study location is within Prudhoe Bay oil field, where construction and operational activities have been ongoing since the early 1970s. Thus, the study evaluated incremental effects of increase in development. Some habituation may have occurred prior to the study.

Relevance to SEIS:

Moderate. Geese and swans were studied, and some aircraft and other disturbance inferences were made. Oilfield disturbance differs from disturbance from military jets, and geese were nesting and fall-staging. Inferences to SEIS should be general.

Keywords:

Oil field construction, Prudhoe Bay, Alaska, Canada goose, greater white-fronted goose, brant, snow goose, tundra swan, nesting, staging, time budgets.

Article 35

Author/Year:	**Title:**
Owens, N. W. 1977.	"Responses of Wintering Brant Geese to Human Disturbance"
Author's Affiliation:	**Published In:**
Colney Research Station, Institute of Terrestrial Ecology, Norfolk NR4 7UD, United Kingdom.	*Wildfowl* 28:5-14.

Summary of Findings:

The authors examined the effects of experimental disturbance (a person approaching the feeding flock on foot) on dark-bellied brant geese as part of a series of four studies to evaluate the effect of construction of an airport at a historical feeding area. Other disturbances recorded were aircraft, small boats, large birds, and loud noises. Variables studied were contraction of feeding area and effects on feeding behavior and flushing.

Over 168 hours of observations, 48% of disturbances were by people, 39% by aircraft (mostly small propeller-driven planes), 9% by loud noises, and 4% by small boats. Disturbances from aircraft caused roughly twice the number of geese to respond as the number that typically responded to disturbances by people, although this may be related to the larger area affected by an aircraft than a person on the ground. Planes below about 500 m (1,640 ft.) and up to 1.5 km away (0.93 mile) generally flushed geese. Slower, noisier aircraft, especially helicopters, caused greater disturbance, and geese did not appear to habituate to small, low-flying aircraft, though they did cease responding to the transport planes that took off regularly from Southern Airport (p. 7)." Effects of a disturbance rarely lasted longer than 20 minutes after it ceased. As geese flushed in response to large birds with slow wingbeats (e.g., gulls, hen harriers), authors postulate that the intensity of response to aircraft and slowness to habituate may be associated with visual resemblance of aircraft to large birds.

When the area available for feeding was larger, disturbances had a smaller effect, as geese could resume feeding in a less-disturbed portion of the habitat.

Scientific Rigor:

Moderate.

E & E Reviewer Comments (Including Limitations of Study):

This is one of several studies that seem to imply that movement by birds away from disturbances allows continuation of pre-disturbance behaviors.

Relevance to SEIS:

Low. Different aircraft type, habitat, and species from those addressed by the Supplemental EIS.

Keywords:

Dark-bellied brant, human disturbance, feeding, behavior, flight, Essex, London Airport.

Article 36

Author/Year:	**Title:**
Salter, R., and R. A. Davis 1974.	"Snow Geese Disturbance by Aircraft on the North Slope, September, 1972"
Author's Affiliation:	**Published In:**
L.G.L., Limited, a private consultancy under contract to Canadian Arctic Gas Study, Limited, and to Alaska Arctic Gas Study Company.	Chapter VII (pp. 258-280) *in* W. W. H. Gunn and J. A. Livingston, Editors, *Disturbance to Birds by Gas Compressor Noise Simulators, Aircraft and Human Activity in the Mackenzie Valley and the North Slope, 1972,* Biological Report Series, Volume 14, February 1974.

Summary of Findings:

The objectives of this study were to determine the short-term effects of aircraft flights over resting and feeding snow geese and to determine flight elevations that would not disturb resting snow geese (p. 258). A single-engine Cessna 185 was used to approach snow geese at various altitudes from 300 ft to 10,000 ft to estimate the horizontal distance at which geese exhibited disturbance avoidance behavior. In addition, the authors conducted repetitive "figure-eight" patterns at 1,000 ft altitudes to determine the effects of "a large number of aircraft flights in a short time over the same area."

The authors observed that flocks flushed (i.e., took flight) at distances ranging from "0 mi" to 9 mi away. They also observed that geese generally flushed at greater horizontal distances when approached from lower altitudes, ranging from 300 ft to 5,000 ft. They also found that six flocks of geese flushed at 0 mi when the Cessna approached at an altitude of 10,000 ft and that "all eleven (11) flocks flew before the aircraft reached them" when the Cessna approached at an altitude of 7,000 ft. While an inverse relationship might be expected between aircraft altitude and flush response distance (i.e., geese flush at a greater distance in response to lower flying aircraft; e.g., Ward et al. 1999), their results indicated that there was a potentially nonlinear and weak correlation between flight altitude and flushing response distance. As some others have found, mid-level altitudes may be most disturbing to geese. However, authors conclude that no practical flight altitude exists that does not frighten snow geese. As a result of the hazing, authors concluded that snow geese flocks could be "herded" from an area and that severe hazing results in breakups of large flocks into smaller flocks.

Scientific Rigor:

Low. Data were collected on one day only, and disturbances were unreplicated to account for any temporal or population variability in disturbance response.

E & E Reviewer Comments (Including Limitations of Study):

There were no marked geese among the study flocks, so non-independence of study flocks cannot be assured. This means that there was no guarantee that successive trials were upon naïve geese, as opposed to those already flushed one or more times that day. Accordingly, geese could have become increasingly sensitized to the disturbance upon successive trials. In addition, data collection (3 September) was timed closely with the normal emigration of geese (15 September), which may have predisposed the subject geese to group flight.

No ground observers were deployed. Accordingly, the authors could provide no assurances that disturbance other than the study plane was not the cause of the response.

A map scale of 1:250,000 was used to estimate distances. The authors stated that distance estimation was difficult, and the landscape featured few landmarks.

Authors also note that the hazing flights (figure-8 patterns flown over the study flock) do not represent actual flight patterns to which study birds would be subjected in real conditions.

Relevance to SEIS:

Low. General inferences cannot be drawn from the conclusions.

Keywords:

Aircraft disturbance, lesser snow geese, North Slope, Alaska

Article 37

Author/Year:	**Title:**
Schweinsburg, R. 1974.	"Disturbance Effects of Aircraft to Waterfowl on North Slope Lakes, June, 1972"
Author's Affiliation:	**Published In:**
L.G.L., Limited, a private consultancy under contract to Canadian Arctic Gas Study, Limited, and to Alaska Arctic Gas Study Company.	Chapter I *in* W. W. H. Gunn and J. A. Livingston, Editors, *Disturbance to Birds by Gas Compressor Noise Simulators, Aircraft and Human Activity in the Mackenzie Valley and the North Slope, 1972*, Biological Report Series, Volume 14, February 1974, pp. 1-49.

Summary of Findings:

A five-day study was intended to test the effect of seaplanes on waterfowl breeding in North Slope, Alaska, ponds. Authors sought to determine whether seaplanes had an effect on the total number and behavior of the birds, whether responses were species-specific, if lake size influenced the response, and whether birds habituated. Three treatment and three control lakes (small, intermediate, and large) were used, although authors determined that baseline data from the treatment lakes were more relevant for comparison than the data from the control lakes Treatment lakes were disturbed by a Cessna 185 floatplane at 1-hour intervals (small N=4 days; intermediate N=2 days; large N=3 days). Numbers and reactions of birds were recorded by single observers.

Species present at the lakes included artic loon, red-throated loon, whistling swan, pintail, American wigeon, northern shoveler, canvasback, scaup, oldsquaw, scoter, and red-breasted merganser.

The authors determined that as the number of aircraft disturbances increased on the small and large lake, the number of waterfowl using the lake decreased and then leveled off (authors note this as "accommodation" (p. 60). There were no detectable differences in numbers of birds before or after disturbance at the intermediate lake. Authors also noted that on the large lake, the decrease in waterfowl use continued on the fourth day when no aircraft flights were conducted, although they also noted the difficulty in making observations due to size and conditions on the lake (e.g., blind spots).

The effect of a golden eagle flying over a lake was greater than that associated with the presence of a seaplane. The population decrease in response to the eagle was greater and did not return to pre-disturbance levels compared to the population decrease in response to the aircraft flights.

The attempt to study effects of disturbance on behavior was unsuccessful The amount of data collected before disturbance began was insufficient to support analysis. Despite this, the authors thought that feeding and sleeping became irregular after disturbance. The authors felt that a similar amount of time was dedicated to eating and sleeping, but the intervals seemed more erratic.

Scientific Rigor:

Low. In general, the authors simply equated observed numbers of birds to aircraft effects. Authors acknowledge a need to ascertain more information on normal behavior of waterfowl in undisturbed conditions. No analysis conducted on species-specific responses.

E & E Reviewer Comments (Including Limitations of Study):

While this study attempted to include controls and was replicated across three different-sized lakes, only minimal pre-disturbance surveys were done to equate waterfowl usage on treatment and control sites or to establish baseline, pre-disturbance patterns. Also, data were collected over a very brief interval, there was no ability to control for nuisance variables (e.g., a passing eagle and its effect on population).

Relevance to SEIS:

Low. General inferences cannot be drawn from the conclusions.

Keywords:

Aircraft disturbance, North Slope, Alaska

Article 38

Author/Year:	Title:
Temple, E. R., W. J. Fleming, and J. A. Dubovsky 1996.	"Reproduction, Growth and Survival of Captive Black Ducks Maintained in a Military Aircraft Operating Area"
Author's Affiliation:	**Published In:**
National Biological Service, Cooperative Fish and Wildlife Research Unit, North Carolina State University.	Chapter H in W. J. Fleming, J. A. Dubovsky, and J. A. Collazo, Editors, An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina, Final Report to U.S. Marine Corps, Cherry Point Marine Air Station.

Summary of Findings:

The authors conducted a 2-year study to determine whether aircraft activity affected American black duck captive reproduction. Two sites were selected, one at Piney Island near the Marine Corps aircraft target range, BT-11, and the second at a control site on Belle Island, located within the Swanquarter National Wildlife Refuge in Hyde County. The two sites had similar vegetation, water quality, and climatic characteristics. The sites differed primarily by level of aircraft activity: the test site at Piney Island averaged 71 noise events greater than 80 dB per day (Leq = 63.2 dBA) compared to the Belle Island site, which averaged <1 per day (Leq = 46.6 dBA).

This study found that the rates of pair formation, nesting chronology, nest initiation, number of eggs per clutch, hatching success, and nest desertion rates did not differ between sites. However, nesting females that were exposed to military aircraft operations removed more eggs from their nests (possibly a result of abrupt startle responses to aircraft activity), and growth and survival of their young were reduced as compared with these behaviors within the control group. The highest mortality rates occurred when ducklings were 8 to 13 days old, during which 57% of the ducklings died at Piney Island versus 15% at Belle Island. Also, gross pathology of dead ducklings was consistent with a diagnosis of stress disorders. The authors opined that exposure to military aircraft activity was associated with reduced reproductive output (growth and survival of ducklings) but indicated that other factors could have contributed to the observed result (e.g., water quality, with increase in salinity due to drought conditions and bacteria). The authors further commented that no cause-and-effect relationship could be inferred.

Scientific Rigor:

High. Study used experimentally imposed disturbance with control group.

Relevance to SEIS:

High. Study was conducted using military aircraft, including AV-8, A-6, F-14, and F/A-18.

E & E Reviewer Comments (Including Limitations of Study):

No additional comments.

Keywords:

Aircraft disturbance, Piney Island, nesting success, hatching success growth, survival.

Article 39

Author/Year:	**Title:**
Ward, D. H., E. J. Taylor, M. A. Wotawa, R. A. Stehn, D. V. Derksen, and C. J. Lensink 1987.	*Behavior of Pacific Black Brant and Other Geese in Response to Aircraft Disturbances and Other Disturbances at Izembek Lagoon, Alaska*
Author's Affiliation:	**Published As:**
U. S. Fish and Wildlife Service, Alaska Wildlife Research Center.	1986 Annual Report, U. S. Fish and Wildlife Service, Alaska Wildlife Research Center.

Summary of Findings:

For 6 weeks in fall 1986, black brant, Canada geese, and emperor geese were studied at Izembek Lagoon, Alaska. This area features the most extensive eelgrass beds in the world, which are used by brant to build fat reserves needed for nesting, brood rearing, and migration. Aircraft disturbance associated with oil exploration had the potential to disrupt brant and geese using this region, thereby potentially altering their reproduction or fitness for migration. The study objectives were to determine the effect of aircraft and other human disturbance on goose behavior, distribution, and habitat use and to evaluate the effect of this disturbance on energetics and reproduction. Authors sought to determine whether a sensitivity threshold exists that can be used for management recommendations (e.g., flight corridors, minimum altitude).

Aerial surveys and ground counts were used to estimate abundance and distribution. Disturbance responses were monitored by observers stationed in ground blinds. For each disturbance, observers recorded: (1) disturbance type; (2) distance; (3) aircraft altitude; (4) social facilitation; (5) tide; (6) wind; (7) species; (8) flock size; (9) flock behavior prior to disturbance; (10) distance from flock to shore; (11) percentage of flock in each behavior; (12) duration of flight, and; (13) duration of response. Experimentally imposed overflights, which were controlled for altitude, flight path, and speed, used eight types of aircraft, including single engine, light twin engine, heavy twin engine, small helicopter, and large helicopter.

Each species' distributions overlapped, but each also had distinct habitat preferences; brant selected the largest eelgrass beds, Canada geese used areas near alternative foods on tundra, and emperor geese used mudflats, but tides and date affected habitat use for all geese. The number of any species within study areas was (as determined by hourly counts) unaffected by disturbances prior to the last count (p. 7).

All species were most numerous within the lagoon at low tide. Brant moved to shoreline during flooding tides as eelgrass habitat became submerged, and Canada geese decreased on the lagoon due to use of tundra habitat. Canada goose abundance was affected by time of day, but local abundance for brant and emperor geese was not.

There were 2,027 experimental and incidental disturbances recorded, and responses were classified as no response, becoming alarmed and massing together, and flying. Although sample sizes were small and variance large, small helicopters caused the greatest disturbance. Canada geese, in contrast to brant, "were not disturbed by single-engine, twin-engine and Grumman goose [a heavy, twin-engine] aircraft at 1,000 ft… Only 5.6% of the

Canada goose flocks (n=18) flew during 1,000 ft small helicopter overflights, compared to 40.9% (n=44) of the brant (p. 11)." Aircraft at lower altitudes caused a greater disturbance response. Only 10% of brant flocks (n=10) within 0.24 mi. of single-engine aircraft flight tracks did not respond to aircraft at 150 to 500 ft., whereas 91% of flocks were not disturbed by overflights at 2,000 to 2,500 ft. The study reported that 32% of brant flocks within 0.24 mi. of twin-engine aircraft flown at 500 feet flew in response, whereas only 10% of flocks flew in response to aircraft at 1,000 feet, within the same horizontal distance. Brant and Canada geese differed in their response to small helicopters (p. 11).

Bald eagles caused the most frequent natural disturbances, which were also the most frequent incidental (i.e., non-experimental) disturbances. Also, eagles caused a greater proportion of brant and Canada goose flocks to flush than any other incidental or experimental disturbance, even experimentally imposed aircraft disturbance. The study reported that 81% of brant flocks and 60% of Canada goose flocks flew in response to eagles within 1 mile, whereas only 57% of brant flocks and none of the Canada goose flocks flushed in response to helicopters within 1 mile flying at 300 feet (p. 12). Helicopters caused the greatest disturbance, and all aircraft caused a greater disturbance at lower altitudes. Disturbance response seemed to be independent of flock size and wind direction, but brant were most prone to disturbance response at high tides.

The report also described as-yet-unanalyzed data on habitat use, forage quality, and time budgets. See Derksen 1991 and Ward 1988, 1994, and 1999.

Scientific Rigor:

High. Data collected on experimentally imposed aircraft overflights and also on non-experimental flights and natural disturbances. Summary data provided are comprehensive

E & E Reviewer Comments (Including Limitations of Study):

No further comments.

Relevance to SEIS:

Low/Moderate. The species, environment, and aircraft are all different from those found in the SEIS. Limited and general inference is probably acceptable

Keywords:

Black brant, emperor goose, Canada goose, distribution, aircraft, disturbance

Article 40

Author/Year:	**Title:**
Ward, D. H., R. A. Stehn, M. A. Wotawa, M. R. North, P. Brooks-Blenden, C. J. Lensink, and D. V. Derksen 1988.	*Response of Pacific Black Brant and Other Geese to Aircraft Overflights at Izembek Lagoon, Alaska*
Author's Affiliation:	**Published As:**
U. S. Fish and Wildlife Service, Alaska Fish and Wildlife Research Center.	1987 Annual Report, U. S. Fish and Wildlife Service, Alaska Fish and Wildlife Research Center.

Summary of Findings:

This study continues the research discussed in Ward 1987. Similar to Ward 1987, the study objectives were to determine the effect of aircraft and other human disturbance on goose behavior, distribution, and habitat use of brant at Izembek Lagoon, Alaska, and the effect of this disturbance on energetics and reproduction. This study also measured noise associated with incidental and experimental aircraft overflights.

Fall-staging brant accumulate body mass that is vital to successful transoceanic migration. Aircraft disturbance at eelgrass beds had the potential to disrupt foraging and, therefore, successful staging and migration. Brant were shown to concentrate in eelgrass beds disproportionately to the size of the area in eelgrass, implying that selection for one or more variables other than strict availability had occurred.

Potential disturbances monitored in the study included aircraft, predators, humans (foot, boats, and gunshots). The behavioral response of geese to disturbance was quantified using a ranking system (no change, alert, mass, and flight). The percent of birds that exhibited each level of response was recorded for each individual flock observed. For each disturbance, authors recorded 1) cause, 2) distance from flock, 3) altitude of aircraft, 4) social facilitation, 5) tide, 6) wind direction, 7) species, 8) flock size, 9) dominant behavior prior to disturbance, 10) distance to shore, 11) direction of the disturbance, 12) percent of flock exhibiting response, 13) duration of flight, and 14) duration of response.

There were 1,967 experimental and incidental disturbances recorded. Aircraft represented the most common disturbance (54%), followed by bald eagles (24%), and hunters (6%); human disturbance was cumulatively the most important of all types. The mean disturbance rate was 1.4 events/hour.

The noise component of aircraft disturbance was measured by relating behavioral responses to observed aircraft sound levels. Five aircraft types were recorded 42 times over 6 days. There was a strong correlation ($R^2 = 0.80$) between noise level and flight response by brant, and the distance of response initiation and magnitude of behavioral response corresponded to aircraft noise intensity. The number of brant in a flock did not affect the disturbance response. Wind direction from the aircraft to the flock was more important for responses generated by helicopters than for those generated by fixed-wing aircraft; at similar distances, a helicopter upwind had a greater effect than a helicopter downwind from a flock. Of fixed-wing aircraft, wind direction only affected disturbance response for multi-engine aircraft. The direction of aircraft travel (either directly toward or lateral to a flock) was an important determinant of disturbance response; aircraft that flew toward flocks ($\leq$ 4 km away) had more influence on disturbance response than did aircraft flying laterally to flocks (> 0.4 km away).

Disturbance response by brant to single- and multi-engine aircraft decreased as altitude and horizontal distance to aircraft increased. Brant responded most to a Bell 205 helicopter, which was considerably louder than other aircraft studied. Unlike responses to other aircraft types, intensity of response to Bell 205 helicopters did not decrease as altitude of the helicopter increased, up to 762 m (2,500 ft.), or response actually increased at higher altitudes. Response to helicopters decreased with lateral distance.

The threshold for response by brant to aircraft was estimated at a sound exposure level (SEL) of 65dBA or a maximum instantaneous noise (L_{max}) of 60 dBA. This response threshold was thought to be considerably lower than that for other birds.

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

Brant may be among the most sensitive of waterfowl. Thus, these results can serve as a worst-case threshold. Aircraft disturbances were experimentally imposed. However, the study and analysis did not control for the effect of habituation of geese to experimental flights. Also, the study investigated the effect of aircraft noise, not just aircraft presence.

Relevance to SEIS:

Low/Moderate. The species, environment, and aircraft are all different from those found in the SEIS. Limited and general inference is probably acceptable.

Keywords:

Disturbance, aircraft, helicopter, overflight, noise, black brant, fall staging.

Article 41

Author/Year:	**Title:**
Ward, D. H., R. A. Stehn, W. P. Erickson, and D. V. Derksen 1999.	"Response of Fall-Staging Brant and Canada Geese to Aircraft Overflights in Southeastern Alaska"
Author's Affiliation:	**Published In:**
U.S. Geological Survey, Alaska Biological Science Center, Anchorage, AK	*Journal of Wildlife Management* 63:373-381.

Summary of Findings:

Planned aircraft (fixed wing and rotary wing) overflights were conducted to measure behavioral response of staging Pacific brant and Canada geese with control of aircraft type, altitude, noise, and lateral distance from flocks. Data were used to develop predictive models of the relation between aircraft type, noise, altitude, lateral distance, and the response of geese, and to determine whether response declines with sequential days of exposure.

About 75% of brant and 9% of Canada goose flocks flew in response to overflights, and response was observed to 1,219 m altitude (4,000 ft) and 4.8 km (3 miles) lateral distance. Canada goose flocks rarely flew in response to fixed- or rotary-wing aircraft; therefore, authors combined alert and flight responses for further analysis. Both species responded more to helicopters than to fixed-wing, propeller-driven aircraft, and both responded more to loud aircraft. Increasing lateral distance between the aircraft and flock was consistently associated with a lower probability of a disturbance response by geese. Altitude as a single factor was a less reliable predictor because aircraft type and noise level effects interacted with altitude as an effect. The greatest response exhibited by geese was to aircraft at an intermediate altitude (305 to 760 m [1,000-2,493 ft]). Helicopters elicited a greater response from both species than did fixed-wing aircraft. Flocks of brant and Canada geese took flight before aircraft were visible to the birds during some events, which suggests aircraft noise was "a cue for escape behaviors."

Authors stated that repetitive disturbances may have a cumulative effect to which waterfowl may habituate and which is dependent on predictability of the location and constancy of the stimulus.

Scientific Rigor:

High

E & E Reviewer Comments (Including Limitations of Study):

No additional comments.

Relevance to SEIS:

High.

Keywords:

Aircraft disturbance, brant, Canada goose, experimental overflight, fall staging, helicopter, Izembek Lagoon, Alaska.

Article 42

Author/Year:	**Title:**
Ward, D. H., R. A. Stehn, and D. V. Derksen 1994.	"Response of Staging Brant to Disturbance at the Izembek Lagoon, Alaska"
Author's Affiliation:	**Published In:**
National Biological Survey, Alaska Fish and Wildlife Research Center.	*Wildlife Society Bulletin* 22:220-228.

Summary of Findings:

The objective of the study was to measure current disturbance levels of fall-staging brant at the Izembek Lagoon, Alaska, and to determine the extent to which disturbance affects behavior. Brant were studied by observing responses to non-experimental disturbances of several categories. A disturbance event was any stimulus that interrupted behaviors of a flock more than one time. The observed rate of disturbance was 0.79 disturbances/hour. Human-related disturbances (e.g., aircraft, boat, and hunting) occurred at an average rate of 0.47 event per hour, and natural disturbances occurred at a rate of 0.24 per hour. Flocks became alert to 54% of observed human disturbances and to 92% of natural disturbances. Flocks took flight in response to 31% of human disturbances and 83% of natural disturbances. Some or all of each flock departed the study area in response to 58% of human disturbances and 47% of natural disturbances. Flocks were disturbed by 49% of aircraft overflights and took flight in response to 26% of the overflights; response varied with aircraft altitude and horizontal distance. Authors excluded aircraft flying higher than 5,000 ft (1,524 m) or more than 5 mi (8 km) from their observation point because flocks never responded to them.

Of all specific disturbances, helicopters resulted in the highest rate of flocks leaving the study area (83%). Brant first became alert to aircraft from the greatest distances of all disturbance types (1.6 mi [2.6 km]). Half of 279 flocks flew in response to aircraft that were less than 0.5 mi ($\leq$ 0.8 km), but only 13% of flocks flew in response to more distant aircraft. On average, each bird was interrupted for a mean of 78 seconds/hour, or 2.2% of the daylight interval; natural disturbance accounted for 51%, and aircraft 22%, of the response time. Although aircraft caused 22% of all interruption time, aircraft accounted for 49% of all disturbance events.

Scientific Rigor:

High.

E & E Reviewer Comments (Including Limitations of Study):

This study quantified natural disturbances (e.g., the presence of predators) and showed that response to predators can be higher than to human disturbances. Fixed-wing aircraft were the most frequent type of disturbance, but bald eagles caused the greatest interruption of brant behavior.

Relevance to SEIS:

Low/Moderate. The species, environment, and aircraft are all different from those found in the SEIS. Limited and general inference is probably acceptable.

Keywords:
Aircraft, Alaska, bald eagle, disturbance, Pacific brant.