**ALASKA DEPARTMENT OF FISH AND GAME**
**DIVISION OF WILDLIFE CONSERVATION**
**PO Box 115526**
**Juneau, AK 99811-5526**

**Alaska Department of Fish and Game**
**State Wildlife Grant**

**GRANT NUMBER:** T-1 **SEGMENT NUMBER:** 6

**PROJECT NUMBER:** 8

**PROJECT TITLE:** Factors affecting the past, current, and future, production and distribution of trumpeter swans in Alaska

**PARTNER:** University of Alaska Fairbanks

**PRINCIPAL INVESTIGATORS:** Mark Lindberg (UAF)

**PROJECT DURATION:** July 1, 2004 – June 30, 2008

**REPORT PERIOD:** July 1, 2007 – June 30, 2008

## I. PROBLEM OR NEED THAT PROMPTED THIS RESEARCH

Trumpeter swans were nearly extinct by the end of the 1800's with remnant populations existing only in Alaska and the Yellowstone National Park area. In 1968 aerial surveys were conducted over all know breeding areas in Alaska to help assess the population. Since 1975, surveys have been conducted every 5 years, however, each year additional areas were added to the survey in response to a perceived change in population extent. This created substantial problems for analysis because it became difficult to separate changes in population size from increases in survey extent. One of the main goals for this research was to produce an unbiased estimate of the rate of population change through time. This required the development of Bayesian models to account for the changes in the amount of area surveyed.

In addition to a rigorous assessment of the population dynamics of this species, it was also important to identify important habitat features of breeding swans for their future conservation. The identification of preferred breeding habitats will be especially important in the future due to climate change, which is expected to be especially acute in Alaska.

## II. REVIEW OF PRIOR RESEARCH AND STUDIES IN PROGRESS ON THE PROBLEM OR NEED

Very little published research is available for trumpeter swans. Trumpeter swan data were collected in Alaska as stated above, but most of the information was not published. The only major publication on Alaskan trumpeter swans was published in 1971 (Hansen, H.A., P.E.K. Shepherd, J.G. King, and W.A. Troyer. 1971. The trumpeter swan in Alaska. Wildlife Monographs 26:3-83.) A general summary of trumpeter swan biology is available in (Mitchell, C.D. 1994. Trumpeter swan (*Cygnus buccinator*) In: The birds of

North America, No. 105. Poole, A. and F. Gill Eds. Philadelphia: The Academy of Natural Sciences, Washington D.C.: The American Ornithologists Union.).

We are unaware of any other studies in progress in Alaska on this species.

## III. APPROACHES USED AND FINDINGS RELATED TO THE OBJECTIVES AND TO PROBLEM OR NEED

Statewide:

OBJECTIVE 1: Estimate spatial and temporal rates of population change in Trumpeter swans.

We used Bayesian models to address this objective because these models allow the inclusion of missing data. Because the survey area increased each year, this resulted in many missing data values for areas that were added in later years. A standard analysis cannot account for this and prevented an unbiased assessment of trends in the past.

Using these models, we estimated that the adult segment of the population grew at an annual rate of 5.9%, and the cygnet population grew at an annual rate of 5.3%. We also found evidence that cygnet production exhibited higher rates of increase at higher latitudes in later years, which may be evidence for population level effects due to climate change. An increase in production in later, warmer years may indicate that the number of ice-free days has increased enough to allow successful reproduction to occur.

OBJECTIVE 2: Describe variation in size, elevation, and latitude of water bodies used by breeding Trumpeter swans.

We used generalized linear mixed models to identify habitat types preferred by breeding swans. We used long-term occupancy data from 4 areas throughout the state: Minto Flats State Game Refuge, Tetlin National Wildlife Refuge, Kenai National Wildlife Refuge, and the Cordova area to build models relating habitat features to occupancy probabilities.

Larger closed-basin wetlands such as lakes and ponds, were occupied by swan broods at much higher rates than other wetland types such as shrubby or forested wetlands. We also found a negative effect of transportation infrastructure on occupancy by broods in some areas, suggesting that swans are sensitive to human disturbance. Our results suggest that the recent and rapid growth of trumpeter swan populations in Alaska may be saturating available breeding habitat and anthropogenic and climate induced changes to swan breeding habitats have the potential to limit future production

OBJECTIVE 3: Estimate spatial and temporal patterns in Trumpeter swan production rates.

See Objective 1.

OBJECTIVE 4: Project maximum sustainable breeding populations for Alaska.

Early on in the project we were instructed that this would take place at the agency level, so we did not address this objective.

OBJECTIVE 5: Provide recommendation for future surveys.

Same as Objective 4.

Minto Flats State Game Refuge:

OBJECTIVE 6: Describe variation in temporal patterns of nesting distribution of trumpeter swans prior to (before 2004) the start of natural gas exploration on this refuge.

This was combined into a larger scale analysis in Objectives 1 and 2.

OBJECTIVE 7: Describe variation in temporal patterns of trumpeter swan production prior to the start of natural gas exploration on this refuge.

Because development failed to occur on the refuge during the study period (see Objective 8), we combined this analysis with that of Objective 2. Temporal patterns of production were addressed as part of this larger analysis and the results indicated that there was variability through time in the occupancy probabilities of breeding habitats, but in general the probability of occupancy of wetlands increased through time. This may indicate that historical occupancy rates are important for individual wetland management decisions because even high quality habitats are not occupied in every year. This is important in light of the evidence that swans react negatively to human disturbance (Objective 2) because historically important habitats could be rendered unsuitable if disturbance levels increase.

OBJECTIVE 8: Develop spatially explicit models of the relationship between development activities and changes in trumpeter swan nesting distribution and production.

No oil and gas development occurred on the refuge during the study period, so this objective was not addressed specifically. Some exploration did occur on part of the refuge where few swans nest, precluding any analysis. The effects of human disturbance and oil and gas development in other areas were addressed in Objective 2.

## IV. MANAGEMENT IMPLICATIONS

This project helped us to understand the population dynamics and habitat requirements of swans in Alaska. Trumpeter swan populations are continuing to grow and there is some evidence of habitat saturation in some areas. At some point wintering areas may become saturated as well and managers will have to decide how many swans can be supported by the available habitat. Some of our work indicated that swans are moving north into new habitats, but that older habitats are becoming saturated and there may be a growing component of non-breeders in the population. As the climate warms, there could be some substantial changes to wetland habitats, such as wetland shrinkage. This could dramatically affect swan productivity by reducing the number or quality of preferred breeding habitats. We identified the habitat types preferred by swans, so managers will now have a better idea of which types are most important for monitoring as the climate changes. Also, the negative impacts of human disturbance that we identified could be very important for the conservation of this species as development in Alaska continues. These birds breed at low densities on the landscape, and we found that occupancy decrease if infrastructure was located within at least ¼ mile of brood-rearing locations. This should be taken into consideration for development of areas such as Minto Flats where there are very few areas that would be less than ¼ mile from a historical brood-rearing area. Even though we did not have a direct comparison before and after

development for Minto Flats, based on our other results it seems probable that occupancy of brood-rearing wetlands would decrease if development occurs.

## V. SUMMARY OF WORK COMPLETED ON JOBS FOR LAST SEGMENT PERIOD ONLY (July 1, 2007 – June 30, 2008)

Overall, during this segment period all analyses were completed and 3 dissertation chapters/manuscripts were produced for future publication. The overall dissertation was also completed and successfully defended in May.

JOB/ACTIVITY 1A: Estimate spatial and temporal rates of population change in Trumpeter swans.

A manuscript/dissertation chapter was finished based on the results from this analysis. The analysis was completed during the previous segment period. This manuscript will be submitted to the Journal of Wildlife Management for publication.

JOB/ACTIVITY 2A: Describe variation in size, elevation, and latitude of water bodies used by breeding Trumpeter swans.

In order to conduct this analysis, wetland maps of the 4 areas had to be digitized by hand. This was completed during this segment period, the analysis was conducted, and 2 manuscripts/dissertation chapters were completed relating occupancy to habitat and climate change factors. These manuscripts will be submitted to appropriate journals for publication in the future.

JOB/ACTIVITY 3A: Estimate spatial and temporal patterns in Trumpeter swan production rates.

See Job/Activity 1.

JOB/ACTIVITY 4A: Project maximum sustainable breeding populations for Alaska.

Early on in the project we were instructed that this would take place at the agency level, so we did not address this objective.

JOB/ACTIVITY 5A: Provide recommendation for future surveys.

Early on in the project we were instructed that this would take place at the agency level, so we did not address this objective.

<u>Minto Flats State Game Refuge:</u>

JOB/ACTIVITY 6A: Describe variation in temporal patterns of nesting distribution of trumpeter swans prior to (before 2004) the start of natural gas exploration on this refuge.

See Job/Activity 2.

JOB/ACTIVITY 7A: Describe variation in temporal patterns of trumpeter swan production prior to the start of natural gas exploration on this refuge.

See Job/Activity 2.

JOB/ACTIVITY 8A: Develop spatially explicit models of the relationship between development activities and changes in trumpeter swan nesting distribution and production.

Not completed/addressed because development did not occur on the refuge during the study period.

## VI. PUBLICATIONS

Schmidt, J.H. 2008. The effects of a changing environment on the population dynamics of trumpeter swans in Alaska. Dissertation. 125p.

(Prepared for submission to *The Journal of Wildlife Mangement*)
Schmidt, J.H., M.S. Lindberg, D.S. Johnson, B. Conant, and J. King. Monitoring Alaskan trumpeter swan population change using Bayesian hierarchical models.

**ABSTRACT**
Time series of survey data provide essential data for management of wildlife. To improve management of swans in Alaska, we analyzed aerial survey data of trumpeter swans, which were collected in all known breeding habitats in Alaska from 1968-2005. As is common for many surveys, these data presented some analytical challenges. For example, during the period of study, numbers of swans counted increased 9-fold and the area surveyed increased 4-fold, which made it difficult to separate changes in the population from changes in the area surveyed. Other survey problems that are commonly encountered include missing data, and differences in observers, sites, or years. Each of these can be addressed individually in a frequentist framework, but a Bayesian approach provides a formal framework which can simultaneously address these issues. We used Bayesian hierarchical negative binomial models of swan counts because the additional scaling parameter in this distribution helped to more accurately describe our data than did over-dispersed Poisson models. We analyzed adult and cygnet counts separately, and to investigate the bias associated with making assumptions about missing values, we reanalyzed the data filling in missing values with 0's prior to the addition of a given geographic unit to the survey. This analysis strategy was in response to the suggestion that survey units were added as swans colonized them, so prior years would have had counts of zero. We estimated that adult populations grew at an average rate of 5.9% annually and cygnet production grew at a rate of 5.3% annually. We also found evidence that cygnet production exhibited higher rates of increase at higher latitudes in later years, which may be evidence for population level effects due to climate change. An increase in production in later, warmer years may indicate that the number of ice-free days has increased enough to allow successful reproduction to occur. Given probable continued increases in trumpeter swan numbers, managers should consider the size of the wintering population that is desired or that can be supported by the available winter habitat and the effects that breeding-range expansion might have on tundra swan populations.

(Prepared for submission to *Global Ecology and Biogeography*)
Schmidt, J.H., M.S. Lindberg, D.S. Johnson, D.L. Verbyla. The effects of climate warming on habitat occupancy of trumpeter swans in Alaska.

**ABSTRACT**
**Aim** To investigate the potential relationship between changes in climate and trumpeter swan habitat occupancy throughout Alaska between 1968 and 2005.
**Location** Alaska, USA
**Methods** Statewide surveys for trumpeter swans were first undertaken in 1968, and from 1975-2005 surveys covering all known breeding areas were conducted every 5 years during August and September. We used Bayesian hierarchical occupancy models to examine the effects of latitude, time, and the average number of days above freezing on occupancy of suitable habitat by trumpeter swans.
**Results** The average number of days above freezing generally decreased as latitude increased. Model selection results indicated support for a model containing relationships between both latitude and the number of days >0°C and occupancy probability. Model fit was determined to be satisfactory based on the Bayesian *P*-value. The predicted probability of occupancy from the best approximating model increased as the number of days >0°C increased. Sites at higher latitudes had lower occupancy probabilities. Even though these parameters were partially correlated, model selection procedures indicated that models containing both latitude and the number of days >0°C were a better explanation of the data than models containing only one of these parameters.
**Main conclusions** Strong support for a relationship between occupancy and the average number of days >0°C indicated that the recent increase in the range of trumpeter swan populations in Alaska may be related to climate warming. This may be resulting in competition between trumpeter and tundra swans for breeding habitat and may impact some segments of these populations. The future impacts of continued climate change on the Alaskan trumpeter swan population are unknown, but this study is one of the few of which we are aware that directly investigates the effects of climate change on an avian species, and the first for a waterfowl species in particular, over most of its range.

(Prepared for submission to *The Auk*)
Schmidt, J.H., M.S. Lindberg, D.S. Johnson, and J.A. Schmutz. Environmental and human influences on trumpeter swan habitat occupancy in Alaska.

**ABSTRACT**
Approximately 70-80% of the entire continental population of trumpeter swans depend heavily on wetland habitats in Alaska for reproduction. This makes the identification of important habitat features and the impacts of human interactions essential for the long-term management of this species. We conducted an analysis of habitat preferences in 4 areas throughout the state and found that some wetland types, especially larger closed-basin wetlands such as lakes and ponds, were occupied by swan broods at much higher rates than other wetland types such as shrubby or forested wetlands. We also found a negative effect of transportation infrastructure on occupancy by broods in and around the Minto Flats State Game Refuge (MFSGR) and the Tetlin National Wildlife Refuge (NWR). This finding is of particular interest because most of the MFSGR has recently

been licensed for oil and gas exploration. We also investigated the potential effects of the shrinkage of closed-basin ponds on habitat occupancy by nesting trumpeter swans. A reduction in the number and size of ponds throughout the state is occurring on a large scale and this could have important impacts on breeding swans in the future. We compared pond use by nesting swans with pond size and change characteristics between 1982 and 1996 and found no relationships between occupancy and changes in pond size. However, we believe that the recent and rapid growth of trumpeter swan populations in Alaska may be saturating available breeding habitat and anthropogenic and climate induced changes to swan breeding habitats have the potential to limit future production.