

1998 ANNUAL REPORT of the WILDLIFE ECOLOGY RESEARCH CHAIR

Dr. Fred Cooke
Senior Chair, Wildlife Ecology
Simon Fraser University

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I. INTRODUCTION.....	3
II. THE CHAIR IN ACTION.....	11
A. SPECIFIC PROJECTS	11
1. The Population Dynamics of Western Sandpiper	11
i. Breeding Studies (Alaska)	11
ii. Migration Studies	12
iii. Wintering Ground Studies	12
2. Winter Ecology of Dunlin	13
3. Physiological ecology of reproduction and migration.....	13
i. Breeding studies.....	14
ii. Migration studies	16
iii. Diving and foraging behaviour of seaducks	18
4. Riske Creek Project.....	19
5. The Triangle Island Project.....	20
6. Winter and Spring Population Ecology of Brant in the Georgia Basin.....	22
7. Population Studies of Harlequin Ducks	22
i. Wintering and Moulting Areas Studies	22
ii. Breeding Ground Studies.....	23
8. Winter Studies of Grebes	24
9. Population Status of Marbled Murrelets	24
10. Demographic Models	26
B. OTHER INITIATIVES.....	28
C. COMMUNITY INVOLVEMENT.....	30
D. FUNDING	31
1. Research Funding Obtained (1997).....	32
2. Research Funding Obtained * or Applied For (1998).....	35
E. PUBLICATIONS.....	38
1. Papers published in refereed journals.....	38
2. Papers submitted to refereed journals.....	41
3. Book chapters, conference proceedings and other publications	41
4. Theses	43
F. PERSONNEL	44
1. Board of Directors	44
2. Research Team	44
i. Faculty and Research Associates.....	44
ii. Research Group	44
III. APPENDIX I. MISSION STATEMENT (JANUARY 1995 - F. COOKE)	45
A. CONSERVATION GOALS, THE CWS PERSPECTIVE	46
1. Habitats	46
2. Bird Species	46

3. Integrated Population Approach.....	49
i. Population Ecology.....	50
ii. Behavioural Ecology	50
iii. Physiological Ecology	51
B. ACADEMIC GOALS, THE <i>SFU</i> PERSPECTIVE	52
1. Population Ecology	52
2. Behavioural Ecology	53
3. Physiological Ecology.....	54
4. General Points	55

I. INTRODUCTION

The aim of this Annual Report is to:

- i) give an overview of our activities since the last report
- ii) outline the progress on new and continuing projects
- iii) describe the personnel involved
- iv) give some indicators of our scientific and community involvement.

We have now completed the first 5 years of the Chair, and are embarking on the next five years. Perhaps the most significant event of the year has been the approval in principle by NSERC, CWS and SFU for the continuing support for the Chair program for a further five years. The final agreements are currently being prepared and once signed will assure the continuation of our program at least until the year 2003. This is a major milestone and we are extremely pleased with the comments we have received from the contributing organisations about our program.

The first year was mainly one of planning the program, defining the objectives and establishing some of the research projects. In the second year, we put into place most of the field research projects. Our third year saw a major increase in our funding through the successful acquisition of two grants from Forest Renewal British Columbia (FRBC), through the Science Council of BC. We also saw a great increase in our data base from the long term projects started earlier and a large surge in the publication of results. This increase has continued and we have also fledged our first graduate students for the program. Eric Reed became our first MSc student to graduate, with his successful defence of his research on the migration patterns and philopatry of Black Brant. He was followed by Brian Carter, who worked on winter feeding of Trumpeter Swans; Debbie van de Wetering, of the CWS office in Whitehorse who carried out a study of the moulting ecology of Barrow's Goldeneye; Andrea McCharles for her work on the feeding ecology of Eiders; Oliver Egeler for his work on the migration physiology of Western Sandpipers and Sean Cullen who studied Eared Grebe dispersal patterns. Brett Sandercock became our first successful PhD student as a result of his breeding ground studies of Western Sandpipers. He now is carrying out post-doctoral work at UC Berkeley on neotropical Parrotlet demography. Greg Robertson was our second PhD

student to graduate when he successfully defended his thesis work on winter ecology of Harlequin Ducks. This thesis was the first ever to our knowledge to have been carried out on this species. Greg has now gone on to post-doctoral work at ACWERN, our sister institution in the east. He also has associate status at the CWS office in St. John's Newfoundland. We should also mention Malcolm Coupe, who carried out an imaginative study on wintering Mergansers as an undergraduate thesis topic, which he successfully defended. Congratulations to all of them and also good luck to Hugh Knechtel, Laura Jones, Brett Vanderkist and James Clowater who are likely to defend in the next 6 months.

We have more than fifty people working in the Chair program at the time of writing. Some are permanent staff, others working on summer field projects. At present there were four continuing field stations; Riske Creek, Triangle Island, Theodosia Inlet and in the Bunster Range. We also continue to examine populations of Western Sandpipers in various parts of their breeding and wintering range.

Barbara Sherman continues to keep track of them all and also keeps our budget balanced. Without her skills, we would surely be buried in a morass of paperwork.

Another milestone was the promotion of the Associate Chair Tony Williams to the rank of Associate Professor. Tony has already had considerable impact on the academic life of Simon Fraser University and his promotion is a recognition of his strength. In addition NSERC acknowledged the importance of his role by offering to contribute to his salary for the second five years of the program.

Wendy Beauchamp who coordinated our Marbled Murrelet program for two years and placed the data collection and analysis on a firm foundation left us in April 1997. Lynn Loughheed has been in charge of logistic arrangements of the project since that time. Dov Lank assumed temporary responsibility for maintaining the project, and we are on the point of hiring a post-doctoral fellow, Cindy Hull, who will be overseeing the scientific program. We wish Wendy well in her future endeavours.

Our research projects can be grouped into eight categories. These categories are:

1) The research program on Triangle Island was established in 1994 when a small research facility was erected on the Ecological Reserve, with the approval of the BC Ministry of Environment, Lands and Parks. We are now in our fifth field season. Data have been collected on the demography, physiology and behaviour of most of the key sea bird species on the island. Doug Bertram is coordinating the project and placing increased emphasis on the use of feeding studies and attention to the behaviour of individuals to understanding population processes. Strong linkages have also been formed with DFO fisheries scientists and oceanographers to understand how climate induced changes in the marine prey base affect upper trophic level predators. The Triangle Island research is part of a NOAA funded study of the effects of the 1997-1998 El Nino on North Pacific seabird populations with collaborators in California, Washington and Alaska. In 1996 Mike Wiley and Laura Cowen acted as joint field managers and in 1997 and 1998 John Ryder has been in charge of the station. Hugh Knechtel continued his MSc thesis on Cassin's Auklets, Laura Jones worked on parent offspring interactions in Rhinoceros Auklets in 1996 and 1997, and in 1998 Louise Blight began her MSc program on the island examining the effects of rodent predation on sea bird productivity. Carina Gjerdrum will begin an MSc in the fall of 1998. Scientists attracted to the Island through the RNP program, Julia Parrish from the University of Washington and Colleen Cassady St Clair from the University of Alberta, continued in 1996 with their work on Common Murres and Tufted Puffins respectively. Since then our own crew has continued to investigate the causes and consequences of variation in breeding performance under the able direction of Doug Bertram.

2) The research network on Western Sandpipers is now well established under the coordination of Dov Lank. The work is funded mainly from NSERC operating grants and the Latin American Program of CWS. Our projects extend from Nome, Alaska to Chitre, Panama where PhD student Patrick O'Hara is working with Francisco Delgado and his students. Other researchers involved in this work include: Bob Elner and Rob Butler of CWS and Ron Ydenberg of SFU, working in the Fraser Delta and collaborating with Ben Haase in Equador; Colin Clark of UBC working on modeling life history decisions; Horacio de la Cueva and four of his MSc students, together with our former post-doc Nils Warnock, at CICESE, in Ensenada, Baja California, Mexico. Contingent on Mexican

funding decisions, one of the CICESE Masters' students will start as a PhD student in fall 1998.

3) Marbled Murrelet research continued at Desolation Sound under the leadership of Doug Bertram of the Chair and Gary Kaiser of CWS. Funding is provided by FRBC, a consortium of 5 forest companies (MacMillan Bloedel, Timber West, Pacific Forest Products, Interfor and Western Forest Products) and a CRD grant from NSERC. The work on this summering population is planned to continue for several more years which will allow us to carry out the first demographic and reproductive physiology study of this elusive species. We have two field camps, one in the old growth forests of the Bunster Range above Powell River and the other nearby at Theodosia Inlet near Desolation Sound. Wendy Beauchamp was coordinator of the project in 1995 and 1996. In 1997 Lynn Lougheed coordinated the field work at Theodosia Inlet and Irene Manley organised the forest field work as well as conducting research for her MSc under the direction of Alton Harestad.

4) Work continues on several bird populations which winter in South Western BC. This has been possible through funds provided by the BC Waterfowl Society, Ducks Unlimited, Pacific Coast Joint Venture, the Georgia Basin Initiative of CWS and the Fraser River Action Plan. Brian Carter has completed his work on the feeding behaviour of wintering Trumpeter Swans on Westham Island. Eric Reed completed his work on migrant and winter resident populations of Brant geese, and has provided much useful information relevant to the management of this species in the region. Recently we have received funds from the Arctic Goose Joint Venture (AGJV) to continue an investigation of this species in collaboration with Sean Boyd and Rick McKelvey. James Clowater has completed his field work on Western Grebes in Saanich Inlet. His discovery of nocturnal feeding during the winter represents a major break through in our understanding of this species. Bonnie Stout was accepted as a PhD student in the fall of 1997 and started work on grebes, concentrating on winter behaviour of Horned and Red-necked Grebes. She also collaborated with Jim Hines from the CWS office in NWT on a study of breeding grebes near Yellowknife, NWT. Stephanie Hazlitt has been working on the breeding biology of Black Oyster-catchers under the supervision on Rob Butler (CWS). Ross

Vennesland has recently started working on the nesting ecology of Great-blue Herons, also under the direction of Rob Butler.

Pippa Shepherd continues her work with Dunlin, and Leslie Ogden Evans started with us as a PhD student in 1997. Both students are investigating behavioural decision-making, the importance of coastal agriculture to the over-wintering success of this species, and the potential effects of changes in farming practices, including a shift from open field agriculture to greenhouse development. The work has and is being funded by private and public interests, including: the Fraser River Action Plan, Agriculture Canada, the Delta Farmland and Wildlife Trust, CWS, the Boundary Bay Conservation Commission, and Wildlife Habitat Canada.

Work on Barrow's Goldeneye continues, with Debbie van de Wetering's moult study in the Yukon linking in with the breeding and wintering studies which Sean Boyd and Saul Schneider of CWS have been conducting. This project also is closely linked to the Goldeneye studies at Riske Creek (see below). Malcolm Coupe carried out extensive field work on the pairing and winter ecology of the three species of mergansers in the Lower Mainland. he carried out this work in conjunction with behavioural studies on Red-breasted Mergansers which was the focus of Johnny Kahlert, a sabbatical visitor from the National Environmental Research Institute in Ronde, Denmark. We continued to collect information on individually neck collared Snow Geese as part of the broader understanding of the structure of wintering populations in western North America. These data were analysed by Evan Cooch and Bart Ebbinge, a sabbatical visitor and leading goose biologist from the Institute of Forestry and Nature Research, Netherlands.

5) What started as a relatively small scale study of one of the wintering waterbirds, the Harlequin Duck, has expanded into a much larger scale project. The aim is to provide the most detailed analysis yet of the life history and population structure of a sea duck and is possible because this species is relatively accessible at all stages of the life cycle. With a demographic focus, the study allows population trends to be assessed, and means and variances of most of the major components of the life history measured, with the long term goal of relating population trends to environmental change. In coordination with Ian

Goudie and members of the Harlequin Duck Conservation Society, we hope to make this one of the most detailed population studies of a sea duck ever carried out. Cyndi Smith's MSc project on the breeding population of Harlequin Ducks at the Banff National Park provides information on the breeding and post-breeding stage of the life cycle, while Greg Robertson's winter study, which was completed in 1997, is now being extended by Mike Rodway and Heidi Regehr, two new PhD students who will be concentrating on the wintering populations at Hornby Island and Boundary Bay. Roxana Torres, a post-doctoral student from University of Mexico carried out extensive studies on the fitness costs of winter feeding of paired and unpaired Harlequin Ducks.

6) Evan Cooch coordinates the statistical and modelling section of the Chair. He has pioneered the wider comprehension of computer based population models through workshops, courses and more recently, handbooks, in conjunction with the authors of the models themselves. This has put our group in the forefront of the field dedicated to making the measurement of survival and other hard-to-quantify life history traits a practical reality in field studies. Evan continues to develop mathematical models of more widespread interest to ecologists. He is focusing in particular on (i) methods for partitioning population stability into component demographic elements, and (ii) estimation of turnover rates on migration stopover sites. These efforts will undoubtedly impact some of our thinking in various field projects.

7) The Riske Creek Project, a joint one with Kathy Martin and Sean Boyd of CWS, is now well established, mainly under the sponsorship of Forest Renewal BC, and co-ordinated by Dov Lank. The project relies on a mix of community, population and behavioural ecology to understand the long term population dynamics of several bird species in the face of environment changes brought about by changing land use practices, particularly those resulting from the effects of logging and grazing on riparian habitats. Kathy Martin's research has focused on all cavity nesting species of birds and mammals, while that of the Chair and Sean Boyd has been to concentrate on waterbirds, particularly those which nest in cavities, such as Barrow's Goldeneye and Bufflehead, but also ground nesting species, such as Lesser Scaup, Green-winged Teal and Eared Grebes. Matthew Evans is in his second year of a study of the cavity nesting ducks (Barrow's Goldeneye

and Bufflehead, and Brent Gurd began his PhD project in 1997 on the effects of changing water regimes and riparian habitats on the community of waterfowl species in the area. Sean Cullen completed his field studies of the Eared Grebes in 1996.

8) The physiological ecology component of the Chair is under the direction of Tony Williams. Christopher Guglielmo and Oliver Egeler are investigating physiological aspects of protein and lipid utilisation, respectively, in migrating shorebirds, and Oliver successfully defended his MSc thesis in April 1998. This work will be continued in the next two years by Rob Stein, a new MSc student, who will focus on the impact of age-specific digestive physiology on foraging and habitat requirement. Julian Christians is continuing his work on physiological variability in reproductive effort and two new students, Francois Vezina (PhD) and Katrina Salvante (MSc) will be joining this research group in Fall 1998. In addition, Erinn Birmingham will be starting an MSc project in 1999, funded by Environment Canada, integrating reproductive physiology with impacts of endocrine-disrupting chemicals. Brett Vanderkist started as an MSc student in Fall 1996 expanding our work on the reproductive endocrinology and molecular biology of marbled murrelets. Finally, Kirsty Bennett (co-supervised by Dr Leah Bendell-Young) has been applying physiological techniques to assess ecosystem health as part of the Alberta Oilsands reclamation project. In addition to these specific graduate projects, the establishment of this analytical facility has allowed a physiological (functional) component to be added to many of the other Chair projects, e.g. application of a novel molecular sexing technique, and improved indicators of body condition, now being used on Triangle Island and in the Marbled Murrelet project.

Because of widespread budgets cuts in Environment Canada, the Research Network Program of the Chair had to be curtailed. Despite this, some residual funding in the program was available to continue the most important of our external programs in 1996-97. We were thus able to extend the following research programs.

<i>Senior Advisor (Affiliation)</i>	<i>Research Network Funding Proposal</i>	<i>Funding Amount</i>
N. Haunerland (SFU)	Flight Muscle Conditioning in Migratory Western Sandpipers: The Role of Fatty Acid Binding Protein	\$8,230.00
H. de la Cueva Saleda (CICESE)	Overwinter Ecology of Western Sandpipers at the Estero de Puenta Banda, Ensenada, Baja, California, Mexico	\$5,000.00
L.W. Oring (Univ. of Nevada, Reno)	Biomechanics of Feeding in Calidrid Sandpipers: What Constitutes Prey?	\$13,185.00
F.S. Delgado (Univ. of Panama)	Summer Residency of Western Sandpipers in Panama	\$13,550.00
M.A. Bishop (U. of Washington & Copper River Delta Inst.) & Nils Warnock (SFU & Univ. of Reno)	Conservation of Western Sandpipers Along the Pacific Flyway	\$6,000.00
A.E. Burger (Univ. of Victoria)	Foraging Ecology of Alcids off Southwestern Vancouver Island	\$6,100.00
J. Parrish (Univ. of Washington)	The Use of Decoys to manipulate Behavior: Common Murres on Triangle Island	\$7,500.00
R.C. Ydenberg (SFU)	Breeding Ecology of Harlequin Ducks in Jasper National Park	\$7,600.00
C. Cassady St. Clair (U. of Alberta)	Factors Limiting the Reproductive Success of Tufted Puffins on Triangle Island	\$5,000.00
R. Butler (SFU)	Territory and Quality in the Black Oystercatcher (<i>haematopus bachmani</i>) in the Strait of Georgia, British Columbia	\$8,800.00

II. THE CHAIR IN ACTION

A. Specific Projects

We have made no attempt to prioritize the projects below. They are presented to give an account of the major initiatives started to date.

1. The Population Dynamics of Western Sandpiper

The multifaceted study of Western Sandpiper continues to flourish. The broadest objective of this study is to provide an understanding of the factors controlling the population of this long-distance, neotropical migrant, which occupies several locations during its annual cycle. Important questions relate to the factors influencing the species in each of these locations and how migration events fit into the events which occur at the various locations. Of conservation concern is the consequence of the removal or deterioration of one or more of these habitats on the survival and reproduction of the species. Events in the wintering grounds may affect migration and breeding events. We have chosen one breeding area, several migration locations and two wintering sites.

i. Breeding Studies (Alaska)

We are examining the long term breeding performance of Western and Semipalmated Sandpipers, two closely related species. The fourth and fifth field seasons at Safety Sound, near Nome, Alaska were completed. Following Brett Sandercock's completion of his PhD work in 1996, students have continued field work under Dov Lank's direction. An MSc student working under Doug Schamel at the University of Alaska, who is himself a PhD student in the Chair, will ensure that basic reproductive data will be gathered for several more years. In association with his PhD thesis work, Doug Schamel has gathered 3 year's breeding data on Western and Semipalmated Sandpipers breeding at Cape Estenberg, on the north side of the Seward peninsula, which has produced intriguing contrasts with the data from Nome. Birds marked at Nome have been relocated in Boundary Bay, Ensenada, Mexico and at our wintering field site in Panama. Brett Sandercock's recently completed thesis and published papers give a thorough account of the variation in reproduction and survival in these two species over the four year period.

ii. Migration Studies

We have played an active role through collaboration with Nils Warnock and Mary-Ann Bishop in examining the variability of individuals in terms of migratory patterns. Individual birds were followed to various migratory stop-over sites. This provided valuable data for testing the importance of wind directions and speeds on migratory decisions. In the Vancouver area, banding continues at Sydney Island and Boundary Bay, in the Lower Mainland, with intriguing results. Migrant sandpipers of 3 species and all age/gender classes are substantially heavier on the Mainland. We are examining possible proximal explanations for this difference.

iii. Wintering Ground Studies

a) Ensenada, Mexico. Guillermo Fernandez continued to study the wintering population ecology of Western Sandpipers in the winter of 1996/97, under the direction Horacio de la Cueva. Resighting, but little banding occurred in 1997/98, supported by Dov Lank. Guillermo has taken a temporary instructor's position at Oaxaca, but we hope to continue, and broaden work in Mexico, by taking on Guillermo as a PhD student in 1998.

b) Chitre, Panama. PhD student Patrick O'Hara is focusing on factors affecting wintering sex and age distributions, on both a microhabitat and geographic scale, and life history considerations associated with decisions whether or not to migrate in a bird's first year of life. He is working with Guillermo Fernandez to contrast aspects of overwinter ecology and demography between overwintering sites 2000 km apart. As a result of an RNP grant to Francisco Delgado, banding and resighting continued throughout the summer months, in both 1996 and 1997, to examine the age and sex distribution of those birds which stayed in their wintering grounds throughout the summer months. The continuing winter banding studies of Delgado and Patrick O'Hara, and detailed study of the winter ecology of individuals of different age/gender classes, will be used to describe patterns of habitat uses, winter philopatry and local survivorship. If local distribution patterns in relation to the sex and age of the birds can be understood, this may lead to insights on other wintering grounds and possible explanations for overall latitudinal sex-age distributions, using Ensenada as a second overwinter reference point.

Patrick has developed a method of identifying 2-year-old birds by plumage and allows age specific patterns of behaviour and demography to be studied more effectively. His preliminary estimates of local adult annual survivorship match those made by Sandercock, based on the breeding data from Alaska.

2. Winter Ecology of Dunlin

Pippa Shepherd's research was designed to answer questions about the basic winter ecology of Dunlin in the Fraser Delta, including fat modulation and antipredator behaviour. Pippa used two seasons' radio telemetry data to show that the Dunlin regularly use the surrounding agricultural lands for feeding at night, particularly when it is raining, and despite the fact that large expanses of mudflat are exposed at night. This may be because the fields provide a better food source which, though susceptible to raptor predation during the day, may be safe at night. Rain on saline mudflats may drive marine invertebrates out of reach of Dunlin and make the fields even more attractive in rainy weather. She is testing these ideas by collecting prey samples in a variety of marine and terrestrial habitats that are used and not used by the Dunlin. She has also collected data on Dunlin interactions with predators whenever possible.

Lesley Evans Ogden joined the chair in autumn 1997 as a second PhD student working on this system. Her emphasis is more applied, focusing on identification of agricultural practices that favour or disfavour shorebird usage. Lesley conducted systematic stratified surveys of day and night farmland usage, experimented with capture methods and sites, and with food sampling techniques.

3. Physiological ecology of reproduction and migration

The main aims of the Chair's research in physiological ecology are three-fold: a) to obtain a better understanding of the mechanisms underlying individual and population-level variation in physiological traits to provide a solid basis for predicting how animal's might respond to environmental change, b) to determine more meaningful intra-specific

measures of body condition, quality and individual health for birds, and 3) to develop and apply new physiological approaches and techniques to conservation biology.

i. Breeding studies

a) Reproductive physiology of zebra finches

Captive-breeding zebra finches are being used as a model system (by Dr T. D. Williams) to study the causes and consequences of variation in female reproductive effort (egg size, clutch size and laying date). Individual variation is marked in all these traits but this is unrelated to 'traditional' measures of individual quality (e.g. size, mass or size-adjusted 'condition'). We are currently investigating the inter-relationship between the reproductive system and the immune system in determining this variability. Other studies are focusing on the affect of the hormone oestradiol on female breeding biology as a precursor to more detailed studies on the impact of environmental oestrogen's (xenoestrogens) on reproduction.

b) Intraspecific variation in reproduction in European starlings

Julian Christians (PhD student) has completed three field seasons investigating the physiological mechanisms underlying intraspecific variation in avian reproductive performance. The focus of this work, a nestbox population of European Starlings (*Sturnus vulgaris*), has proven to be a tractable system in which to study and manipulate the physiology of free living, breeding birds. Data have been collected on variability for a range of physiological traits (e.g. body composition, plasma metabolites) in relation to reproductive performance (egg size, clutch size and laying date). In addition to this observational information, various experimental manipulations have been performed. For instance, it has been possible to experimentally increase the oestradiol levels of breeding females and to observe its effects on physiology and reproductive performance. This technique is useful not only for manipulating reproductive effort, but also as a model for studying the effects of anthropogenic xenoestrogens on breeding females. Other work, performed in collaboration with Jay Aiken and Melissa Evanson, two undergraduate students at SFU, seeks to elucidate the trade-offs between reproduction and the immune

system. One aim of this study is to develop measures of immunocompetence which could be used to monitor health of other free-living species.

c) Birds as bio-indicators of ecological viability in wetlands receiving oil sands waste

Kirsty Bennett (MSc student, co-supervised with Dr Leah Bendall-Young, SFU) started a two-year project investigating the validity of using waterfowl as bio-indicators in habitats receiving oil sands waste in the Peace-Athabasca delta area, Alberta. Breeding adults and chicks will be reared on seepage and control wetlands and data collected on a suite of physiological end-points (for both the reproductive and immune system) to assess individual health and the impact of contaminants on reproductive output and chick growth. This is part of a broader project assessing the ecological viability of these wetlands, and supported by ESTAC/NSERC, Suncor and Syncrude.

Dr Tony Williams, in collaboration with Dr Judit Smit (University of Saskatchewan) completed a project on passerine immunotoxicity assay development. This work was funded by Suncor Energy Reclamation Group as part of the Fort McMurray (Alberta) Oilsands Reclamation Research Project. This work validated several techniques for the assessment of sub-lethal effects on immune status and individual health in relation to environmental contaminants.

d) Factors affecting chick provisioning in seabirds

Laura Jones (MSc student) completed the first year of a study on Triangle Island examining whether rhinoceros auklet parents can regulate provisioning effort in response to the nutritional condition of the chick and chick sex. In 1996, a chick exchange experiment was conducted in which rhinoceros auklet chicks with a large mass at age are switched with chicks of the same age, but low mass. Daily mass increments were used to determine provisioning levels before and after the exchange. Using a novel molecular DNA technique, blood samples will be used to determine the sex of chicks with known provisioning histories. This will be the first study to look at provisioning in relation to sex in seabirds and could have important implications for life history theory. Coupled with information on food availability the information generated by this study will also be

critical for evaluating the utility of seabirds as indicators of marine resources. Laura won 2nd place in the student poster competition for this work at the 1997 Pacific Seabird Conference.

e) Physiological indicators of reproductive status and condition in Marbled Murrelets

The main aim of this project (forming the MSc research of Brett Vanderkist) is to develop novel, non-destructive physiological and molecular techniques to investigate the breeding biology of the Marbled Murrelet indirectly using blood samples obtained from birds caught off the nest (e.g by mist-netting). Using a molecular DNA sexing technique, we have determined the sex of a total of 282 birds caught by mist-netting during the breeding season at Desolation Sound, B.C. The sex-ratio of this capture sample has been heavily male-biased in all three years: 1994, 2.5 males: 1 female (n = 59); 1995, 1.9:1 (n = 118) and 1996, 1.84:1 (n = 105). This was a totally unexpected result. If we were capturing breeding pairs (our initial working assumption), and as murrelets have biparental care, we would have predicted an approximate 1:1 sex ratio. We are currently investigating the reasons for this sex-bias which may have important implications for the conservation and management of this species. The ability to sex birds will also greatly enhance many other aspects of this project allowing us, for example, to investigate sex-specific patterns of survival, marine habitat use, etc. Preliminary data on plasma biochemistry suggest that all the birds we are capturing at Theodosia Inlet are in the post-laying stage of breeding (most likely chick-rearing birds). We are validating the interpretation of these data by comparing them with data obtained from Cassin's auklets for which we know the timing of breeding or actual breeding stage. Again this information on the breeding status of our captured birds will improve our interpretation of other data on local movements, behavior, etc.

ii. Migration studies

a) Age and sex-specific modulation of body composition during the migratory cycle

Western Sandpipers have now been collected from all stages of the migratory cycle: wintering and pre-migration (Panama) and Spring and Fall migration (Fraser estuary), for birds of both sexes and ages (by Christopher Guglielmo, Tony D. Williams and Patrick

O'Hara). Detailed body composition analysis (wet, dry and lean/lipid mass) has been completed for 90 birds, and analysis of plasma samples is underway. Preliminary results clearly demonstrate that widely used measures of individual 'condition' or 'quality' are misleading in determining major physiological changes, and therefore potentially 'performance', during migration. These measures have traditionally been an important component of the assessment of the viability and health of bird populations and/or their habitats. For example, the body mass and 'condition' of adult and juvenile female western sandpipers is identical during Fall migration, but the bird's mass is distributed in very different ways in the body with juveniles having larger gut, liver and heart mass and relatively lower fat mass. These differences might be related to patterns of age-specific mortality which occur during migration.

b) Fatty acid binding protein (FABP) and flight muscle conditioning

Chris Guglielmo completed his third year of doctoral research on the seasonal modulation of body composition and metabolic biochemistry in relation to migration in Western Sandpipers. A major component of the project is a comparative study of Western Sandpipers sampled at several phases of the annual cycle (wintering and pre-migrant birds in the Republic of Panama, and Spring and Fall migrants at Boundary Bay, British Columbia). He has found significant season and age dependent variation in body condition. During the non-migratory season all organ systems were reduced by as much as 40% in mass, however, contrary to *a priori* expectations these systems did not hypertrophy in advance of premigratory fattening or departure from the tropical wintering area. Chris has isolated and characterized avian muscle fatty acid-binding protein (M-FABP) for the first time, and has found that cytosolic levels of M-FABP in heart and flight muscle of migrating Western Sandpipers are several fold higher than reported in any other vertebrate. In future work he will use an immunoassay to determine if increased expression of M-FABP in flight muscle is a component of the seasonal biochemical changes associated with migration. Chris has also been investigating the potential role of flight-induced muscle damage on migration strategy in this species, but has found little evidence to suggest that muscle damage is a significant factor determining flight performance or stop-over behaviour. In collaboration with Tony Williams and Oliver Egeler, Chris has helped conduct a study of plasma-borne lipid metabolites as measures

of physiological state or fattening rate of captive and wild birds. Recent evidence indicates that some metabolites are useful predictors of mass change in captive Western Sandpipers. Chris is using blood samples collected from wild birds at various seasons to evaluate the utility of these metabolites for study of fattening dynamics of birds during migratory stop-overs.

c) Importance of lipid dynamics for migration in Arctic-nesting shorebirds

Oliver Egeler graduated in January 1998, completing his MSc study investigating the importance of the quality of fat stored by shorebirds prior to and during migration. He showed that: a) there is marked seasonal variation in fatty acid composition of western sandpipers depot fat, and b) that there is seasonal upregulation of enzyme systems associated with fattening. These data were compared to fatty acid composition of prey samples collected from Playa el Agallito in Panama and Boundary Bay in Vancouver (with the aid of Patrick O'Hara and Chris Guglielmo). Experiments on captive Western Sandpipers have shown that dietary manipulation can have drastic effects on the levels of some fatty acids whereas others seem to be unaffected. Notably, those fatty acids that are primarily responsible for the increase in unsaturation during migration are also the ones that are not sensitive to dietary manipulation. Levels of these fatty acids seem to be maintained by endogenous synthesis when they are absent in the diet. Seasonal variation in the activities of two enzymes involved in fatty acid biosynthesis has also been demonstrated. Fatty acid synthase and stearoyl-CoA desaturase activities are induced in parallel during the spring migratory period to enhance liver lipid synthesis. The induction of these enzymes may play a critical role in the ability to fatten rapidly during migration. This work is relevant to the importance of micro-habitat quality and diet (prey) composition for successful migration in birds.

iii. Diving and foraging behaviour of seaducks

Andrea MacCharles successfully defended her Masters degree in August 1997 on diving and foraging behaviour of wintering Common Eiders (*Somateria mollissima*) at Cape St. Mary's, Newfoundland. The main conclusions from this study were that a) eiders rarely exceeded their physiological dive limit, and most likely did not incur major physiological costs during intensive foraging, b) variation in foraging effort (dive:pause ratio) was

related to prey type (mussel vs. urchin) and some ecological factors (e.g. tidal cycle, seasonal prey depletion) but these explained only 35-43% of the total variation in diving behaviour, c) residual variation in foraging effort was most likely related to social factors, with birds diving and surfacing synchronously as a group. Cape St. Mary's is an Ecological Reserve and some management implications and considerations were generated by this project.

4. Riske Creek Project

This research, coordinated by Dov Lank, is carried out collaboratively with Kathy Martin (UBC and CWS) and Sean Boyd (CWS) and is designed to investigate bird populations and their responses to habitat alterations, particularly those related to forestry. In addition to scientific goals, we will make recommendations with respect to riparian forest practice regulations for these forest types. Long term (5 year) funding for this project was obtained from Forest Renewal BC in July 1996. We also obtained funding from the Interior Wetlands Program, administered by Ducks Unlimited, Canada.

The research of the Chair mainly involved species of waterbirds using the Becher's Prairie near Riske Creek in the Central Interior of BC. To expand the work on cavity nesting ducks, Matt Evans began graduate work on nesting preferences of Barrow's Goldeneye and Bufflehead, and the reproductive consequences of their breeding decisions, as part of the long term program of Sean Boyd's on these species. This work is coordinated with Kathy Martin's research on cavity nesting birds in the woodlands and forests adjacent to some of the ponds.

We built on the long term waterfowl surveys carried out by J-P Savard and André Breault of CWS, but carried out more detailed observations throughout the breeding seasons to understand how the birds used the habitat during the pre-nesting, nesting, brood-rearing and moulting period. We studied Lesser Scaup and Green-winged Teal in 1996 and 1997 using radio marked and nasal disked birds in order to understand patterns of dispersal, recruitment and survival. Sean Cullen concluded an MSc project on the population of Eared Grebes on the prairie, concentrating on the movement of birds, (both intra- and

inter-seasonally) among the ponds in the region, in conjunction with Sean Boyd and CWS, who have been studying these grebes for several years.

PhD student Brent Gurd started a community ecology project in 1997 examining the effects of habitat manipulations on the species composition of waterfowl species in the pond and lake complex.

5. The Triangle Island Project

Integrated Marine Ecology The Ecological Reserve on Triangle Island is the largest and most diverse seabird colony in BC and includes the worlds largest population of Cassins Auklet, significant populations of Rhinoceros Auklet and BC's largest populations of Common Murre and Tufted Puffins. Consequently, it is a key site for the conservation and stewardship responsibilities of CWS and a fantastic colony for intensive comparative research on seabird populations. Demographic studies, a cornerstone of the Chair's seabird program, focus on individual performance and population processes. We seek to understand the causes and population consequences of variation in survival and reproduction for alcids with different life history traits. Of particular interest is the general issue of how climate induced fluctuations in recruitment to marine populations affect seabird populations processes. We have formed strong linkages with DFO to address this issue. At the time of writing the chair has obtained funds from the 1989 Nestucca oil spill settlement and has an integrated CWS/DFO/Chair program underway. Available time series information from expeditions to Triangle Island in the 1970s and 1980s have been collected and reconstructed to facilitate detection of interdecadal patterns. A striking trend is the significant change towards earlier reproduction for the four main alcids under study: Cassins Auklet, Common Murre, Rhinoceros Auklet and Tufted Puffin. Recent declines in breeding productivity are apparent for Rhinoceros Auklet and Tufted Puffin have had marginal to virtually no breeding success since the Chair program began in 1994. Cassins Auklet also had very poor production of young in 1996. Long term changes in the diet composition are also apparent for Cassins and Rhinoceros Auklet.

Intensive night banding has continued and we now have estimates for survival for both species. Cassin's Auklet values differ between netting sites on the island and were generally lower than expected. This discovery coupled with a significant decline in the burrow use in permanent plots between 1989 and 1994 warrants close and continued attention to the status of the world's largest colony. Rhinoceros Auklet local survival estimates did not differ between sites and were higher than Cassin's Auklets, within the range expected.

El Nino Study A previously unfunded proposal to US GLOBEC from PRBO and the Chair helped provide the concepts to quickly respond to an October 1997 announcement of opportunity from US NOAA for El Nino related studies. Triangle Island is in a pivotal position located in the transition zone between the northern downwelling domain and southern upwelling domain. The proposal to compare the effects of the present El Nino to past performance based upon established time series data was funded in December 1997. At the time of writing the Triangle Island program is conducting concurrent comparative studies of seabird breeding performance with collaborators in California (PRBO), Washington (U. of Washington), BC (CWS) and Alaska (USGS, USFWS, U. of Alaska), one of the largest scale coordinated seabird monitoring programs ever established in the North Pacific.

Hugh Knechtel continued his studies of the factors affecting Cassin's Auklet egg size and chick growth. In 1996 Chair Research Network funds continued to support a study of the effects of gull kleptoparasitism on Tufted Puffin reproductive success by Colleen Cassidy-St. Clair from the University of Alberta. Julia Parrish from the University of Washington continued her study of factors affecting attendance rates of Common Murres. The unique but small colony of BC murres had low attendance rates and the longest chick fledging period that has been reported to date for any colony. Mike Wiley and Kerry Woo investigated nesting success in the Black Oystercatcher population in 1996. We experimented with the use of radar to monitor population numbers and nocturnal patterns of activity. These data were analysed by Laura Cowen and promises to be an effective method for future research and population monitoring. Laura Jones continued her MSc

research on the parental provisioning in response to variation in chick condition in 1996 and 1997 (see also section d, page 15). Louise Blight started an MSc project in 1998 investigating the impact of mammalian egg predators on Rhinoceros Auklet breeding success.

6. Winter and Spring Population Ecology of Brant in the Georgia Basin

Work continues on the wintering population of Brant from Boundary Bay. The objectives of the study were to determine whether there is a wintering population, to determine its size and distribution within the Puget Sound - Strait of Georgia area, and to differentiate wintering birds from migratory ones, which pass through the area from mid February until early May.

Eric Reed completed his MSc thesis in 1997 and his data indicate there is a resident population in Boundary Bay in winter and that there is a quite strong philopatry from year to year (approx. 70% for residents). Population size has not been estimated with great confidence yet, but is likely to be between 600 and 1,000 birds. The number of birds wintering in the area seems to be increasing. Maximal number of Brant seen in Boundary Bay in 1993-94 during the winter was 400, while it was 450 in 1994-95, and 550 in 1995-96. Future work for which funds have been received from the Arctic Goose Joint Venture will concentrate on the migrant population, their requirements and management and their interactions with the winter residents. Kate Hagmeier will be starting her MSc thesis under the co-supervision of Sean Boyd on this topic in the fall.

7. Population Studies of Harlequin Ducks

i. Wintering and Moulting Areas Studies

In 1992, Ian Goudie initiated a wintering study in the Strait of Georgia as part of a broader study of wintering populations of sea ducks. Several moulting populations were banded for demographic studies. One of these populations, near White Rock, formed the basis of a detailed study by Greg Robertson, a PhD student, on the demography and winter dispersal of this species. He has provided the first detailed description of the

moulting and basic plumages of the species, and has observations on the movement patterns of more than 100 individually marked birds. He has documented re-pairing of previously paired birds, and shown that most re-uniting of previously paired birds occurs early in the winter, whereas new pairs are established in March or April. Exchange of birds among different wintering populations has been quantified, but winter and moulting ground philopatry is very strong among previously paired birds. Annual survival is high among this species.

ii. Breeding Ground Studies

a) Jasper National Park, ALTA

The investigation of the breeding biology of Harlequin Ducks in Jasper National Park completed its third year. The study focused on the relationship between food availability and nesting success of the ducks in the Maligne Valley. Bill Hunt successfully defended his MSc based on the work in 1997. This study is now continuing under the supervision of Ron Ydenberg of SFU and Pete Clarkson of Jasper National Park.

b) Banff National Park

In 1995 a second study of breeding birds was started at Banff National Park, under the direction of Cyndi Smith of Parks Canada. In 1996 it was expanded to include Kananaskis Country. In January, 1997 Cyndi joined our group and began an MSc. She is investigating the movements and dispersal of post-fledging juvenile Harlequin Ducks and their subsequent recruitment into the breeding population. This stage of the life cycle is difficult to study and has been largely ignored to date. She has implanted radio transmitters in juveniles and females on the breeding streams in Alberta to relocate them at wintering locations in the Strait of Georgia. Mortality of post-fledging juveniles was high and none was relocated on the wintering grounds, but several adults were from widely dispersed sites from the Strait of Juan de Fuca to as far north as Haida Gwaii. To date one bird marked in the breeding area was relocated in our White Rock study site.

8. Winter Studies of Grebes

James Clowater, an MSc student at SFU has completed the field work for his project on food utilization and distribution of Western Grebes in the Straits of Georgia during the winter months. This forms part of a larger picture aimed at understanding the importance of the Coastal Waters of BC for wintering water bird populations. James has made the interesting discovery that Western Grebes feed little during the daylight hours but start feeding actively around dusk and dawn. This coincides with the upward vertical nocturnal migrations of Euphausiids, which may in turn attract fish species, which feed on them and may be the prey of the Grebes.

A second grebe study began in the winter of 1997/98. Bonnie Stout started a PhD project on the wintering and pairing behaviour of grebes. Her work will concentrate on Horned and Red-necked Grebes and will require both breeding ground and wintering field work. The question of when grebes pair has not been resolved and has important implications to population structure. She is spending her first summer field season near Yellowknife, NWT where large numbers of both species breed.

9. Population Status of Marbled Murrelets

The long-term collaborative research project on Marbled Murrelets continues in Desolation Sound, BC. Gary Kaiser (CWS); Louise Waterhouse (BC Forest Service); and Fred Cooke, Tony Williams, Doug Bertram, (Simon Fraser University/CWS/NSERC Wildlife Ecology Research Chair) are coordinating studies of population demography and genetics, reproductive physiology and marine and nesting habitat use. Two SFU graduate students are also involved: Irene Manley, an MSc student with Alton Harestad, has completed a study of nesting habitat selection and is currently writing up her work. Cecilia Betancourt-Lougheed, co-supervised by Fred Cooke and Doug Bertram has completed an MSc project on marine habitat use and movement patterns of murrelets and is also preparing to defend her thesis. A new student, Laura McFarlane-Tranquillo, will be continuing this study in 1998.

Mainly through tree-climbing after the nesting season was over, 62 Marbled Murrelet nests were located in the Desolation Sound area by Irene Manley and her crew during 3

years of study. This provided the most complete sample of nests ever discovered. The information obtained on nest site characteristics represents a large increase in knowledge of habitat use as only about 20 Marbled Murrelet nests have been found in all of B.C. to date. All of the nests found in 1995 were in high elevation patches of old-growth forests within 5-15 km of marine foraging areas. A description of nest site characteristics is essential for preservation of this species in the face of continued logging. A proportion of the nest trees were reused both within and between seasons, but there are clearly many new trees chosen each season.

Gary Kaiser (CWS) explored other possible study sites in the Queen Charlotte Islands in 1996, and Green Inlet on the mainland coast in 1997, but none proved to be suitable. At Green Inlet, he carried out an intensive capture and banding project using our new dip-netting technique, and caught around 200 Marbled Murrelets. Although we have no immediate plans to continue this aspect of the work, it will allow possible comparisons of a population from an area where habitat is less fragmented by forestry to a population in Desolation Sound where logging has been more intense.

In 1996 and 1997 we continued our mist-netting program in Theodosia Inlet, bringing our total of birds caught by this method to 665. More importantly there was a considerable increase in our frequency of recaptures in 1997, allowing us for the first time to calculate and adult survival rate for this species. The value of 85% was not unexpected for an alcid of this size. We expanded our capture effort considerably by developing a new dip-netting technique whereby birds could be captured at night from small boats by nightlighting and slowly approaching them with dip-nets. We caught 109 birds with this approach. More importantly, we were for the first time able to catch juvenile birds soon after their arrival from the nest sites. We caught 29 juveniles and were able for the first time to describe the plumage of birds at this stage and to individually mark a sample of known aged birds.

In conjunction with the banding, blood and feather samples were collected for DNA and hormonal analysis to help sex the birds and also to understand the breeding status of captured individuals. The endocrinology aspects are being carried out by Brett Vanderkist

under the supervision of Tony Williams and in collaboration with John Wingfield (University of Washington).

10. Demographic Models

Demography studies in the Chair have involved both investigations of the modern methods of estimation and enumeration, and use of these estimates in a broadly theoretical context.

We have a number of projects which are aimed specifically at further exploring the mechanics and application of robust methods of estimation, and additional projects where we are exploring the theoretical ramifications of demographic variation and change.

The two major analytical projects concern (i) estimation of average residency time and turnover rate, and (ii) analysis of the influence of life history variation on population trajectories and stability.

Residency time & turnover rate: How long individual animals spend during migration stopovers is of considerable interest, both in terms of practical management of many migratory species, and also in terms of theoretical interest in the causes and consequence of migratory behaviour. Clearly, the decision to stop during a seasonal migration is motivated by interaction of several possibly unrelated factors, including (a) weather, (b) distance already traveled, (c) time of season, and potentially most important (d) current physiological state of the individual (which in turn may be significantly influenced by factors (a)-(c), as well as others). Average residency time has traditionally been estimated in terms of the difference in time elapsed between peak arrival and peak departure dates. While this is clearly a reasonable first approach, it suffers from the general problems of ignoring individual variation, and is most useful when arrival and departure of individuals is highly synchronous at the population level. More recently, there have been attempts made to estimate average residency time directly using radio-telemetry devices. While this clearly is the optimal approach, it is generally restricted in terms of the numbers of individuals which can be radio-marked, and as such, there may be problems extrapolating to the population as a whole. We are investigating a number of different

mark-recapture approaches to this problem, including (i) extensions of Pradel's combined recruitment estimator (*sensu* Pradel 1997), which simultaneously incorporates both input and exit from the population, (ii) using an estimator based on frequencies of reobservation of marked individuals. This later approach is particularly appropriate for cases where animals are not physically recaptured. We are currently comparing the relative advantages of the two approaches, using a combination of computer simulations and field testing using data from several Chair projects.

Demographic sensitivity: We are using 2 new approaches to analysis of population demographics to partition variation in geometric growth rates (λ) into contributions from the fundamental components (most broadly, fertility and survival). While classical sensitivity analyses of structured (matrix) models are not new, several new approaches to deriving comparisons in component sensitivities have been described, which allow for more thorough investigation of those parts of the demography which contribute to variation in abundance. In particular, we are looking at the degree to which these tools might be accessible as means of looking at population stability under known levels of environmental perturbation. This is particularly important for smaller, threatened populations where normal techniques may not adequately accommodate demographic stochasticity. Several Chair projects involve such species, and these methods may ultimately prove useful in application to these studies.

In addition to the fundamental areas of research, we are completing earlier work on some of the metapopulation analyses of the Pacific Flyway snow goose system. Some of the results of these analyses have already been presented at a recent international conference. We are also increasingly involved in reevaluation of suggested snow goose management schemes being considered for control of mid-continent snow goose populations. In addition, we are also contributing to the completion of a major text on using program MARK, which is the definitive software application for omnibus survival estimation. Co-authored with Gary White (the developer of MARK), the book is anticipated to become the standard reference for using the software. This book, following on the heels of the Surge User's manual (now in its 2nd Edition), is a good example of Chair contribution to

disseminating some recent technological advances for the larger wildlife science community.

B. Other Initiatives

One of the key requirements of a major research program is the development of an intellectual framework for ideas and projects. To this end, we have attended a series of symposia, seminars and workshops to disseminate our ideas outlined above. These activities include:

- i) The fourth annual Western Sandpiper workshop, was held late November 9-10, 1996, in Ensenada, Mexico, organised by Dov Lank. Over 30 active researchers attended, including most of our Latin American collaborators. A fifth workshop is planned for November 1998.
- ii) The Chair is co-sponsoring the third Annual meeting of the Canadian Society of Ornithology to be held in Vancouver in August 1998. Dov Lank and Connie Smith are playing major organisational roles.
- iii) The 9th North American Arctic Goose Conference and Workshop was held in Victoria, BC in January 1998. Sean Boyd was the Chair of the Local Committee and Evan Cooch played a major role in organising this program and gave several presentations.
- iv) Ten members of the Chair participated in the 25th Annual Pacific Seabird Group Conference at Monterey California. Three papers and five posters were presented and Brett Vanderkist received an award for the best student presentation.
- v) The Senior Chair continued to represent NSERC in its assessment of ACWERN, a similar cooperative venture to our Chair involving CWS, NSERC and Universities. It is located in Atlantic Canada.
- vi) The Senior Chair is a Council Member of Bird Studies Canada, an NGO established to coordinate bird studies across Canada and to coordinate research initiatives among amateurs and professionals. He organised the second meeting in Delta, BC, in April 1996 and has played a major role in the development of the research program of the organisation.

- vii) The Chair, in conjunction with Ron Ydenberg, SFU, and Rob Butler CWS, has been active in the planning of a major conference on Sea Duck Ecology to be held in Parksville, Vancouver Island in March 1999.
- viii) Fred Cooke became a Member of the Executive of the American Ornithologists' Union for 1996-97 and a member of the executive of the Canadian Society of Ornithology in February 1998. He is also one of Canada's representatives on the Council of the International Ornithology Congress.
- ix) Open Houses to present our work to the public and to members of SFU and CWS have been held each year either at SFU or the Pacific Wildlife Research Centre, Ladner. Talks and posters are presented by members of the group.
- x) Greg Robertson, Chris Guglielmo, Brett Sandercock and Ceci Lougheed gave talks at the 1998 Annual meeting of the AOU in St Louis Missouri.
- xi) BC Seabird Workshops were held at SFU organised by Dr. D. Bertram and attended by SFU, CWS and Ministry of Forests representatives.
- xii) Marbled Murrelet research findings were presented to user groups and interested scientists. Three meetings were held; one with MOF officials in Powell River, one at CWS with a major emphasis on the Forest Companies and one organised by MOF officials in Nanaimo to discuss forest survey methods
- xiii) Two presentations were given at the Harlequin Duck workshop at the Pacific Flyway Council Meetings in Oregon in February 1998.
- xiv) Fred Cooke was an invited speaker at the International Goose Conference in Zwolle, Netherlands in which the problems of expanding goose populations was the main theme.
- xv) Chris Guglielmo organized and hosted a Conservation Forum Seminar Series with bi-weekly seminars on a range of wildlife conservation issues.

C. Community Involvement

- i) Fred Cooke gave a seminar in the SFU President's 1997 Lecture Series explaining the work of the Chair.
- ii) Several Chair members presented talks to naturalist and conservation groups throughout the years about the work of the Chair.
- iii) Fred Cooke and James Clowater gave interviews with *CBC*, *Discovery Channel* and *BCTV*.
- iv) Fred Cooke was appointed Chair of the Biodiversity panel of FRBC.
- v) Fred Cooke continued, with the Surrey and White Rock Naturalists, a monthly survey of the water birds of the western Boundary Bay.
- vi) Fred Cooke served as an executive member of the Surrey and White Rock Naturalists.
- vii) Fred Cooke presented the keynote address and James Clowater and Bonnie Stout presented papers at the Annual meeting of the Washington Ornithological Society in Mount Vernon in February 1998.

D. Funding

Our total funding has increased considerably since the establishment of the Chair. Almost all of this increase has been due to the acquisition of funds from outside sources (see Figure 1.) Our forecast budget for 1998/99 is more than \$1,560,000.

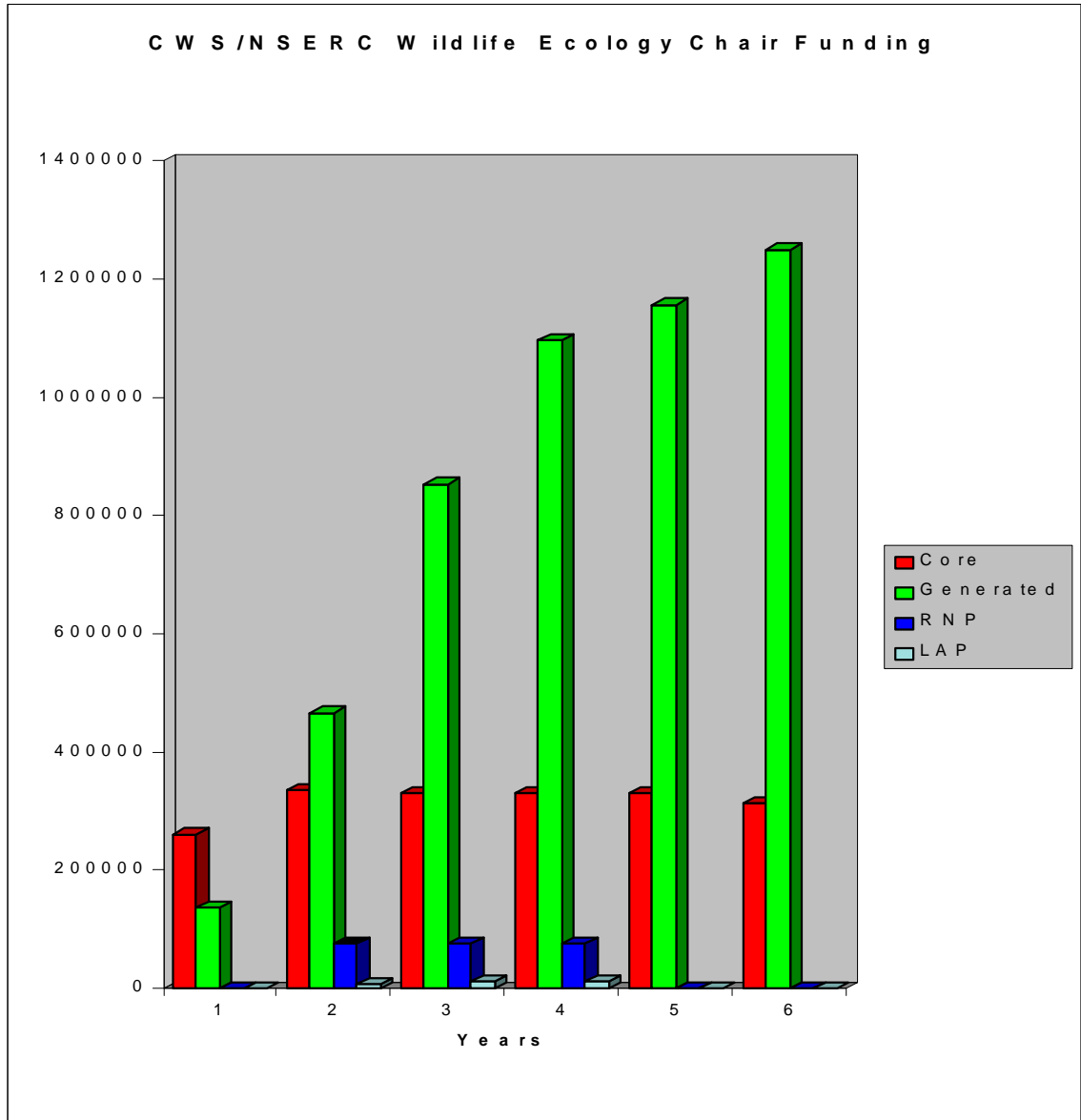


Figure 1

1. Research Funding Obtained (1997)

<i>Applicant</i>	<i>Source of Funding</i>	<i>Amount (per annum)</i>
	Graduate Research Fellowships (S. Cullen, O. Egeler, C. Guglielmo, L. Jones, C. Lougheed, G. Robertson, C. Smith)	\$30,950.00
	Skills Now Summer Works Program (D. Bertram, R. Butler, E. Cooch, F. Cooke, D. Lank, L. Lougheed)	\$12,229.00
Bennett, K.	Syncrude/Financial Post Environmental Health Scholarship	\$1,000.00
Bertram, D.	NOAA El Nino 1997- 1998 and Spatio-Temporal Patterns of Productivity for the California Current, Gulf of Alaska and Bering Sea Coastal Marine Ecosystems	\$33,500.00
Bertram, D.	Pacific Seabird Group “Contribution to Seabird Monitoring Database”	\$1,440.00
Blight, L.	NSERC Graduate Scholarship	\$15,700.00
Boyd, S./ Cooke, F.	Arctic Goose Joint Venture “Winter and Spring Staging Ecology of Pacific Black Brant in BC”	\$21,500.00 (1 st of 3 yrs)
Butler, R./ F. Cooke	Canadian Wildlife Service Great Blue Heron Research in BC	\$9,000.00
Christians, J.	NSERC Graduate Scholarship	\$17,400.00
Cooke, F.	Canadian Wildlife Service Harlequin Duck Study – Strait of Georgia	\$10,000.00
Cooke, F.	Forest Industry Donations “Demography of Marbled Murrelets”	\$44,500.00 (3 rd of 3 yrs)
Cooke, F.	NSERC CRD Matching Funds “Demography of Marbled Murrelets”	\$89,000.00 (3 rd of 3 yrs)
Cooke, F.	Science Council of B.C. - FRBC “Nesting Habitats, Abundance and Ecology of Marbled Murrelets on the B.C. Coast”	\$190,000.00 (2 nd of 5 yrs)
Cooke, F.	Science Council of B.C. - FRBC “Effects of Forest Management on Biodiversity of Riparian Ecosystems in Interior Forests of the Cariboo-Chilcotin”	\$212,375.00 (2 nd of 5 yrs)
Cooke, F.	IWWR “Winter Philopatry of Harlequin Ducks”	\$12,135.00

<i>Applicant</i>	<i>Source of Funding</i>	<i>Amount (per annum)</i>
Cooke, F.	NSERC Individual Operating Grant	\$79,000.00 (2 nd of 4 yrs)
Cooke, F/ T.D. Williams	NSERC Equipment Grant Infrared Borrow Probe System	\$12,721.00
Evans Ogden, L.	American Ornithologists Union	\$2,160.00
Evans Ogden, L.	NSERC Graduate Scholarship	\$17,400.00
Evans Ogden, L.	Science Horizons “Conservation of Shorebirds in Suburban Vancouver”	\$12,000.00
Guglielmo, C.	President’s PhD Research Stipend	\$4,850.00
Gurd, B.	NSERC Graduate Scholarship	\$17,400.00
Hazlitt, S.	Science Horizons “Conservation of Black Oystercatchers in the Gulf Islands”	\$12,000.00
Jones, L.	Anne Vallee Scholarship	\$1,000.00
Lank, D.B.	Agriculture Canada “Use of Farmland by Over-wintering Shorebirds in the Fraser River Delta, BC”	\$8,500.00
Lank, D.B.	Boundary Bay Conservation Society “Use of Farmland by Over-wintering Shorebirds in the Fraser River Delta, BC”	\$500.00
Lank, D.B.	Delta Farmland Trust “Use of Farmland by Over-wintering Shorebirds in the Fraser River Delta, BC”	\$5,000.00
Lank, D.B./ Evans Ogden, L.	Canadian Wildlife Service “Shorebird Use of Delta Farm Fields”	\$4,800.00 (1 st of 2 yrs)
Lank, D.B.	NSERC Individual Operating Grant "Genetic Polymorphism in Male Mating Strategy."	\$17,500.00 (3 rd of 4 yrs)
Lank, D.B.	Northern Studies Training Program Study of Western Sandpipers in Nome, Alaska	\$2,500.00
Lank, D.B.	Pacific Wildlife Corn Association “Use of Farmland by Over-wintering Shorebirds in the Fraser River Delta, BC”	\$3,000.00
Regehr, H.	NSERC Graduate Scholarship	\$17,400.00
Robertson, G.	President’s PhD Research Stipend	\$4,850.00
Rodway, M.	NSERC Graduate Scholarship	\$17,400.00

<i>Applicant</i>	<i>Source of Funding</i>	<i>Amount (per annum)</i>
Schamel, D.	Ducks Unlimited	\$17,280.00
Schamel, D.	United States National Parks	\$7,920.00
Schamel, D.	UAF Natural Resources Fund	\$25,344.00
Schamel, D.	USF & WS Cost-Share Challenge Grant	\$3,600.00
Shepherd, P.	NSERC Graduate Scholarship	\$17,400.00
Shepherd, P.	Society of Canadian Ornithologists	\$1,000.00
Smith, C.	Alberta Biodiversity Challenge Grant	\$10,000.00
Stout, B.	CD Nelson Award	\$16,000.00
Stout, B.	Wilson Ornithological Society Paul A. Stewart Award	\$288.00
Vanderkist, B.	NSERC Graduate Scholarship	\$17,400.00
Vennesland, R.	Science Horizons "Demography of the Great Blue Heron"	\$5,000.00
Williams, T.D./ LBendell-Young	Environmental Science & Technology Alliance of Canada/NSERC* "Ecological viability of wetlands associated with oilsands development."	\$61,000.00 (first of 2 yrs)
Williams, T.D.	NSERC Individual Operating Grant "Reproductive Investment in Wild Birds"	\$34,000.00 (4 th of 4 yrs)
	TOTAL:	\$1,156,942.00

2. Research Funding Obtained * or Applied For (1998)

<i>Applicant</i>	<i>Source of Funding</i>	<i>Amount (per annum)</i>
	Graduate Research Fellowships* (M. Evans, C. Guglielmo, L. Jones, C. Lougheed, P. O'Hara, K. Salvante, P. Shepherd, C. Smith, L. Tranquillo)	\$40,050.00
Bertram, D. /Kaiser, G.	Nestucca* Oil and Seabirds on Coastal Vancouver Island: The Power of Information for Impact Assessment and Response	\$95,000.00
Blight, L.	NSERC Graduate Scholarship*	\$17,270.00
Blight, L.	John K. Cooper Foundation*	\$1,000.00
Boyd, S./ Cooke, F.	Arctic Goose Joint Venture* “Winter and Spring Staging Ecology of Pacific Black Brant in BC”	\$21,500.00 (2nd of 3 yrs)
Butler, R./ F. Cooke	Canadian Wildlife Service* Great Blue Heron Research in BC	\$8,300.00
Christians, J.	NSERC Graduate Scholarship*	\$19,140.00
Cooke, F.	Canadian Wildlife Service* Harlequin Duck Study – Strait of Georgia	\$10,000.00
Cooke, F.	Canadian Wildlife Service* Georgia Basin Initiative	\$30,000.00 (1 st of 5 yrs)
Cooke, F.	Forest Industry Donations* “Demography of Marbled Murrelets”	\$15,000.00
Cooke, F.	NSCA – Marbled Murrelet*	\$7,200.00
Cooke, F.	NSERC Individual Operating Grant*	\$79,000.00 (3rd of 4 yrs)
Cooke, F./ R. Ydenberg/ R. Butler/L. Bendell-Young	NSERC Strategic Grant “Integrated population research into bird conservation in the Georgia Basin”	\$154,400.00 (1 st of 5 yrs)
Cooke, F	Science Council of B.C. – FRBC* “Nesting Habitats, Abundance and Ecology of Marbled Murrelets on the B.C. Coast”	\$190,000.00 (3rd of 5 yrs)

<i>Applicant</i>	<i>Source of Funding</i>	<i>Amount (per annum)</i>
Cooke, F.	Science Council of B.C. – FRBC* “Effects of Forest Management on Biodiversity of Riparian Ecosystems in Interior Forests of the Cariboo-Chilcotin”	\$212,375.00 (3rd of 5 yrs)
Evans Ogden, L. /Lank, D.B.	Agriculture Canada* “Use of Farmland by Over-wintering Shorebirds in the Fraser River Delta, BC”	\$12,000.00
Evans Ogden, L.	Cooper Ornithological Society*	\$1,460.00
Evans Ogden, L.	NSERC Graduate Scholarship*	\$19,140.00
Evans Ogden, L.	Wildlife Habitat Canada* “The Importance of Agricultural Land to Over-Wintering Shorebirds in the Fraser River Delta, BC	\$12,000.00 (1 st of 3yrs)
Gurd, B.	NSERC Graduate Scholarship*	\$19,140.00
Hazlitt, S.	Science Horizons* “Conservation of Black Oystercatchers in the Gulf Islands”	\$12,000.00
Lank, D.B./ Evans Ogden, L.	Canadian Wildlife Service* “Shorebird Use of Delta Farm Fields”	\$4,800.00 (2 nd of 2 yrs)
Lank, D.B./ Shepherd, P.	Canadian Wildlife Service* “Shorebird Use of Delta Farm Fields”	\$4,000.00
Lank, D.B.	First Jobs In Science*	\$6,000.00
Lank, D.B.	NSERC Individual Operating Grant* "Genetic Polymorphism in Male Mating Strategy."	\$17,500.00 (4 th of 4 yrs)
Lank, D.B.	Northern Studies Training Program* Study of Western Sandpipers in Nome, Alaska	\$2,500.00
Lank D.B., Cooke, F.	Skills Now Summer Works Program*	\$4,500.00
Regehr, H.	NSERC Graduate Scholarship*	\$19,140.00
Rodway, M.	NSERC Graduate Scholarship*	\$19,140.00
Shepherd, P.	President’s PhD Research Stipend	\$4,850.00
Smith, C.	Alberta Biodiversity Challenge Grant*	\$10,000.00
Vanderkist, B.	NSERC Graduate Scholarship*	\$19,140.00
Vennesland, R.	Science Horizons* “Demography of the Great Blue Heron”	\$12,000.00

<i>Applicant</i>	<i>Source of Funding</i>	<i>Amount (per annum)</i>
Williams, T.D./ LBendell-Young	Environmental Science & Technology Alliance of Canada/NSERC* “Ecological viability of wetlands associated with oilsands development.”	\$61,000.00
Williams, T.D.	Environment Canada “Endocrine-disrupting chemicals and avian reproduction.”	\$7,500.00 (1 st of 3 yrs)
Williams, T.D.	NSERC Individual Research Grant*	\$35,100.00 (1 st of 4 yrs)
Williams, T.D.	Suncor Energy Reclamation Group	\$10,500.00
Ydenberg, R./ A. Farrell/ T.D. Williams	NSERC Equipment Grant* Respirometry System	\$36,290.00
	TOTAL:	\$1,249,935.00

E. Publications

This list reflects those publications produced since our last report. We continue to publish actively and increasingly. The 20 publications in press and 14 submitted attest to this activity. Most of our publications reflect the research carried out in the main Chair programs and most refer to work carried out in the Pacific North-West. We are however interacting with scientists throughout Canada and beyond and some of our publications reflect this. We enclose publications by scientists funded by our RNP program in addition to those within our group. This year for the first time there is a listing of the theses produced by graduate students in our group at SFU.

1. Papers published in refereed journals

- Backwell, P.R.Y., P.D. O'Hara and J.H. Christy. In press. Prey availability and selective foraging in shorebirds. *Anim. Behav.*
- Balzer, A.L. and T.D. Williams. In press. Do female finches vary primary reproductive effort in relation to mate attractiveness? *Behaviour*
- Bertram, D.F., L. Cowen and A.E. Burger. In press. Monitoring populations and activity of colonial burrow nesting seabirds: the application of radar. *J. Field Ornithol.*
- Clark, C.W. and R.W. Butler. In press. Variable winds, predation risk and food availability: a dynamic optimization model of the spring migration of the Western Sandpiper. *Evol. Ecol.*
- Cooch, E.G., D.B. Lank, R.F. Rockwell and F. Cooke. In press. Body size and recruitment in snow geese. *Bird Study*
- Cooch, E.G. and W.A. Link. In press. Estimating transition probabilities in unmarked populations - entropy revisited. *Bird Study*
- Guglielmo, C.G., N.H. Haunerland and T.D. Williams. In press. Fatty acid binding protein: a major protein in the flight muscle of the western sandpiper. *Comp. Physiol. Biochem. B.*
- Reed, E., E.G. Cooch, F. Cooke and I. Goudie. In press. Migration patterns of black brant in Boundary Bay, BC. *J. Wildl. Manage.*
- Regehr, H.M., M.S. Rodway and W.A. Montevecchi. In press. Anti-predator benefits of nest-site selection in Black-legged Kittiwakes. *Can. J. Zool.*
- Robertson, G.J. In press. Egg adoption can explain joint egg laying in common eiders. *Beh. Ecol. Sociobiol.*
- Robertson, G.J. and F. Cooke. In press. Winter philopatry in migratory waterfowl. *Auk*
- Rodway, M.S. In press. Activity patterns, diet, and feeding efficiency of Harlequin Ducks breeding in northern Labrador. *Can. J. Zool.*
- Rodway, M.S. In press. Habitat use by Harlequin Ducks breeding in Hebron Fiord, Labrador. *Can. J. Zool.*
- Rodway, M.S., J.W. Chardine and W.A. Montevecchi. In press. Intra-colony variation in breeding performance of Atlantic Puffins. *Colonial Waterbirds*

- Rodway, M.S., J.W. Gosse Jr., I. Fong and W.A. Montevecchi. In press. Discovery of a Harlequin Duck nest in eastern North America. *Wilson Bull.*
- Shepherd, P. and S. Boates. In press. Effects of a commercial baitworm harvest on Semipalmated Sandpipers (*Calidris pusilla*) and their prey in the Bay of Fundy Hemisphere Shorebird Reserve. *Cons. Biol.*
- Williams, T.D. and S.P. Ternan. In press. Food intake, locomotion and egg-laying in zebra finches: contributions to reproductive energy demand? *Physiol. Zool.*
- Bertram, D.F. and R.R. Strathmann. 1998. Effects of maternal and larval nutrition on developmental plasticity and growth rates of planktotrophic larvae of echinoids. *Ecology* 79:315-327.
- Ganter, B. and F. Cooke. 1998. Colonial nesters in a deteriorating local habitat: local philopatry and colony dynamics of lesser snow geese. *Auk* 115:642-652.
- Reed, E.T., E.G. Cooch, R.I. Goudie and F. Cooke. 1998. Site fidelity of Black Brant wintering and spring staging in the Strait of Georgia, British Columbia. *Condor* 100:426-437.
- Robertson, G.J., F. Cooke, R.I. Goudie and W.S. Boyd. 1998. Molt speed predicts pairing success in male Harlequin Ducks. *Anim. Behav.* 55:.
- Robertson, G.J., F. Cooke, R.I. Goudie and W.S. Boyd. 1998. The timing of pair formation in Harlequin Ducks. *Condor* 100:551-555.
- SandercocK, B. 1998. Assortative mating and sexual size dimorphism in Western and Semipalmated Sandpipers. *Auk* 115:786-790.
- SandercocK, B. 1998. Methods for determining chronology of nesting events in Western and Semipalmated sandpipers. *J. Field Ornithol.* 69:235-243.
- Bertram, D.F., T.J. Miller and W.C. Leggett. 1997. Individual variation in growth and development during the early life stages of winter flounder. *Fish. Bull.* 95:1-10.
- Butler, R.W., T.D. Williams, N. Warnock and M.-A. Bishop. 1997. Wind assistance: a requirement for migration of small shorebirds? *Auk* 114:456-466.
- Cooch, E.G., D.B. Lank, R. Robertson and F. Cooke. 1997. Effects of parental age and environmental change on offspring sex ratio in a precocial bird. *J. Anim. Ecol.* 66:189-202.
- Cooke, F., G.J. Robertson, R.I. Goudie and W.S. Boyd. 1997. Molt and the basic plumage of male Harlequin Ducks. *Condor* 99:83-90.
- Crespi, B. and B. Vanderkist. 1997. Fluctuating asymmetry in vestigial and functional traits of a haplodiploid insect. *Heredity* 79:624-630.
- Gowans, B., G.J. Robertson and F. Cooke. 1997. Behaviour and chronology of pair formation by Harlequin Ducks *Histrionicus histrionicus*. *Wildfowl* 48:135-146.
- Hitchcock, C. and C. Gratto-Trevor. 1997. Diagnosing a shorebird local population decline with a stage-structured population model. *Ecology* 78:522-534.
- Lank, D.B. and D.M. Hughie. 1997. The resident's dilemma: a female choice model for the evolution of alternative male reproductive strategies in lekking male ruffs (*Philomachus pugnax*). *Behav. Ecol.* 8:218-225.
- Morbey, Y.E. and R.C. Ydenberg. 1997. Intraspecific variability in nestling growth and fledging behaviour of Cassins Auklets at Triangle Island, British Columbia. *Condor* 99:361-371.

- Robertson, G.J., F. Cooke, R.I. Goudie and W.S. Boyd. 1997. The timing of arrival and moult chronology of Harlequin Ducks *Histrionicus histrionicus*. *Wildfowl* 48:147-155.
- Samuel, M.D., D.R. Goldberg, D.J. Shadduck, J.I. Price and E.G. Cooch. 1997. Avian cholera bacterium isolated from healthy Lesser Snow Goose. *J. Wildl. Diseases* 33:332-335.
- Sandercock, B.K. 1997. The breeding biology of Red-necked Phalaropes *Phalaropus lobatus* at Nome, Alaska. *Wader Study Group Bul.* 83:50-54.
- Sandercock, B. 1997. Incubation capacity and clutch size determination in two calidrine sandpipers: a test of the four-egg threshold. *Oecologia* 110:50-59.
- Sandercock, B.K. and C.L. Gratto-Trevor. 1997. Local survival in Semipalmated Sandpipers *Calidris pusilla* breeding at La Perouse Bay, Canada. *Ibis* 139:305-312.
- Warnock, N., G.W. Page and B.K. Sandercock. 1997. Local survival of Dunlin wintering in California. *Condor* 99:906-915.
- Williams, T.D., P. Monaghan, P.I. Mitchell, I. Scott, D.G. Houston, S. Ramsey and K. Ensor. 1997. Evaluation of a non-destructive method for determining egg composition using total body electrical conductivity (TOBEC) measurements. *J. Zool., Lond.* 243:611-622.
- Bertram, D.F., C.F.J. Welham and R.C. Ydenberg. 1996 Flexible effort in breeding seabirds: adjustment of provisioning according to nestling age and mass. *Can. J. Zool.* 74:1876-1881
- Butler, R.W., F.S. Delgado, H. de la Cueva, V. Pulido and B.K. Sandercock. 1996. Migration routes of the Western sandpiper. *Wilson Bull.* 108:662-672.
- Cooch, E.G., D.B. Lank and F. Cooke. 1996. Intra-seasonal variation in the development of sexual size dimorphism in a precocial bird: evidence from the lesser snow goose. *J. Anim. Ecol.* 65:439-450.
- Ganter, B. and F. Cooke. 1996. Pre-incubation feeding activities and energy budgets of snow geese: can food on the breeding grounds influence fecundity? *Oecologia* 106:153-165.
- Ganter, B., P. Mineau and F. Cooke. 1996. Long-term vegetation changes in a snow goose nesting habitat. *Can. J. Zool.* 74:965-969.
- Guglielmo, C.G., W.H. Karasov and W.J. Jakubus 1996. Nutritional costs of a plant secondary metabolite explain selective foraging in an avian herbivore, the ruffed grouse. *Ecology* 77: 1103-1115.
- Jehl, J.J. 1996. Mass mortality events of eared grebes in North America. *J. Field Ornithol.* 67:471-476.
- Sandercock, B. 1996. Egg-capping and eggshell removal by Western and Semipalmated sandpipers. *Condor* 98:431-433.
- Sewell, M.A. 1996. Detection of the impact of predation by migratory shorebirds: an experimental test in the Fraser River estuary, British Columbia (Canada). *Mar. Ecol. Prog. Ser.* 144:23-40.
- Williams, T.D. 1996. Variation in reproductive effort in female zebra finches (*Taeniopygia guttata*) in relation to nutrient-specific dietary supplements during egg-laying. *Physiol. Zool.* 65:1255-1275.

2. Papers submitted to refereed journals

- Blight, L. and Stevens. Submitted. Partial melanism in a King Penguin at South Georgia. *Ibis*
- Christians, J. Submitted. Controlling for body mass: is part-whole regression important? *Physiol. Ecol.*
- Cooch, E.G., J.-D. Lebreton and F. Cooke. Submitted. The effects of age-structure on a constant harvest model - application of a matrix modeling approach. *J. Wildl. Manage.*
- Cooch, E.G., R.F. Rockwell and A. Dzubin. Submitted. How old are you? Using body size to estimate age. *J. Field Ornithol.*
- Egeler, O. and T.D. Williams. Submitted. Seasonal variation in fatty acid composition of depot fat in the Western Sandpiper (*Calidris mauri*). *Auk*.
- Gurd, D.B. and T.D. Nudds. Submitted. Insular biogeography of mammals in Canadian parks: a re-analysis. *J. Biogeog.*
- Kahlert, J., M. Coupe and F. Cooke. Submitted. Wintering segregation and timing of pair formation in Red-breasted Mergansers. *Wildfowl*.
- Lougheed, L.W., A. Breault and D.B. Lank. Submitted. Estimating statistical power to evaluate ongoing waterfowl population monitoring. *J. Wildl. Manage.*
- Robertson, G.J., F. Cooke, R.I. Goudie and W.S. Boyd. Submitted. Estimating temporary emigration rates with supplementary information: an example with Harlequin Ducks. *The Ring*
- Robertson, G.J., F. Cooke, R.I. Goudie and W.S. Boyd. Submitted. Site fidelity, mating systems, and winter philopatry in Harlequin Ducks *Histrionicus histrionicus*. *Behav. Ecol.*
- Rodway, M.S., H.M. Regehr and J.W. Chardine. Submitted. Status of the largest colony of Atlantic Puffins in North America. *Colonial Waterbirds*
- Sandercock, B.K., D.B. Lank and F. Cooke. Submitted. Seasonal declines in the reproductive effort of arctic-breeding sandpipers: different tactics in two birds with an invariant clutch size. *Oikos*
- Vanderkist, B.A., X-H. Xue, R.A. Griffiths, K. Martin, W. Beauchamp and T.D. Williams. Submitted. Sex-specific behavioural differences in Marbled Murrelets (*Brachyramphus marmoratus*): evidence from male-biased sex-ratios? *Condor*.
- Williams, T.D., C.G. Guglielmo, O.Egeler and C.J. Martyniuk. Submitted. Plasma lipid metabolites provide information on mass change over several days in captive Western Sandpipers (*Calidris mauri*). *Auk*.

3. Book chapters, conference proceedings and other publications

- Black, J.M., E.G. Cooch, M.J.J. Loonen and M. Owen. In press. Geographical variation in body size in a barnacle goose metapopulation: the effect of temporal and spatial scale. *In: Proceedings of the Svalbard Barnacle Goose Conference.*

- Cooke, F. 1996. Waterbird surveys of Boundary Bay - Crescent Beach to White Rock, 1994-1994. Part 2. *Discovery* 25:53-58.
- Cooke, F. In press. Population studies of Marbled Murrelets (*Brachyramphus marmoratus*) in British Columbia. *In: Proceedings of the Society of Canadian Ornithologists Symposium.*
- Derocher, A.E., G.W. Kaiser, F. Cooke, I.A. Manley and M.J. Gill. 1996. Research on Marbled Murrelets in the Desolation Sound area during the 1994 breeding season. Technical Report Series No. 257. Canadian Wildlife Service, Pacific and Yukon Region, B.C. 54 pp.
- Gurd, D.B. 1997. Impacts of timber management on wildlife: conceptual and analytical issues. Forest Fragmentation and Biodiversity Program, Report # 24.
- Jakubas, W.J., C.G. Guglielmo and W.H. Karasov. 1997. Dilution and detoxication costs: relevance to avian herbivore food selection. *In: J.R. Mason (ED) Repellents in wildlife management: Proceedings of a symposium.* USDA National Wildlife Research Center, Fort Collins CO, USA.
- Reed, J.M., N. Warnock and L.W. Oring (eds). 1997. Conservation and management of shorebirds in the western Great Basin of North America. : International Wader Studies, 81 pp.
- Reed, J.M., N. Warnock and L.W. Oring. 1997. Censusing shorebirds in the western Great Basin of North America. *In: Conservation and management of shorebirds in the western Great Basin of North America*, eds. Reed, J.M., N. Warnock and L.W. Oring, pp. 29-36. : International Wader Studies.
- Robertson, G.J., F. Cooke, I. Goudie and S. Boyd. in press. Within year fidelity of Harlequin ducks to a moulting and wintering area. *In: Proceedings of the Pacific Seabird Group/Canadian Wildlife Service Seaduck Symposium.*
- Rockwell, R.F., E.G. Cooch and S. Brault. 1997. Dynamics of the mid-continent population of Lesser Snow Geese - projected impacts of reductions in survival and fertility on population growth rates. *In: Arctic ecosystems in peril: report of the arctic goose habitat working group*, Batt, B.D.J., ed. Arctic Goose Joint Venture Special Publication, U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario, p. 73-100.
- Warnock, N., J.M. Reed and L.W. Oring. 1997. Synthesis: shorebirds in the arid western Great Basin of North America. *In: Conservation and management of shorebirds in the Great Basin of North America*, eds. Reed, J.M., N. Warnock and L.W. Oring, pp. 80-81. : International Wader Studies.
- Warnock, N. 1996. Local and regional differences in habitat utilization by Dunlins (*Caldris alpina*) as revealed by radiotelemetry: conservation implications. *In: Shorebird Ecology and Conservation in the Western Hemisphere*, eds. Hicklin, P. et al, . : International Wader Studies 8.
- Williams, T.D. In press. Avian reproduction - Overview. *In: Encyclopedia of Reproduction*, eds. Knobil, E. and J.D. Neill, . San Diego: Academic Press.

4. Theses

- Cullen, S.A. 1998. Population biology of Eared Grebes in naturally fragmented habitat. MSc, Simon Fraser University, Burnaby, B.C. 89 pp.
- Egeler, O. 1998. Aspects of fatty acid synthesis and composition in relation to migration in the Western Sandpiper (*Calidris mauri*). MSc, Simon Fraser University, Burnaby, B.C. 99 pp.
- Carter, B.P. 1997. Winter habitat use by Trumpeter Swans (*Cygnus buccinator*) in the Fraser Delta, British Columbia. MSc, Simon Fraser University, Burnaby, B.C. 78 pp.
- MacCharles, A. 1997. Diving and foraging behaviour of wintering Common Eiders (*Somateria mollissima*) at Capre St. Mary's, Newfoundland. MSc, Simon Fraser University, Burnaby, B.C. pp.
- Reed, E.T. 1997. Migration patterns and philopatry of the Black Brant (*Branta bernicla nigricans*) in the Strait of Georgia, British Columbia. MSc, Simon Fraser University, Burnaby, B.C. 93 pp.
- Robertson, G.J. 1997. Pair formation, mating system, and winter philopatry of Harlequin Ducks (*Histrionicus histrionicus*). Ph.D., Simon Fraser University, Burnaby, BC. 179 pp.
- SandercocK, B.K. 1997. Factors affecting the breeding demography of Western Sandpipers (*Calidris mauri*) and Semipalmated Sandpipers (*C. pusilla*) at Nome, Alaska. Ph.D., Simon Fraser University, Burnaby, B.C. pp.
- van der Wetering, D.E. 1997. MoulT characteristics and habitat selection of postbreeding male Barrow's Goldeneye (*Bucephala islandica*) in northern Yukon. MSc, Simon Fraser University, Burnaby, BC. 68 pp.

F. Personnel

1. Board of Directors

<i>Name</i>	<i>Position</i>	<i>Affiliation</i>
Dr. Larry Dill	Professor	SFU
Dr. Robert Elner	Head of Ecosystem Research	CWS
Dr. Chris Pharo (CWS alt.)	Head PWRC	CWS
Dr. Nico Verbeek (SFU alt.)	Professor	SFU
Dr. Brian Wilson	Regional Director, <i>ECB, DOE</i>	CWS
Dr. Ron Ydenberg	Professor	SFU

2. Research Team

i. Faculty and Research Associates

<i>Name</i>	<i>Position</i>
Dr. Fred Cooke	Senior Chair
Dr. Tony Williams	Associate Chair
Dr. Evan Cooch	Term Assistant Professor
Dr. Dov Lank	Term Assistant Professor
Dr. Doug Bertram	University Research Associate

ii. Research Group

<i>Sabbatical Visitor</i>	<i>Postdoctoral Fellow</i>	<i>PhD Student</i>	<i>MSc Student</i>	<i>Others</i>
Bart Ebbinge Johnny Kahlert	Cindy Hull Roxana Torres	Julian Christians Lesley Evans-Ogden Brent Gurd Chris Guglielmo Patrick O'Hara Heidi Regehr Mike Rodway Douglas Schamel Pippa Shepherd Bonnie Stout <i>Defended</i> Greg Robertson Brett Sandercock	Louise Blight James Clowater Matt Evans Kate Hagmeier Stephanie Hazlitt* Laura Jones Hugh Knechtel Ceci Lougheed Irene Manley** Cyndi Smith Laura Tranquillo Brett Vanderkist Ross Vennesland* <i>Defended</i> Brian Carter Sean Cullen Oliver Egeler Andrea MacCharles Eric Reed Debbie van de Wetering	Malcolm Coupe Laura Cowen Mark Drever Lynn Lougheed Marty Mossop John Ryder Barbara Sherman Connie Smith

*supervised by Dr. Ron Ydenberg; ** supervised by Dr. Alton Harestad

III. APPENDIX I. MISSION STATEMENT (January 1995 - F. Cooke)

The mandate of the Chair is to foster high quality, graduate level research in the field of wildlife ecology, with specialisations in behavioural, population and physiological ecology. The central concept is to provide an interface between the mission-oriented research and management policies of the Canadian Wildlife Service and the more curiosity-driven research of the university community. By encouraging this interface, the government agencies would gain access to a broader base of scientific information for government policy and decision making and university researchers would benefit from a broader practical application for the more theoretical ideas which their disciplines generate.

With these perspectives in mind, I have formulated the mission of the Chair

- i) by defining how the mandate of the Chair fits into the broader objectives of the CWS, Pacific and Yukon Region and
- ii) by considering the theoretical framework of wildlife ecology and what questions the Chair is in position to focus on most effectively.

A. Conservation Goals, The CWS Perspective

To conserve and protect wildlife and habitat, managers require scientific advice based on an understanding of population dynamics and ecosystem functioning. If we can discover the processes involved in population dynamics of particular species in their environment then we can begin to understand the dynamics of those ecosystems in which they live.

Under the Migratory Birds Convention and Canada Wildlife Acts, the CWS is required to protect and maintain migratory bird populations through protection of habitats, policy decisions, public forums, influence and research. Such an all-embracing mandate requires focused objectives and cooperation with other research and management agencies. From the perspective of CWS, Pacific and Yukon Region, 3 major ecotypes are defined.

- i) Marine and Coastal,
- ii) Wetlands and Freshwater
- iii) Forest and Grasslands.

Detailed definitions and understanding of priority ecosystems (e.g. Strait of Georgia) is the mandate of the Wildlife Ecology Division, with whom we will coordinate for advice on the relationship between our target species and the ecosystems in which they occur.

1. Habitats

When the Chair was established it was agreed that the research emphasis would be on birds of the Marine and Coastal environment. Specific ecosystems are as follows:

- i) Coastal Salt and Freshwater Marshes
- ii) Mudflats, Sandy and Rocky Shorelines
- iii) Agricultural Lands in the Fraser Lowlands
- iv) Inshore waters of the Fraser Delta and the Strait of Georgia
- v) Open Sea
- vi) Off-shore Islands

2. Bird Species

Each of these environments provide food and shelter for many of Canada's waterfowl,

shorebirds and seabirds, the taxa which will be the main research focus of the Chair. Our aim is to focus on a few of the important target bird species for detailed research with the objective of understanding not only the demographic processes but through them, the dynamics of the ecosystems of which the birds are a part.

The choice of species is based on our assessment of their importance to the ecosystems where they occur, their likely importance as species of conservation concern and their suitability as research organisms. Additionally we felt it important to cover year round residents, winter visitors, passage migrants, summer residents, and species which breed in one area and winter in another.

The key to conservation of birds is understanding the demographic processes which influence population numbers. Ultimately we are interested in the factors that influence reproduction and survival, and for this reason it is important to have the ability to examine these factors throughout the life cycle of the birds. We have therefore chosen species amenable to direct or indirect study throughout the annual cycle.

The species of birds which we plan to concentrate on, their seasonal status, and the environments in which they primarily occur in BC are listed below:

<i>Species</i>	<i>Seasonal Status</i>	<i>Habitat</i>
Snow Goose	winter	salt-marshes agricultural fields
Trumpeter Swan	winter *	salt-marshes agricultural fields
American Widgeon	winter *	mud flats agricultural fields
Harlequin Duck	resident (different habitats)	rocky shores, inshore waters, mountain streams
Barrow's Goldeneye	resident (different habitats)	inland ponds and open sea
Brant	winter and transient	mudflats inshore waters
Western Sandpiper	transient	mudflats
Dunlin	winter	mudflats
Grebes sp.	resident (different habitats)	inshore waters and inland lakes and ponds
Cassin's Auklet	summer	open sea off-shore islands
Rhinoceros Auklet	resident (different habitats)	open sea, inshore waters, off-shore islands
Tufted Puffin	resident (different habitats)	open sea off-shore islands
Pigeon Guillemot	resident	inshore waters, rocky shores, off-shore islands
Marbled Murrelet	resident (different habitats)	inshore waters, old growth forest

* also breeds in interior parts of province

3. Integrated Population Approach

We take as a useful model the approach to bird conservation pioneered in United Kingdom by the British Trust for Ornithology (*BTO*), referred to as Integrated Population Monitoring (*IPM*). It identifies the following stages.

Stage 1. Is there a mechanism in place to detect conservation problems associated with bird populations? This would usually be associated with disturbing changes in population size due to anthropogenic effects on the environment of the birds,

Stage 2. If disturbing changes are recognized, can one identify the stages in the life-cycle that are affected? If survival is involved, does it affect all age groups equally? If reproduction is involved, at what stage - egg production, fledgling success or recruitment? At what level does the problem lie?

Stage 3. If the stage of the life cycle that is affected has been identified, can one identify the causal components that influence it? For example, if over-winter mortality is high, is this due to changes in food availability, predator pressure (including hunting pressure), contaminant levels or other factors?

Stage 4. Can remedial steps be taken? What management advice can we give?

IPM provides us with a logical framework for bird conservation but still presents a formidable task. Fortunately there is already considerable background information available on most of the species we have chosen through the work of the *CWS*. For example, the production of the book "Birds of British Columbia" represents an important initiative by *CWS* as do the various programs, such as Christmas counts, breeding bird surveys, nest record schemes that involve the public, particularly bird watchers, in the monitoring function.

The role of the Chair in this program relates more to stages 2 and 3, the demographic aspects of the *IPM* and in this we hope to work closely with scientists of the Wildlife Ecology Division, using a team approach. The specifics of this approach will be pointed out under the individual research projects.

The scientific approaches to *IPM* fall under three headings:

- i. Population Ecology,
- ii. Behavioural Ecology and
- iii. Physiological Ecology

although in reality there are no such sharp divisions between these groups.

i. Population Ecology

Our general aim will be to expand existing projects or set up new field research projects that monitor variability in reproductive and survival performance of the species of concern. To investigate variation in reproduction will entail several seasons of field work on reasonably large samples of nesting birds. Where possible, we intend to embark on a program of individually marking birds, and to collect blood, tissue and feather samples from the birds to assess genetic variability and contaminant levels. The aim of the research is to identify the environmental factors responsible for variation in reproductive performance and to detect long term demographic trends. To examine variation in survival rates, we will use individually marked birds and Capture-Mark-Recapture (*CMR*) models to assess variability of local and age-specific survival, immigration and emigration. Where possible we will build on existing data-bases of banded birds.

These data will be used for population modelling to help us understand both the demographic processes and the sensitivity of populations to environmental perturbations. The systems ecologist to be hired by *CWS* will be essential for this aspect of the research.

ii. Behavioural Ecology

Behavioural ecology seeks to understand the natural behaviour of animals including foraging, distribution, daily and annual movements, reproductive behaviour and life history. The central tenet of the discipline is that all these behaviours evolved as a result of identifiable and measurable factors acting on the lifetime reproductive success of individuals. Behavioural ecology developed from the cross-fertilization between long-term field studies of animals in their natural habitats, theoretical insights into the evolution of behaviour, and the successful conduct of quantitative, experimental work in both laboratory and field. Using these approaches, much progress has been made over the

past few decades in understanding animal behaviour.

We can use behavioural ecological approaches to help understand why animals use their environment as they do, aiming to more than simply describe. For example, we may be able to describe the dispersion of a species over available feeding sites, but to be able to predict the outcome of a change resulting from , for example, development, we need to investigate the basis of the distribution. Behavioural ecology has developed a number of tools, including dynamic programming and games theory to help investigate this basis, and identify the ecological constraints under which birds find themselves.

iii. Physiological Ecology

Ecological constraints are more readily understood if we have some knowledge of the underlying physiological processes, essential for maintenance, reproduction and survival. The appointment of a physiological ecologist to the Associate Chair position will fill a gap that is evident in most other demographic studies. By looking at intra-specific variability of physiological processes we hope to discover the responses of birds to environmental perturbations such as might be imposed by environmental contaminants for example. In this way we hope to interface with the Ecosystem Health Section, Wildlife Ecology Division.

Physiological ecology is concerned with how animals function, whereas population and behavioural ecology seek to explain why animals function the way they do. In the past, these two questions have often been considered to be independent, and physiological ecologists have been accused of showing only that 'animals live where they can'. Although it is now becoming increasingly apparent that the ecology and evolution of any species can not be considered in isolation from its physiology - and in fact that these two approaches are complementary - this continues to be a weakness of many other demographic studies. At the most general level, the efficiency of energy and nutrient intake, its processing, allocation and expenditure is critical to the survival and reproductive success of individuals and populations. Within-species, individual variation in physiological traits can be as marked as that in ecological, behavioural or morphological traits, although the causes and consequences of this variation are poorly

understood. An understanding of the mechanisms underlying this intra-specific variability in physiological traits is essential in determining the constraints that might limit the ability of individuals, populations and species to respond to chemical and biological changes in the environment.

Reproduction and migration represent two major aspects of the life cycles of most birds, and in particular of those species that have been targeted as being of primary importance in this study (colonially-breeding seabirds and migratory shorebirds and waterfowl). These will therefore form the focus of the work of the Associate Chair. Reproductive output is dependent on breeding propensity and breeding effort (the number and size of eggs laid) and these vary markedly between individuals. Understanding the physiological basis of egg production, and egg-size variation, in wild birds will represent one of the two main goals of this project. Egg production has been demonstrated to be the phase of the life-cycle of birds that is most sensitive to environmental change (particularly with regard to pollution and habitat alteration). Secondly, efficient utilisation of food resources and control of body reserves is essential for the successful completion of migration and for over-winter survival. Again, it is known that there is marked intra-specific variation, for example, in the rate of fat deposition between individuals. The second goal of this project will be to investigate the physiological basis of this variation in relation to possible constraints operating on diet choice, digestive capabilities and fat storage.

B. Academic Goals, The SFU Perspective

1. Population Ecology

What are the major academic issues in population ecology, which the Chair can contribute to the discipline as a whole? We identify two large areas where the projects outlined here can contribute. Firstly, although many long term bird population studies have investigated variation in reproduction, much less has been done in terms of variation in survival. This is partly due to the fact that more effort and resources are required to collect the data, and partly because until recently the necessary mathematical models have not been available. Recently however, new software packages have become

available and we have spent considerable time learning these new techniques with the view to applying them to long term bird-banding data. Having pioneered this with the La Pérouse Bay data set, we are now in a position to adapt it for other data sets, both those already in existence and those which we generate during the mandate of the Chair. One of the academic goals of the Chair therefore will be to develop a Canadian centre where the measurement of survival variation can be measured and assessed. To this end, we have hired Dr. E. Cooch whose mathematical and computer skills make him ideal for this work. As well, Dr. R. Pradel, who helped to develop the Survival General Estimation (*SURGE*) program for investigating survival variation has joined our team as a post-doctoral fellow (*PDF*). We also plan to hold workshops to teach these methods and make them more readily available for Canadian academics and wildlife biologists.

The *SURGE* and other recent methodologies are also valuable for examining patterns of philopatry in birds and will be used for a theoretical and practical exploration of the whole question of philopatry in birds. Although some general predictions about natal and breeding philopatry can now be made, there is very little understanding about the processes involved in winter and migration philopatry. Many applied questions depend on an understanding of the rules that determine whether a bird will return to a previously used location. Often it is important to know whether the populations of birds in an area are residents, transients or a mix of the two. Turnover rates of birds within populations are also important in assessing impact of birds on their environment. Both these questions ultimately depend on understanding the principles of philopatry away from the breeding ground. We hope to concentrate on these questions as a unifying theme for our population work.

2. Behavioural Ecology

Although population ecology and behavioural ecology have been closely tied during their histories, fundamental assumptions remain unique to each. In particular, population models consider neither adaptive adjustments in behaviour nor the possibility of behavioural evolution in making predictions. Yet there is every reason to believe that these are fundamentally important processes.

The discipline of behavioural ecology as a whole has set, as a major goal, the integration of behavioural and population theory into a unified whole. Several major works of the past decade have been devoted to considering the ecological consequences of adaptive behaviour, but so far, the real progress has been very limited.

The Chair will be able to make a major contribution in this area because of the cross-fertilization between large and active groups in both population and behavioural ecology. The aim is to understand intra-specific life history variation, and to use that as a basis for population predictions, rather than the reverse, which is the existing procedure. This would constitute a major and important advance, and we plan to be major contributors in this area.

3. Physiological Ecology

The principal academic goal of research in Physiological Ecology will be to gain an understanding of the significance of, and mechanisms underlying, individual and age-specific expression of physiological traits. As a model system, the work will initially investigate the physiological basis of reproductive investment in egg-laying and the functional significance of egg-size variation in birds. Specifically, the project will concentrate on three main aspects: 1) energetic costs of egg production, 2) the relationship between egg-size and offspring fitness, and 3) mechanisms and constraints in egg-laying females. The approach taken will be to conduct experimental work under more-or-less controlled conditions, for example using captive breeding birds or perhaps a nest-box breeding population, and then to test ideas and hypotheses generated in this way on selected free-living species of particular interest to the Chair. A similar approach would be taken toward the study of the physiological basis of, and possible constraints on, diet choice, digestive capabilities and fat deposition. This work would concentrate on migratory shorebirds, probably Dunlin or western sandpipers, and the aim would be to establish a population of these birds in captivity.

These two areas of research are linked by the common goals of understanding

- 1) individual differences in the patterns of resource acquisition and expenditure, and
- 2) the adaptive significance of individual variation in physiological traits in free-living

birds, this in turn allowing a better understanding of their likely responses to environmental change.

4. General Points

In addition to the specific themes outlined above, we hope that the projects which we undertake will lead to a more general understanding of avian demographic processes which will have applicability to the conservation problems associated with both lesser known and endangered species. Often the detailed study necessary for conservation action is not possible if the species is rare and sensitive to disturbance and conservationists have no option but to extrapolate from more widespread and better studied species. For example, the work with Western Sandpipers may provide valuable insights into the management and protection of the endangered Piping Plover.