

copy - Hileadg in GAAZ article p. 22 only
(GAAZ article p. 22 only)

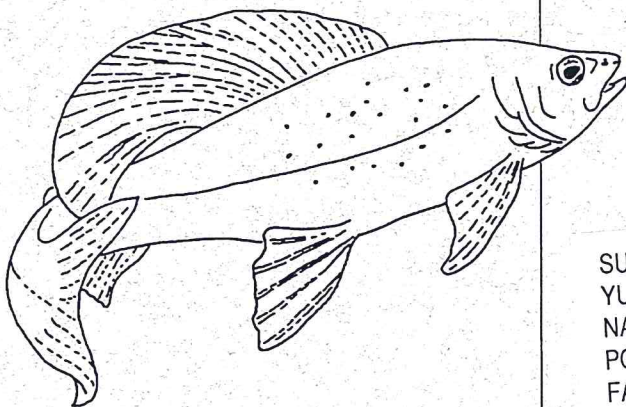
Library

K 2621



Alaska
Cooperative
Fish and Wildlife
Research Unit

Annual Report, 1995



SUPERINTENDENT
YUKON-CHARLEY RIVERS NATIONAL PRESERVE
NATIONAL PARK SERVICE
PO BOX 74680
FAIRBANKS AR

RECEIVED JAN 31 1997

Not for Publication

Because this report is one of progress, the data presented are often incomplete and the conclusions reached may not be final. Consequently, permission to publish any of the information contained herein is withheld pending approval from the Alaska Cooperative Fish and Wildlife Research Unit.

Annual Report—1995

Alaska Cooperative Fish and Wildlife Research Unit

Unit Roster	iv
Staff.....	iv
Sponsors	iv
Students	iv
Coordinating Committee	v
Cooperators.....	v
Introduction	1
Statement of Direction	2
Research Reports	3
(Listed by Principal Investigator)	
• R. Terry Bowyer	
<i>Neil Barten</i> : Forage Availability & Nutrient Composition of Caribou Calving Sites on the Mentasta Caribou Range	3
<i>David Person</i> : The Ecology of the Alexander Archipelago Wolf & Responses to Habitat Change	4
<i>David Person</i> : Population Viability Analysis for Alexander Archipelago Wolf in Southeastern Alaska	8
• R. Terry Bowyer & Roger Ruess	
<i>Elizabeth A. Lenart</i> : The Effects of Weather on Caribou Forage Productivity & Nutrition within the Range of the Chisana Herd	10
• Michael A. Castellini & Brendan Kelly	
<i>Gay Sheffield</i> : Methodological Development & A Re-analysis of Walrus Feeding Data	11
• Joseph A. Cook	
<i>Ellen Weintraub Lance</i> : Phylogeographic Variation & the Island Syndrome in Holarctic Tundra Voles	13
• Erich H. Follmann	
<i>Craig Perham</i> : Home Range, Habitat Selection, & Movements of Lynx in Eastern Interior Alaska	14
• Anthony J. Gharrett	
<i>Cheryl L. Seifert</i> : Genetic Variation of Wild Alaskan Steelhead Trout.....	14
• David R. Klein	
<i>Merav Ben-David</i> : Seasonal Changes in Diets of Mink & Marten in Southeast Alaska.....	15
<i>Maria Berger</i> : Summer Habitat Relationships & Foraging Ecology of the Delta Caribou Herd.....	16
<i>Claudia Ihl</i> : Interactions between Muskoxen & Reindeer on the Seward Peninsula	16
<i>Frank Mörschel</i> : The Role of Weather & Parasitic Insects in the Summer Ecology of the Delta Caribou Herd	18
<i>Eric Post</i> : Comparative Foraging Ecology & Social Dynamics of Caribou.....	19
<i>Jeffrey Selinger</i> : Seasonal Habitat Relationships of Adult Female Deer on Kodiak Island, Alaska	21

• Jacqueline D. LaPerriere	
Water Quality Inventory & Monitoring—Gates of the Arctic National Park & Preserve.....	22
Water Quality Inventory & Monitoring—Katmai National Park & Preserve	23
Jim Edmundson: Influence of Temperature on Juvenile Sockeye Salmon Growth in Alaska Lakes	24
Thomas Simpson: Lake Productivity Indices as Estimators of Carrying Capacity of Burbot & Northern Pike in Interior Alaska.....	25
Klaus Wuttig: Influences of Hydrology & Water Quality of the Sloughs of the Tanana River on Arctic Grayling Habitat	26
• Edward C. Murphy	
Dean Kildaw: The Abundance & Habitat Requirements of Red-legged Kittiwakes on St. George Island, Alaska.....	26
• Terrance J. Quinn II	
Lewis Coggins Jr.: Effects of Ageing Error & Sample Size on Sustained Yield from Alaska's Sport Fisheries	29
• Terrance J. Quinn II & Ole A. Mathisen	
Randolph Ericksen: Age Validation & Revised Growth Parameters of Coastal Cutthroat Trout in Two Southeast Alaska Lakes	31
• Eric A. Rexstad	
William Anker: Development of a Simulation Model for Flyway Management of Pacific Black Brant	32
Pamela Furtsch: Techniques for Monitoring Density & Correlates of Inter-annual Variation for Northern Red-backed Voles in Denali National Park & Preserve, Alaska	34
Sampling Protocol for Small Mammal Monitoring, Denali National Park & Preserve	35
• James B. Reynolds	
Steve Brink: Summer Habitat Ecology of Rainbow Trout in the Middle Fork of the Gulkana River, Alaska	38
Thomas Cappiello: Spawning Run Characteristics of Dolly Varden in the Kugururok River, Noatak Drainage, Alaska	39
Michael Daigneault & Brent Peterson: Relation of the Chena River Lakes Flood Control Project to Outmigration & Abundance of Juvenile Salmonids	39
Robert Foy: Energetic & Food Source Comparisons of Dolly Varden Char in the Kugururok River, Alaska.....	41
Raymond Hander: Spawning Substrate & Capacity for Coho Salmon in the Ayakulik River, Kodiak National Wildlife Refuge	43
Brian Lubinski: Winter Habitat of Arctic Grayling in an Interior Alaska Stream	44
• James B. Reynolds & Keith Criddle	
Margaret Merritt: Application of Decision Analysis in the Evaluation of Recreational Fishery Management Problems.....	45
• Daniel D. Roby	
Stomach Oils & Reproductive Energetics in Antarctic Seabirds	46
Brian Lance: Diet & Nestling Growth of Red-legged Kittiwakes and Black-legged Kittiwakes: An Interspecies Cross-Fostering Experiment.....	47
Steve Matsuoka: Habitat Selection & Nesting Ecology of Townsend's Warblers in Southcentral Alaska	47

<i>Angela Palmer & Dana Nordmeyer</i> : Effects of Aircraft Overflights on Birds of Prey—Phase II	49
<i>Alex Prichard</i> : Pigeon Guillemots as Bioindicators of Nearshore Ecosystem Health	51
<i>Gerald Zuercher</i> : Seasonal Changes in Body Mass & Composition of Northern Red-backed Vole in Interior Alaska	52
• Roger Ruess	
<i>Amy Zacheis</i> : Interactions between Lesser Snow Geese & Forage Plants in Upper Cook Inlet	54
• Alan M. Springer	
<i>Suzann Speckman</i> : Marbled Murrelet Distribution & Abundance in Relation to the Marine Environment	55
• Robert G. White	
<i>Karen Gerhart</i> : Nutritional & Ecological Determinants of Growth & Reproduction in Caribou	58
Unit Communications	60
Scientific Publications	60
Theses and Dissertations	61
Reports	62
Papers Presented	63
Unit Honors and Awards	66

Unit Roster

Alaska Cooperative Fish and Wildlife Research Unit
209 Irving I Building
P.O. Box 757020
University of Alaska Fairbanks
Fairbanks, AK 99775-7020
Telephone: 907.474.7661
Fax: 907.474.6716

Staff

James B. Reynolds, Unit Leader
David R. Klein, Senior Scientist
Jacqueline D. LaPerriere, Assistant Leader-Fisheries
A. David McGuire, Assistant Leader-Ecology¹
Daniel D. Roby, Assistant Leader-Wildlife²
Norma L. Mosso, Administrative Assistant
Kathleen R. Pearse, Administrative Assistant
Judy D. Romans, Secretary/Receptionist
Elizabeth A. Sturm, Research Technician
Joy R. Heimgartner, Student Assistant

Sponsors

Alaska Department of Fish and Game
University of Alaska Fairbanks
U.S. National Biological Service
Wildlife Management Institute

Graduate Students

William Anker (M.S.)	Raymond Hander (M.S.)
Neil Barten (M.S.)	Michael Hansen (Ph.D.)
Merav Ben-David (Ph.D.)	Claudia Ihl (M.S.)
Maria Berger (M.S.)	S. Dean Kildaw (Ph.D.)
Steve Brink (M.S.)	Brian Lance (M.S.)
John Burch (M.S.)	Ellen Weintraub Lance (M.S.)
Thomas Cappiello (M.S.)	Elizabeth Lenart (M.S.)
Lewis Coggins, Jr. (M.S.)	Mark Lindberg (Ph.D.)
Michael Daigneault (M.S.)	Brian Lubinski (M.S.)
Jim Edmundson (M.S.)	Margaret MacCluskie (Ph.D.)
Randolph Ericksen (M.S.)	Julie Kitchens Maier (Ph.D.)
Robert Foy (M.S.)	Steve Matsuoka (M.S.)
Pamela Furtsch (M.S.)	Margaret Merritt (Ph.D.)
Karen Gerhart (Ph.D.)	Frank Mörschel (M.S.)

¹ Joined the Unit in August 1995.

² Transferred to the Oregon Cooperative Wildlife Research Unit in July 1995; graduate students Dana Nordmeyer and Angela Palmer transferred to Oregon State University in September 1995.

Dana Nordmeyer (M.S.)
Angela Palmer (M.S.)
Craig Perham (M.S.)
David Person (Ph.D.)
Brent Peterson (M.S.)
Eric Post (Ph.D.)
Alex Prichard (M.S.)
Cheryl Seifert (M.S.)
Jeffrey Selinger (M.S.)

Gay Sheffield (M.S.)
Thomas Simpson (M.S.)
Michael Smith (M.S.)
Suzann Speckman (M.S.)
T. Christopher Stark (M.S.)
Klaus Wuttig (M.S.)
Amy Zacheis (M.S.)
Gerald Zuercher (M.S.)

Coordinating Committee

W. Reid Goforth, Chief, Division of Cooperative Research, U.S. National Biological Service, Washington, D.C.

Carl L. Rosier, Commissioner, Alaska Department of Fish and Game, Juneau, Alaska

Robert G. White, Director, Institute of Arctic Biology, University of Alaska Fairbanks

Rollin D. Sparrowe, President, Wildlife Management Institute, Washington, D.C.

Cooperators

Alaska Department of Fish & Game

Fred Andersen
Peter Bente
David Bernard
John Coady
Alfred DeCicco
Stephen DuBois
Steven Elliott
James Faro
Douglas Fleming
Rodney Flynn
Craig Gardner
James Hasbrouck
Douglas Jones
Matthew Kirchhoff
Robert Marshall
Douglas McBride
Thomas McCarthy
Margaret Merritt
Roger Smith
Jay Ver Hoef

Bureau of Land Management

Michael Coffeen
Randi Jandt
Dennis Tol

National Biological Service

Layne Adams
Denali National Park
Resource & Research Unit
Gerald Garner
Colleen Handel
Jerry Hupp
Kurt Jenkins
John Mosesso
Dale Taylor
Lyman Thorsteinson

National Park Service

Nancy Deschu
Richard Harris
Ross Kavanagh
Rick Potts
Patricia Rost
Gary Vequist
Joe Van Horn
Larry Whalon

University of Alaska Fairbanks

R. Terry Bowyer
Michael Castellini
Joseph Cook
Keith Criddle
Lawrence Duffy
Erich Follmann

Anthony Gharrett
Brendan Kelly
Daniel Mann
Ole Mathisen
Edward Murphy
Terrance Quinn II
Eric Rexstad
Roger Ruess
James Sedinger
Alan Springer
Robert White

U.S. Army Corps of Engineers

Kim Kuk
John Schaake

U.S. Fish & Wildlife Service

Alaska Maritime National Refuge
Robert Ambrose
Vic Barnes
Donald A. Chatto
Christian Dau
Terrance Doyle
John Lindell
Dana Seagars
Denny Zwiefelhofer

U.S. Forest Service

Chugach National Forest
Cole Crocker-Bedford
Thomas Hanley
Barry Noon
Tongass National Forest

Other Individuals and Organizations

ABR, Inc.
Robert Ritchie and Steve Murphy
British Antarctic Survey
J. P. Croxall and P. A. Prince
Captain Michael Carter, USAF
Chugach State Park
City of St. George
Rose Fosdick
Reindeer Herders Assoc., Nome
John R. Jones
University of Missouri
Herbie Karmun, Deering
Municipality of Anchorage
National Marine Fisheries Service
Pacific Flyway Council
A. R. Place
Center for Marine Biotechnology
University of Maryland
Prince William Sound Aquaculture Corporation
Prince William Sound Science Center
Steve Ranney
Fishing & Flying Cordova-Yakutat
Ken Spiers, U.S. Army
Department of Natural Resources

Introduction

Nineteen ninety-five was a significant year for the Alaska Cooperative Fish and Wildlife Research Unit. Much of the planning and preparations that began two years earlier, when the Alaska Unit was designated a “prototype unit” by the National Biological Service, came to fruition. The purpose of the designation was to demonstrate how a Cooperative Unit could expand its program to include an emphasis on “ecosystem research” while continuing to meet the traditional needs of research in support of fish and wildlife management. As a result of this opportunity, the Alaska Unit needed to (1) enlarge its staff to include an Assistant Leader for Ecology, (2) merge the staffs of the former Wildlife and Fishery Units from separate buildings into the same location, and (3) renegotiate the Cooperative Agreement to reflect these changes in program and operation. The new Cooperative Agreement was signed by representatives of the Alaska Department of Fish and Game, National Biological Service, University of Alaska Fairbanks, and Wildlife Management Institute and took effect in February 1995. During the 1994–95 academic year, negotiations were completed to house the Unit in three adjacent office suites in the Laurence Irving Building, centered around the location of the former Wildlife Unit; remodeling plans were completed and construction initiated in February 1995. The search for a new Assistant Leader was completed with the appointment of Dr. A. David McGuire to the faculty of the Institute of Arctic Biology and the Department of Biology and Wildlife; he assumed his responsibilities in August 1995. During summer 1995, all Unit staff were busy with occupying the newly remodeled offices. Ms. Judy Romans joined the Unit support staff as a secretary/receptionist with her duties and salary split equally between the Unit and the Department of Biology and Wildlife. By the fall semester, the expansion of the Alaska Unit was complete and all Unit staff members were adapting to a newly integrated operation. However, Dr. Dan Roby, Assistant Leader for Wildlife transferred to the Oregon Cooperative Wildlife Research Unit in July 1995, leaving a vacancy in the Unit staff and the challenge to fill it as quickly as possible. In summary, 1995 was a year of administrative progress that would set a new level of research and graduate training by the Alaska Unit in the years to come.

This report for 1995 centers on the progress in research and related graduate student training sponsored by the Alaska Unit. The research reports are organized under the names of Principal Investigators, either Unit-based faculty or cooperating faculty, who lead projects. This organization reflects the fact that it is the Principal Investigator that is the Project Leader and it is the Unit Project, defined as a research-oriented activity sponsored through the Alaska Unit, that is the foundation of the Alaska Unit program. All activity and progress reported herein are those happenings that occurred in connection with Alaska Unit Projects.

The following projects were completed in 1995 (in order of their presentation in this report):

- Phylogeographic variation and the island syndrome in holarctic tundra voles
- Home range, habitat selection, and movements of lynx in eastern interior Alaska
- Summer habitat relationships and foraging ecology of the Delta Bison Herd
- Comparative foraging ecology and social dynamics of caribou
- Seasonal habitat relationships of adult female deer on Kodiak Island, Alaska
- Water quality inventory and monitoring—Katmai National Park and Preserve
- Techniques for monitoring density and correlates of inter-annual variation for northern red-backed voles in Denali National Park and Preserve, Alaska
- Summer habitat ecology of rainbow trout in the Middle Fork of the Gulkana River, Alaska
- Spawning run characteristics of Dolly Varden in the Kugururok River, Noatak drainage, Alaska
- Winter habitat of Arctic grayling in an interior Alaska stream
- Application of decision analysis in the evaluation of recreational fishery management problems
- Stomach oils and representative energetics in Atlantic seabirds
- Diet and nestling growth of red-legged and black-legged kittiwakes: An interspecies cross-fostering experiment
- Seasonal changes in body mass and composition of northern red-backed voles in interior Alaska
- Nutritional and ecological determinants of growth and reproduction in caribou

Statement of Direction

The research program of the Unit will be aimed at understanding the ecology of Alaska's fish and wildlife; evaluating impacts of land use and development on these resources; and relating effects of social and economic needs to production and harvest of natural populations.

In addition to the expected Unit functions of graduate student training/instruction and technical assistance, research efforts will be directed at problems of productivity, socioeconomic impacts, and perturbation on fish and wildlife populations, their habitats and ecosystems. Fisheries research will emphasize water quality, habitat characteristics, and life history requirements of arctic and subarctic fish populations. Wildlife research will focus on evaluation of habitat quality and ecology of northern birds and mammals. Unit research will also be directed at integrated studies of fish and wildlife at the ecosystem level.

Research Reports

R. Terry Bowyer

Forage Availability and Nutrient Composition of Caribou Calving Sites on the Mentasta Caribou Range

Student Investigator: Neil L. Barten (M.S.)

Cooperator: Dr. Kurt Jenkins, Wrangell-St. Elias National Park and Preserve, NBS

Funding Source: National Park Service

Background

The Mentasta Caribou Herd, which calves in northern Wrangell-St. Elias National Park and Preserve (WRST), has traditionally been an important subsistence resource for people of the upper Copper River Basin. Until recently, the Mentasta herd numbered 2000–3000 animals. Since 1989, however, the population has declined to approximately 800 animals in 1994 and 1995. Calf recruitment also has declined since 1989 and reached an all-time low of 1.5 calves:100 cows during autumn 1991.

Although the decline of this herd is related to low recruitment, causes of this sudden reduction after 1989 are poorly understood. Low recruitment may be related to increased predation, inferior summer nutrition, inferior winter nutrition, or adverse winter-spring weather that influences calving distribution and success. The purpose of this study is to describe factors influencing birth-site selection of caribou and neonatal survival as the first step toward understanding factors limiting population growth.

Research Design

The aim of this project was to monitor sites used by parturient and nonparturient female caribou for 2-week intervals before, during, and following calving. At each site, habitat variables were recorded, and vegetation sampled and collected for nutrient analysis. This will allow us to compare habitat use, and forage availability between sites used by the two categories of females. Our sampling was divided into the following time periods: (1) *preparturient*: sites used by both pregnant and nonpregnant females were sampled. ($n=20$ sites); (2) *1-3 days post-calving*: sites of females with and without calves were sampled (40 sites: 20 sites/parturient 20 sites/nonparturient); and (3) *7-10 days post-calving*: sites of cows with and without calves were again sampled (40 sites: 20 sites/parturient 20 sites/nonparturient).

In 1994, only 64 sites were sampled because of an earlier-than-usual calving season and poor weather. In 1995, however, we were able to complete our 100 samples.

Each birth site was selected randomly by choosing a radiocollar frequency of a female caribou and following the telemetry signals with a helicopter. This sampling was accomplished without replacement to assure independent samples in each category. Vegetation sampling began with a 50-m tape oriented in a random direction. At each 1-m interval, the forage class (graminoid, deciduous shrub, forb, lichen etc.) or species was determined and recorded. This line-intercept method allowed us to describe the major vegetation types at each site. In addition, six 20- by 50-cm quadrats were sampled along the tape to estimate biomass of available forage. Finally, the phenological stage of each

species was determined, and samples of each plant were collected for nutrient analysis.

Fecal pellets were collected for microhistological analysis and determination of fecal nitrogen, to determine types of forage the caribou were utilizing, and to provide an index of diet quality. We attempted to collect fecal pellets from parturient and nonparturient cows during each of the calving periods, but this was a difficult task. The project goal was to collect 5 samples from each of three different groups during each period of the calving season. Our collections for preparturient and 7-10 post parturient were obtained easily, but the 1-3 day samples were not fulfilled due to small group sizes, which led to difficulty in finding pellets.

Project Status

Data were collected during the 1994 and 1995 calving seasons. All forage samples have been analyzed for nitrogen content and in-vitro dry matter digestibility. Fecal pellets were sent to Washington State University for analysis. These results are expected by early February 1996. Preliminary analysis shows a significant difference in elevation of sites used by parturient and nonparturient females during early calving, with this difference disappearing 7-10 days post calving. Forage availability also differs dramatically between sites used by these two groups of female caribou during early calving, but becomes more uniform 7-10 days post calving. Causes for this appear to be a movement by parturient females to higher, less-vegetated sites just prior to calving. They remain at these sites for the first week following parturition, then move to lower elevation sites forming mixed herds of parturient and nonparturient females.

Further data analysis should help us answer questions regarding habitat selection during calving, displayed by female caribou in the Mentasta herd.

The Ecology of the Alexander Archipelago Wolf and Responses to Habitat Change

Student Investigator: David K. Person (Ph.D.)

Cooperators: Matthew Kirchhoff, ADFG; Layne Adams, NBS; Cole Crocker-Bedford, USFS

Funding Sources: National Biological Service; U.S. Forest Service; Alaska Department of Fish and Game

The Alexander Archipelago wolf (*Canis lupus ligoni*) of southeastern Alaska presents a difficult challenge to wildlife biologists: the conservation of a large predator in a highly fragmented environment that is undergoing rapid and long-term habitat change due to timber harvesting. The task is made more difficult because little is known about the basic ecology of wolves in southeastern Alaska, although much is known about wolves elsewhere.

To predict future trends in Archipelago wolf populations, we need to know how wolves respond spatially, behaviorally, and numerically to changes in habitat composition that will affect Sitka black-tailed deer (*Odocoileus hemionus sitkensis*), their principal prey.

Objectives

We intended to radiocollar and monitor wolves occupying logged and relatively pristine landscapes to compare home ranges, pack sizes, and activity patterns. We expected to observe larger pack home ranges (with pack size treated as a

covariate) for wolves in logged areas than for those in less developed areas because deer density was expected to be lower (USFS 1993). We also expected to observe less site fidelity within home ranges of wolves occupying logged landscapes due to human disturbance and the distribution of prey.

Study Area

The Alexander Archipelago is located in southeastern Alaska between Yakutat Bay and Dixon Entrance (Fig. 1). The study area comprises Prince of Wales and the adjacent islands. Timber harvesting has occurred in the area since the early 1900s; to date, approximately 400,000 acres of old-growth forest have been cut and over 3,000 miles of road have been built on Prince of Wales Island (USFS GIS database, 1993). For a detailed description of the area, refer to Person and Ingle (1995).

Methods

Wolves were captured using leghold traps, modified to prevent serious injury. Study animals were anesthetized, fitted with radiocollars, and released. Wolves were monitored from ground and from aircraft. For more detailed descriptions of capture, handling, radiocollaring, and tracking study animals, as well as controlling data quality and statistical procedures, refer to Person and Ingle (1995).

Results to Date

Thirty-one wolves were captured between February 1993 and November 1994. Twenty-four of these animals, representing 8-10 different packs, were radiocollared and released. Of the 7 wolves not instrumented, one was euthanized because of trap-related injuries, one was killed in the trap by other wolves, one escaped from an experimental padded-jaw trap, two broke the traps and escaped, one was stolen, and one was shot in the trap before we could process it.

The 24 radiocollared wolves included 5 adult females, 6 adult males, 6 yearling females, 1 yearling male, 2 juvenile females, and 4 juvenile males. The study animals represent 7-9 packs occupying Prince of Wales Island and one pack occupying Kosciusko Island (Fig. 2).

To date, a total of 1,451 radio relocations have been recorded, both from the ground and from aircraft. Approximately 30% of these observations were at night. Mohr's minimum convex polygon (MCP) and 95% adaptive kernel (ADK) (Worton 1989, Kie 1994) home ranges were estimated for 13 wolves, each with more than 30 relocations. Home ranges were also estimated for 7 packs. Seventy-five percent ADK home ranges were used to define core areas. The average 95% ADK home range for resident wolves was 274 km² (± 94), and the average MCP home range was 226 km² (± 67). Core areas averaged 98 km² (± 60), which suggests that wolves spend 75% of their time within only 30 to 40% of their home ranges. Pack home ranges averaged 296 km² (± 182) for 95% ADK home ranges and 264 km² (± 127) for MCP home ranges. Pack sizes ranged from 2 to 12 wolves with an average of 7.5 (± 1.9) animals.

Radiocollared wolves are most active at night, which we define as the time period 1/2 hour after sunset to 1/2 hour before sunrise. For resident wolves, 61.1% of the radio locations during nighttime indicated movement, compared to 40% in daytime ($P < 0.0001$, $N = 515$). Dispersing animals showed the same pattern, with 54.7% of the radio locations indicating movement at night versus 39.6% during daytime ($P < 0.001$, $N = 234$). Overall, residents were active 45.8% of the time and dispersers were active 44.4% of the time.

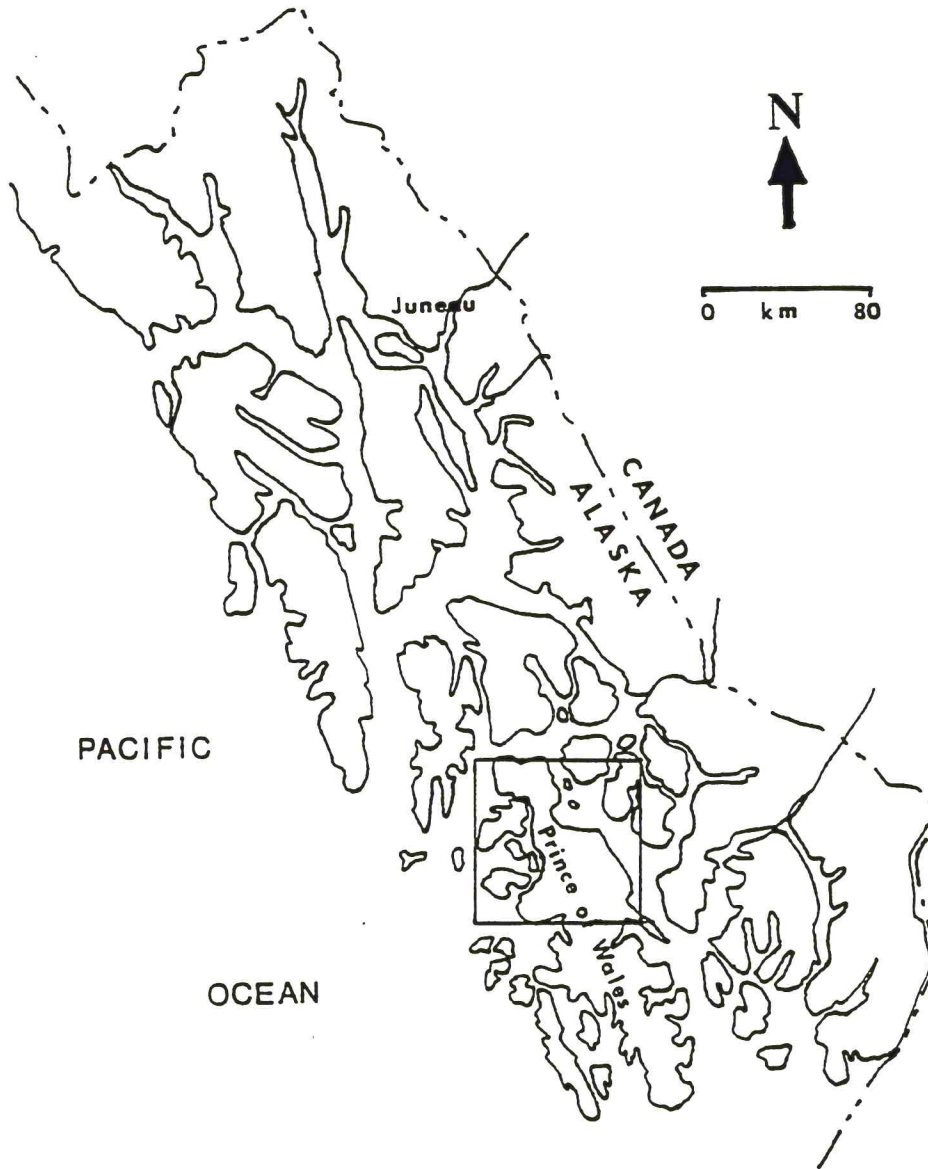


Figure 1. Alexander Archipelago in southeast Alaska. Box indicates location of study area to be used during the intensive phase of this research.

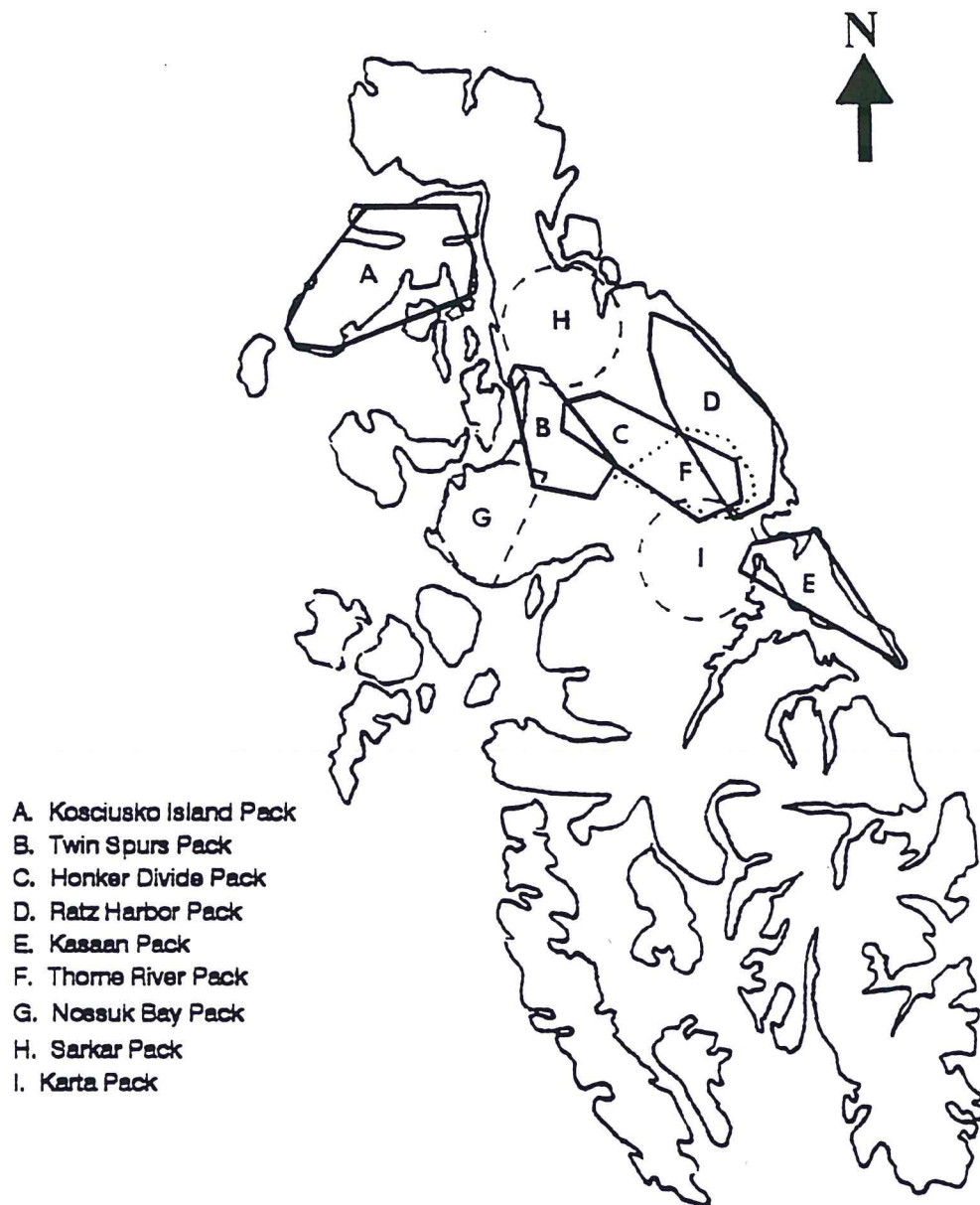


Figure 2. Home ranges and locations for 9 wolf packs on Prince of Wales and Kosciuszko Islands. Solid lines show minimum convex polygon home ranges for packs with greater than 30 radiolocations. Dotted line shows home range of Thorne River pack in 1993. Dashed lines show approximate home range boundaries for packs with less than 30 radiolocations.

Dispersal rates for the periods 1 June 1993–1 June 1994 and 1 June 1994–1 June 1995 were 39% ($\pm 23\%$, $N=18$) and 30% ($\pm 29\%$, $N=10$), respectively. The average monthly dispersal rate was 5% (95% C.I.=0–17%), with peaks occurring in January and March. Six of the 10 dispersers were adults, 2 were yearlings, and 2 were juveniles. Minimum dispersal distances from the point of capture ranged between 13–181 km.

Kie, J. 1994. Program CALHOME. U.S. Forest Service, Pacific Southwest Forest Experimental Station.

Person, D. K. and M. A. Ingle. 1995. Ecology of the Alexander Archipelago wolf and responses to habitat change. Prog. Rep. No. 3, Alaska Dept. Fish and Game. 39 pp.

U.S. Forest Service. 1993. A proposed strategy for maintaining well-distributed, viable populations of wildlife associated with old-growth forests in southeast Alaska. Interagency Comm. Rep., Juneau, AK. 278 pp.

Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164–168.

Population Viability Analysis for the Alexander Archipelago Wolf in Southeastern Alaska

Student Investigator: David K. Person (Ph.D.)

Cooperators: Dr. Barry Noon, USFS; Matthew Kirchhoff, ADFG; John Lindell, USFWS

Funding Source: U.S. Fish and Wildlife Service

The Alexander Archipelago wolf (*Canis lupus ligoni*) inhabits the southeastern panhandle of Alaska from Yakutat Bay to Dixon Entrance. Wolves occur on all of the islands south of Frederick Sound and along the mainland. Approximately 85% of the range of Archipelago wolves is encompassed by the Tongass National Forest, which is being extensively logged (USFS 1991). The most productive and accessible forest stands are also the most valuable as wintering habitat for Sitka black-tailed deer (*Odocoileus hemionus sitkensis*), the principal prey of wolves. Under the current forest plan, >40% of this critical habitat will be clearcut, resulting in declines in deer carrying capacity. Consequently, wolf numbers are expected to decline particularly on some of the southern islands, such as Prince of Wales Island, where deer populations will be reduced by >60%.

Objectives

We will conduct a preliminary population viability analysis for the Alexander Archipelago wolf. We will focus on wolves inhabiting Prince of Wales Island (POWI) because we have adequate data on this population, they represent >30% of the total wolf population in southeastern Alaska, and POWI has been extensively logged. Our objectives will be to construct a series of models that mimic the population dynamics of wolves and deer, and then subject the models to scenarios incorporating different levels of future timber harvesting and human development. Predictions of wolf population persistence and extinction probabilities will be made. This analysis will be strictly preliminary and in our view the models produced will be most valuable as research tools that will help guide future field work.

Methods

We will develop two different series of models. The first will consist of differential equations based on the theta-logistic model of population growth

(Gilpin and Ayala 1973) modified to model the population dynamics of deer and wolves (Person 1993). These models will be stochastic and incorporate estimates of reproduction, mortality, dispersal, and habitat availability and use from the following data sources: (1) wolf data from ecological study on POWI 1992-1995, ADFG harvest statistics, review of the literature; (2) deer data from ADFG and USFS research and monitoring efforts; and (3) habitat, topography, deer habitat capability, and timber harvest data from USFS GIS database. The models will predict trajectories for island-wide wolf and deer populations and will not be spatially explicit.

The second set of models will be stochastic, rule-based and spatially explicit (Dunning et al. 1995). They will model wolf and deer population dynamics at a much smaller scale than the first suite of models and will be used to evaluate the effects of local disturbances. The kernel for the models will be based on wolf-deer equilibrium ratios (Keith 1983) and model inputs will come from the same data sources described previously. The proposed kernel makes biological sense because a substantial body of evidence suggests that the ungulate biomass available to wolves is the most important factor influencing reproduction (Keith 1983, Fuller 1989), mortality (Fuller 1989), and dispersal (Ballard et al. 1987, Peterson and Page 1988).

Results to Date

The project is in the early stages of model development. The differential equations for the first set of models have been developed (Person 1993); however, the dispersal function still needs to be refined by incorporating the most recent data from the field work on Prince of Wales Island. Once updated, simulations will begin to tune the model against historical data from POWI and the adjacent islands concerning the permanence of wolf populations on islands of various sizes and isolation. We will shortly be preparing a manuscript for publication describing the behavior of this suite of models.

The spatially explicit model is also under development. We explored the behavior of the equilibrium function (Keith 1983) that we propose as the kernel and have completed a thorough mathematical and simulation analysis of the properties of this function (Person et al., in prep.). We concluded that it will serve as the basic "rule" dominating the behavior of the complete model.

- Ballard, W. B., J. S. Whitman, and C. L. Gardner. 1987. Ecology of an exploited wolf population in south-central Alaska. *Wildl. Monogr.* 98. 54 pp.
- Dunning, J. B., D. J. Stewart, B. J. Danielson, B. R. Noon, T. L. Root, R. H. Lamberson, and E. E. Stevens. 1995. Spatially explicit population models: current forms and future uses. *Ecol. Appl.* 5:3-11.
- Fuller, T. K. 1989. Population dynamics of wolves in north-central Minnesota. *Wildl. Monogr.* 105. 41 pp.
- Gilpin, M. E. and F. J. Ayala. 1973. Global models of growth and competition. *Proc. Nat. Acad. Sci.* 70:3590-3593.
- Keith, L. B. 1983. Population dynamics of wolves. Pages 66-77 in L. N. Carbyn, ed. *Wolves in Canada and Alaska*. Can. Wildl. Serv. Rep. Ser. 45. 135pp.
- Person, D. K. 1993. Ecology of the Alexander Archipelago wolf and responses to habitat change. *Prog. Rep. No. 1*. Alaska Dept. Fish and Game.
- Peterson, R. O. and R. E. Page. 1988. The rise and fall of the Isle Royale wolves, 1975-1986. *J. Mammal.* 69:89-99.
- U.S. Forest Service. 1991. Tongass land management plan revision supplement to the draft environmental impact statement. USDA Forest Service Manage. Bull. R10-MB-99.

The Effects of Weather on Caribou Forage Productivity and Nutrition within the Range of the Chisana Herd

Student Investigator: Elizabeth A. Lenart (M.S.)

Cooperators: Jay Ver Hoef and Craig Gardner, Division of Wildlife Conservation, ADFG

Funding Source: Alaska Department of Fish and Game

Objective

Our objective is to investigate the effects of summer temperature, precipitation, and variable sunlight on forage production within the summer range of the Chisana caribou (*Rangifer tarandus*) herd. In addition, we will examine relationships between historical weather patterns and parameters of the caribou population.

Hypotheses

To determine the effects of simulated variation in sunlight intensity, precipitation, temperature on nutrient quality, biomass, and digestibility of forages within the summer range of the Chisana caribou, we will test the following null hypotheses that changes in (1) available sunlight do not affect forage nutrient quality, biomass, and digestibility; (2) amount of precipitation do not affect forage nutrient quality, biomass, and digestibility; (3) temperature do not affect forage nutrient quality, biomass, and digestibility; (4) temperature and precipitation combined do not affect forage nutrient quality, biomass, and digestibility; and (5) sunlight availability and precipitation combined do not affect nutrient quality, biomass, and digestibility.

To determine relationships between calf production and survival and weather patterns in the Chisana caribou range, we will test the following null hypotheses: (1) during the period of caribou decline (1989–1993), patterns of summer rainfall, summer temperature, and winter snowfall were not different from previous years when the herd appeared stable or increasing; and (2) there is no significant relationship between climatic variables and rate of population decline.

Study Design

A 48-m by 60-m grid consisting of 30 treatment plots was established in a traditional post-calving area of the Chisana herd. Each plot contained eight subplots, making a total of 240 vegetation subplots, each 0.25 m². Five replicates of six treatments (including controls) were applied to plots in a low tundra-mat community consisting of small deciduous shrubs, forbs, graminoids, and lichen. The treatments included (1) unaltered control; (2) control with supplemental watering; (3) clear plastic tarp; (4) clear plastic tarp with supplemental watering; (5) 50% shade tarp; and (6) 50% shade tarp with supplemental watering. The clear tarps and shade tarps were 1.8 m by 3.6 m. One 0.25-m² subplot was clipped during the four time periods (June 9, June 26, July 18, August 9) in 1994 and 1995. Thus, we will be able to examine plant response to two seasons of treatment. Thirty liters of water was added to those treatments requiring water once a week beginning June 22, 1994–August 6, 1994 and June 27, 1995–August 1, 1995. A hobo temp recording temperature every 1.6 hr and a rain gauge were placed at one of the five replicates for each of the six treatments. On July 16,

1994 and July 14, 1995, soil core samples were collected from each plot. Five replicates of 3 treatments (including controls) were applied to plots in a community consisting mainly of *Salix pulchra*. These plots were not treated until July 10, 1994 due to weather and time. The treatments included (1) unaltered control, (2) clear plastic tarp, and (3) 50% shade tarp. Treatments were not applied until July 20 due to weather. Approximately 25 annual shoots were clipped from each plot on August 1, 1994 and July 10 and August 5, 1995. A hobo temp and rain gauge were placed at one of the 5 replicates for each of the 3 treatments.

Biomass will be determined for vegetation collected from the tundra plots. Forage vegetation samples will be analyzed for nitrogen and in-vitro dry matter digestibility for all vegetation clipped.

Caribou fecal pellets were collected throughout summer 1994 and 1995 and have been sent to Washington State University to determine diet composition by identifying forage fragments from microhistological characteristics and to examine fecal nitrogen as an index to diet quality.

Historical weather data (e.g., annual averages for summer temperature, summer precipitation, snow depth, and snow-free days) will be collected from Nabesna weather stations to assess the influence of weather patterns on the Chisana caribou population (e.g., calf:cow ratios, population abundance). This weather data will be compared to a local weather station that was set up in camp.

Project Status

All clipped vegetation from the tundra community habitat has been sorted into dead matter, live forbs, live deciduous shrubs, live sedges and grasses, and lichen. They were oven dried at 54°C and biomass was determined. One-half of the samples collected in 1994 have been analyzed for nitrogen and in-vitro dry matter digestibility. The remaining tundra vegetation is currently being analyzed for nitrogen and in-vitro dry matter digestibility.

Biomass and percent cover (estimated during clipping) is currently being statistically analyzed. All shoots that were clipped from the *Salix pulchra* plots have been air dried and will be ground and analyzed for nitrogen, in-vitro digestibility, and tannin content.

Michael A. Castellini and Brendan Kelly

Methodological Development and a Reanalysis of Pacific Walrus Feeding Data

Student Investigator: Gay G. Sheffield (M.S.)

Cooperators: Gerald Garner, Alaska Science Center, NBS; Dana Seagars, Marine Mammals Management, USFWS

Funding Source: National Biological Service

Walrus eat a wide variety of benthic invertebrates. Most information regarding feeding by walrus has been derived from stomach contents (Fay 1982). Previous analyses of Pacific walrus (*Odobenus rosmarus divergens*) stomachs assumed that all prey taxa digested at the same rate. If that assumption is incorrect, the interpretation of walrus prey selection may have been biased by the effects of digestion .

The objectives of this project are to (1) determine the relative rates of digestion of common walrus prey items; (2) determine possible digestive biases (3) compile and reanalyze existing Pacific walrus stomach content data, making estimations of diet based on location, age class, and sex of walrus; and (4) test for geographical and temporal changes in walrus diets.

Methods

Ninety-eight prey items (11 genera) were individually digested in the laboratory. Prey were introduced whole, with the exception of the molluscs (shells removed), to a mixture of 70% physiological saline, 20% pepsin, and 10% HCl at 37°C. Items were constantly agitated with a magnetic stirbar (40 rpm). Prey items were weighed and the presence or absence of tissues that allowed identification of taxa was recorded for 6 hours.

A Monte Carlo randomization test was used to test the null hypothesis that distribution of failures (hour when identification was no longer possible) is equal for all prey taxa. Spearman rank association tests determined if there was an association between taxa weights and the hour of failure (time when taxa was no longer identifiable). Kaplan-Meier survival estimates (Pollock 1989) with binomial confidence limits were calculated based on the hour of failure for each taxa tested.

Sixty-seven stomachs collected in the northeast Chukchi Sea were selected, in a preliminary analysis, from the entire database and reanalyzed based on the results of the digestion trials. The contents of stomachs which contained the presence of a rapidly digesting taxon, were compared to the contents of stomachs in which rapidly digesting taxa were absent. Contingency table analyses were conducted using Fisher's exact test with an experiment wise error rate of <0.05 (Bonferroni's procedure).

Results

Digestion was significantly different between walrus prey taxa tested ($p=.0001$). A positive correlation between Bivalvia, Polychaeta, and Echiura prey weights and the rate at which they become unidentifiable was determined. No correlation between Sipuncula, Malacostraca prey weights and the rate with which they become unidentifiable was determined. Molluscs, crustaceans, and echiurid worms possess diagnostic tissues that resisted digestion for 5 hr or more. Sipunculid and polychaete worms were digested rapidly and could not be identified beyond 2 to 3 hr. Twenty-one stomachs from the northeast Chukchi that contained polychaetes showed a significantly higher occurrence of bivalves, priapulid worms, and crustaceans ($p<0.05$) than did 46 stomachs without polychaetes.

Discussion

The contents of walrus stomachs, sampled without regard to the stage of digestion, overrepresent prey possessing diagnostic tissues resistant to digestion. Bivalve, echiura, and polychaete taxa present in the stomach will be biased toward the heavier (larger) individuals as they are able to resist the effects of digestion more than lighter (smaller) individuals of the same taxa. Polychaetes in walrus stomachs are good indicators of recent feeding, because they are ubiquitous in the benthos (Fay et al 1977; Feder and Naidu 1991), and they are digested quickly beyond recognition.

We are selecting stomachs containing polychaetes from a data base of 759 stomachs to re-analyze the diet of the Pacific walrus and to test for geographical and temporal changes in several locations.

- Fay, F. H. 1982. The biology and ecology of the Pacific walrus, *Odobenus rosmarus divergens* Illiger. U.S. Dept. of the Interior, Fish and Wildlife Service, North American Fauna No. 74. 279 pp.
- Fay, F. H., H. M. Feder, and S. W. Stoker. 1977. An estimate of the impact of the Pacific walrus population on its food resources in the Bering Sea. PB-273-505, National Tech. Info. Service. 38 pp.
- Feder, H. M., A. S. Naidu, J. M. Hameedi, S. C. Jewett, and W. R. Johnson. 1991. The Chukchi Sea continental shelf: Benthos-environmental interactions. Inst. Marine Science Report 92-1. 250 pp.
- Pollock, K. H., S. R. Winterstein, C. M. Bunck, and P. D. Curtis. 1989. Survival analysis in telemetry studies: the staggered entry design. J. Wildl. Manage. 53(1): 7-15

Joseph A. Cook

Phylogeographic Variation and the Island Syndrome in Holarctic Tundra Voles (*Microtus oeconomus*)

Student Investigator: Ellen Weintraub Lance (M.S.)

Cooperators: Chugach and Tongass National Forests; Steve Ranney, Fishing and Flying, Cordova-Yakutat; Alaska Department of Fish and Game; Prince William Sound Aquaculture Corporation; and Prince William Sound Science Center

Funding Sources: Chugach National Forest and U.S. Fish and Wildlife Service

Editor's Note: Ellen Lance defended her thesis November 10, 1995, and graduated from the University of Alaska Fairbanks in December 1995. The thesis abstract follows.

Abstract—Phylogeographic patterns of genetic and morphologic variation were explored among six subspecies of the Holarctic tundra vole (*Microtus oeconomus*), but focused on those populations occurring in southcoastal Alaska. Allozyme electrophoresis and karyotyping revealed that, although levels of intraspecific variation were low compared to other species of *Microtus*, allozymic divergence was concordant with regional glacial history. Tundra voles from interior Alaska became established prior to the last glacial retreat. However, populations from southcoastal Alaska were founded more recently. Tundra voles from Montague Island, an endemic subspecies, exhibited features of the island syndrome (i.e., gigantism, older age structure). Factors potentially responsible for insular gigantism were assessed. The findings of this study fail to support the hypothesis that the island syndrome is a direct result of interspecific competition. Other density-dependent factors, such as predation, may be responsible for body size and demographic changes in these insular rodents.

Erich H. Follmann

Home Range, Habitat Selection, and Movements of Lynx (*Lynx canadensis*) in Eastern Interior Alaska

Student Investigator: Craig J. Perham (M.S.)

Cooperators: Terry Doyle, Tetlin National Wildlife Refuge, USFWS; Dr. Kurt Jenkins, Wrangell-St. Elias National Park and Preserve, NBS

Funding Sources: U.S. Fish and Wildlife Service; National Park Service; and Alaska Department of Fish and Game

Editor's Note: Craig Perham defended his thesis June 2, 1995, and graduated from the University of Alaska Fairbanks in December 1995. The thesis abstract follows.

Abstract—Lynx home ranges, habitat selection, and daily track deposition rates were determined in interior Alaska. Male home ranges averaged 167 km² in 1991-92 and 127 km² in 1992-93, but varied (14-270 km²); females averaged 33 km² in 1991-92 and 48 km² in 1992-93. Nomadic lynx displayed erratic movements and large ranges, whereas others dispersed from the study area. Lynx with small home ranges may use snowshoe hare refugia whereas other lynx may range over expanded areas to acquire food. Lynx preferred broadleaf and mixed forests and avoid dwarf shrub/tundra. Lynx used a 1959 burn more than expected; more recent burns (<11 years) were used less than expected. Track deposition was significantly related to snowfall, temperature and barometric pressure change ($P < 0.001$); the overall model, however, explained only 16% of the variation in deposition ($R^2 = 0.162$). Temperature was most related to track deposition; as temperature increased, track deposition became more variable.

Anthony J. Gharrett

Genetic Variation of Wild Alaskan Steelhead Trout

Student Investigator: Cheryl L. Seifert (M.S.)

Faculty Supervisor: Dr. Anthony J. Gharrett

Cooperators: Steve Elliott and J. Douglas Jones, Division of Sport Fisheries, ADFG

Funding Source: Alaska Department of Fish and Game

The primary objective of this thesis project is to estimate the genetic divergence among populations of wild Alaskan steelhead trout. Also, this research examines the placement of Alaskan stocks into the coastwide picture of steelhead stocks. The goal of this effort is develop tools to identify and separate steelhead stocks. This study examines steelhead from Karta River and Eagle Creek on Prince of Wales Island, Karluk River on Kodiak Island, Situk River in Yakutat, and Sitkoh Creek on Chichagof Island.

Samples of heart, liver, eye, and muscle were used for protein electrophoresis, which was completed in August 1994. A total of 38 enzymes were stained for each sample. A total of 19 enzymes (50%) showed variation; the rest were invariant. Data analysis has shown that heterogeneity exists among Alaskan collections of steelhead trout. Initial tests showed heterogeneity between rainbow and steelhead trout within a particular collection. To clarify

this variation, further analysis was conducted that compared different ages within drainages for rainbow and steelhead trout. Test results showed that there was no heterogeneity for rainbow trout within a drainage, but there was some year-to-year heterogeneity among steelhead trout. When combined, analytical tests showed no significant differences between rainbow and steelhead of a particular age, revealing no evidence that rainbow and steelhead trout are different within drainages. Based on these results, each drainage represents a single population of steelhead trout. Several enzymes were found to be variant in only some of the populations tested and could be used as markers for stock separation. Analysis is continuing on the electrophoretic data to determine the placement of Alaskan steelhead trout among those reported coastwide.

Intestinal samples were analyzed in December 1994 for parasite content. Results showed that Alaskan steelhead trout have relatively few parasites when compared with steelhead from British Columbia and the Pacific Northwest. Based upon the absence of parasite markers in Alaskan stocks, steelhead trout of unknown origin could be identified as Alaskan only by missing parasites rather than by those present. A test of prevalence will be conducted on these data to determine the significance of these results.

Blood samples were collected and are currently being used for mitochondrial DNA (mtDNA) analysis using polymerase chain reaction. Isolation of mtDNA from the blood samples is ongoing. Several regions of the mtDNA will be amplified and cut with 10 different enzymes to detect variation.

David R. Klein

Seasonal Changes in Diets of Mink (*Mustela vison*) and Marten (*Martes americana*) in Southeast Alaska

Student Investigator: Merav Ben-David (Ph.D.)

Cooperators: Thomas A. Hanley, Pacific Northwest Station, USFS; Rodney Flynn, Division of Wildlife Conservation, ADFG

Funding Source: U.S. Forest Service

Seasonal changes in food availability and feeding habits of mink and marten on Chichagof Island, Southeast Alaska, were studied using the analysis of natural abundance of stable isotopes. Dependence of the two species on marine-derived nutrients, carried to the terrestrial system via the upstream migration of spawning Pacific salmon (*Oncorhynchus* spp.), was compared. Twenty-four mink and 75 marten were live-trapped repeatedly in early summer (prior to salmon runs), early fall (post salmon runs), late winter, and in spring (during the breeding season). A blood sample was obtained from each individual. In addition, 25 mink carcasses and 167 marten carcasses were obtained from trappers during late autumn 1991–94. Concurrently, prey availability was monitored, and tissues from prey items were collected. Stable isotope abundance in prey tissues and blood samples was compared, showing that riverine mink depend on salmon carcasses, roe and fry, with little seasonal or individual variation, whereas coastal mink rely on intertidal organisms in spring and summer but shift to feed on salmon carcasses when these become available in autumn. In addition, analysis of blood progesterone revealed that female mink in the study area appear to shift their timing of reproduction so their lactation coincides with the availability of salmon carcasses. Marten, on the other hand, show individual variation in their food choice, with some individuals feeding exclusively on

terrestrial organisms, while others include salmon carcasses in their diets. Incorporation of salmon in the diet depended largely on the availability of small rodents and the position of the animal home range on the landscape. The results suggest that although salmon carcasses are not a preferred food item for marten, they act as a suitable alternative to maintain body condition and allow successful reproduction even in years when preferred food is not readily available.

Summer Habitat Relationships and Foraging Ecology of the Delta Bison Herd

Student Investigator: Maria Berger (M.S.)

Cooperators: Stephen DuBois, Division of Wildlife Conservation, ADFG; Ken Spiers, U.S. Army Department of Natural Resources

Funding Source: Alaska Department of Fish and Game

Editor's Note: Maria Berger defended her thesis December 1, 1995, and graduated from the University of Alaska Fairbanks in May 1996. The thesis abstract follows.

Abstract—Investigations of habitat use, diet composition and diet selection of introduced plains bison (*Bison bison bison*) in interior Alaska in summer were conducted during 1989 through 1991. Bison used early- and mid-successional plant communities on the floodplain of the Delta River and wetlands above the floodplain. Grasses predominated in summer diets of bison, but substantial amounts of willow (*Salix*) were included. Other shrubs were used much less than available, as were sedges. The role of sedges in bison diets may be changing as bison increasingly have exploited sedge-dominated wetland habitats. Experimental studies of the effects of bison grazing on forage productivity, forage quality and plant species composition were conducted in the mid-successional graminoid meadow, the traditional summer range of Delta bison. Bison grazing had no effect on productivity but did increase nitrogen concentration of graminoids. Changes in plant species composition occurred in response to protection from grazing for 9 years.

Interactions between Muskoxen and Reindeer on the Seward Peninsula

Student Investigator: Claudia Ihl (M.S.)

Cooperators: Richard Harris, NPS; John Coady, ADFG; Randi Jandt, BLM; Herbie Karmun, Reindeer Herder, Deering; Rose Fosdick, Reindeer Herders Association, Nome

Funding Sources: Alaska Science Center, National Biological Service; Division of Cooperative Research, National Biological Service; National Park Service

Background

Reindeer were established on the Seward Peninsula about 100 years ago to provide a stable food supply for native peoples. Since then, reindeer husbandry has become a significant part of native culture on the Seward Peninsula. Today, there are about 25,000 reindeer distributed among 15 herds on the Seward Peninsula. Since muskoxen were introduced in 1971 and 1980, their numbers have been increasing steadily to over 1,000 animals, raising concerns among local reindeer herders about possible competition for forage or potentially detrimental behavioral interactions between the two species. Our study will

examine habitat and forage use patterns of muskoxen and reindeer on the Seward Peninsula, the degree of possible disease and parasite transfer between them and their behavioral interactions.

Objectives and Methods

Objective 1: Determine degree of overlap in winter range use and spatial distribution of muskoxen and reindeer in the study area.

Muskoxen and reindeer will be radiocollared in January and March 1996. Existing data on seasonal locations of muskoxen and reindeer, data from observations in the field and existing data on major habitat types and weather patterns will be combined to provide a large-scale assessment of muskox and reindeer habitat and range use patterns and how they relate to major range characteristics

Objective 2: Determine patterns of winter forage use and factors influencing choice of feeding sites for both species.

Late-winter feeding sites and adjacent areas will be accessed in March and April and characterized according to snow depth and hardness, plant composition of feeding craters, above-snow vegetation and general site characteristics such as slope and exposure. Fecal samples from both species will be collected and analyzed for plant species composition in the diet. Feeding sites will be relocated in summer to accurately record habitat type and plant composition.

Objective 3: Determine comparative levels of parasites and incidence of brucellosis that may be present in both species.

Blood samples will be taken when the animals are radiocollared and analyzed for brucellosis. Fecal samples from both species will be analyzed for egg density of several parasite groups.

Objective 4: Record and assess the nature of behavioral interactions observed between muskoxen and reindeer.

Since the primary focus of this research lies on the first two objectives, behavioral interactions will be recorded when they are incidental with other research activities. Data recorded will include the recent history of both groups at the observation site, age and sex classes of the reacting animals, the nature of initial reactions and whether initial reactions were followed by approach or retreat.

Field work is scheduled to begin in March 1996. The study area is the reindeer range of herder Herbie Karmun near Deering, northeastern Seward Peninsula. During a preliminary field season in 1995, the suitability of the Karmun range as a study area was confirmed, the cooperation of the people of Deering was confirmed, several major wintering sites for muskoxen and reindeer were identified and a site for a field base camp was selected.

Editor's Note: The project is jointly funded by the Alaska Science Center, National Biological Service (NBS); the Division of Cooperative Research, NBS; and the National Park Service through an interagency agreement to fund university research on NPS lands in Alaska.

The Role of Weather and Parasitic Insects in the Summer Ecology of the Delta Caribou Herd

Student Investigator: Frank M. Mörschel (M.S.)

Cooperator: Patrick Valkenburg, Division of Wildlife Conservation, ADFG

Funding Source: Alaska Department of Fish and Game

Introduction, objectives and procedures were described in the 1993 annual report.

Progress to Date

During summer 1995, I conducted my second field season. Caribou were followed by foot. A helicopter and fixed-wing aircraft from the Alaska Department of Fish and Game were available for tracking caribou movements and providing logistic support. Caribou behavior, weather data and insect abundance data were collected from June until caribou dispersal in August, when observation was no longer possible.

A total of 198 caribou were observed during this field season for a total of 138 hours using focal observational techniques. Additionally, 569 group scans were recorded.

Data Analysis

Each focal observation was fitted into one of 6 categorized times of day (2:00-5:59, 6:00-9:59, 10:00-13:59, 14:00-17:59, 18:00-21:59 and 22:00-1:59 hours). If one observation overlapped one of these timeblocks, the shorter part was excluded from analysis. For each of these observations, the number of activity changes per observation time was calculated. Weather parameters (temperature, wind speed, cloud cover, humidity, and combinations of these) were summarized as weighted averages into one value per observation. The same was done for mosquito abundance index, oestrid fly presence, group size, group density, habitat, movement rate, altitude, distance to snow, size of nearest snowpatch, aspect, slope and exposure. Daytime category (see above) and season (pre-mosquito, mosquito or mixed [mosq.+oestrid flies] season) were also noted.

These data were analyzed for correlation with the Spearman's rank correlation test. Differences between means of activity changes (a log (y+1) transfer was used to normalize data) for the above-noted independent variables were tested with a Kruskal-Wallis-Test and Analysis of Variance-approach. If test results differed for these tests, both results were reported.

Additionally, analysis of proportion of time spent in various behaviors (standing, lying, feeding, walking, running, trotting), as well as scan samples, is under way.

Preliminary Results (1995 data only)

According to the Spearman's Rank Test, the log-transfer of activity changes/min. is positively correlated with season, temperature, mosquito harassment index and oestrid presence. The log-transfer of activity changes/min. is negatively correlated with cloud cover. The mosquito harassment index is positively correlated with season and temperature and negatively with windspeed. Oestrid fly abundance is positively correlated with season and temperature.

Discussion (1995 data only)

Mosquitoes were first noticed on June 11, 1995. They remained present until the end of my field season (August 1). In general, mosquito abundance (measured

according to harassment level experienced by observer) was never very high during summer. In 29% of the observations in the mosquito and mixed season, no harassment was experienced. In 67% of the observations there was light harassment and in 4% moderate harassment. Severe harassment was never experienced. Mosquito abundance did not differ for different times of the day. However, this might be partly due to very low sample sizes between 2200 and 0559 hours. Mosquitoes became active above 7°C and did not show any positive relationship with temperature above that threshold. Mosquito abundance decreased with increasing windspeed. They were not active above windspeeds of 6 m/sec. Mosquito abundance did not show any relationship with cloud cover or humidity.

Oestrid flies were first seen on June 21, 1995 and remained present until the end of my field season. Since I was not able to measure abundance of oestrid flies, only presence/absence was determined according to caribou behavior. In 30% of the observations in the mixed season (oestrid fly and mosquito season), oestrid flies were present. Oestrids became active above 9°C. Their presence seemed to be positively correlated with temperature. Oestrid fly presence was not influenced by windspeed, as long it did not exceed 5 m/sec. Above that threshold windspeed, oestrids were never present. Cloud cover and humidity had no apparent influence on oestrid presence.

The number of activity changes per minute of caribou was not influenced by time of day. Again, this could be due to low sample sizes between 2200 and 0559 hours. There is a significant increase in activity changes between seasons (Kruskal-Wallis test: $p=0.000$)(Fig. 1). This is due to the presence of parasitic insects. Even though mosquito abundance was considered relatively low, they had a significant impact on caribou behavior, causing a major increase in activity changes per minute. The presence of oestrid flies increased the activity changes/minute again, but to a lesser extent than mosquito presence did. The relative impact of these two types of parasitic insects can also be seen in Figure 2. Here mosquitoes alone have a more severe impact on activity changes /minute of caribou than oestrid flies alone. However, this might be due to differences in abundance of these insects. Since I have no measurement of abundance for oestrid flies, their impact could have been underestimated. The sample size for only oestrid flies is also very small.

The number of activity changes per minute increases with increasing temperature. This is probably due to the increase in mosquito and oestrid abundance with temperature. There seems to be no clear relationship between activity changes/min. and cloud cover or humidity.

Comparative Foraging Ecology and Social Dynamics of Caribou (*Rangifer tarandus*)

Student Investigator: Eric S. Post (Ph.D.)

Cooperators: Christian Dau, Izembek National Wildlife Refuge, USFWS; Tom McCarthy, Division of Wildlife Conservation, ADFG

Funding Sources: U.S. Fish and Wildlife Service; Alaska Department of Fish and Game; and University of Alaska

Editor's Note: Eric Post defended his thesis September 28, 1995, and graduated from the University of Alaska Fairbanks in December 1995. The thesis abstract follows.

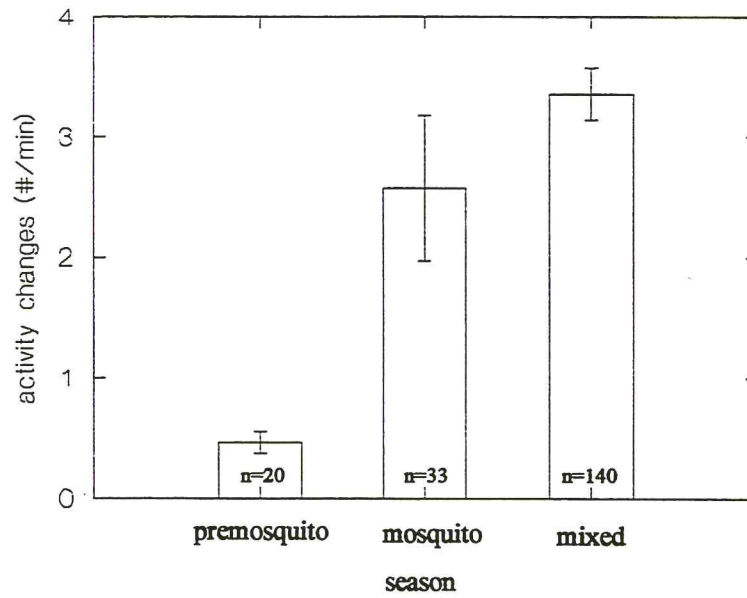


Figure 1: Average activity changes of caribou per minute for 3 seasons

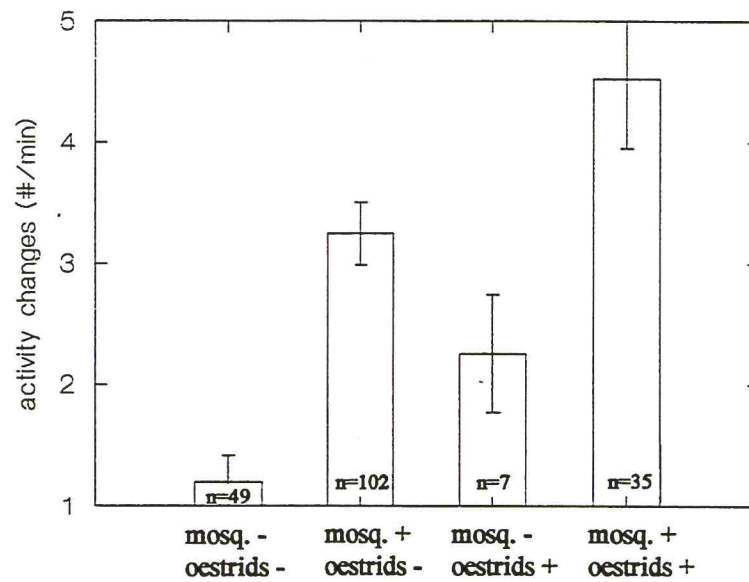


Figure 2: Average activity changes of caribou per minute for absence (-) and presence (+) of parasitic insects.

Abstract—The Southern Alaska Peninsula Caribou (*Rangifer tarandus*) Herd (SAPCH) and its two sub-groups were the focus of a study addressing the hypotheses: (1) food limitation during winter caused a decline in the herd; and (2) higher calf productivity within the Caribou River group than within the Black Hill group was related to greater forage availability on the seasonal ranges of the Caribou River group. Intense, systematic range and calving surveys in 1991 and 1992 supported the hypothesis of food limitation during winter, and indicated that greater calf production in the Caribou River group was related to earlier commencement of the season of plant growth and greater forage availability on the summer range of that group, coupled with earlier parturition among females of the Caribou River herd.

In a comparative study involving the two SAPCH groups and the West Greenland Caribou Herd, daily variation in sizes of foraging groups, densities of caribou within feeding sites, distances between individuals within feeding sites, distances moved by foraging groups, and frequency of group movement was modeled using the following ecological parameters: predation risk, insect harassment (by mosquitoes), range patchiness, feeding-site patchiness, feeding-site area, and range-wide density of caribou. Models revealed that intraseasonal social dynamics of foraging caribou were governed in most instances by patterns of forage availability and distribution across landscapes and within feeding sites, in some instances by insect harassment and social pressures, but in no instance by levels of predation risk inherent to the ranges on which they foraged.

In a study of the interrelationships between characteristics of graminoids and intensity of grazing by caribou, vegetation on each of the Black Hill and Caribou River ranges was sampled and tested for responses to clipping. Biomass density (g/m^3) of forage, shoot density ($\#/\text{m}^2$), and nutrient and mineral densities (g/m^3) and concentrations ($\text{g}/100 \text{ g tissue}$) correlated positively with use of sites by caribou. Productivity and responses to clipping were independent of previous use, but consistent within ranges. These results indicate that caribou are sensitive to local variation in forage quantity and quality, and preferentially use sites with higher returns of nutrients and minerals.

Seasonal Habitat Relationships of Adult Female Deer on Kodiak Island, Alaska

Student Investigator: Jeffrey S. Selinger (M.S.)

Cooperators: Denny Zwiefelhofer and Vic Barnes, Kodiak National Wildlife Refuge, USFWS; Roger Smith, Division of Wildlife Conservation, ADFG

Funding Source: U.S. Fish and Wildlife Service

Editor's Note: Jeff Selinger defended his thesis May 8, 1995, and graduated from the University of Alaska Fairbanks in December 1995. The thesis abstract follows.

Abstract—Movements of adult female deer (*Odocoileus hemionus sitkensis*) were monitored using radio-collars ($n=21$) in a region lacking old-growth conifer forest on Kodiak Island, Alaska, from 17 July 1990 to 8 July 1991. Mean distance between seasonal ranges for 7 deer that migrated from the study area during winter was 22 km ($SD=10.2 \text{ km}$), whereas $\leq 5 \text{ km}$ separated seasonal ranges of 14 deer that remained in the study area throughout the year. Mean movement date to winter range was 30 October ($SD=38 \text{ days}$), and to summer range, 29 May ($SD=18 \text{ days}$). Overall habitat use differed significantly ($P \leq 0.001$) between seasons. Habitats used more than available ($P \leq 0.01$) were tall shrub closed in

summer and tall shrub open in winter. Using the 95% adaptive kernel method (Worton 1989), mean summer home range (454 ha, $n=11$, range 134–819 ha, $SD=227$ ha) was larger ($P<0.001$) than the mean winter home range (107 ha, $n=9$, range 67–217 ha, $SD=56$ ha).

Jacqueline D. LaPerriere

Water Quality Inventory and Monitoring—Gates of the Arctic National Park and Preserve

Cooperators: Ross Kavanagh, Gary Vequist, Patty Rost, and Nancy Deschu, NPS; Dr. John R. Jones, University of Missouri

Funding Source: National Park Service

The final synoptic survey of lakes of Gates of the Arctic National Park and Preserve was conducted in early July 1995. Previous surveys were done in 1992 and 1993. Lakes sampled all three years are Chandler, Kipmik, Matcharak, Takahula, and Walker. Lakes sampled twice include Agiak, Amiolyak, Itkillik, Narvak, Nutuvukti, and Summit. Lakes sampled once include Pingo, Minakakosa, Selby, and in 1995, Kurupa and Tulalik.

Kurupa and Summit lakes were quite turbid this past summer, most probably due to recent snowmelt. Prior to this trip we classified these lakes as clear. Now we realize that those with extensive bare rock slopes near the water's edge are turbid immediately after snowmelt. We had seen local turbidity near an inlet to Summit Lake in mid-July 1993, during a thunderstorm that initiated a landslide.

The lakes on the north side of the Brooks Range have not been observed stratified and probably circulate often during coastal and mountain storms. Lakes on the south side of the Brooks Range develop summer stratification with quite warm surface waters. We were able to swim in Selby Lake in early July 1993, when the air temperature was above 90°F for three days. On July 21, 1993, when we sampled Selby Lake for the synoptic survey, the surface water was at 21.5°C.

The set of underwater thermographs at Takahula Lake, which was to record temperatures at selected depths to the bottom of the lake from September 1994 to summer 1995, was unsuccessful. It washed to shore during September 1994 when the line apparently broke away from the anchor. Therefore, we still do not know whether the cold temperatures at depth ($<4^{\circ}\text{C}$ from 30 m to the lake bottom) recorded each of the three summer are caused by an incomplete spring overturn or some other factor.

Nutrient stimulation bioassays of phytoplankton were conducted at Agiak, Chandler, Kipmik, and Matcharak lakes. Chandler was phosphorus limited, and the other three were nitrogen limited.

Nitrogen limitation is a common characteristics of terrestrial tundra vegetation and may be similarly common to tundra lakes. Chandler Lake, which is a calcium-sulfate lake, may favor domination of the phytoplankton by blue-green bacteria, which can tolerate the low availability of carbon dioxide. Because these plankters can also fix atmospheric nitrogen, phosphorus is left as the limiting nutrient.

Water Quality and Inventory—Katmai National Park and Preserve

Cooperators: Gary Vequist, Ross Kavanagh, and Rick Potts, NPS; Dr. John R. Jones, University of Missouri

Funding Source: National Park Service

This project is now completed. A shortened executive summary of the final report follows:

Lakes

The large lakes of Katmai National Park and Preserve do not thermally stratify in the ordinary summer; however, they might stratify in an unusual summer that had a long time period without storms. The recurrent mixing by winds associated with storms causes heat to be added deep into these lakes until they begin autumnal cooling. The large volume of heated water may help these lake ecosystems to be quite productive of juvenile sockeye salmon (*Oncorhynchus nerka*) found in most of them. These lakes are oligotrophic as regards nutrient concentrations and standing crop of planktonic algae, and have the orthograde dissolved oxygen profiles of typical oligotrophic lakes. These lakes are very clear (S.D. = 11 m; range 5.3–17 m), except for the Iliuk Arm of Naknek Lake, which receives volcanic materials from the Valley of Ten Thousand Smokes and rock flour from glacial melting.

Six of these lakes are of the ordinary calcium bicarbonate type, but Kukaklek Lake has about as much chloride as bicarbonate, Naknek Lake has about as much sulfate as bicarbonate, and Kulik Lake has approximately equal proportions of all three major anions. Battle Lake is a rare type of lake, a dilute calcium sulfate lake, wherein sulfate dominates the ions (~71%). All major ions except sulfate and chloride varied with altitude among these lakes.

Nitrogen limitation of the plankton algae was reconfirmed in Brooks Lake (a condition described about 30 years earlier by Charles Goldman during his dissertation research), and nutrient stimulation bioassays also found nitrogen limitation in Grosvenor and Kulik (and possible Nonvianuk, where the effect was not statistically significant) lakes. Nitrogen and phosphorus together were further stimulating to plankton algae in most of the lakes tested, but nitrogen was inhibiting in Kulik Lake alone and in combination with phosphorus. Therefore, management models of sockeye salmon in these lakes must not assume general nitrogen limitation.

Plankton algal chlorophyll *a* content, an indicator of biomass, varied directly among lakes with total phosphorus and with inverse Secchi depth (a measure of water clarity). Therefore, evaluation of eutrophication and management of these lakes can be conducted using known models of the influence of phosphorus (and nitrogen) on planktonic algae and thus on water clarity measured by Secchi transparency. Only Secchi transparency need be routinely monitored.

A direct relationship between standing crop of plankton algae (as chlorophyll *a*) and standing crop of zooplankton (as ash-free dry weight) was found among the Katmai lakes.

Streams

Streams were typically only sampled once during this study. The only repeat samples were taken yearly on inlets to Brooks Lake.

Most streams sampled in Katmai National Park and Preserve by this project were found to be very dilute. The Ukak and Savonoski Rivers, on the other hand,

had higher ion sums than the stream world average and also carried heavy sediment loads from glacial and volcanic deposit inputs. The most dilute streams were the inlets of Battle Lake, which were also very low in alkalinity.

The Ukak and Savonoski rivers had measurable concentrations of total recoverable copper and aluminum in concentrations that exceeded the criterion for the protection of aquatic life from chronic toxicity. Boron was high (0.17 mg/L) in the Ukak River, undoubtedly due to volcanic springs. Lithium, another volcanic indicator, was measurable in the Savonoski and Ukak rivers. Titanium, an indicator of igneous lithography, was highly elevated in these two streams and in American, Headwaters, and Margot creeks in the Naknek drainage.

One inlet to Kulik Lake was apparently the flow from a thermal spring. It was about 8–9°C warmer than the other inlets to that lake, and its conductivity was an order of magnitude higher. Its anions were dominated by sulfate. Strontium was apparently an order of magnitude higher there than in any other stream. Boron and lithium were not seen elevated in this sample; therefore, this spring is probably not volcanic.

Total phosphorus and total nitrogen, measured spectrophotometrically, were both elevated in 1991 in Headwaters and Up-a-Tree creeks, tributaries of Brooks Lake, during the historically high salmon run caused by a commercial fishers' strike in Bristol Bay. Those two streams were in all three years the highest and second highest of Brooks Lake inlets in total nitrogen and total phosphorus.

Sestonic chlorophyll-*a* (a measurement of detached and floating benthic algae) varied among Katmai streams with total phosphorus, as was found in clearwater, subarctic streams previously. A direct correlation with turbidity was also found, but this probably arises because in these clearwater streams sestonic algae may be the major source of turbidity (rather than inorganic sediments).

Influence of Temperature on Juvenile Sockeye Salmon Growth in Alaska Lakes

Student Investigator: Jim A. Edmundson

Cooperator: Alaska Department of Fish and Game

Since 1980, the Alaska Department of Fish and Game (ADFG) has been conducting limnological research on sockeye salmon nursery lakes throughout coastal regions of Alaska, from Ketchikan in the southeast panhandle to Cold Bay on the Alaska Peninsula. To date, limnological and fisheries information has been gathered from nearly 300 lakes statewide. The emphasis has been on factors limiting freshwater production and has focused on lake fertility (nutrients) and available forage (zooplankton). This in turn has led to the development of various lake carrying-capacity models for rearing sockeye juveniles (Koenings and Burkett 1987). Application of these models through nutrient additions and fish stocking techniques has been successful in increasing sockeye salmon production in numerous Alaska lakes (Kyle et al., in press). However, considerable variation exists in juvenile sockeye abundance, size, and age composition both within and among lakes that cannot be explained by recruitment (escapement or stocking) or lake fertility.

Physical characteristics of lakes such as light penetration and temperature have profound effects on aquatic productivity. Solar irradiance provides energy to lakes, but morphometry, climate, and the nature of the light-attenuating components within the water column determine the thermal structure (e.g.,

mixing depth) and heat content of lakes. Koenings and Edmundson (1991) showed that Alaska (sockeye) lakes exhibit considerable differences in light penetration because of varying amounts of algae (chlorophyll), organic stain (color), and glacial silt (turbidity). Since the depth of light penetration influences thermal structure and heat capacity, it is hypothesized that light condition influences temperature, which plays an important role in juvenile sockeye salmon growth patterns and production.

The purpose of this project is to determine if light and thermal regimes explain intra- and inter-lake variation in juvenile sockeye salmon growth patterns. Physical factors, especially temperature, may be important criteria in fishery management and enhancement programs. Data preparation is currently underway and an M.S. research proposal will be presented during the Alaska Cooperative Fish and Wildlife Research Unit Annual Meeting in March 1996.

Koenings, J. P. and R. D. Burkett. 1987. The production of sockeye (*Oncorhynchus nerka*) smolts relative to temperature regimes, euphotic volume, fry density, and forage base within Alaskan lakes. Pages 216-234 in H. D. Smith, L. Margolis, and C. C. Woods (eds.). Sockeye Salmon (*Oncorhynchus nerka*) Population Biology and Future Management. Can. Spec. Publ. Fish. Aquat. Sci. 96p.

Koenings, J. P. and J. A. Edmundson. 1991. Secchi disk and photometer estimates of light regimes in Alaska lakes: effects of yellow color and turbidity. *Limnol. Oceanogr.* 36:91-105.

Kyle, G. B., J. P. Koenings, and J. A. Edmundson. In press. An overview of Alaska lake-rearing salmon enhancement strategy: nutrient enrichment and juvenile stocking. In A. Milner and M. Oswood (eds.). *Freshwaters of Alaska*. Springer-Verlag.

Lakes Productivity Indices as Estimators of Carrying Capacity of Burbot and Northern Pike in Interior Alaska

Student Investigator: Thomas D. Simpson (M.S.)

Cooperators: Fred Andersen and Drs. David Bernard and Margaret Merritt, Division of Sport Fisheries, ADFG

Funding Source: Alaska Department of Fish and Game

Alaskan lakes are receiving more sport fishing pressure each year, necessitating increased regulatory management to prevent overfishing. Traditional methods of stock assessment for estimating carrying capacity, and subsequently sustained yield, are expensive and especially difficult in Alaska due to the large number of remote lakes and the extensive time series of abundance estimates required. An alternate approach is to estimate carrying capacity based on biotic and abiotic indices of lake productivity.

We selected two Alaskan sport fish species, burbot, *Lota lota*, and northern pike, *Esox lucius*, to test this approach because sufficient stock assessment data were available to estimate carrying capacities of lake populations. Morphometric and limnological data were collected from twelve lakes where carrying capacity has been estimated for burbot and from four lakes where estimates were available for northern pike. The lakes ranged in trophic status from oligotrophic to mesotrophic/eutrophic.

Of the variables measured, conductivity was most highly correlated with carrying capacity (kg ha^{-1}) of burbot. A simple regression model of conductivity accounted for nearly 94% of the variability in carrying capacity of burbot among

lakes ($p < 0.001$). Percent nearshore area (< 5 m depth) was the most important predictor variable in explaining the variance in carrying capacity ($\text{kg} \cdot \text{ha}^{-1}$) of northern pike among lakes ($r^2 = 0.87$; $p = 0.065$). Results suggest that empirical models based on limnological and morphometric characteristics of lakes could be used to predict the carrying capacity of burbot and northern pike in Alaska.

Influences of Hydrology and Water Quality of the Sloughs of the Tanana River on Arctic Grayling Habitat

Student Investigator: Klaus G. Wuttig (M.S.)

Cooperators: Douglas Fleming and Dr. Margaret Merritt, Division of Sport Fisheries, ADFG

Funding Source: Alaska Department of Fish and Game

The goal of this project is to study the possible cultural eutrophication of Badger Slough and its effects on Arctic grayling. Badger Slough has historically been a very productive and valuable spring fishery for Arctic grayling and is possibly very important in terms of recruitment to the Chena River. A comparative stream study will be conducted using Piledriver Slough and 23 Mile Slough. Badger Slough was blocked off in 1941 and is heavily developed. Piledriver Slough was blocked off in 1976, has experienced little development, and is representative of Badger Slough during the 1970s. Twenty-three Mile Slough is in the process of naturally being blocked, runs clear in spring and early fall, and representative of Badger Slough immediately after blockage. To assess the degree to which these sloughs have eutrophied, water quality and hydrological measurements are to be taken from spring 1996 to summer 1997. The data collected will be used to make inferences as to the impact eutrophication has on Arctic grayling.

Edward C. Murphy

The Abundance and Habitat of Red-Legged Kittiwakes on St. George Island, Alaska

Student Investigator: S. Dean Kildaw (Ph.D.)

Cooperator: John Mosesso, NBS

Funding Source: Species-at-Risk Initiative, National Biological Service

The red-legged kittiwake (*Rissa brevirostris*) is a small fish-eating gull that may pose the most serious conservation and resource management problem in the state of Alaska. In contrast to the more abundant and widely distributed black-legged kittiwake (*Rissa tridactyla*), red-legged kittiwakes are endemic to the Bering Sea where their breeding distribution is extremely localized—80% to 90% of the world's population of red-legged kittiwakes breeds on St George Island, one of only four known breeding sites. Kittiwakes on St. George experienced poor reproductive success and marked population declines (ca. 50%) during the 1980s, prompting the USFWS to list the red-legged kittiwake as a Category 2 "potentially threatened" species. Attempts to define the status the red-legged kittiwake have been frustrated by a lack of information on population size and factors that limit its reproductive success on St. George. This study has the following objectives:

- (1) to determine the number of red-legged kittiwakes breeding on St. George

Island; (2) to characterize the nesting habitat used by red-legged kittiwakes on St. George; and (3) to determine the nest site preferences of red-legged kittiwakes and evaluate the possibility that black-legged kittiwakes competitively exclude red-legged kittiwakes from preferred nest sites.

Field work was conducted on St. George Island between April and August 1995 where several nesting areas of red-legged kittiwakes and black-legged kittiwakes are accessible by ladder or rope at both low-elevation and high-elevation sites. To address the first objective, I used methods modified from Hickey and Craighead (1977) and photographed cliffs around the entire perimeter of St. George with a Pentax 6x7cm, medium-format camera from an inflatable Zodiac boat. Photos each covered an area of 90m x 90m and were overlapped both vertically and horizontally to generate a complete, 2-dimensional "map" of the cliffs. I am in the process of counting the total number of kittiwakes on St. George Island from these photographic negatives using a 7-20 power dissecting scope. When completed, counts will be corrected by a kittiwake observability factor and adjusted by the ratio of red-legged:black-legged kittiwakes on land-based census plots to arrive at abundance estimates for each of the two kittiwake species on St. George Island.

To address the second objective, I measured characteristics of 255 red-legged and 203 black-legged kittiwake nesting ledges. I used climbing ropes to access nest sites at both low- and high-elevation sites on St. George Island and measured the following features of each site (modified from Squibb and Hunt 1983): ledge depth, ledge breadth, ledge slope, back-wall slope, and the presence or absence of a rock overhang within 50 cm of the center of the nest. Nesting ledges used by red-legged kittiwakes were significantly shallower (15.2 cm vs 21.4 cm), narrower (29.6 cm vs 38.8 cm), and were more often located beneath an overhang (47% vs 34%) than those ledges used by black-legged kittiwakes. Ledge slope and back-wall slope did not differ between species.

To address the third objective, I established 243 narrow (12 cm) and 243 wide (23 cm) wooden nesting platforms at 17 high-elevation and 28 low-elevation sites on St. George Island during summers 1994 and 1995. Ledges were attached to the cliff-face using a climbing rope and a Hilti charge-driven nail gun 2-4 weeks prior to the initiation of egg laying by kittiwakes. I visited artificial ledges every 1-3 days for the duration of each summer to monitor occupancy, the stage of nest development, and the stage of reproductive advancement of each ledge. When presented with a super-abundance of narrow and wide ledges that were equipped with or without an overhang, red-legged kittiwakes preferred narrow ledges, black-legged kittiwakes preferred wide ledges, and both species avoided ledges with overhangs. When ledges were established in areas that differed in both the density and species composition of natural kittiwake nests, both kittiwake species preferred artificial ledges located within high-density clusters of conspecifics. From these results I conclude that red-legged kittiwakes are not competitively displaced to narrow ledges by the larger-bodied black-legged kittiwake; rather they actively select the narrow ledges that they are observed to use in nature.

Hatch S. A., G. V. Byrd, D. B. Irons, and G. L. Hunt, Jr. 1993. Status and ecology of kittiwakes (*Rissa tridactyla* and *R. brevirostris*) in the North Pacific. In K. Vermeer, K. T. Briggs, K. H. Morgan, and D. Siegel-Causey, (eds.). The Status, Ecology and Conservation of Marine Birds in the North Pacific. Can. Wildl. Serv. Spec. Pub., Ottawa.

Hickey, J. J. and F. L. Craighead. 1977. A census of seabirds on the Pribilof Islands. U.S. Dep. Commerce, NOAA; OCSEAP Final Rep. 2:96-195.

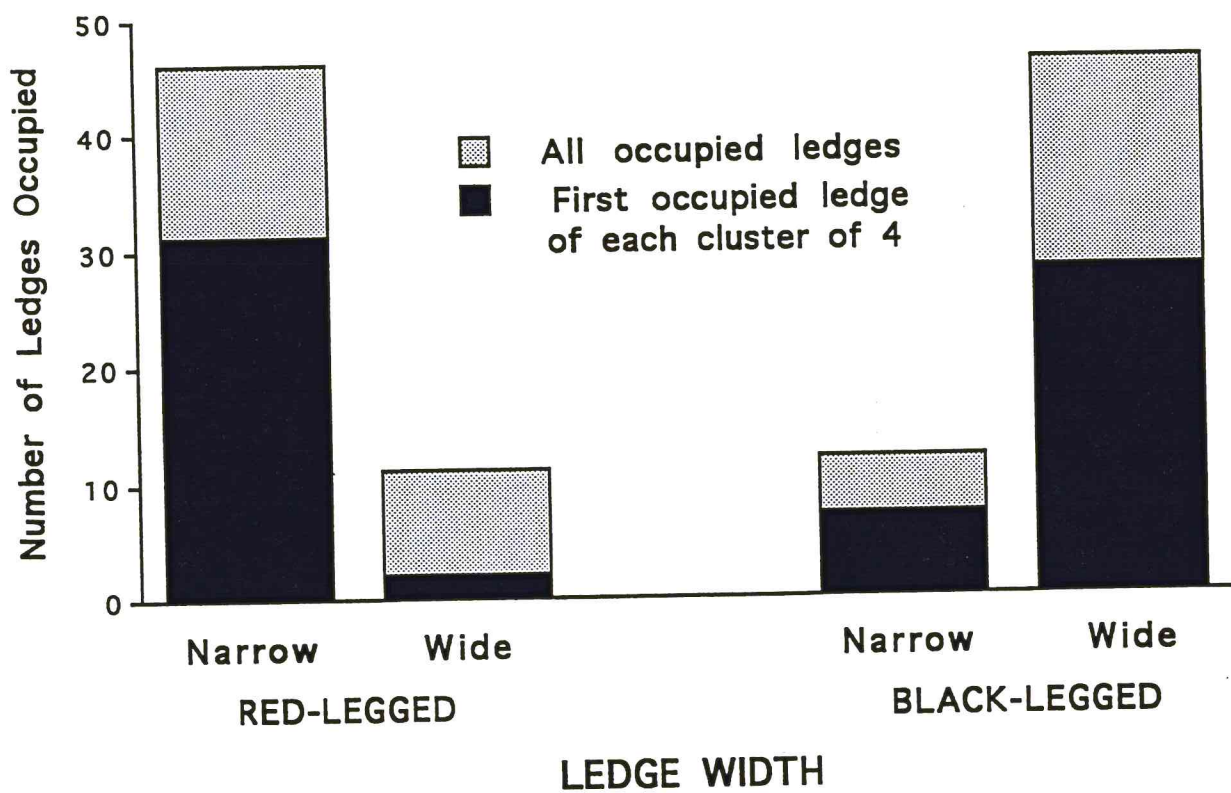


Figure 1. The use of narrow and wide artificial ledges by red-legged and black-legged kittiwakes.

Squibb, R. C. and G. L. Hunt. 1983. A comparison of nesting ledges used by seabirds on St. George Island. *Ecology* 64:727-734.

Terrance J. Quinn II

Effects of Ageing Error and Sample Size on Estimates of Sustained Yield from Alaska's Sport Fisheries

Student Investigator: Lewis G. Coggins, Jr. (M.S.)

Cooperators: James Hasbrouck and Douglas McBride, Division of Sport Fisheries, ADFG

Funding Source: Alaska Department of Fish and Game

The objective of this project is to use Monte Carlo computer simulation to examine the effect of ageing error and sample size on catch-at-age analysis and subsequent estimation of sustained yield.

Methods

An age-structured population is generated and subjected to simulated fishing over time such that true abundance-at-age and true catch-at-age are known. Measurement error in the form of ageing error and random sampling error is introduced in the simulation such that observed catch-at-age differs from true catch-at-age. Catch-at-age analysis is then used to estimate key parameters such as fishing mortality, gear selectivity and early life survival. These estimates along with auxiliary estimates of fecundity, maturity, and natural mortality are used to calculate sustained yield. Since true catch-at-age is known without error, sustained yield is also estimated with perfect information. By comparing the estimates of sustained yield using perfect information with estimates of sustained yield using information altered through the introduction of measurement error, the effect of sample size and ageing error on estimates of sustained yield is examined.

Ageing error is introduced into the simulation by modeling a variety of ageing procedures and reader types. The ageing procedures include (1) ageing a structure once by a single reader; (2) ageing a structure 3 times by a single reader and setting the structure age equal to the mode of the replicate ages; (3) ageing a structure once by 2 readers and setting the structure age equal to the agreed ages from the replicate readings; and (4) ageing a structure 3 times each by 2 readers, finding the modal age for each reader's replicate readings, and setting the structure age equal to the agreed modal ages. When implementing the above ageing procedures, the replicate readings may not contain modes, or the ages from 2 readers may not agree. In these situations further model structure is required. In procedure 2 when replicate ages do not contain a mode, the structure age is either set equal to the median of the replicate ages, or the structure is disregarded from the sample. These two strategies allow for the examination of the effect of disregarding structures with non-modal ages. In procedure 3 when the ages from 2 readers do not agree, an expert third reader is surveyed and the structure age is set equal to the expert reader's age. A description of the expert reader will be provided in the following discussion of reader types. In procedure 4, issues of non-modal replicate ages and disagreements between readers are resolved similarly as in procedures 2 and 3.

A total of 5 reader types are modeled for use in the above procedures. Reader R0 is the perfect reader and is used only in the first procedure to obtain the true age distribution of the catch. Reader R1 is defined as the expert reader and is

characterized as precise and unbiased. Reader R2 is characterized as imprecise and unbiased. Reader R3 is characterized as precise and biased. Finally, reader R4 is characterized as imprecise and biased. Let a be the observed age, b be the true age, c be the bias (positive or negative) of an inaccurate reader, s be a constant standard deviation, and $s(b)$ be a standard deviation as a function of true age. The statistical characterizations of each reader are $R0\ a = b$; $R1\ a \sim N(b, \sigma^2)$; $R2\ a \sim N(b, \sigma(b)^2)$; $R3\ a \sim N(b-c, \sigma^2)$; and $R4\ a \sim N(b-c, \sigma(b)^2)$.

Random sampling error is introduced in the simulation by specifying a range of sample sizes. This allows for the effect of sample size on estimates of sustained yield to be examined.

Catch at age analysis with auxiliary information is performed as in Deriso et al. (1989) and Quinn and Deriso (in prep). As is suggested by these authors in cases where the catch data contains multinomial measurement error due to ageing error, parameter estimation is accomplished by maximizing a chi-square term for catch deviations in the objective function rather than a simple catch sum of squares term.

The estimation of sustained yield is accomplished two ways corresponding to approaches 1 and 3 in Quinn and Szarzi (1993). The first approach is according to a Leslie matrix formulation with no spawner-recruit information available. A sustained yield is estimated which will keep the population at a constant size equal to the present population size. The second approach used to estimate sustained yield is a "per recruit" analysis. A sustained yield is estimated which maximizes the catch of fully mature fish. This is often a desirable goal in the management of recreational fisheries.

Progress to Date and Expected Completion Date

Progress since the last reporting period has included extensive program development and testing. A substantial amount of unexpected modification to the program structure has been required to cause the simulation to be both realistic and reliable. These modifications should lend considerable applicability to project conclusions. It is expected that this project will be completed no later than December 1996.

Deriso, R. B., P. R. Neal, and T. J. Quinn II. 1989. Further aspects of catch-age analysis with auxiliary information. Pages 127-135 in R. J. Beamish and G. A. Mcfarlane (eds.). *Effects of Ocean Variability on Recruitment and an Evaluation of Parameters Used in Stock Assessment Models*. Can. Spec. Publ. Fish. Aquat. Sci. 108.

Quinn, T. J., II and R. B. Deriso. In prep. *Quantitative Fish Dynamics*. Oxford Univ. Press, New York

Quinn, T. J. II and N. J. Szarzi. 1993. Determination of sustained yield in Alaska's recreational fisheries. *Proc. Int. Symp. Manage. Strat. Expl. Fish. Pop. Alaska Sea Grant*, Fairbanks, AK.

Age Validation and Revised Growth Parameters of Coastal Cutthroat Trout in Two Southeast Alaska Lakes

Student Investigator: Randolph P. Ericksen (M.S.)

Cooperators: Douglas Jones and Robert Marshall, Division of Sport Fisheries, ADFG

Funding Source: Alaska Department of Fish and Game

The objectives of this project are (1) to estimate the accuracy and precision of ages determined using scales collected from cutthroat trout in Southeast Alaska; (2) to model age and growth of cutthroat trout for two diverse systems in Southeast Alaska; and (3) to evaluate sustained yield of cutthroat trout in these systems.

Scale samples from this study were collected at Turner and Florence Lakes. These lakes are typical of two extremes of non-anadromous cutthroat trout populations found in Southeast Alaska. Turner Lake is a deep, unproductive lake renowned for having a small number of large-sized fish. Florence Lake is characterized as being a productive shallow lake, with an abundant population of relatively small fish. Mark-recapture population estimates were first conducted on these lakes in 1988 (Jones et al. 1989). Since that time, population estimates were conducted at Florence Lake on an annual basis through 1994 and at Turner Lake during 1989, 1990, 1994, and 1995.

Accuracy and precision of scale ages will be estimated through multiple readings of scale samples by several readers. Aging accuracy will be measured as agreement between the estimated ages and "true" ages determined by validation. Scales from younger-aged fish will be validated through comparison of fish length, otolith age, and scale age. To validate older-aged fish, scales from tagged cutthroat trout will be compared to scales from the same fish recaptured at least one year later. Aging precision will be measured as agreement between and within readers.

Age and growth will be modeled using standard methods. Scale samples from each lake will be aged by a trained reader having a high accuracy and precision of reading ages. Growth will be estimated through length measurements collected from tagged fish recaptured over time, and through back calculation methods.

Sustained yield will be estimated using an age-structured method (Quinn and Szarzi 1993). The potential effects of aging error on sustained yield estimates will be evaluated using corrected and uncorrected ages.

Progress to Date

An inventory of available specimens last year indicated that we were deficient in the number of samples needed to complete this project. During summer 1995, we collected additional scale and otolith samples at Turner and Florence Lakes. Work continued through the fall in the preparation and analysis of these samples.

Jones, J. D., A. E. Bingham, and R. D. Harding. 1989. Cutthroat trout studies, Turner/Florence Lakes, Alaska, during 1988. Alaska Department of Fish and Game, Fishery Data Series No. 111. Juneau.

Quinn, T. J. II and N. J. Szarzi. 1993. Determination of sustained yield in Alaska's recreational fisheries. In G. Kruse, D. M. Eggers, R. J. Marasco, G. Pautzke, and T. J. Quinn II (eds.). Proceedings of the International Symposium on Management Strategies for Exploited Fish Populations. Alaska Sea Grant Program Report No. 93-02, University of Alaska Fairbanks.

Eric A. Rexstad

Development of a Simulation Model for Flyway Management of Pacific Black Brant

Student Investigator: William E. Anker

Cooperators: Pacific Flyway Council; USFWS

Funding Source: National Biological Service

Significant declines in the populations of Pacific Black Brant (*Branta bernicla nigricans*) over the past 30 years have led to concern regarding appropriate management strategies. Midwinter populations showed steady declines from the early 1960s through the mid-1970s, particularly in the continental United States. Colonies on the Yukon- Kuskokwim (Y-K) Delta exhibited nesting declines of more than 60% in the 1980s (Sedinger et al. 1993). A computer-based simulation model is being developed to explore the population dynamics of this species and to aid wildlife professionals in crafting future management plans.

General model structure is illustrated in Figure 1. Brant migrate each winter to Mexico from staging grounds at Izembek. They return each spring to breeding grounds on the Y-K Delta at Tutakoke River, Kokechik Bay, Baird Inlet, and Kigigak Island, as well as some breeding grounds in the Arctic. The population is represented by an age vector for each colony (with Arctic breeders treated as a single "colony") plus an additional vector for dispersed breeders. Multiplying an appropriate transition matrix (a square matrix of the same dimension as the number of age classes) by a given age vector results in a new vector that represents the population structure after the effects of mortality and/or reproduction. Breeding is modeled with a Leslie transition matrix (Leslie 1945) which incorporates survival and fecundity estimates. Migration and overwinter survival are modeled with a transition matrix in which survival estimates are located along the diagonal. A great deal of model complexity stems from computations of these survival and fecundity probabilities. Determination of functional relationships has been a significant challenge, often aggravated by limited data.

We have added many refinements over the past year. Most significant of these is the incorporation of density-dependent processes such as juvenile growth, survival and harvest rates. These effects are modeled using a combination of logistic and linear functional relationships. The manner in which nonbreeders and failed breeders are dealt with has also been improved. Current work is focusing on adding stochastic components to simulate environmental variation. This is presently limited to nest success estimates but will be extended to other parameters as well. Sensitivity analyses will begin when the model is completed.

Simulation models offer the opportunity to synthesize knowledge gained from many diverse studies and to explore the behavior of populations in response to changes in environmental parameters. The primary purpose of this model is to test the likely effects of potential harvest strategies on the population

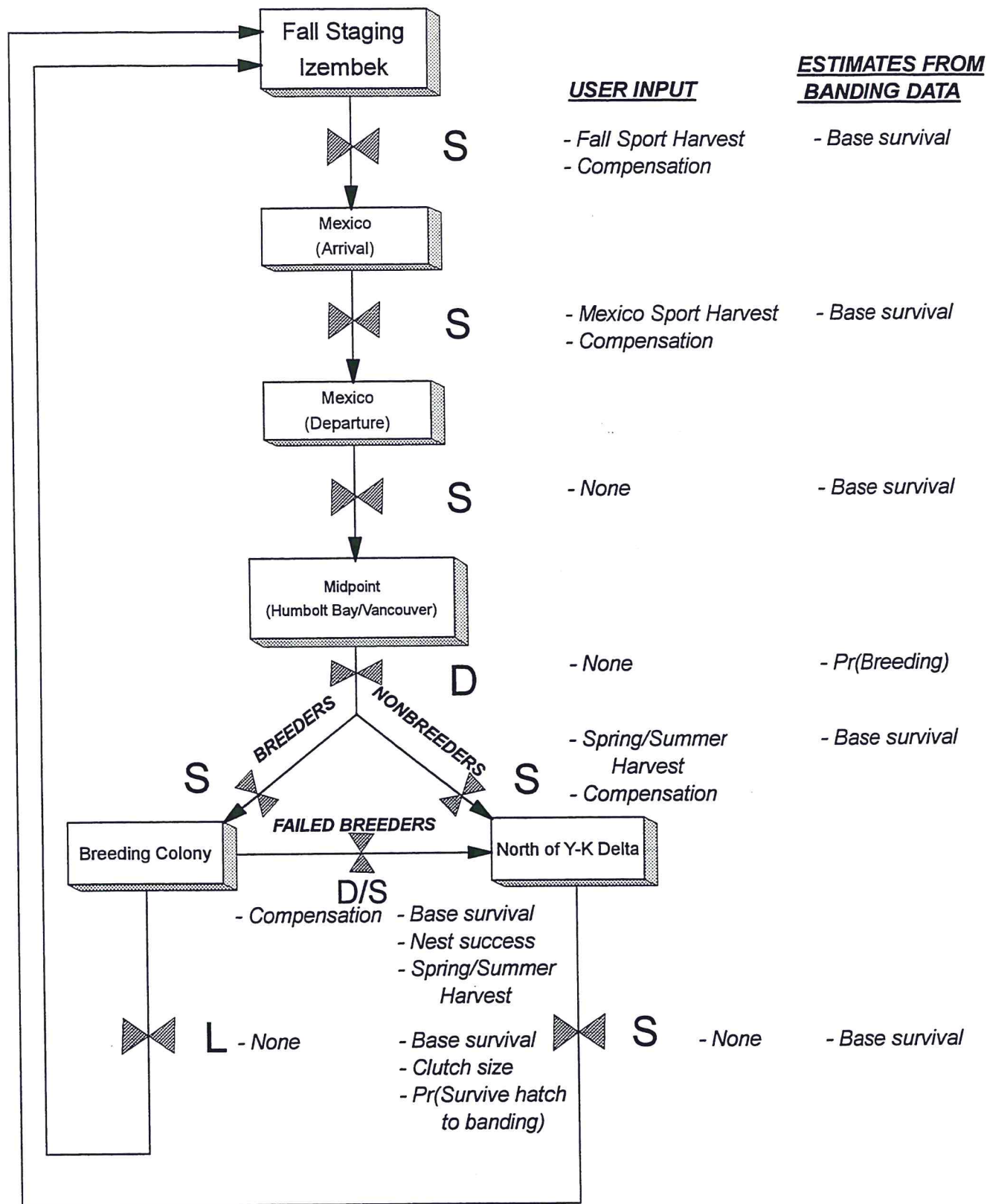


Figure 1: General model structure. S = Survival transition, L = Leslie transition, D = Distribution function.

dynamics of Brant. It will hopefully enable managers to optimize harvest regulations for achievement of specific population goals. Further areas of study also suggest themselves. For example, what population levels are optimum for the long-term persistence and/or stability of the population under current environmental conditions and harvest pressure? How might changes in Brant habitat or harvest patterns affect the population and how should management strategies adapt to such conditions? Does the effect of harvest vary temporally or spatially, and does sport or subsistence harvest appear to have a greater impact on the population? Current dogma suggests that subsistence harvest should have a greater impact since it occurs during the breeding season, but this has not been thoroughly examined. The successful integration of prevailing knowledge of Brant biology may lead to answers to these and other questions and could have a significant impact on future management approaches.

Leslie, P. H. 1945. On the use of matrices in certain population mathematics. *Biometrika* 33:183–212.

Sedinger, J. S., C. J. Lensink, D. H. Ward, R. M. Anthony, M. L. Wege, and G. V. Byrd. 1993. Current status and recent dynamics of the Black Brant *Branta bernicla* breeding population. *Wildfowl* 44:49–59.

Techniques for Monitoring Density and Correlates of Inter-annual Variation for Northern Red-backed Voles (*Clethrionomys rutilus*) in Denali National Park and Preserve, Alaska

Student Investigator: Pamela R. Furtsch (M.S.)

Cooperator: Resource and Research Unit, Denali National Park, NBS

Funding Source: National Biological Service

Editor's Note: Pamela Furtsch defended her thesis June 28, 1995, and graduated from the University of Alaska Fairbanks in December 1995. The thesis abstract follows. A project report by the faculty supervisor follows the abstract.

Abstract—Northern Red-Backed Voles (*Clethrionomys rutilus*) were live-trapped on four grids in 1992 and 1993 in riparian and forest habitats between June and September in the Rock Creek watershed of Denali National Park and Preserve (DNPP). Trapping was conducted on two grids and an additional three webs in 1994 to compare precision of estimators associated with trap configuration. Animals were uniquely marked using passive integrated transponder (PIT) tags and released. Spring abundance was variable between years; 1993 had significantly more voles than did 1994 ($P < 0.01$). Peak abundance in the autumn was significantly higher in 1993 than 1994 ($P < 0.01$). The percent of reproductive individuals was a significant factor contributing to this inter-annual variation ($P < 0.01$). Density estimates were calculated for 1993 and 1994 using abundance/effective area, distance-sampling, and nested-grid estimators. When numbers of captures were low only the abundance/effective area approach provided precise estimates of density.

Sampling Protocol for Small Mammal Monitoring, Denali National Park and Preserve

Student Investigator: Pamela R. Furtsch (M.S.)

Cooperators: Lyman Thorsteinson and Dale Taylor, NBS; Joe Van Horn, NPS

Funding Source: National Biological Service

In the fourth year of investigation into the dynamics of small mammal populations in Denali National Park and Preserve (DNPP), a pattern of abundance detected in the previous 3 years was continued. Intensive monitoring in the Rock Creek watershed measured abundance, density, survival and recruitment rates on 5 plots at 6 instances during the field season. Initial reconnaissance in the area of Wonder Lake and Igloo Creek was conducted once during the 1995 field season.

Methodology

A field crew of 3 permanent members was supplemented during the 17 June-1 September field season by 7 other volunteers at various times during the summer. The sampling design was temporally identical to the design used in 1993-94 field seasons: 5-day sampling sessions at 2-week intervals. Abundance/density was estimated during each of the 6 sessions. Spatially, the sampling design was identical to the 1994 design, with 3 trapping webs (128 m in diameter, containing 166 Sherman traps) and 2 trapping grids (90 m on a side, containing 100 Sherman traps) located so as to have representation of 2 habitat types and east- and west-facing aspects.

Closed population models (Otis et al. 1978) were used to produce point estimates and confidence intervals of abundance for each of 6 sessions on the 5 plots. Distance sampling models (Buckland et al. 1993) were used to estimate density on the trapping webs. Open population models (Pollock et al. 1990) were used to estimate survival and recruitment rates between sampling occasions on all plots.

Three animals were equipped with 2.5-g radio collars (AVM Electronics) to measure movement patterns during the field season. These data were assessed qualitatively to assess the assumption of closure invoked by both closed population and the distance sampling models.

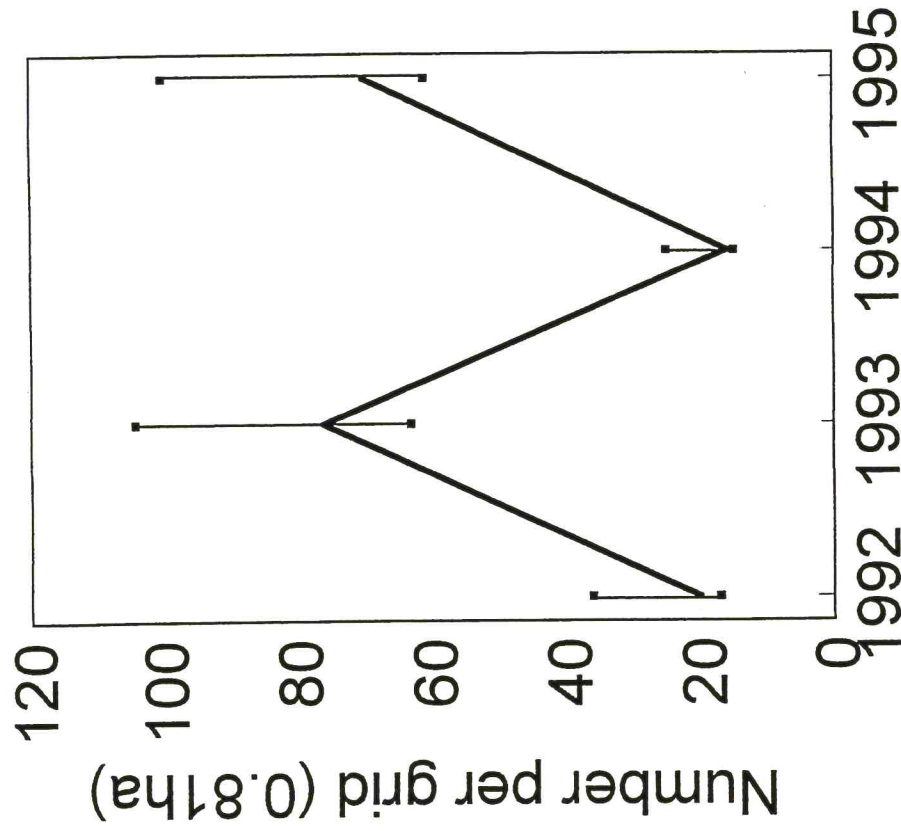
Findings to Date

Approximately 6000 small mammal encounters of nearly 1200 unique individuals were recorded in 1995, making this year the most active field season in the Rock Creek watershed. Abundance of northern red-backed voles (*Clethrionomys rutilus*) have experienced from 2- to 10-fold increases in abundance within the snowfree season. More significantly, between years, peak fall abundances have undergone 4-fold differences between "poor" years of 1992 and 1994 and "good" years of 1993 and 1995 (Figure 1). Winter weather severity may play a significant role in determining population levels in subsequent snowfree seasons by influencing survival rates (Figure 2). These data are collected by NPS automated meteorology stations, and will be incorporated into future analyses.

Differences in peak fall abundance among habitats have not been detected ($\chi^2=4.07$, 3df, $P=0.25$). Annual differences in survival rate ($\chi^2=59.5$, 1df, $P<0.01$) and recruitment rates ($\chi^2=8.8$, 1df, $P<0.01$) were detected between years in which adequate data were available for comparison (1993 vs. 1995). This implies that "snapshot" measures of fall abundance cannot detect differences in demographic processes that give rise to population sizes that appear comparable. Compared

Forest Lower Grid

Clethrionomys, End of Field Season



Riparian Lower Grid

Clethrionomys, End of Field Season

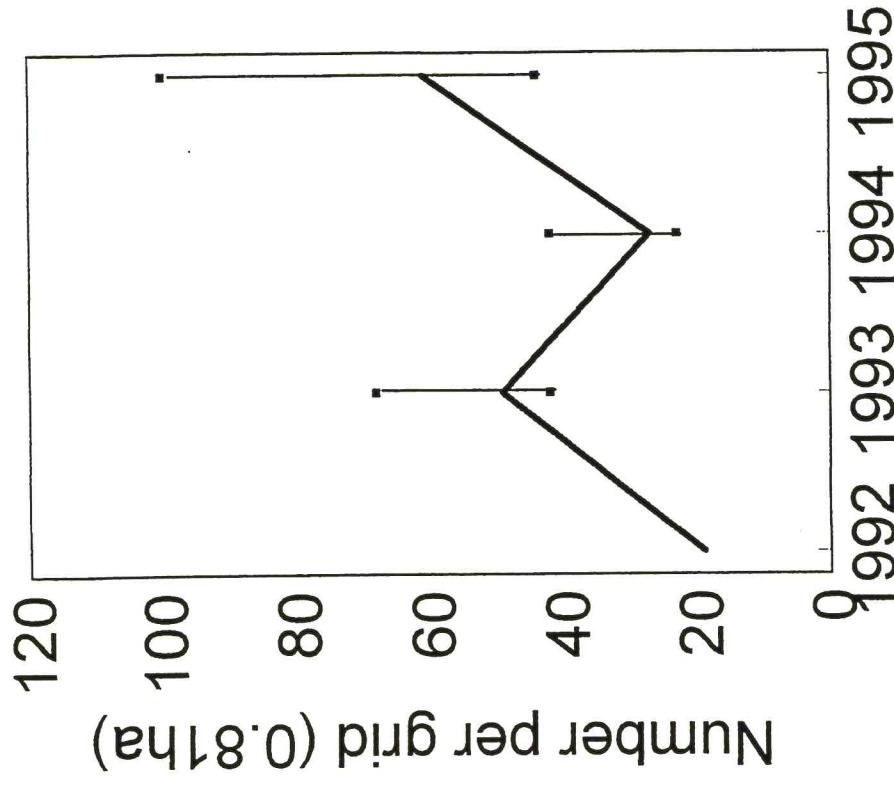


Figure 1. Peak fall abundances, Rock Cr. 1992-95, 2 habitat types.

ABIOTIC ENVIRONMENT DENALI NAT'L PARK

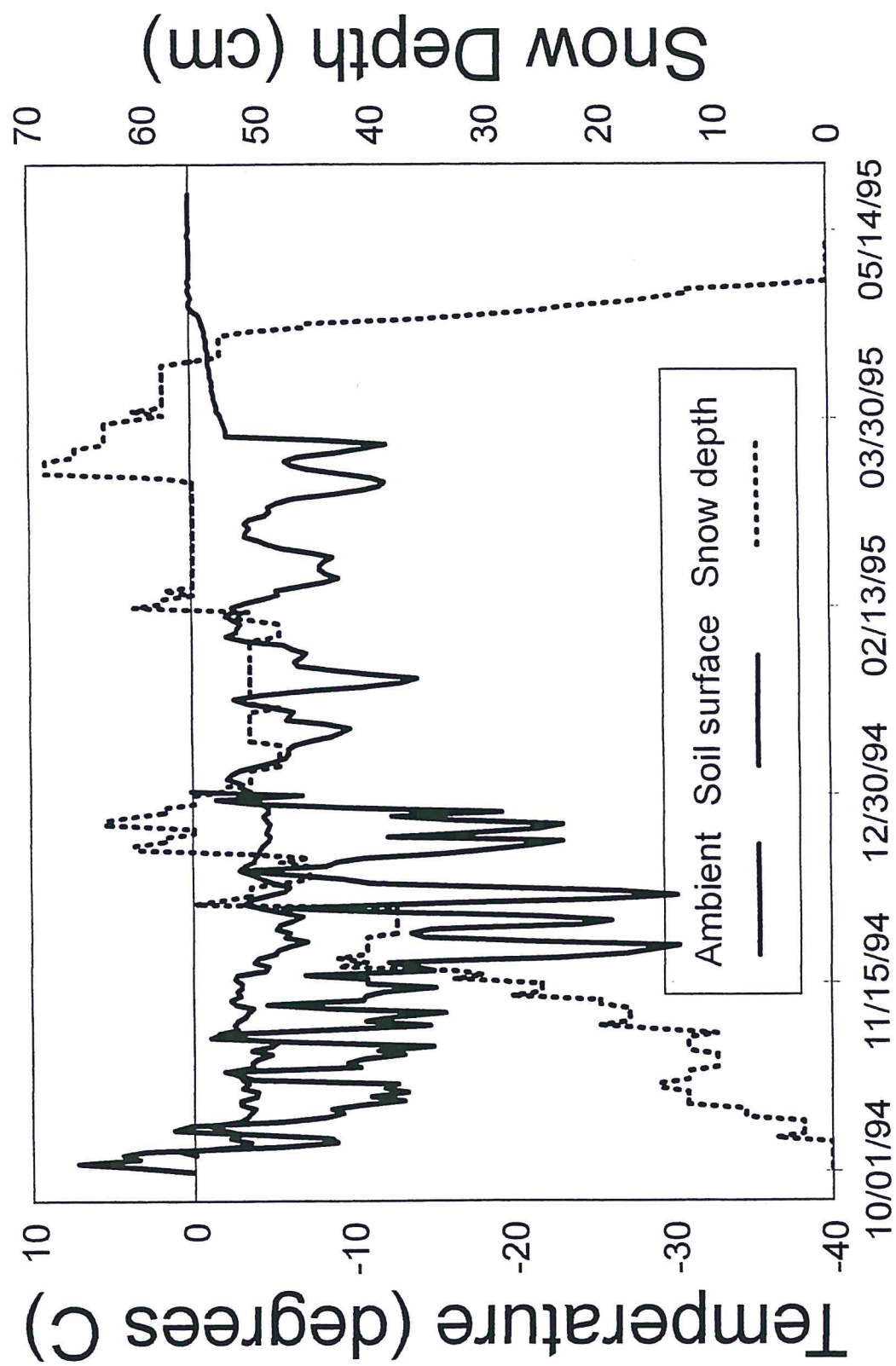


Figure 2. Abiotic conditions, winter 1994-5.

with 1993, survival rate was lower and recruitment was higher in both habitat types in 1995. This could be the consequence of actual lowered survival, or an artifact of potentially higher dispersal rates of animals in 1995.

Comparisons of abundance and density estimates on all plots during the 1995 field season demonstrated density can only be estimated with a coefficient of variation of 30% under favorable circumstances, while abundance can be estimated with coefficients of 10%, which are much more sensitive measures of population change for monitoring purposes.

Buckland, S., K. P. Burnham, D. R. Anderson, and J. L. Laake. 1993. Distance Sampling. Chapman Hall Publ. Co., New York. 358 pp.

Otis, D. L., K. P. Burnham, G. C. White, and D. R. Anderson. 1978. Statistical inference from capture data on closed animal populations. Wildl. Monogr. 62:1-135.

Pollock, K. H., J. D. Nichols, C. Brownie, and J. E. Hines. 1990. Statistical inference for capture-recapture experiments. Wildl. Monogr. 107:1-97.

James B. Reynolds

Summer Habitat Ecology of Rainbow Trout in the Middle Fork of the Gulkana River, Alaska

Student Investigator: Steve R. Brink (M.S.)

Cooperators: Dennis Tol and Michael Coffeen, BLM

Funding Source: Bureau of Land Management

Editor's Note: Steve Brink defended his thesis May 10, 1995, and graduated from the University of Alaska Fairbanks in August 1995. The thesis abstract follows.

Abstract—The Gulkana River supports one of the northernmost populations of rainbow trout (including steelhead) *Oncorhynchus mykiss* in Alaska. The Habitat Suitability Index (HSI) model for rainbow trout was evaluated and modified with respect to rainbow trout in the Middle Fork of the Gulkana River. General stream habitat descriptors were measured and related to trout abundance. The existing HSI model did not address seasonal movements displayed by this population. Seasonal movements of rainbow trout resulted from their suppression of preferences for physical habitat features in favor of the opportunity to follow spawning salmon for egg predation. A modified HSI model was developed that incorporated the effect of seasonal movements and identified the summer habitat for all life stages of rainbow trout in the Middle Fork. The upper Middle Fork is critical summer habitat for Gulkana River rainbow trout and steelhead and requires continued protection if this population is to remain viable.

Spawning Run Characteristics of Dolly Varden in the Kugururok River, Noatak Drainage, Alaska

Student Investigator: Thomas A. Cappiello (M.S.)

Cooperators: Alfred DeCicco, Division of Sport Fisheries, ADFG; Ross Kavanagh and Larry Whalon, NPS

Funding Source: National Park Service

Editor's Note: Thomas Cappiello defended his thesis May 19, 1995, and graduated from the University of Alaska Fairbanks in August 1995. The thesis abstract follows.

Abstract—Biological information was collected on fall and summer spawning runs of Dolly Varden in the Kugururok River, in northwest Alaska. Partial weirs, angling, and beach seining were used to capture fish in 1993; angling was used in 1994. Run timing of both spawning groups was similar to other northern Dolly Varden populations. Males of both summer and fall spawners had higher mean lengths and greater length ranges than females. Lengths of migrating summer spawners in 1994 were larger than those in 1993. Weight-length relationships among the groups for both years were equal. Condition factors of spawners were lower than migrants; migrating fall spawners had the highest condition. The proportion of female summer spawners (82%) on the spawning grounds in 1993 was unusually high. Recommendations are to continue to monitor harvests and escapements and maintain at historic levels, determine implications of skewed sex ratios on spawning success, and genetically identify stocks.

Relation of the Chena River Lakes Flood Control Project to Outmigration and Abundance of Juvenile Salmonids

Student Investigators: Michael J. Daigneault (M.S.) and Brent Peterson (M.S.)

Cooperators: Kim Kuk and John Schaaque, USCOE

Funding Source: U.S. Army Corps of Engineers

Background

The Chena River Lakes Flood Control Project (hereafter called the Chena River Dam) was authorized in 1968 and completed in 1973 to protect Fairbanks, Alaska, from flooding by the Chena River. Main features of the project are a 11.3-km diversion dam across the Chena River in the vicinity of North Pole, Alaska, and a 33.3-km system of levees and groins along the nearby Tanana River. The diversion dam includes flood control gates on the Chena River and a cleared floodway that contains a temporary reservoir of floodwater when the gates are partially closed to control downstream discharge. The maximum flow objective for the project is 12,000 cfs through downtown Fairbanks.

Thus far, the three largest control events were in 1985, 1991, and 1992, all during the spring breakup period (May to early June) when juvenile chum salmon *Oncorhynchus keta* and juvenile chinook salmon *O. tshawytscha* begin downstream migration to the Bering Sea. Chum salmon outmigrate soon after hatching, at age 0, during peak flow associated with spring breakup. Chinook salmon outmigrate as age-1 or age-2 juveniles over a longer period, but primarily May and June.

Public concern has been expressed that control events during spring may affect these outmigrants through delay and, ultimately, increased mortality or

reduced abundance. During 1981-83, the U.S. Fish and Wildlife Service documented the timing and duration of outmigration just downstream of the floodgates, but this study was not designed to evaluate the effects of project operation on outmigration or abundance.

Purpose

This study will evaluate the effects, if any, of the operation of the Chena River Dam on the outmigration and abundance of juvenile salmonids in the Chena River. The objectives of this study are to (1) evaluate the contribution of the Chena River to the abundance of chum and chinook salmon in the Tanana and Yukon River systems; (2) compare the movement, abundance, and survival of outmigrants in event years with that in non-event years; and (3) compare the health and condition of outmigrants in areas upstream and downstream of the Chena River Dam, during event and non-event years.

Study Areas and Trapping Methods

Two trapping sites were selected during 1994 feasibility work for use in the 1995 field season. The rotary screw traps at these two sites were found to successfully capture salmon outmigrants in the 1995 field season. The upstream site was found to produce unacceptably low capture rates compared to the downstream site, so it will be moved a short distance downstream in 1996 to an area found to sustain higher water velocity. The traps were most efficient when operated in the highest water velocity available, capturing the greatest number of fish per hour. This appears to be a predictable phenomenon; as water velocity increases following periods of significant precipitation, catch rate correspondingly increases.

A third trapping site will be added in 1996, between the two existing sites but below the dam. This third site will allow estimates of survival which were not possible in 1995 due to the failure of baited minnow traps to capture outmigrants. Therefore, a third trap is needed to complement the operation of the two rotary screw traps; a modified inclined-plane trap will be used at the middle site in 1996.

Injury and Descaling

Individual fish were examined for the presence of injury and scale loss. Investigations of juvenile chum salmon proved to be challenging due to the small size of captured fry (35-55 mm). Scale loss analysis of chum salmon provided little useful information due to the subjectivity of the scale loss criteria and the failure of chum fry to possess fully developed scales. However, the injury investigation of chum fry provided extensive practical information. Chinook salmon smolts were larger (80-100 mm) and easier to investigate. Data from both the scale loss and injury investigations proved to be useful. The occurrence of scale loss and injury was quite low for chum and chinook salmon at both the upstream and downstream trapping location. No apparent trends have developed that would indicate whether a certain group of fish is more susceptible to injury and scale loss than any other.

Stomach Content Analysis

Sampling effort for Arctic grayling *Thymallus arcticus* was limited by the effectiveness of hook and line gear. Therefore, limited information is available for the first half of May when the Chena River is carrying a high sediment load and defined pools are washed out. Stomach pumping proved to be an effective means of determining the diet of Arctic grayling without harming the fish. Predation upon chum salmon was minimal and grayling diet was dominated by invertebrates. No apparent difference in diet composition was observed among

the upstream and downstream sites. The importance of Arctic grayling predation on chum fry appears to be underestimated due to the inefficiency of hook and line gear early in the season during the apparent peak of chum fry migration.

Blood Sampling

Blood sampling efforts were unsuccessful due to the size of the fry and the limited amount of blood that is available. The information to be gained from blood chemistry analysis was determined to be vital in assessing the effects of dam passage on the stress levels of migrating fry. Therefore, new methodologies for collection and pooling of the samples have been developed to ensure that this information will not be lost.

Energetic and Food Source Comparisons of Dolly Varden Char in the Kuguruk River, Alaska

Student Investigator: Robert J. Foy (M.S.)

Cooperator: Larry Whalon, NPS

Funding Source: National Park Service

The Kuguruk River is an important spawning tributary for anadromous northern form Dolly Varden char *Salvelinus malma* in the Noatak River drainage. Dolly Varden are an important subsistence resource for area Natives and are becoming an increasingly desirable sport fish. Dolly Varden are also taken incidentally in the Kotzebue Sound commercial chum salmon *Oncorhynchus kisutch* fishery. Two migration patterns of Dolly Varden that relate to overwintering and spawning have been used to identify "summer" spawners and "fall" spawners.

The summer and fall spawners can be described as having separate life history strategies. After feeding in the ocean, fall spawners enter freshwater in September and October to spawn and overwinter. This behavior allows for the possibility of repeat spawning which will increase their contribution to the stock. Summer spawners overwinter, spawn in August and September, and overwinter again, spending a total of 20 months in freshwater. This behavior does not allow repeat spawning.

It is hypothesized that the total energetic cost of living between spawning events is greater for the summer spawners than the fall spawners. Previous observation has found that the char do not actively feed in freshwater. Stable isotope analysis of diet source will test the validity of this hypothesis. Assuming that these char do not feed in freshwater, the overwintering strategy of the summer spawners necessitates enough energy reserves to survive 20 months without feeding. The comparison of gastrointestinal tract, muscle, and liver energetics between the summer and fall spawners will test the hypothesis that summer spawners have lower energy reserves. The reproductive strategies of the two spawner groups are also expected to differ in order to compensate for the time spent in freshwater. Analysis of the gonadal tissue will test the hypothesis that the fecundities of the summer spawners will be lower in order to conserve energy for overwintering. The overwintering and reproductive strategies of Dolly Varden char have led me to question the benefit of the summer spawner's life history strategy. The purpose of my study will be to determine energetic and diet source differences between the two runs of Dolly Varden and to use this information to interpret the rationale for both life history strategies.

The objectives of this study are to (1) determine energetic characteristics of five tissues (liver, gonads, gastrointestinal tract, ventral, and remaining muscle) of summer spawners, fall spawners, and overwintering Dolly Varden char; (2) compare energetic characteristics of summer and fall spawning Dolly Varden char; (3) compare reproductive fitness of summer spawners and fall spawners; and (4) determine the relative importance of diet source, marine or freshwater, for these char.

This project will provide some answers to the complex life history of the northern form Dolly Varden that will allow agencies to better understand and manage this unique and important resource.

Collection and Analysis

The 1995 field season consisted of three periods of collection in order to target particular reproductive stages of the char. The Kugururok River was fished from 20 June to 7 July and 30 summer run char were collected while they migrated up the river. All fish showed visible signs of maturity and the ability to spawn at the end of the summer. Arctic grayling and aquatic invertebrates were also collected from the Kugururok River to establish a database of stable isotope ratio standards from which to compare Dolly Varden $d^{13}C$ and $d^{34}S$ values. The river was floated in the month of September in order to collect 36 summer run fish, all of which were mature enough to spawn or were spent at the time of collection. Twenty-five fish not mature enough to spawn were also collected near the mouth of the Kugururok. These fish were most likely fresh from the sea, staging to overwinter in the lower river. In October, three fall run char were collected and were partially or completely spent. Additional fall run fish were not collected due to logistical and weather constraints.

Upon capture, blood and heart samples were taken and preserved for genetic studies. The remains of the fish were frozen and transported to Fairbanks for analysis. Five tissues and the remaining carcass were analyzed for lipid, water, and ash content for each of the collected fish. Eggs will be counted from females to determine fecundities. Dried aliquots from each sample were saved for protein and stable isotope analysis.

Results

Preliminary results are reported for 13 summer run fish. Significant patterns were found in the percent water, protein, lipid, and ash for various tissues from Dolly Varden char. Protein ranged from 17 to 29% of each tissue with the gonads containing 29%. This appears to be at the expense of water weight which was 62% for the gonads. The muscle, liver, and carcass had higher percentages (65 to 75%). Percent ash was similar in all tissues between 1 and 3%. Lipid was 25% of the ventral muscle, 11% of the carcass, and from 4 to 7% in the remaining tissues. It should be noted that the ventral muscle was included in the carcass for 10 fish and contributed significantly to its higher lipid content. Only three fish had the ventral muscle removed and analyzed separately.

Isotope analysis showed heavier nitrogen (17 ppt) incorporated in the gonads than the other tissues (15 ppt). Stable isotope analysis showed that the gastrointestinal tract, liver, and muscle averaged -19 ppt whereas the gonads and carcass averaged -20 ppt. These nitrogen and the carbon values in each of the tissues sampled indicate marine food sources. For the purposes of the project these data are exploratory and will be complemented by analysis of the remaining samples.

Spawning Substrate and Capacity for Coho Salmon in the Ayakulik River, Kodiak National Wildlife Refuge

Student Investigator: Raymond F. Hander (M.S.)

Cooperator: Donald A. Chatto, Kodiak National Wildlife Refuge, USFWS

Funding Source: U.S. Fish and Wildlife Service

The lack of management information on coho salmon (*Oncorhynchus kisutch*) escapement on the Kodiak National Wildlife Refuge (KNWR) has prompted the need for assessment of spawning habitat. A total of 36 drainages on KNWR, ranging from large lake/river systems to small, short streams, are used by coho salmon. These coho salmon runs contribute to a multimillion-dollar commercial fishery in the Kodiak area and are highly prized by sport fishers using the refuge. In addition, coho salmon are a critical late food source for brown bears and bald eagles.

An issue identified in the refuge Fishery Management Plan and the Kodiak Regional Comprehensive Salmon Plan, and by the Alaska Department of Fish and Game (ADFG), is the increasing harvest of coho salmon and the lack of management information on escapement, including estimates of potential production and evaluation of aerial index surveys. Assessment of coho salmon escapement is hindered by the lack of manpower and funding and the late arrival (September-November) of returning spawners. As a result, some drainages on the refuge have tentative escapement goals, or none at all. Because the ADFG and KNWR conduct index surveys and share a common database, updated and accurate information is essential for managers to detect conservation problems before they become severe.

Evaluation of stream substrate habitat to estimate its "carrying capacity" for coho salmon spawners is utilized as an approach for estimation of potential production of coho salmon. This information could be useful as a management tool and may be applicable to other lake and non-lake drainages both on and off KNWR lands.

Suitable stream substrate habitat regulates the production of a stream for anadromous fish. Although spawning habitat is important to developing embryos, this study will only address criteria for spawning. Stream substrate composition directly affects suitability of potential spawning habitat.

The goal of this study is to calculate optimum coho salmon escapement into the Ayakulik River based on available stream substrate habitat area. The objectives are to (1) develop a database containing stream substrate area measurements for coho salmon in the Ayakulik River; (2) determine the relation between amount of estimated spawning area and the number of adult coho salmon in a section using aerial and foot surveys; and (3) determine an optimal escapement goal for coho salmon in the Ayakulik River, based on the area of optimum spawning substrate habitat.

The Ayakulik River was divided into 81 sections using a 1:63,360-scale USGS topographic map and aerial photos. Section lengths are approximately 1000 m and can be recognized from the air and on the ground by using a geographic positioning system and geographic landmarks such as river bends, confluence of tributaries, and bluffs. Preliminary survey of the river suggests there are four areas (strata) of the river that represent different basic substrate types.

In the 1994 field season, stratum sampling of river sections for stream substrate maps was accomplished based on the 1993 variance estimate and the

logistical amount of time available to complete the work. A total of 28 river sections were sampled using 50-m subsections as the basic unit of measure. Those sections that were not completely mapped were subsampled based on stratum variance. Irregular polygons were mapped within each 50-m subsection based on changes in principal surface substrate materials compared to reference measurements that relate to substrate size criteria of 1.3-10.2 cm in diameter. The areas that meet this criteria were used to estimate the total amount of optimum (3.6-8.0-cm diameter), suboptimum (1.3-3.6 and 8.0-10.2 cm), and marginally usable (0.0-1.3 and >10.2 cm) spawning substrate for coho salmon.

During late October, peak coho spawning time, a stream foot survey was conducted to estimate coho salmon spawners in sampled sections. All sections in the upper three strata were completed, and the lower stratum was not logistically possible to foot survey. Aerial index surveys were attempted for the second spawning season in a row, but weather conditions precluded the ability to obtain coho salmon counts.

Preliminary results suggest a significant relation between the estimated number of coho salmon and the estimated spawning area comprised of optimum ($r^2=0.35$, $p=0.01$) and suboptimum and optimum substrate combined ($r^2=0.31$, $p=0.02$). When I added marginally usable substrate with optimum and suboptimum, I found no relation indicating that more spawning area does not necessarily lead to an increase in the number of fish that could use that area ($r^2=0.26$, $p=0.13$). Optimum and suboptimum substrate combined lead to positive results and yield what is likely a minimum number of coho salmon that could use the estimated area.

Winter Habitat of Arctic Grayling in an Interior Alaska Stream

Student Investigator: Brian R. Lubinski (M.S.)
Cooperator: Bureau of Land Management

Editor's Note: Brian Lubinski defended his thesis March 20, 1995, and graduated from the University of Alaska Fairbanks in May 1995. The thesis abstract follows.

Abstract—Placer mining and the lack of information on winter ecology of Arctic grayling *Thymallus arcticus* has raised concern for this popular sportfish. A study was designed to validate aerial radio telemetry data and to locate and describe overwinter areas (OWA) of Arctic grayling in Beaver Creek, Alaska. Reliance on aerial data alone resulted in overestimation of survival and misidentification of 14 of 26 designated OWAs. Twenty-one Arctic grayling were tracked downstream 12–58 km to 12 OWAs spanning a 31-km section of Beaver Creek. Radio-tagged and untagged Arctic grayling occupied areas with ice thickness of 0.4–1.4 m overlying 0.06–0.52 m of water, flowing at 0.03–0.56 m/s. During winter, discharge, cross-sectional area, velocities, and water width in four OWAs decreased until late March; then, cross-sectional area increased due to an increase in discharge that pushed the ice upward. Adult Arctic grayling overwintered downstream of habitat disturbances, and occupied much shallower winter habitats than expected.

Application of Decision Analysis in the Evaluation of Recreational Fishery Management Problems

Student Investigator: Margaret F. Merritt (Ph.D.)

Cooperator: Alaska Department of Fish and Game

Editor's Note: Margaret Merritt defended her thesis March 22, 1995, and graduated from the University of Alaska Fairbanks in May 1995. The thesis abstract follows.

Abstract—Fisheries management is a decision-making process, yet typically formal decision analysis techniques are not used in structuring problems, quantifying interactions, or arriving at a prioritized solution. Decision analysis tools are applied in the decision-making process for Alaska's recreational fisheries management as a means to reduce risk in management at the policy (Chapter 2) and field (Chapter 3) levels. In Chapter 2 the analytic hierarchy process is applied to the recreational fishery for chinook salmon (*Oncorhynchus tshawytscha*) in the Kenai River. Model structure is developed through an iterative interview process involving individuals asked to represent the perspectives of 15 different stakeholders. Individual stakeholder judgments are combined used a geometric mean, and maximum and maximin criteria. The sensitivity of the results to under-representation is explored through various models. Despite the contentious differences of perspective represented among stakeholders, the analytic hierarchy process identifies management options that enjoy broad support and limited opposition.

In Chapter 3 decision analysis is applied to the recreational spear fishery for humpback whitefish (*Coregonus pidschian*) in the Chatanika River. A modified form of catch-age analysis is used to combine information derived from creel surveys and run age composition with auxiliary information in the form of mark-recapture estimates of abundance. Four systems are used in weighting annual observations: prior beliefs regarding their reliability, by the inverses of their variances, through a combination of these two weighting schemes, and equal (no) weights. The perception-weighted model generates the most reasonable estimates of abundance, which are relatively precise and associated with small bias. Forecasts of mature exploitable abundance are calculated based on various recruitment scenarios, maturity schedules, and exploitation rates. From these outcomes, the odds of stock abundance occurring below a threshold level are presented.

By applying decision analysis methodologies which incorporate judgments and perceptions into decision-making affecting fisheries, sensitivity to uncertain information is made explicit, components of the problem are structured, interactions among components of the problem are quantified, and options are prioritized, thus increasing the chances of finding an optimal solution.

Stomach Oils and Representative Energetics in Antarctic Seabirds

Cooperators: Dr. A. R. Place, Center of Marine Biotechnology, University of Maryland; Dr. J. P. Croxall and P. A. Prince, British Antarctic Survey

Funding Source: Office of Polar Programs, National Science Foundation

Executive Summary of Completed Project

This research investigated the ecological and energetic significance of stomach oil for seabirds breeding in the Antarctic, as well as the physiological factors responsible for stomach oil production. Stomach oils, a complex mixture of neutral dietary lipids, are a unique adaptation of the Procellariiformes, the predominant surface-feeding seabirds of the Antarctic. With the exception of diving petrels, all procellariiforms produce stomach oils and feed them to their young. The subjects of our study were Antarctic prions (*Pachyptila desolata*), a species that feeds its young stomach oils, and South Georgia diving petrels (*Pelecanoides georgicus*), a species that lacks stomach oils.

Field research was conducted on Bird Island, South Georgia, during the 1991-92 austral summer in cooperation with the British Antarctic Survey. We determined how ingested stomach oil influences (1) gastrointestinal transit rates, (2) lipid assimilation efficiencies, (3) patterns of lipid storage, (4) growth and development rates, (5) adult foraging efficiency, and (6) net production efficiency of the parent/offspring unit. Chicks of the two study species (N=30 pairs) were cross-fostered soon after hatching, and their growth, development, and rates of lipid deposition, as well as those of control chicks, were monitored throughout the nestling period. Dilution space of tritiated glycerol triether (GTE), a nonassimilable lipid phase marker, was used to estimate stomach oil volume in control and cross-fostered chicks.

Chicks of the two study species (N=24) were also brought into the lab and raised on either high-oil or low-oil diets. Growth rates of lab-reared chicks were monitored and excreta was collected for analysis of biochemical composition. Patterns of lipid deposition in lab-reared chicks, as well as cross-fostered and control chicks in the field, were tracked nondestructively using the total body electrical conductivity (TOBEC) technique for body composition analysis. Relative transit rates and lipid assimilation efficiencies in the two species on the two diets were measured by feeding three radio-labeled markers: tritiated GTE, carbon-14 labeled polyethylene glycol (nonassimilable aqueous phase marker), and C-14 labeled triolein (assimilable neutral lipid phase marker). Free-ranging metabolic rates of adults during the chick-rearing period were measured using the doubly-labeled water (DLW) technique. Prion and diving petrel chick meals were also collected from adults for analysis of biochemical composition.

Diving petrel adults were unable to raise foster prion chicks, presumably due to the absence of stomach oil in meals fed to chicks. Prion adults successfully raised most foster diving petrel chicks, but growth rates were significantly lower than controls. The results of laboratory feeding experiments indicated that high oil diets resulted in lower assimilation efficiency in diving petrels, but not prions. The higher foraging efficiency of adult prions compared with diving petrels is essential for the production of stomach oil and the transfer of this energy-rich dietary component to their young. Stomach oils are an important adaptation for

enhancing the energy density of chick meals in petrel species that forage far from the breeding colony and feed their chicks infrequently.

Diet and Nestling Growth of Red-legged and Black-legged Kittiwakes: An Interspecies Cross-Fostering Experiment

Student Investigator: Brian K. Lance (M.S.)

Cooperators: Alaska Maritime National Wildlife Refuge, USFWS; National Marine Fisheries Service; Drs. Edward C. Murphy and Alan M. Springer, UAF; City of St. George

Funding Source: Angus Gavin Migratory Bird Research Fund

Editor's Note: Brian Lance defended his thesis December 5 and graduated from the University of Alaska Fairbanks in May 1996. The thesis abstract follows.

Abstract—I conducted an interspecific cross-fostering experiment to investigate how diet composition and feeding rates affected nestling survival, growth, and gastrointestinal development of Red-legged and Black-legged kittiwakes on St. George Island, Alaska. Red-legged Kittiwakes (*Rissa brevirostris*) fed nestlings primarily lanternfish (Myctophidae), a high-lipid diet, whereas Black-legged Kittiwakes (*R. tridactyla*) fed nestlings mostly walleye pollock (*Theragra chalcogramma*), a low-lipid diet. Nestling meal size was similar for the two species, but Red-legged Kittiwakes fed nestlings at about half the rate of Black-legged Kittiwakes. Interspecific differences in nestling growth were explained by differences in adult body mass. Survival rates and lead body mass did not differ between fostered nestlings and conspecific controls. Nestlings raised by Red-legged Kittiwakes had 50% larger fat reserves than those raised by Black-legged Kittiwakes. Thus growth rates of lean tissue were genetically constrained, while rates of fat deposition were determined by diet. Interspecific differences in gastrointestinal anatomy were partly genetic and partly dietary in nature.

Habitat Selection and Nesting Ecology of Townsend's Warblers (*Dendroica townsendi*) in southcentral Alaska

Student Investigator: Steven M. Matsuoka (M.S.)

Cooperators: Colleen Handel, Alaska Science Center, NBS; Chugach State Park; and the Municipality of Anchorage

Funding Source: National Biological Service

The overall goal of this research is to identify components of vegetation structure and floristics that influence the breeding season distribution and reproductive success of Townsend's Warblers; specifically, to (1) identify habitat characteristics that influence the distribution of breeding territories, nests sites, and foraging adults; (2) identify sources of reproductive failure; and (3) determine nesting success and how it varies with variation in habitat.

Field work was conducted during 1993–94 on two mixed forest study plots located in south Campbell Creek drainage, Anchorage, Alaska. The lower elevation site consisted of 26 ha of coniferous-deciduous forest with an average coniferous canopy cover of 22% and an average total canopy cover of 68%. The upper-elevation site consisted of 35 ha of coniferous-deciduous forest with an average coniferous canopy cover of 11% and an average total canopy cover of 38%.

We measured the structural and floristic characteristics of the available habitat at randomly selected points in each study area (n=42) for comparison with habitat associated with territories (n=40), nest sites (n=33), and foraging individuals during the pre-hatching (n=59) and post-hatching (n=38) stages of the nesting cycle to test for habitat selection. We measured the structural characteristics of trees used for nesting for comparison to adjacent trees not used for nesting to test for selection of trees within defended territories. We monitored nests at regular intervals to determine nesting success and to identify sources of nesting failure.

Territories, nests site, and foraging adults all displayed a positive association with white spruce (*Picea glauca*) trees in both mixed-forests study area. Territories and nests were located in areas with greater densities of large white spruce (dbh≥38 cm) than were generally available in either study area. Nests were placed almost exclusively in white spruce (97%) with only one nest located in paper birch (*Betula papyrifera*). Nests displayed further selection for large white spruce trees as nests in the lower elevation study area were located in larger diameter white spruce trees than adjacent white spruce trees not used for nesting.

Before chicks hatched, foraging adults in both study areas displayed a positive association with medium-size white (15 cm≤dbh<38 cm) foraging substrates. Foraging observations during the pre-hatching period were primarily recorded in this substrate. During the post-hatching period, time spent foraging in medium-size white spruce decreased significantly and increased in alder (*Alnus* sp.) and medium-size paper birch. Paper birch of all sizes, alder, and small and large white spruce were used less frequently than expected or randomly in relation to their availability during both periods in both study areas.

Nest survival was significantly higher during the incubation period (86.7%) than during the nestling period (59.2%) of the nesting cycle. Estimated nesting success across the nesting cycle was 51.3% (n=24). Predation was the dominant source of nesting failure accounting for 80% of total failures and an estimated 41.5% reduction in nesting success. Nestling parasitism by the larvae of bird blow flies, *Protocalliphora* (Diptera: Calliphoridae) was prevalent in our study. Fifty-five percent of nests with nestlings and 50% of nests fledging young were infested with *P. braueri* and *P. spenceri*. Although no nestling mortality was directly attributable to *Protocalliphora*, the combination of severe infestation and cold, wet weather resulted in nestling mortality in 4 nests.

Variation in reproduction was related to variation in habitat at nest sites. Nests placed in larger white spruce trees were more likely to fledge young and less likely to suffer predation relative to nests located in smaller white spruce trees. Nests located in areas with low densities of woody shrubs were less likely to suffer *Protocalliphora* infestation relative to nests located in areas with higher densities of woody shrubs.

In conclusion,

- Large white spruce trees are important in the selection of territories and nests site.
- Large white spruce trees are important in reducing nest failure by conceal both nests and adult movement around nests from nest predators.
- Medium-size white spruce are important in providing food resources for Townsend's Warblers.
- The larvae of bird blow flies are prevalent parasites of nestling Townsend's Warblers.

- Infestation by bird blow fly larvae is associated with microhabitats with high densities of woody shrubs.

Prospectus

Defense of the thesis and completion of degree requirements are planned for spring 1996.

Effects of Aircraft Overflights on Birds of Prey—Phase 2

Student Investigators: Angela Palmer (M.S.) and Dana Nordmeyer (M.S.)

Cooperators: Robert Ritchie and Steve Murphy, ABR, Inc.; Captain Michael Carter, Armstrong Laboratory, U.S. Air Force; Robert Ambrose, USFWS; Peter Bente, Division of Wildlife Conservation, ADFG

Funding Source: U.S. Air Force

Objectives

1. Determine the effects of dose (timing, frequency, and intensity) of exposure to jet aircraft overflights on nesting success (proportion of incubating pairs that successfully raise at least 1 nestling) and productivity (number of nestlings successfully raised per incubating pair) of peregrine falcons in Interior Alaska.
2. Determine the types and intensities of behavioral responses to jet aircraft overflights by peregrine falcon adults and their young.
3. Determine the overflight variables that best correlate with the intensity and type of observed behavioral responses by peregrine falcons.
4. Determine the influence of phase of the nesting cycle on the type and intensity of behavioral response to jet aircraft overflights by peregrine falcons.
5. Determine the extent to which the type and intensity of behavioral response to jet aircraft overflights is correlated with subsequent nesting success and productivity of peregrine falcons.
6. Determine the effects of jet aircraft overflights on time-activity budgets and nestling provisioning rates of adult peregrine falcons.
7. Determine the relationship of adult hunting proficiency/prey availability (nestling provisioning rate) to sensitivity of nestling peregrine falcons to jet aircraft overflights.
8. Determine the extent and time course of habituation (reduction in the intensity of response) to jet aircraft overflights by peregrine falcons.

Status Report

The first full season of field work was conducted during the 1995 breeding season. Behavioral observations were recorded from 13 May through 17 August at peregrine falcon aeries along the Tanana River between Tanacross and Sawmill Landing, Alaska. There were 14 active aeries along this 120-km stretch of river, and observations of parental behavior were feasible at 11 of these. Five of the 11 observable aeries were within Military Training Routes (MTRs) and thus could serve as experimental aeries (subject to overflights), while the other six served as controls (no intentional overflights). Field crews of 2-4 observers were present at observation blinds near aeries during overflights.

The types and intensities of behavioral responses to overflights were observed using 10X binoculars, 15-45X spotting scopes, and Questar telescopes. Behavioral responses of adults and nestlings were categorized in the field and recorded on video using Canon L2 Hi-8 mm cameras equipped with 250-mm

telephoto lens and 2X teleconverters for further categorization in the lab. Video cameras were usually focused on the nest ledge, so tapes primarily document responses of incubating/brooding adults and nestlings.

Animal Noise Monitors (ANMs) were used to measure various parameters of noise dose associated with overflights. Early in the incubation period (May), stationary ANMs were deployed on cliffs near each of the 11 observable aeries: two at each experimental site and one at each control site. In addition, another noise monitor was deployed on the ground between the field crew and the aerie during periods when the aerie was under observation. Field crews also recorded various parameters of overflights, such as aircraft type, altitude, distance from nest site, approach direction, etc. These data will be used to assess those factors that best predict the type and intensity of behavioral response by peregrine falcons to jet aircraft overflights.

Observations of behavioral responses to overflights by breeding adults were recorded during the incubation period, the mid-nestling rearing period (day 11-24 post-hatch), the late nestling rearing period (day 25-35 post-hatch), and the fledging period (day 36-42 post-hatch) of the nesting cycle. Observations of responses by young falcons were also recorded during the nestling rearing and fledging periods. Experimental aeries were exposed to a total of 23 overflights during incubation, 14 overflights during mid-nestling rearing, 24 overflights during late nestling rearing, and 13 overflights during fledging.

Nesting success and productivity are comprised of egg production, clutch size, egg survival, hatching success, nestling survival, and fledging success. Several other factors are frequently associated with overall nesting success, such as date of clutch initiation, nestling growth performance, and condition of young at fledging. Attempts were made to measure all of these parameters in order to acquire as much information on reproductive output as possible. Egg production, clutch size, and egg survival were not determined in 1995 because of the excessive disturbance required to obtain these data. Nestling growth performance was only measured at three aeries (one experimental and two controls) because scheduled overflights precluded visits to the other aeries. In the future, every effort will be made to assure that overflights are scheduled so as not to conflict with nest visits to measure nestling growth performance.

A total of 509 hours of behavioral observations at nests were recorded, 326 at experimental aeries and 182 at controls. Adult nest attendance and time-activity budgets of adults and young present at or near the aerie were recorded every minute using the instantaneous scan technique. We also recorded data on the frequency and size of prey items delivered to nestlings in order to compare nestling provisioning rates before and after overflights, as well as between experimental and control aeries. Prey remains were collected at 10 of the 11 observable aeries after the young had fledged. The taxonomic composition of prey remains will be used to help assess prey availability. At two of the nest ledges no prey remains were present when the aerie was visited.

Habituation of breeding adult peregrine falcons to jet aircraft overflights will be evaluated over the three years of the study. Consequently, it is important to identify individual breeding adults in order to compare behavioral responses among years of the study. In 1995, existing leg bands on adults were read whenever possible and detailed descriptions of each individual in life or from video images were recorded.

Prospectus

The two Graduate Research Assistants on this project, Angela Palmer and Dana Nordmeyer, will continue analyzing data collected during the 1995 field season. Additional data will be collected in the field during the 1996 breeding season. The study population will be peregrine falcons breeding along the Tanana River between Delta and Tanacross. Ms. Palmer will focus her M.S. thesis research on the factors that influence time-activity budgets and nestling provisioning rates of peregrine falcons, as well as the influence of stage of the nesting cycle and prey availability on response to overflight disturbance. Ms. Nordmeyer will focus her M.S. thesis research on identifying those attributes of overflights that best predict behavioral responses, how responses are correlated with subsequent nesting success, and the role of habituation in determining responses by peregrine falcons.

Pigeon Guillemots as Bioindicators of Nearshore Ecosystem Health

Student Investigator: Alexander K. Prichard (M.S.)

Cooperators: Drs. R. Terry Bowyer and Lawrence K. Duffy, UAF; Dr. Jim Faro, Division of Wildlife Conservation, ADFG

Funding Sources: Minerals Management Service; Alaska Department of Fish and Game

We are currently trying to develop Pigeon Guillemots (*Cepphus columba*) as a bioindicator of contaminants in neritic food webs. Understanding physiological responses to hydrocarbon pollution will allow us to develop a method of assessing the biological significance of contaminants in the coastal marine environment. As semicolonial nesters and top-trophic level predators of nearshore demersal fish, guillemots are well suited to this purpose.

Objectives of this project are to (1) identify active guillemot sites in Kachemak Bay, southcentral Alaska; (2) determine growth rates, provisioning rates, and productivity of guillemots breeding in Kachemak Bay; (3) more accurately assess the effects of oil exposure on reproductive success and the growth and development of nestlings; (4) use blood samples from nestlings and adults to determine levels of acute blood phase proteins (i.e., haptoglobin, albumin, and methalione, which are indicative of damage), cytokines (i.e., IL-1 and IL-6), and liver enzymes (i.e., AST), and (5) generate risk assessments based on these biomarkers.

In 1995 we finished our second field season. The field crew, consisting of Alex Prichard and three undergraduate field assistants (Mike Litzow, Matt Kopec, and John Shook), conducted field work in Kachemak Bay from mid-May to mid-August 1995. Sixty-two active and accessible nests were located and monitored in 1994, and 87 were located and monitored in 1995.

In May a survey was conducted of the south shore of Kachemak Bay from Seldovia Bay to Bear Cove. Shoreline was surveyed from one hour before to one hour after high tide. A total of 557 birds were observed within 100 m of shore. Concentrations were observed in Seldovia Bay, Neptune Bay, China Poot Bay, Halibut Cove, Mallard Bay, and Bear Cove. The numbers observed suggest that populations are similar to 1978 estimates.

Colony attendance was recorded during foraging observations and will be analyzed to determine the effect of day, tide stage, location, and weather. This

will allow future surveys to be conducted at times of peak attendance to more accurately follow population level trends.

Nesting success in 1995 was calculated using the Mayfield method, which allows for different lengths of observations. Nesting success was 25.83% in 1995. Average clutch size was 1.8, giving a productivity of 0.465 fledglings/nest. This compares to 0.384 fledglings/nest for 1994. Low nesting success was due largely to predation and abandonment during incubation. Forty-four percent of eggs laid in 1995 hatched; 57% of chicks hatched survived to 30 days of age.

A controlled-dose experiment was conducted during 1995. Fifty-one chicks were separated into three groups. One group was fed sandlance containing 0.05 ml weathered Prudhoe Bay Crude Oil (PBCO), a second group was fed sandlance containing 0.2 ml PBCO, and a final group was given corn oil as a control. Blood samples were taken immediately before dosing at 20 and 25 days of age, and a third blood sample was taken at 30 days of age. Growth rates, provisioning rates, and blood indices will be compared between the three groups. Thirty chicks were collected at 30 days of age. CP-450 induction in the liver and lipid reserves will be compared between treatments.

Diet was similar between years, but large differences occurred among locations within Kachemak Bay. The proportion of sandlance in the diet varied from 82% in China Poot Bay to just 1.8% in southwestern Kachemak Bay (Figure 1). Schooling forage fishes such as sandlance and herring are high in energy but generally transient. Benthic fishes such as sculpin and gunnells are lower in energy but consistently available. Both sandlance and benthic species could be heavily impacted by subtidal oil contamination. Changes in forage fish species after an oil spill could have a major impact on nearshore ecosystems. Guillemots bring one fish at a time back to the nest and appear to feed opportunistically from the available fish species, so guillemot foraging should reflect changes in local conditions.

By quantifying biochemical effects of environmental contaminants on biomarkers in a sentinel species, an understanding of the ecological significance of sublethal doses of contaminants can be developed and biological impacts of future pollution can be more accurately assessed.

Seasonal Changes in Body Mass and Composition of Northern Red-backed Voles (*Clethrionomys rutilus*) in Interior Alaska

Student Investigator: Gerald L. Zuercher (M.S.)

Cooperator: Dr. Eric A. Rexstad, Institute of Arctic Biology, UAF

Funding Sources: President's Special Project Fund, University of Alaska Fairbanks; Multi-User Biological Equipment Grant, National Science Foundation

Editor's Note: Gerald Zuercher defended his thesis September 8, 1995, and graduated from the University of Alaska Fairbanks in December 1995. The thesis abstract follows.

Abstract—Northern red-backed voles (*Clethrionomys rutilus*) undergo a pronounced annual cycle in body mass: highest in summer, lowest in winter. I trapped voles throughout 1994 to determine how body composition and relative size of body components contributed to this cycle. Seasonal changes in body mass were primarily due to changes in body water and lean dry matter. Total body fat was low throughout the year, peaking in spring and early summer. Relative ash

Pigeon Guillemot Diet Kachemak Bay 1995

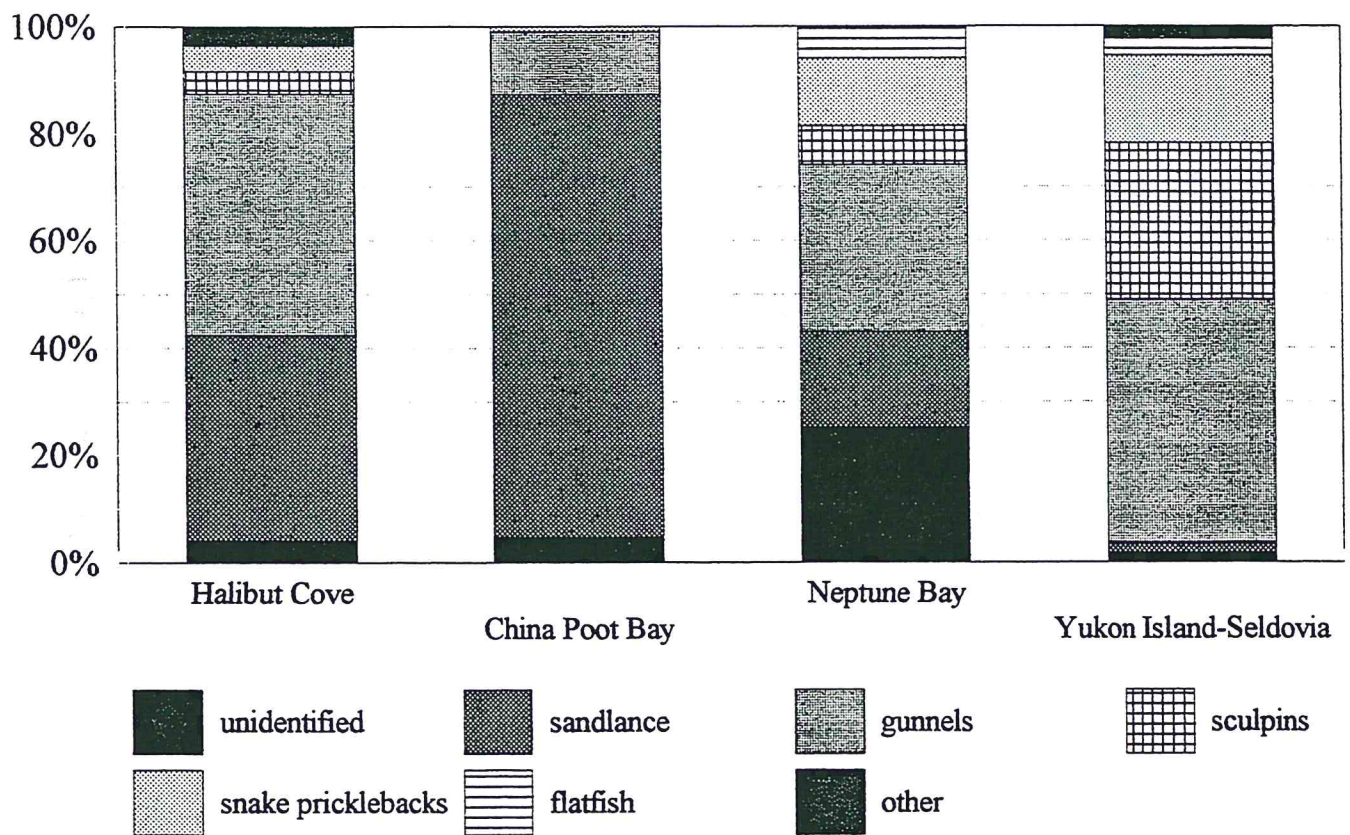


Figure 1. Variation in diet between locations.

content was lowest in early summer. Most body components declined in dry mass and percent water during autumn, with skeletomuscular components contributing most to loss of body mass. Most body components declined in proportion to declines in body mass, but a few components declined proportionally greater than or less than body mass. Total Body Electrical Conductivity (TOBEC) of live voles explained 94% of the variation in lean mass and body water, but accuracy of fat estimates was poor.

Roger Ruess

Interactions between Lesser Snow Geese and Forage Plants in Upper Cook Inlet

Student Investigator: Amy B. Zacheis (M.S.)

Cooperator: Dr. Jerry Hupp, Alaska Science Center, NBS

Funding Source: National Biological Service

Lesser snow geese (*Chen caerulescens caerulescens*) stage in Upper Cook Inlet (UCI) for about 3 weeks (mid-April to early May), feeding for 10 days to 2 weeks in Susitna Flats, and then move slowly southwest along the coast before heading north through the mountains. The National Biological Service (NBS) has initiated studies to assess the movements and habitat use of the snow geese, and to document the distribution and availability of plant communities used by the geese in the marshes. My part of this study will examine (a) the impact of geese foraging on the plant communities, (b) the changing nutritional and energetic value of potential forage species, and (c) differences in forage quality between plant species.

Questions to Be Addressed in This Study

Part I: Impacts of geese feeding on plant communities

What are the effects of herbivory on the aboveground biomass achieved at peak season, and on the nitrogen and carbon content of the plants? What is the effect of herbivory on species composition?

Part II: Forage quality

What is the relative nutritional value of five potential forage species (with value measured in terms of nonstructural carbohydrates, nitrogen, moisture, and fiber)? How do these parameters change following snow melt, and are snow geese in Susitna Flats at the time of highest quality forage?

Experimental Design

Part I: Impacts of geese feeding on plant communities

To address the question of how snow geese affect the plant communities of Susitna Flats, we set up study sites in summer 1994. One-hundred four pairs of 1-m x 1-m plots were arranged along 13 different transects. One plot randomly selected from each pair was the exclosure plot; the other acted as a control. Species composition and aerial cover were visually assessed for each pair to check for similarity as a basis for pairing.

A 25-cm x 25-cm quadrat was clipped from each plot in summer 1994. All live and standing dead biomass was cut at the ground level, sorted by species, dried and weighed for initial biomass measurements. In early April 1995, before the

snow geese arrived, the exclosed plots were surrounded by fences of rebar and wire. The fences were taken down 3 weeks later.

In early August 1995 (time of peak biomass), the aboveground biomass in another randomly chosen 25-cm x 25-cm quadrat in each plot was clipped. Aboveground material was sorted by species, dried, and will be weighed. Material will be analyzed for total carbon and total nitrogen using a LECO CNS autoanalyzer. These same procedures will be repeated in April and August of 1996.

Part II: Forage quality

To examine changes in the nutritional quality of potential forage species over time, and interspecific differences in these factors, we set up plots in stands of five different potential forage species: *Triglochin maritimum*, *Plantago maritima*, *Carex ramenskii*, *Carex lyngbyei*, and *Potentilla egedii*. The plots were 2 m x 1 m, and were replicated five times, with replicates separated by a minimum of 100 m.

In April 1995 we set up short fences around the plots as soon as the snow melted to protect them from herbivory. We sampled live biomass (emergent or overwinter shoots) at three different times: immediately after snow melt, and at each of two following 10-day intervals. The last sample was taken within a few weeks of green-up in May, after the geese had departed.

Samples have been analyzed for total carbon and total nitrogen on the LECO autoanalyzer. Samples will be analyzed for adf, ndf, and soluble carbohydrates at the University of Missouri Chemistry Laboratory.

Project Status

Part I of the study has been expanded for the 1996 field season. Additional long-term paired exclosure/control plots have been set up that are large enough for 5 years of clipping. Small paired exclosure/control plots have also been prepared that will be harvested in early May to give an estimate of offtake by the birds. And an additional experiment using captive birds has been designed and the plots set up. The purpose of this experiment is to separate the effects of herbivory and of defecation (fertilization) on the plant communities. Using the captive birds, plots will receive varying intensities of feeding and defecation. Plants will be harvested in August, separated by species, dried, weighed, and analyzed for total carbon and nitrogen.

Part II of the study is complete except for work at the Missouri Chemistry Laboratory. The data have not yet been analyzed.

Alan M. Springer

Marbled Murrelet Distribution and Abundance in Relation to the Marine Environment

Student Investigator: Suzann G. Speckman (M.S.)

Cooperator: John Lindell, USFWS

Funding Sources: Angus Gavin Migratory Bird Research Grant; U.S. Fish and Wildlife Service

Murrelets nest predominately on wide, moss-covered limbs in old-growth trees within 75 km of the sea; only about 3.1% of the Marbled Murrelets in Alaska are found outside the range of old-growth coniferous rainforest, from the Alaska Peninsula westward (Piatt 1992), and these birds probably nest on the ground.

Murrelets avoid predators by flying to and from their nests under cover of darkness. A technique has been developed that uses numbers of sightings and calls of murrelets in the forest before dawn to provide a relative index of forest and breeding activity (Ralph et al. 1994), but this technique cannot provide accurate numbers of Marbled Murrelets for census purposes. Therefore, population counts of murrelets and monitoring of trends in total abundance must be done at sea, where both breeding and non-breeding birds are easily visible during daylight hours.

Population estimates for the Marbled Murrelet in Alaska have ranged from "hundreds of thousands, to millions" to 320,000 (Piatt 1992). Alaskan populations are quite large compared to those of the western coastal states, but increasingly, Marbled Murrelets confront the additive effects of logging, oil drilling and transport, salmon mariculture, entanglement in gillnets, and at-sea disposal of mining effluents, placing additional pressures on murrelet populations.

Many biologists believe that murrelet numbers are declining in Alaska, but more information is needed to verify the status of the species. Counts of Marbled Murrelets in different parts of the state have been made, but methods have not been consistent. Survey periods are often weeks or months long, spanning 2 or more phases of the breeding cycle, and counts have been made during all daylight hours and at all tide stages. The variation among individual counts is high, between both days and years, and presently cannot be reconciled. The variability among these counts may be great enough to mask all but extreme changes in population numbers.

A clear need exists for censusing protocol that can be used to ensure comparability of data between observers, times, and areas. This study determines some of the factors affecting murrelet movements and abundance at sea so that censuses can be conducted in a standardized fashion and a program can be designed to monitor trends; accurate assessment of population trends will ensure that management decisions are timely and appropriate.

We surveyed Marbled Murrelets in Auke Bay and Fritz Cove, an area about 8 km long and 4-5 km wide, just north of Juneau, Alaska. Daily counts of murrelets were made from May 6–August 15 in 1992 and from May 12–August 13 in 1993, spanning the period from courtship through fledging of chicks. Boat surveys were initiated at 0600 along a transect line established 200 m from shore. All birds and mammals within 100 m of the boat were considered on transect, and everything beyond 100 m was counted as off transect. Shore-based tidal surveys were conducted approximately once a week on days of maximum and minimum tidal oscillation. Plots were established along the shores of Auke Bay and Fritz Cove, and numbers of murrelets were counted at low, rising, high, and falling tides from vantage points overlooking the water.

Murrelet numbers were highly variable in both years, ranging from a low of 41 to a high of 1650. Both years of the study were divided into two seasons, from May 6–May 31 for Season 1 and June 1–August 15 for Season 2. For both 1992 and 1993, counts of murrelets on transect and the total number of murrelets were highly correlated with tide height for Season 2, and neither count was correlated with tide height during Season 1 (Figure 1).

Marbled Murrelets gather in large numbers in nearshore areas each morning during the few hours following sunrise. In May, size of these morning flocks does not seem to be affected by the tide. Beginning in June and continuing at least through mid-August, which corresponds to the period when murrelets are laying eggs, incubating, and rearing chicks, correlation of morning flock size with tide height may be a result of increased feeding pressure as adults have to feed

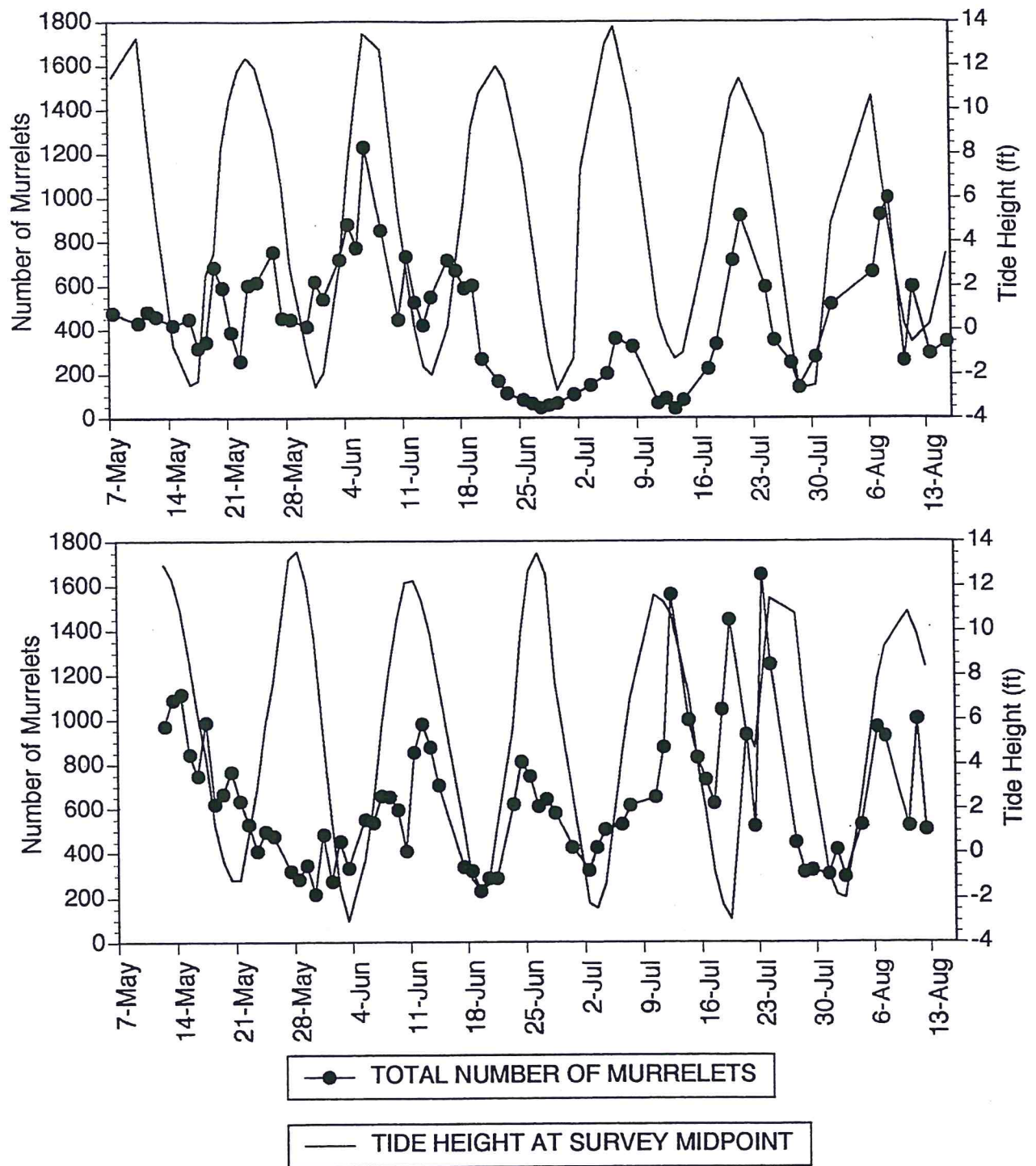


Figure 1. The total number of Marbled Murrelets in Auke Bay and Fritz Cove was highly correlated with tide height at the survey midpoint, from June 01 through the end of the summer for both 1992 and 1993. Surveys began at 0600 and lasted about 2 hours.

themselves and provide meals for chicks. Small schooling fishes and zooplankton can be concentrated by tidal currents, providing some areas with more dense prey concentrations than other areas, and murrelets may move between feeding areas as the tide changes to better exploit these ephemeral food patches.

The high variability between counts on both day-to-day and year-to-year scales has important implications for monitoring Marbled Murrelets. Shore-based tidal surveys indicate that murrelet numbers are highest during early morning, and gradually decline throughout the day. Counts made before 1300 are significantly higher than counts made after 1300. Numbers are also highest during high and falling tides, and lowest during low and rising tides. Variability among counts is inconsistent among times of day and tide stages, so that no time or tide is less variable than another. Variability between years is lowest from the beginning of May to mid-June. Surveying during periods of low variability would allow direct comparisons between counts to be made and simplify recognition of trends. Therefore, a preliminary recommendation of this study is for monitoring surveys of Marbled Murrelets to take place during May and the first part of June, from first light until 1300. Surveys should be made during high and falling tides. This way, numbers are maximized without an associated increase in variability.

The next phase of this analysis will be to calculate power curves for these surveys, in order to determine the number of surveys necessary to detect a certain percent change in population.

Piatt, J. F. 1992. Marbled Murrelet distribution in Alaska. Unpubl. report, U.S. Fish and Wildlife Service, Anchorage, AK. 9 pp.

Ralph, C. J., S. K. Nelson, M. M. Shaughnessy, S. L. Miller, and T. E. Hamer. 1994. Methods for surveying for Marbled Murrelets in forests: a protocol for land management and research. Unpubl. report, Pacific Seabird Group Marbled Murrelet Technical Committee.

Robert G. White

Nutritional and Ecological Determinants of Growth and Reproduction in Caribou

Student Investigator: Karen L. Gerhart (Ph.D.)

Funding Sources: Alaska Department of Fish and Game; U.S. Fish and Wildlife Service; Institute of Arctic Biology; and a National Science Foundation Graduate Fellowship

Editor's Note: Karen Gerhart graduated from the University of Alaska Fairbanks in December 1995. The thesis abstract follows.

Abstract—I investigated the mechanisms by which differences in body weight and body composition (fat, protein) of female caribou (*Rangifer tarandus granti*) from the Central Arctic and Porcupine herds might determine changes in pregnancy rate and calf growth. Allometric relations between chemical components and body weight variables were highly significant, despite tremendous seasonal changes in composition. Between October 1989 and May 1990, body fat and body protein of adult females of the Central Arctic Herd declined by maxima of 45 and 29%, respectively; an additional 32% of fat was lost by July. Extensive mobilization of fat and protein indicates winter

undernutrition. Marked hypertrophy of liver and kidneys in summer suggests the presence of metabolizable protein reserves. Birth weights of calves were similar between sexes, but male calves grew relatively faster during summer and were significantly heavier than females in autumn. Both fat content and growth rate of calves declined between 4 and 6 weeks post-calving, perhaps in response to insect harassment. Weight gains of wild calves were greatly reduced or absent after 100 d of age, while captive calves continued to grow until 175 d, suggesting that first-summer growth of caribou is determined in part by nutrient availability. Birth weight and growth rate of wild calves from birth to 3-4 weeks of age accounted for nearly 79% of the variability in autumn weights, again implying summer nutrient limitation. Female caribou were unable to entirely compensate for the metabolic and ecological costs of lactation: in autumn, lactating females had 42% less fat and 9% less protein than nonlactating females. Unlike females from the Central Arctic Herd, those from the Porcupine Herd did not demonstrate compensatory weight gains over summer; instead, autumn weight was highly correlated to June weight. Probability of pregnancy was positively correlated with body weight and fat content in early winter. Females that extended lactation into November were less fertile than predicted by body size or condition. I believe that these females were exhibiting lactational infertility.

Unit Communications

Scientific Publications

- Allaye Chan-McLeod, A. C., R. G. White, and D. E. Russell. 1995. Body mass and composition indices for female barren-ground caribou. *Journal of Wildlife Management* 59:278-291.
- Asch, A. and D. D. Roby. 1995. Some factors affecting precision of the total body electrical conductivity technique for measuring body composition in live birds. *Wilson Bulletin* 107(2):306-316.
- Bernard, D. R., K. R. Hepler, J. D. Jones, M. E. Whalen, and D. N. McBride. 1995. Some tests of the "migration hypothesis" for anadromous Dolly Varden (southern form). *Transactions of the American Fisheries Society* 124:297-307.
- Cameron, R. D. and D. B. Stone. 1995. To weigh or to mass? The question is in the balance. *Wildlife Society Bulletin* 23:109.
- Cameron, R. D., E. A. Lenart, D. J. Reed, K. R. Whitten, and W. T. Smith. 1995. Abundance and movements of caribou in the oilfield complex near Prudhoe Bay, Alaska. *Rangifer* 15(1):3-7.
- Flint, P. L., M. S. Lindberg, M. C. MacCluskie, and J. S. Sedinger. 1994. The adaptive significance of hatching synchrony of waterfowl eggs. *Wildfowl* 45:248-254.
- Flint, P. L., K. H. Pollock, D. Thomas, and J. S. Sedinger. 1995. Estimating prefledging survival: allowing for brood mixing and dependence among brood mates. *Journal of Wildlife Management* 59(3):448-455.
- Flint, P. L., J. S. Sedinger, and K. H. Pollock. 1995. Survival of juvenile black brant during brood rearing. *Journal of Wildlife Management* 59(3):455-463.
- Follmann, E. H. 1995. David Burnett Dunn, 1968-1994. *Wildlife Society Bulletin* 23:301-302.
- Hughes, N. F. and J. B. Reynolds. 1994. Why do Arctic grayling (*Thymallus arcticus*) get bigger as you go upstream? *Canadian Journal of Fisheries and Aquatic Sciences* 51(10):2154-2163.
- Joyce, L. A., J. R. Mills, L. S. Heath, A. D. McGuire, R. W. Haynes, and R. A. Birdsey. 1995. Forest sector impacts from changes in forest productivity under climate change. *Journal of Biogeography* 22:703-713.
- Kittel, T. G. F., N. A. Rosenbloom, T. H. Painter, D. S. Schimel, and VEMAP Modelling Participants (including A. D. McGuire). 1995. The VEMAP integrated database for modelling United States ecosystem/vegetation sensitivity to climate change. *Journal of Biogeography* 22:857-862.
- Klein, D. R. 1995. The introduction, increase, and demise of wolves on Coronation Island, Alaska. Pages 275-280 in L. N. Carbyn, S. H. Fritts, and D. R. Seip, eds. *Ecology and Conservation of Wolves in a Changing World*. Canadian Circumpolar Institute, Occasional Publication No. 35.
- Klein, D. R. and C. Bay. 1995. Digestibility of forage types by arctic hares. *Ecoscience* 2(1):100-102.
- LaPerriere, J. D. 1995. Riffle algal ecology of small streams during the rainy season: islands of Hawaii, Maui, and Oahu. *Tropical Ecology* 36(1):59-72.

- Lindberg, M. S., J. S. Sedinger, and E. A. Rexstad. 1995. Estimating nest site fidelity of adult female black brant with multi-state modeling and geographic information systems. *Journal of Applied Statistics* 22:725-735.
- McGuire, A. D., J. M. Melillo, and L. A. Joyce. 1995. The role of nitrogen in the response of forest net primary production to elevated atmospheric carbon dioxide. *Annual Review Ecological Systems* 26:473-503.
- McGuire, A. D., J. M. Melillo, D. W. Kicklighter, and L. A. Joyce. 1995. Equilibrium responses of soil carbon to climate change: Empirical and process-based estimates. *Journal of Biogeography* 22:785-796.
- Reynolds, J. B. 1995. Development and status of electric fishing as a scientific sampling technique. Pages 49-61 in G. T. Sakagawa, editor. *Assessment Methodologies and Management. Proceedings of the World Fisheries Congress, Theme 5*, Oxford & IBH Publishing Company, New Delhi.
- Reynolds, J. B. and A. L. Kolz. 1995. Comment: Reducing electrofishing-induced injury of rainbow trout. *North American Journal of Fisheries Management* 15:963-965.
- Sedinger, J. S., M. W. Eichholz, and P. L. Flint. 1995. Variation in brood behavior of black brant. *Condor* 97:107-115.
- Sedinger, J. S., P. L. Flint, and M. S. Lindberg. 1995. Environmental influence on life-history traits: Growth, survival, and fecundity in black brant (*Branta bernicla*). *Ecology* 76:2404-2414.
- Sedinger, J. S., R. G. White, and J. Hupp. 1995. Metabolizability and partitioning of energy and protein in green plants by yearling lesser snow geese. *Condor* 97:116-122.
- Smith, M. E., J. L. Hechtel, and E. H. Follmann. 1994. Black bear denning ecology in interior Alaska. *International Conference on Bear Research and Management* 9(1):513-522.
- Syroechkovskii, E. E. and D. R. Klein, Scientific Editor. 1995. *Wild Reindeer*. Oxonian Press, New Delhi. 290 pp.
- VEMAP Members (Melillo, J. M., J. Borchers, J. Chaney, H. Fisher, S. Fox, A. Haxeltine, A. Janetos, D. W. Kicklighter, T. G. F. Kittel, A. D. McGuire, et al.). 1995. Vegetation/Ecosystem Modeling and Analysis Project: Comparing biogeography and biogeochemistry models in a continental-scale study of terrestrial ecosystem responses to climate change and CO₂ doubling. *Global Biogeochemical Cycles* 9(4):407-437.
- Ward, D. H. and P. L. Flint. 1995. Effects of harness-attached transmitters on premigration and reproduction of brant. *Journal of Wildlife Management* 59:39-46.

Theses

- Brink, S. R. 1995. Summer habitat ecology of rainbow trout in the middle fork of the Gulkana River, Alaska. M.S. thesis, University of Alaska Fairbanks. 158 pp.
- Cappiello, T. A. 1995. Spawning run characteristics of Dolly Varden in the Kugururok River, Noatak drainage, Alaska. M.S. thesis, University of Alaska Fairbanks. 85 pp.
- Furtsch, P. R. 1995. Techniques for monitoring density and correlates of inter-annual variation for northern red-backed voles (*Clethrionomys rutilus*) in

- Denali National Park and Preserve, Alaska. M.S. thesis, University of Alaska Fairbanks. 131 pp.
- Gerhart, K. L. 1995. Nutritional and ecological determinants of growth and reproduction in caribou. Ph.D. thesis, University of Alaska Fairbanks. 147 pp.
- Lance, E. W. 1995. Phylogeographic variation and the Island Syndrome in Holarctic tundra voles (*Microtus oeconomus*). M.S. thesis, University of Alaska Fairbanks. 83 pp.
- Lubinski, B. R. 1995. Winter habitat of Arctic grayling in an interior Alaska stream. M.S. thesis, University of Alaska Fairbanks. 143 pp.
- Merritt, M. F. 1995. Application of decision analysis in the evaluation of recreational fishery management problems. Ph.D. thesis, University of Alaska Fairbanks. 183 pp.
- Perham, C. J. 1995. Home range, habitat selection, and movements of lynx (*Lynx canadensis*) in eastern interior Alaska. M.S. thesis, University of Alaska Fairbanks. 139 pp.
- Post, E. S. 1995. Comparative foraging ecology and social dynamics of caribou (*Rangifer tarandus*). Ph.D. thesis, University of Alaska Fairbanks. 169 pp.
- Selinger, J. S. 1995. Seasonal habitat relationships of adult female deer on Kodiak Island, Alaska. M.S. thesis, University of Alaska Fairbanks. 49 pp.
- Zuercher, G. L. 1995. Seasonal changes in body mass and composition of northern red-backed voles (*Clethrionomys rutilus*) in interior Alaska. M.S. thesis, University of Alaska Fairbanks. 127 pp.

Reports

- Berger, M. 1995. Reindeer range assessments on the Yukon Delta National Wildlife Refuge, summer 1995. Final report to the Koyukuk/Nowitna National Wildlife Refuge, U.S. Fish and Wildlife Service. 7 pp.
- Daigneault, M. J., B. D. Peterson, and J. B. Reynolds. 1995. Relation of the Chena River Lakes Flood Control Project to outmigration and abundance of juvenile salmonids. Progress Report to the U.S. Army Corps of Engineers. 34 pp.
- Klein, D. R. 1995. Tundra or arctic hares. Page 359 in *Our Living Resources*. National Biological Service, U.S. Department of the Interior.
- Lance, B. K. and D. D. Roby. 1995. Adaptive significance of lampfish diets for reproduction in red-legged kittiwakes. *Pacific Seabirds* 22(1):36.
- Lance, E. W. and J. A. Cook. 1995. Status report on the Montague Island tundra vole (*Microtus oeconomus elymocetes*), a Category II species. Final report to the U.S. Fish and Wildlife Service. 49 pp.
- McGuire, A. D. and L. A. Joyce. 1995. Responses of net primary production to changes in CO₂ and climate. Pages 9-45 in L. A. Joyce, ed. *Productivity of America's Forests and Climate Change*. General Technical Report RM-271, U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Ft. Collins, Colorado.
- Reynolds, J. B. 1994. Effects of jet-driven and propeller-driven boat turbulence in salmonid reproduction in Alaskan streams. Final report to the National Park Service. 9 pp.

- Reynolds, J. B., T. A. Cappiello, and R. F. Foy. 1995. Spawning run characteristics of Dolly Varden in the Kugururok River, Noatak drainage, Alaska. Annual progress report to the National Park Service. 17 pp.
- Reynolds, J. B., T. C. Stark, S. R. Brink, and J. F. Spielman. 1994. Progress during 1994, analysis of habitats and habitat requirements for young rainbow trout and steelhead in the Gulkana River, Alaska. Annual progress report to the Bureau of Land Management, Agreement No. AK-1422L974-A2-0034. 26 pp.
- Xiao, X., D. W. Kicklighter, J. M. Melillo, A. D. McGuire, P. H. Stone, and A. P. Sokolov. 1995. Responses of primary production and total carbon storage to changes in climate and atmospheric CO₂ concentration. MIT Joint Program on the Science and Policy of Global Change, Report 3, Massachusetts Institute of Technology. 20 pp.

Papers Presented

- Ben-David, M. September 1995. Seasonal diets of coastal and riverine mink in southeast Alaska. Forty-sixth Arctic Division Science Conference, American Association for the Advancement of Science, Fairbanks, Alaska.
- Bowyer, R. T. and D. D. Roby. August 1995. Reconciling density-dependent and density-independent regulation in populations of northern ungulates. Second International Arctic Ungulate Conference, Fairbanks, Alaska.
- Daigneault, M. November 1995. General health and condition of outmigrating juvenile chinook and chum salmon near the Chena River flood control dam. 18th Annual Smolt Workshop, Oregon State University, Corvallis, OR.
- Finn, J. E., E. E. Knudsen, C. V. Burger, and L. Holland-Bartels. November 1995. Separation of sockeye salmon (*Oncorhynchus nerka*) fry based on otolith elemental composition. 22nd Annual Meeting, Alaska Chapter, American Fisheries Society, Wasilla, AK.
- Flynn, R. L. and M. Ben-David. August 1995. Diet and reproductive performance in *Martes americana*. Marten Symposium, Edmonton, Alberta, Canada.
- Hander, R. November 1995. Spawning habitat and capacity for coho salmon in the Ayakulik River, Kodiak National Wildlife Refuge. 22nd Annual Meeting, Alaska Chapter, American Fisheries Society, Wasilla, AK.
- Hansen, M. and D. R. Klein. August 1995. Seasonal dietary composition and nutrient intake of free-ranging adult Dall sheep. Second International Arctic Ungulate Conference, Fairbanks, Alaska.
- Hayes, D. L., A. K. Prichard, G. M. Blundell, and D. D. Roby. November 1995. Diet and productivity of pigeon guillemots. Joint Conference of the Colonial Waterbird Society and the Pacific Seabird Group, Victoria, British Columbia.
- Hupp, J., R. G. White, J. S. Sedinger, and D. Robertson. January 1995. Retention time of forage intake and fecal output in lesser snow geese. Eighth North American Arctic Goose Conference, Albuquerque, New Mexico.
- Ihl, C. and D. R. Klein. August 1995. Interactions between muskoxen and reindeer on the Seward Peninsula/western Alaska. Second International Arctic Ungulate Conference, Fairbanks, Alaska.
- Kildaw, D. November 1995. Nest site preferences of red-legged and black-legged kittiwakes on St. George Island, Alaska. Joint Conference of the Colonial Waterbird Society and the Pacific Seabird Group, Victoria, British Columbia.

- Klein, D. R. February 1995. Caribou in the Alaskan Arctic. Wild Alaska--A Threatened Legacy, Washington, D.C.
- Klein, D. R. August 1995. Ecological constraints on ungulates in the High Arctic. Second International Arctic Ungulate Conference, Fairbanks, Alaska.
- Klein, D. R. September 1995. Large mammals in the changing northern landscape. Forty-sixth Arctic Division Science Conference, American Association for the Advancement of Science, Fairbanks, Alaska.
- Klein, D. R. September 1995. The arctic tundra and its resources. EuroMAB V Conference, Kangerlussuaq, Greenland.
- Klein, D. R. and P. Valkenburg. August 1995. Effects of summer weather variables on leaves of *Salix pulchra* as forage for caribou. Second International Arctic Ungulate Conference, Fairbanks, Alaska.
- Lance, B. K. and D. D. Roby. January 1995. Adaptive significance of lampfish diets for reproduction in red-legged kittiwakes. Twenty-second annual meeting, Pacific Seabird Group, San Diego, California.
- LaPerriere, J. D. November 1995. Influences on light penetration and Secchi depth in Alaska lakes. NALMS 95, 15th International Symposium on Lake, Reservoir and Watershed Management, North American Lake Management Society, Toronto, Ontario.
- Lenart, E., J. M. Ver Hoef, and R. T. Bowyer. August 1995. Effects of summer weather on forage productivity and nutrition for caribou. Second International Arctic Ungulate Conference, Fairbanks, Alaska.
- Lindberg, M. January 1995. Bird site fidelity of adult female black brant, Tutakoke River, Alaska. Eighth North American Arctic Goose Conference, Albuquerque, New Mexico.
- Lindberg, M., J. Sedinger, and E. Rexstad. September 1995. Multistate models of factors affecting nest-site fidelity in black brant. Second Annual Conference of the Wildlife Society, Portland, Oregon.
- MacCluskie, M. and J. Sedinger. September 1995. Nutrient reserve dynamics of northern shovelers breeding in interior Alaska. Second Annual Conference of the Wildlife Society, Portland, Oregon.
- Maier, J., H. Maier, and R. G. White. August 1995. Effects of cold weather on radiocollar activity. Second International Arctic Ungulate Conference, Fairbanks, Alaska.
- Maier, J. and R. G. White. August 1995. Effects of ecological factors on activity patterns of caribou: implications for management. Second International Arctic Ungulate Conference, Fairbanks, Alaska.
- McGuire, A. D. September 1995. The responses of net primary production (NPP) and total carbon storage for the continental United States in atmospheric CO₂, climate, and changing vegetation. Forty-sixth Arctic Division Science Conference, American Association for the Advancement of Science, Fairbanks, Alaska.
- McGuire, A. D. September 1995. The role of the nitrogen cycle in the global response of net primary production and carbon storage to double atmospheric carbon dioxide. Global Analysis, Interpretation, and Modelling (GAIM) Science Conference, Garmisch-Partenkirchen, Germany.
- Mörschel, F. August 1995. The role of weather and parasitic insects in the summer ecology of the Delta Caribou Herd. Second International Arctic Ungulate Conference, Fairbanks, Alaska.

- Peterson, B. and M. Daigneault. November 1995. The relationship of the Chena River Lakes Flood Control Dam to the outmigration of juvenile salmon. 22nd Annual Meeting, Alaska Chapter, American Fisheries Society, Wasilla, AK.
- Post, E. and D. R. Klein. August 1995. Range ecology of a food-limited caribou herd in Alaska. Second International Arctic Ungulate Conference, Fairbanks, Alaska.
- Sedinger, J. S. January 1995. Environmental conditions during the growth period influence future fitness in geese. Eighth North American Arctic Goose Conference, Albuquerque, New Mexico.
- Sheffield, G. December 1995. Digestive bias and a reanalysis of walrus feeding data. Annual Meeting, Society of Marine Mammalogy, Orlando, FL.
- Simpson, T. and J. D. LaPerriere. November 1995. Lake productivity indices as estimators of carrying capacity of burbot and northern pike in interior Alaska. NALMS 95, 15th International Symposium on Lake, Reservoir and Watershed Management, North American Lake Management Society, Toronto, Ontario.
- Tae, K. and D. Mann. September 1995. Processes controlling Sitka spruce distribution and range expansion on Kodiak Island. Forty-sixth Arctic Division Science Conference, American Association for the Advancement of Science, Fairbanks, Alaska.
- Ward, D., E. Rexstad, J. Sedinger, and N. Dowe. January 1995. Seasonal and annual survival of adult black brant. Eighth North American Arctic Goose Conference, Albuquerque, New Mexico.
- White, R. G., K. Gerhart, D. Van DeWetering, and D. E. Russell. August 1995. Milk composition during late lactation: a tool for the diagnosis of lactational infertility in caribou. Second International Arctic Ungulate Conference, Fairbanks, Alaska.
- Zuercher, G., D. D. Roby, and E. Rexstad. September 1995. Validation of two new Total Body Electrical Conductivity (TOBEC) instruments for estimating body composition of northern red-backed voles. Forty-sixth Arctic Division Science Conference, American Association for the Advancement of Science, Fairbanks, Alaska.

Unit Honors and Awards

Klein, David. Senior Scientist. August 1995. Commendation by the Fairbanks Convention and Visitors Bureau for his efforts as conference organizer of the Second International Arctic Ungulate Conference. The Institute of Arctic Biology and the Alaska Cooperative Fish and Wildlife Research Unit received the Bureau's "Meeting of the Month" award.

Klein, David. Senior Scientist. August 1995. Special Performance Award, Division of Cooperative Research, National Biological Service.

Reynolds, James. Unit Leader. November 1995. Length-of-Service Award in recognition of 30 years of service to the U.S. government.

Reynolds, James. Unit Leader. August 1995. Special Performance Award, Division of Cooperative Research, National Biological Service.

Roby, Daniel. Assistant Leader Wildlife. August 1995. Special Performance Award, Division of Cooperative Research, National Biological Service.

