

SIXTH ANNUAL REPORT of the CENTRE FOR WILDLIFE ECOLOGY

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I. INTRODUCTION	3
II. THE “CWE” IN ACTION.....	5
A. SPECIFIC PROJECTS	5
1. The Triangle Island Seabird Research Station	5
2. The Western Sandpiper Research Network.....	7
a. Breeding Studies (Alaska)	8
b. Migration Studies (BC and Washington):	8
c. Wintering Ground Studies	11
3. The Marbled Murrelet Project.....	12
4. The Georgia Basin Ecosystem Initiative: Species accounts.....	15
a. Winter and Spring Ecology of Pacific Black Brant.....	15
b. Population Studies of Harlequin Ducks.....	16
c. Scoters	17
d. Snow Geese	19
e. Winter Ecology of Dunlin	19
f. Great Blue Herons	20
g. American Dippers.....	21
5. The Riske Creek Field Station	22
6. Waterbirds in the North.....	22
a. Population change in seaducks in Prince William Sound.....	23
b. Timing of reproduction in Greater Scaup.....	23
c. Seaduck breeding and moulting biology off Alaska’s North Slope	23
d. Foraging ecology of breeding Red-throated Loons	24
e. Courtship and pair formation in Horned and Red-necked Grebes.....	24
f. Parental care in eiders.....	25
7. Physiological ecology of reproduction and migration.....	25
a. Reproductive physiology	26
b. Endocrine disrupters and ecotoxicology.....	27
c. Migration physiology of western sandpipers.....	28
B. OTHER INITIATIVES.....	30
1. Scientific Meetings or Workshops	30
2. Awards, Honours and Appointments (alphabetically and chronologically).....	33
C. COMMUNITY INVOLVEMENT.....	35
D. FUNDING	36
1. Centre for Wildlife Ecology Funding History (Chart)	37
2. 2000/2001 fiscal year (1 April 2000 through 31 March 2001)	38
3. 2001/2002 fiscal year (1 April 2001 through 31 March 2002)	40
E. PUBLICATIONS.....	43
1. Papers in Refereed Journals	43
2. Papers Submitted to Refereed Journals.....	49
3. Conference Proceedings and Book Chapters	50
4. Other Publications	51
5. Theses.....	52
F. PERSONNEL	54

1. Board of Directors	54
2. Research Team	54
i. Faculty and Research Associates	54
ii. Research Group	54
III. APPENDIX I. MISSION STATEMENT (JANUARY 1995 - F. COOKE)	56
A. CONSERVATION GOALS, THE <i>CWS</i> PERSPECTIVE	56
1. Habitats	57
2. Bird Species	57
3. Integrated Population Approach.....	59
B. ACADEMIC GOALS, THE <i>SFU</i> PERSPECTIVE	62
1. Population Ecology	62
2. Behavioural Ecology	63
3. Physiological Ecology.....	63
4. General Points	64
IV. APPENDIX II. MISSION STATEMENT (APRIL 2002 – R. YDENBERG).....	65
A. HISTORY	65
B. MISSION STATEMENT.....	65

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.

Since our last report (August 1999), there have been substantial changes for the Centre. We are now in our ninth year, and in the second year under our new name, the Centre for Wildlife Ecology (CWE). Fred Cooke, the Senior Chair from 1993-2001, has retired, and Dr. Ron Ydenberg has assumed the directorship of the CWE. Tony Williams retains the position of Associate Director. Plans are progressing for hiring a faculty replacement for Fred, who would play a key role in the CWE. A job search in Fall 2001 was unsuccessful in locating a candidate acceptable to both the CWE and the department, so the position has been re-advertised. Interviews should be conducted this spring. Simon Fraser University has committed funds to allow the Centre to replace Fred with another high profile avian academic. This represents a substantial financial commitment, and is a strong sign of university support for our work.

Dov Lank remains with us as a University Research Associate and Adjunct Professor. Dov is responsible for directing several large-scale projects, including the Marbled Murrelet project (along with Fred, who continues to take an active role from across the ocean) and the Western Sandpiper Research Network. Two new Research Associates have joined the Centre since our last report. Dr. Dan Esler, formerly of the US Geological Survey in Alaska, joined us in January 2001 as the director of the waterfowl program. He is one of the leading sea-duck specialists in North America. In July 2001, Dr. Mark Hipfner was hired to replace Doug Bertram as scientific director of the Triangle Island Seabird Research Station. (Doug left the CWE to become Director of the Marbled Murrelet Recovery Team.) Mark has extensive experience working on seabirds in Canada and Alaska. His thesis research concentrated on breeding biology of Thick-billed Murres and Razorbills in Labrador and Nunavut, and he co-authored the accounts for both of these species for the American Ornithologists' Union's Birds of North America series.

Since the last Annual Report, six PhD and 14 MSc students have completed their degrees (see p. 55, Personnel). Their accomplishments are discussed in detail under the “Specific projects” section relevant to their work. Many new students have joined the group since the last report (see list on p. 54), and their projects are discussed in upcoming sections.

In July 2001, Barbara Sherman, the CWE Administrative Asst. who has kept us on course and solvent since 1995, left us to become Departmental Administrator for the SFU Biology department. Although we were very sorry to see her leave, we wish her well in her new position. Barb was replaced by Judy Higham, who, after 8 months in her new job, has learned the ropes and is guiding the ship safely! Connie Smith continues in her post as Research Assistant, watching over data storage, permits and the laboratory.

Our research projects can be grouped into seven categories, which will be discussed in detail in the next section. These categories are:

- 1) Seabird research at the **Triangle Island Research Station**, an ecological reserve on the outermost of the Scott Islands chain, under the direction of Mark Hipfner and John Ryder. This station was established in 1994, and research continues to build a long-term database on seabird ecology, behaviour and demography.
- 2) The research network on **Western Sandpipers** continues to thrive under the coordination of Dov Lank. This project, which involves cooperation of researchers all over western North America, examines all life history stages of Western Sandpipers: at their breeding grounds in Alaska, at migratory stages areas all along the western coast of North America and at wintering grounds in México and Panama.
- 3) The **Marbled Murrelet** project, begun in 1994, has continued to grow and provide data on MAMU demography and breeding habitat preferences that are critical to the management of this threatened species.
- 4) Through the **Georgia Basin Ecosystem Initiative (GBEI)**, we have identified several bird populations for special study. CWE personnel have been involved with studies on Snow Geese, Brant, Harlequin Ducks, Scoters, Great Blue Herons, Dunlin, Marbled Murrelet (see above) and American Dippers.

- 5) The **Riske Creek Project**, conducted in the BC interior near Williams Lake, studied the long term population dynamics of several bird species in the face of environmental changes brought about by modified land use practices, particularly those resulting from the effects of logging and grazing on riparian habitats. Although CWE involvement with this project ended in 2001, a summary of results is provided in this report.
- 6) Under the direction of Dan Esler, the CWE has begun new work on several species of **waterbirds in the north**, including Harlequin Ducks, Greater Scaup, Common Eiders, Long-tailed Ducks and Red-throated Loons. Also falling into this grouping is Bonnie Stout's work on courtship and pairing of Horned and Red-throated Grebes in the NWT, and work by Ron Ydenberg and Markus Öst (from University of Helsinki) on cooperative parental care in eiders.
- 7) Tony Williams and several students in the CWE are pursuing **physiological studies** of migration, egg production and ecotoxicology in several species of birds, including Zebra Finches, Starlings, Greater Scaup, Mallard Ducks and Western Sandpipers.

II. THE "CWE" 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 of CWE.

1. The Triangle Island Seabird Research Station

Background: The Ecological Reserve on Triangle Island supports the largest and most diverse seabird colony in BC, including the world's largest population of Cassin's Auklet, globally significant populations of Rhinoceros Auklet, and BC's largest populations of Tufted Puffin and Common Murre. As part of the Scott Island Group, Triangle Island is recognized as an internationally Important Bird Area (IBA). The ocean region around the Scott Islands is also being considered for status as a Marine Protected Area (MPA). Triangle Island is our key site for inter-specific and inter-colony compara-

tive seabird research. Our main objective is to detect population changes, understand their causes, and provide advice to managers for conservation options. Our core investigations examine breeding propensity and chronology, reproductive performance, nestling diet and development, parental provisioning patterns, attendance patterns, adult survival, and at-sea foraging distributions of seabirds through the application of radio-telemetry. Of particular interest is the issue of how climate-induced fluctuations in the timing and availability of marine prey populations affects seabird reproduction and survival. We also conduct inter-colony comparisons with Seabird Rocks in southern BC.

The Triangle Station: We opened our research and monitoring station on Triangle Island for year 8 on April 15th 2001 with continued logistical support from the Canadian Coast Guard. Dr. Mark Hipfner replaced Dr. Doug Bertram as research director in July 2001, John Ryder continued in his role as supervisor of logistical support, and Krista Amey and James Burns led the field crew in summer 2001. We maintained our time series focus on the plankton-eating Cassin's Auklet, and fish-eating Rhinoceros Auklet, Tufted Puffin and Common Murres, coupled with Graduate student research (see below). As part of our Nestucca Trust Fund commitments we conducted our third and final season of radio telemetry operations to identify foraging areas of Cassin's Auklets around the proposed Scott Islands MPA with the assistance of Dr. Sean Boyd (CWS) and Michael Dunn (CWS).

Seabird Rocks: In July of 2001, a small team visited Seabird Rocks (West Coast Vancouver Island in Pacific Rim National Park) for 24 hr to investigate Rhinoceros Auklet nestling developmental state and diet as part of our Nestucca time series.

“Nestucca” Trust Fund: Our integrated ecosystem study with Department of Fisheries and Oceans (DFO) collects time series information on temporal and spatial variation in zooplankton communities and ocean properties, coupled with detailed seabird population data. This season marked the fourth year of our five-year collaborative investigations. Ocean temperatures remained cool in 2001, with major influences on zooplankton community composition, biomass and temporal availability. Research ships obtained samples at monthly intervals along the Triangle sampling line and at a series of historical stations near Triangle Island. The cruises collected physical and chemical water property data, zooplankton, and on some trips, juvenile salmonids. Expert seabird observers were

placed on vessels when possible to conduct pelagic seabird surveys, in collaboration with Ken Morgan (CWS). In general, reproductive performance in 2001 was good for Cassin's Auklet, Rhinoceros Auklet, and Common Murre, but after a good start Tufted Puffins once again suffered through a poor breeding season marked by high rates of chick mortality late in the season. Growth rates of chicks for all species were lower than values reported for 1999-2000.

Foraging Distributions: In 2001, we concluded our three-year at-sea foraging distribution studies of Cassin's Auklets. We deployed radios on 38 breeding Cassin's Auklets and flew aerial telemetry surveys to locate birds at-sea in June. We flew surveys in a Beaver floatplane and determined that the birds were foraging in a new location 50-100 km northwest of Triangle Island, in contrast to 1999-2000. Cruises along the Triangle sampling line southwest of the colony noted the presence of large quantities of polyps in the areas where birds were found foraging in 1999-2000, and these polyps may have consumed the zooplankton prey that Cassin's Auklets feed on (D. Mackas, IOS, pers. comm.). These studies were both supported through the NESTUCCA trust fund.

Graduate students: Louise Blight defended her MSc thesis in July 2000 on egg neglect by Rhinoceros Auklets on Triangle Island. Carina Gjerdrum successfully defended her MSc thesis on "Nestling growth and parental provisioning of Tufted Puffins (*Fratercula cirrhata*) on Triangle Island, B.C." in April 2001. In summer 2001, Gwyllim Blackburn started an MSc examining reproductive ecology of Tufted Puffins at Triangle Island. This project will continue in 2002, with a focus on examining ornament quality as indicators of parental quality. These studies have contributed greatly to our understanding of Tufted Puffin life history traits.

2. The Western Sandpiper Research Network

A majority of the world's 3.5 – 4.0 million Western Sandpipers stop briefly to refuel in Boundary Bay or on Robert's Bank during their annual northward migration, providing a thrilling sight for local residents. A good fraction of the species population also stops over on southward migration, following a flight over the Gulf of Alaska. Because of this, the species is ranked in the highest priority class in the draft BC-Yukon region CWS Shorebird Management Plan. Our multifaceted research is documenting and modeling

the factors controlling the population size, migratory routes and timing, ecological relationships with predators and prey, habitat use, and physiological ecology of this long-distance, neotropical migrant. Our integrated approach allows us to examine how factors at one location affect events at another. How do events in the wintering grounds, migration sites, and breeding grounds interconnect? Where are population bottlenecks? Of direct conservation concern is the consequence of the removal or deterioration of one or more locations on survival and reproduction. For the past 10 years, we have pursued and aided fieldwork at three breeding sites, several migration locations, and four wintering sites. Dov Lank has organized Western Sandpiper workshops to help keep researchers in touch, and runs a list-server for this purpose. As a result of our work, the Western Sandpiper is now the best-studied shorebird in the Western Hemisphere.

a. Breeding Studies (Alaska)

We examined the breeding performance of Western and Semipalmated Sandpipers, two closely related species. Brett Sandercock continued publication of papers based on his chair PhD work at Safety Sound, near Nome, AK. The eighth field season at the site was completed in July 2000, under Julie Neville, an MSc student supervised by Doug Schamel at the University of Alaska. Doug completed his PhD degree with the CWE in Dec 2000, and continues to collaborate with us. Julie defended her MSc in March 2002 and her results are being integrated with chair studies of migration strategies (see below). In the spring of 2001, CWE MSc student Amanda Niehaus joined ongoing field work on western sandpipers with a second research group, headed by Brian McCaffrey (USFWS) and Dan Rauthruff (MSc, Humboldt State), at their field site in Alaska's Y-K Delta. Amanda examined aspects of parental care and pre-migratory departures, as well as experimenting with nest predator exclusion methods. Her thesis work will focus on novel explanations for the migratory departure of parents and their young, including consideration of why females leave broods about a week prior to males.

b. Migration Studies (BC and Washington):

Our work on migration strategies has considered two major areas: effects of food and predation danger on habitat choice and stopover strategies. We continued our comparison of feeding and predator danger conditions in the Fraser River Delta versus a small mudflat on Sidney Island.

On the food side, Bob Elner (CWS) continued promoting the view that Western

Sandpipers can and do utilize meiofaunal and organic surface “slime” in their diets (see Sutherland, Shepherd and Elner, 2000). In addition to field measurements, Elner’s collaborators have imaged the feeding apparatus of the species and shown the existence of structures well suited for such a feeding mode. These important findings feed directly into behavioral work on this species here and on the wintering grounds.

Nick Wolf, an MSc student of Ron Ydenberg’s, completed his thesis examining invertebrate food availability and usage between sites. Consistent with Chris Guglielmo’s earlier physiological results (which have also been replicated in another season by Dana Seaman), Wolf’s results in the main confirm the hypothesis that Sidney Island is actually a better place for a sandpiper to eat.

In spring and fall of 2001, a small army of field workers, supported by grants to Williams and Ydenberg and CWS funds, sampled feeding behavior, food availability, and the birds themselves (blood samples) near Vancouver and at sites in Washington State (see Dana Seaman’s work in the landscape physiological ecology section). MSc student Andrea Pomeroy, working with Rob Butler, is developing her project around spatial heterogeneity of resource availability and usage by sandpipers. The synergy of conducting behavioural, physiological and ecological work is substantial, with cooperation and extensive sharing of data collection and usage among participants. This approach is being repeated in 2002.

At a broader scale, PhD student Silke Nebel is gathering data on differential foraging behavior at sites throughout the wintering range (see below).

The effects of predators on the behaviour of their prey is a well developed theme within the SFU Behavioural Ecology Research Group, which helped establish the CWE nine years ago. Ron Ydenberg, Dov Lank, and Rob Butler have been examining how migratory falcons interact with migratory sandpipers and alter aspects of the latter’s behaviour, including their habitat choice on migration. This research is timely because raptor populations in many areas of the industrialized world are actually increasing, following artificially low levels resulting from the widespread use of DDT in agriculture in the 1950s. CWE researchers are taking advantage of this worldwide predator reintroduction experiment to determine effects on shorebirds. The results thus far have direct and novel implications for conservation and management of these species. Two papers developing these themes have been published, and two more are ready for

submission.

Using data gathered by CWS researchers since the late 1970s, and newer observations from CWE studies, we have shown that shorebirds have changed their habitat preferences as falcon populations have increased. Small sandpipers are decreasing their usage of smaller migratory stopover sites, where attacking falcons may more easily surprise them than is the case at large, open sites. Despite an abundance of food at the small mudflat on Sydney Island, for example, few sandpipers now stop at this site during southward migration relative to the numbers using the site 20 years ago. Those birds that do use the site are disproportionately young, stay for shorter periods than formerly, and weigh 10% less than those feeding on the large mudflats of the Fraser River Delta and Boundary Bay. James Burns completed his MSc thesis in 2001, which showed that heavier sandpipers were slower on takeoff than lighter ones, making them more vulnerable to predators. We argue that increasing predation danger over the past 15 years has shifted the mass at which sandpipers may forage with reasonable safety at smaller sites, resulting in less usage of these sites.

We are also considering how predation danger from migrant falcons affects migratory timing and routes, and even aspects of parental care on the breeding grounds. Sandpipers benefit by migrating at times when falcons are still occupied with their own breeding, and thus dispersed over the landscape. Adult sandpipers migrate southwards a month prior to young, often leaving the young in the arctic prior to fledging. We interpret this with respect to the adult's need to moult following migration, and the advantage of having completed moult prior to the arrival of migratory falcons. Young birds do not moult following migration, and thus may suffer less from a later migratory flight. Western sandpipers fly directly over the Gulf of Alaska when migrating south, but make short hops along the coast when going north. The birds are exposed to relatively small numbers of falcons on this leg of their southward journey, while falcons accompany northward birds. We thus interpret this difference as reflecting the relative danger of travelling as a heavy bird, under different predation danger regimes, during the two seasons.

These studies show that a previously overlooked decision making process is of substantial importance for conservation planning. Predation-sensitive habitat shifts, and changes in the length of stopover behaviour, strongly affect the design of population

monitoring schemes and habitat reserves. A shift towards lighter weight migrants with shorter stopover times can produce the appearance of a population decline in population survey data, when none actually occurs. This effect will be particularly strong when monitoring is biased towards smaller, predation-prone sites, which may often be the case since smaller sites are easier to count accurately than larger sites. As with general reserve design, several smaller mudflats may not be of equal value to migrants as a large one of similar total size. Finally, the research points out that interactions at several trophic levels need to be considered in management decisions.

c. Wintering Ground Studies

- i. Panama: Patrick O'Hara completed his PhD early in 2002. His work incorporates demography, morphometrics, and extensive analysis of his own data and that gathered at other wintering sites by fellow students and Western Sandpiper network collaborators. He examines the potential effects of feather-wear and body size on migration distance, and on migration versus residency patterns and decisions of Western sandpipers. First year birds retain their primaries for the first 14 months of their life. We propose that the flight performance of these primaries may explain why most first-year birds wintering in Panama do not migrate northward until their second year. If they did leave for the breeding grounds as yearlings, they would be making three trips between Alaska and Panama on the same primaries. Patrick's first paper, which considers this question of migration versus oversummering and the timing of moult of first year birds, is in press in *Ardea*. Additional chapters examine age-specific preparation for migration and annual survivorship, and body size and shape, and feather-wear differences among wintering sites. The capstone of his thesis is experimental work showing that shortening the flight feathers of adults increases their probability of remaining in Panama rather than departing on northward migration. This novel and exciting work will be submitted for publication this summer.

- ii. Mexico. Guillermo Fernandez, supported by a Mexican Graduate Fellowship, has completed three seasons of fieldwork at Bahía Santa Maria, Sinaloa, Mexico, focusing on differential habitat usage by age and sex classes of Western Sandpipers, and factors affecting a low frequency of territoriality among wintering birds at this site. In addition to his research, he is participating in the development of a Mexican

shorebird conservation plan, and helped promote recognition of his study area, which was recently designated a Western Hemisphere Shorebird Reserve Network site. He has continued to publish manuscripts from his MSc work in Baja California based on work supported by CWS in earlier years.

- iii. Broad Geographical Patterns. Silke Nebel, a PhD student working with Ydenberg and Lank, is studying factors affecting the migration distance and wintering distribution of Western Sandpipers, including both foraging and predation related aspects. Her first chapter is an accepted paper reviewing the sex and age distributions of non-breeding Western Sandpipers, which again drew on datasets provided by network collaborators. Her work relates to that of students looking intensively at single sites (Mexico, Panama) in the sense of providing some opportunity to see whether patterns of differential use at a local levels can be scaled up to account for broad geographical patterns.
- iv. UV and feather-wear. Peggy Yen, who has worked with a number of CWE projects during her undergraduate career at SFU, is following up on Patrick's work by considering the potential effects of UV exposure for feather-wear of birds spending the non-breeding season at different locations. Through our collaborative network, she has obtained feathers from birds from sites throughout the range, and developed a novel index to quantify wear attributable to UV exposure.

3. The Marbled Murrelet Project

Work continues for the eighth consecutive year on this project. The ongoing team includes Fred Cooke, Dov Lank, Nadine Parker, Laura McFarlane Tranquilla, Peggy Yen and Yuri Zharikov of CWE, and Louise Waterhouse from the BC Ministry of Forests. Dov Lank joined the team when Fred Cooke moved back to England in the fall of 2001 in anticipation of his retirement this spring. Both Falk Huettmann and Emmanuelle Cam departed at the end of last year after completing major pieces of work as post-docs with the project. Falk has moved on to the University of Calgary and Emmanuelle to a research project in Spain. Yuri Zharikov was hired as a postdoc in April 2002.

In 2001, we continued fieldwork at two field sites - our long-term study at Desolation Sound, BC and our second season at Clayoquot Sound, on Vancouver Island. Two

Masters students completed their theses – Laura McFarlane Tranquilla, on breeding, stress response, and disturbance of Marbled Murrelets, and Russell Bradley on breeding ecology of radio-marked Marbled Murrelets. Laura has since been hired by the project to assist with ongoing data analyses and publication. Russell accepted a position with the Point Reyes Bird Observatory in California in December 2001. Fred Cooke and Dov Lank are serving on the Marbled Murrelet Recovery Team, which is headed by former CWE staff member Doug Bertram. This participation enables the results of this research to be rapidly assimilated into policy guidelines for management of this threatened species.

The dipnet program continued in Desolation, however, no mistnetting was conducted due to the declining capture success in previous seasons. The main objectives were to capture and tag adult murrelets for nest finding purposes; and, later in the season, to capture and tag juvenile murrelets as part of a study investigating post-fledging survival and dispersal. A manuscript documenting the demographic assessment of the Desolation Sound population from our capture-mark-recapture data was recently submitted to Conservation Biology by Emmanuelle Cam *et al.* Adult survival (annual) was estimated as 0.83 (95% CI 0.72-0.90) with the mist net and dip net data and 0.93 (95% CI 0.63-0.99) with the mist net data only. Despite the wide confidence intervals, our estimates are consistent with the range specified by other authors for Marbled Murrelets.

Nest finding continues to be successful using radio telemetry. Since 1998 we have found 121 (37 for 2001) active nests in the Desolation Sound area using this technique. We made several new discoveries in 2001 that substantially add to the currently sparse knowledge of Marbled Murrelet biology. Two ‘re-nesting’ attempts were observed, involving two radioed individuals. In addition, we were able to shed some light on the question of site fidelity, by recapturing and tagging an individual that was a confirmed nesting bird during the 1999 season. The individual nested again in 2001, and the nest was located only 75m from the nest found in 1999.

Although we are still in the throes of analysis, we have drawn a number of conclusions concerning nesting habitat preferences of Marbled Murrelets. We found that Marbled Murrelets do select primarily for steeper slopes in old forest habitat (>140 years) with a slight preference for lower elevations. They exhibit higher nesting success in

steeper slopes and higher elevations. Nest locations suggest intensive use of small Old Forest patches (<200 ha) as opposed to larger Old Forest patches (>200ha). Almost all nest locations are found near steep 'botanical gradients'. This is partly at variance with earlier conclusions on nesting habitat in B.C. from studies using traditional methods to locate nests or using occupied detection surveys. We believe that this difference could be due to previously unequal sampling effort, mostly related to accessibility problems, and to the pre-selection of habitats to be searched. Falk Huettmann *et al.* recently submitted a manuscript resulting from these analyses to the Journal of Wildlife Management. Our findings will help guide land management decisions designed to protect suitable nesting habitat for this species.

Russell Bradley's Master thesis has yielded a number of interesting insights into the breeding ecology of the Marbled Murrelet. It appears that male breeding birds visited their nests, and likely provisioned young, more than females during chick rearing. These findings have offered a behavioural explanation for a previously reported annual male bias of birds flying inland during the chick-rearing period at Theodosia Inlet in Desolation Sound from 1994-1999. It was also found that early breeding birds commuted further from foraging areas to nests, and nested at sites of steeper slopes than later breeding birds. The earlier birds were more successful, while higher nest site elevation, steeper nest site slope, and longer commuting distance were all associated with greater success. In addition, data from radio marked birds showed no evidence to suggest that nesting near forest edges, particularly natural edges, reduces reproductive success in Marbled Murrelets.

Investigations into the breeding physiology of and stress responses in Marbled Murrelets were completed in 2001. Analyses of vitellogenin (VTG) levels (protein found in the blood of egg-producing females) indicate a five-month breeding season, the timing of which is similar year to year (1999-2000). Our analyses also identified possible consequences of disturbance from capture in some birds - approximately half of the females that were 'fecund' (with elevated VTG levels) at capture were never recorded as initiating a nesting attempt (from radio-tracking data). In addition, there appeared to be a 15 day delay in the timing of the nesting attempt for some females, i.e. the initiation of their attempt was later than would have been expected based on their VTG levels at

capture. However, the extent to which natural failure of the breeding attempt or natural re-nesting is encompassed in what we perceive as ‘capture effects’ is unclear.

Work continued for a second year in Clayoquot Sound on Vancouver Island. Despite starting fieldwork at in early April, over one month earlier than in 2000, sea conditions and the birds’ behaviour made it difficult for us to capture a larger number of birds early enough in the season to allow us to locate their nests. As in 2000, we suspected that many of the birds received transmitters after incubation was completed, so our chances of finding nest sites were minimal. We attempted to locate these birds as they made dawn or dusk feeding trips to their nest sites by stationing crews in various river drainages at regular intervals throughout June and early July, and we were successful in three cases. We were able to determine the probable nest location to the patch level for two of these birds, and the actual nest location for one. We made several interesting discoveries regarding the movements of birds tagged at this study site. Two of the birds radio tagged in Clayoquot Sound were discovered nesting in the vicinity of Buttle Lake, approximately 40 km inland. Birds from both of these nests were detected on the west and east coasts of Vancouver Island during chick rearing. In addition to these, an individual with a white underwing (indicative of a yearling bird) captured and tagged in Clayoquot Sound was also detected on the east coast of the island during the 2001 season. These results have interesting implications for the interpretation of murrelet ‘populations’.

4. The Georgia Basin Ecosystem Initiative: Species accounts

a. Winter and Spring Ecology of Pacific Black Brant

The 2000-2001 season was the final one for research on the wintering population of Brant in Boundary Bay and the annual spring migration of Brant through the Strait of Georgia. Radio telemetry played an integral part in the project as 45 Brant were implanted with radio transmitters on the moulting grounds in Alaska. This was done in conjunction with David Ward (US Geological Survey, Alaska Biological Science Centre). The radioed birds were tracked on their wintering grounds, during the northern migration, and then to the breeding grounds. There were two wintering birds in Boundary Bay with radios, which were tracked daily. In addition, 12 other radioed birds were detected on their migration through the Strait of Georgia. These data allowed us to

identify staging areas, understand timing of migration, and turnover rates at staging areas.

Kate Hagmeier, an MSc student under the supervision of Sean Boyd, is finishing up a study of the wintering and migrant Brant of Boundary Bay and eastern Vancouver Island, through funds from the Arctic Goose Joint Venture (AGJV). An exciting finding is that the rare high western Arctic subspecies *Branta bernicla hrota*, is increasingly wintering in the Vancouver area. This population comprises fewer than 8000 birds and has been declining in recent years. Its main wintering area is Padilla Bay in Washington State. This rare population is receiving increasing attention from conservationists and wildlife managers.

Other aspects of the field research include conducting counts for estimates of abundance, juvenile recruitment and the number of Western Canadian High Arctic Brant (*Branta bernicla hrota*) in the Boundary Bay wintering population. Similar surveys were conducted for migrants moving through Boundary Bay and also in the Parksville-Qualicum area of Vancouver Island. The increasing number of *B.b.hrota* in BC, a stock with a world population of fewer than 8000 birds, represents an interesting management issue for CWS.

b. Population Studies of Harlequin Ducks

CWE and CWS have had long-standing conservation concerns and research interest regarding harlequin ducks in the Strait of Georgia. Past studies have resulted in an unprecedented understanding of ecology and demography of a seaduck. This work continues through the work of Heidi Regehr and Michael Rodway, PhD students with the CWE. Heidi's work addresses dispersal of harlequin ducks and the subsequent implications for population structure and demography. She and collaborators have documented that at least some ducklings are accompanied to wintering areas by their mothers, which has never before been described for ducks. Also, her data describe the movement probabilities of birds, by age and sex cohorts, among areas of the Strait of Georgia across seasons. Michael is tackling the subject of timing of pairing in harlequin ducks and factors that influence timing, including the process of mate selection and associated constraints, spacing behaviour, and the role of herring spawn. He has found that herring spawn results in dramatic changes to harlequin duck distribution, diet, and behaviour, and speculates that this may have subsequent consequences for the process of mate selection.

Heidi and Michael's research is a continuation of the large scale banding program started by CWS in 1993 under the direction of Ian Goudie. Banding has been carried out at several locations throughout the Strait of Georgia, with moulting birds receiving an alphanumeric coloured legband allowing individual recognition when birds were sighted later as they hauled out on the rocks. In later years this individual recognition was enhanced by the use of small nasal disks. We concentrated our work mainly on four moulting/wintering populations, at Campbell River, Cape Lazo, Hornby Island and Boundary Bay. The objectives were to understand survival, migration and recruitment patterns of these four populations in order to characterize which habitats were most favorable for Harlequin Ducks. Two of these populations, those at Hornby Island and Boundary Bay have been studied in considerable detail in order to understand the age and sex specific demography and winter dispersal of this species. The high visibility of individually banded birds allowed us to carry out detailed observations of moult in this species and continue to collect information on times of year when birds renew previous pair bonds or form new ones. We have our first evidence of divorce, and it appears that first time breeders pair later in the winter than older birds that have lost a previous mate.

Regular banding during moult ceased in 2000. Birds seemed to be increasingly aware of our activities and our success rate was low. In 2000 we focused instead on using floating mist nets during September to catch juveniles and accompanying females, in order to explore the phenomenon of family dispersal. Two families were caught and a total of 15 juvenile birds (see above).

In 2000, Nicole McCutchen, a MSc student of Ron Ydenberg's, made observations of marked Harlequin Ducks while conducting her research on effects of stonefly abundance on Harlequin habitat usage in Jasper National Park. Cyndi Smith completed MSc work with Harlequin Ducks in 2000, and returned to her previous job with Parks Canada. In the Banff Region, 40 breeding HADU were banded, and observations of marked birds were made by N. Sonosky (working for Cyndi Smith). These data were added to our master database of Harlequin Duck banding and resightings.

c. Scoters

The CWE has three projects concerning Surf Scoters in the Strait of Georgia. This work was initiated because Surf Scoters are an abundant winter visitor to the BC coast and also because there are indications of population declines in the northern breeding

locations. Little is known about this species of duck in contrast to the large number of studies of dabbling ducks, which are widely hunted. The first study, by Debbie Lacroix under the supervision of Ron Ydenberg, investigated the relationship between the scoters and their major food source, the mussel. Scoters are extremely efficient at depleting whole mussel beds and their strategy appears to be to deplete particular beds, which are then left until they re-grow over a time interval of at least a year. There appear to be sufficient mussel beds that the amount of food available in future years is adequate for existing scoter populations.

Sam Iverson is assessing the recruitment rate of young Surf Scoters using winter age ratios. He has determined that young male surf scoters can be accurately distinguished from adults by plumage characteristics, particularly during late winter. Hence, simple monitoring tools can be used to infer important information about productivity and population dynamics. Also, Sam considered factors related to distributions of surf scoter age and sex classes, and discovered that differential foraging efficiency among cohorts in habitats with clams likely explains observed differences in habitat use.

The third CWE study on Surf Scoters began in the winter of 2001-2002, led by Dan Esler, Sean Boyd, and Ron Ydenberg, as a collaborative program involving CWE, CWS, and an array of agency, university, and industry partners. This research addresses interactions between wintering surf and white-winged scoter populations and shellfish aquaculture, which are concentrated in similar areas and require similar resources. To address this issue, we need to understand the processes by which scoters choose foraging patches, the attributes of habitat patches that influence scoter foraging decisions, the scale over which scoters forage, the effects of scoter foraging on shellfish resources, the effects of variation in prey densities and types on scoter foraging and distribution, and the population-level demographic consequences of these interactions. In turn, this will generate data that will (1) indicate the mechanisms by which conflicts or benefits of the shellfish industry could occur, (2) evaluate the population-level effects of the shellfish industry, and (3) predict effects of current and projected levels of shellfish industry activity. This work was recently initiated in Baynes Sound, and will expand to Barkley and Desolation Sounds in subsequent winters.

d. Snow Geese

Snow Geese form life long pair bonds and are inferred, from breeding ground studies, to choose their lifetime partners during their second winter of life. The process of this first pair formation has never been directly observed, because it is impossible to know the age of non-juvenile birds by plumage. Only by observing individually marked birds could one study the process of first pair formation in this species. We were fortunate, through collaboration with colleagues in Wrangel Island in NE Russia, to be able to study a large number of individually neck-collared yearling Snow Geese, banded in 1998, 1999 and 2000 by Vasya Baranyuk as part of our cooperative research program with Russia. These birds, which were unpaired when they arrived at the Fraser and Skagit Deltas, were observed throughout their second, third and fourth winters, and data on pairing behaviour and family structure are being collected. Birds of known age (beyond immature plumaged birds) have never previously been studied on the wintering grounds. Preliminary results suggest that birds from the Wrangel Island population pair for the first time at a much later age than those birds from the mid-continent population. This might explain the much slower population growth rate of this population relative to the birds in the rest of North America. Data have been analysed and a paper is currently being completed for publication.

e. Winter Ecology of Dunlin

The Fraser River Delta hosts the only significant population of wintering shore-birds in Canada (approximately 40,000 birds). Most recently two PhD students of Dov Lank's have studied this system, with funding obtained from Wildlife Habitat Canada, the Fraser River Action Plan, Agriculture Canada, NSERC, the Pacific Habitat Joint Venture and other sources. Pippa Shepherd defended her thesis "Space use, habitat preferences, and time-activity budgets of non-breeding Dunlin (*Calidris alpina pacifica*) in the Fraser River Delta, B.C." in April 2001. Pippa used radio-telemetry to examine: macro-habitat choices and movement patterns relative to invertebrate prey densities; site fidelity and habitat preferences at regional and local scales; and time activity budgets both day and night. She found that individual bird's home range sizes vary with measures of marine invertebrate abundance, with smaller home ranges where food is richer. Dunlin were site-faithful, and although they showed a preference for marine habitats, most also used a range of terrestrial habitats, particularly at night. Of the terrestrial

habitats available, Dunlin preferred soil-based agricultural crops, and pasture in particular. Dunlin spent on average at least (depending on season) 15.7 hours per 24-hour day foraging, and at least another 3 hours per day flying (measured in spring), leaving on average at most 5.3 hours per day for activities such as roosting, preening, vigilance, and other activities. The percentage of time that Dunlin spent feeding did not differ between day and night, nor between marine and terrestrial macro-habitats, although the relative use of marine and terrestrial habitats varied considerably among individuals. Pippa found that the sex ratios of Dunlin in the Fraser Delta are similar to those at overwintering in California.

Lesley Evans Ogden is finishing writing up her PhD thesis on the use of agricultural land by non-breeding shorebirds in the Fraser Delta, with a defense scheduled for June 2002. Lesley's work has quantified what types of fields are utilized by Dunlin, Black-bellied Plover, and Killdeer, and examined what environmental (e.g. weather, tide) and biological factors (e.g. abundance of predators) predict field use. Dunlin use of fields was strongly biased towards nighttime usage, whereas Plovers and Killdeer used fields more often by day. To estimate the relative importance of marine vs. terrestrial habitat to diet, Lesley has collaborated with Keith Hobson (CWS, Saskatoon) to examine stable isotope ratios of blood samples from Dunlin captured along the shore and in fields. On average, agricultural fields account for about 30% of dunlins' diets. However, Lesley found high inter-individual variation in the extent to which fields are used (0–87% of diet), differences between years, and an age and body shape bias in use of fields, with juveniles and relatively short-billed birds deriving a greater proportion of diet from fields. She also experimentally quantified isotopic turnover rates and tissue assimilation for captive Dunlin. Lesley suggests that several farm management techniques, such as long-term application of manure and use of laser leveling, will enhance farmland for shorebirds and that relatively large fields close to shore should be targeted for conservation and management.

f. Great Blue Herons

Ross Vennesland completed his MSc thesis on Great Blue Herons in south-coastal British Columbia in December 2000. He studied the effects of disturbance by humans and predators on 35 breeding colonies in the region. Breeding abandonment was high,

with 42% of 31 colonies totally abandoned in 1999. Smaller colonies were more likely to be abandoned than larger ones. Colony productivity was negatively and significantly related to disturbance by Bald Eagles and, to a lesser extent, by humans. Ross found through experimental approaches to colonies that herons did habituate to non-threatening human activity near breeding areas. However, this response varied significantly among colonies, with more urban colonies being less disrupted. He recommended a setback distance of 165 m to protect heron colonies from human disturbance, but noted that this precaution would do nothing to modify the negative effect of eagle predation. Rob Butler of the CWS continues to monitor and study the population of Great Blue Herons in this area.

g. American Dippers

Under supervision of Leah Bendell-Young at SFU and John Elliott of CWS, Christy (Peterson) Morrissey is conducting a population study of the American Dipper in the Georgia Basin, with particular emphasis on the wintering ecology. Relatively little work has been done in British Columbia where the southern portion of province apparently hosts high densities of dippers in the winter months, which greatly exceed the breeding population. Christy is investigating the relationship between water quality and population trends by determining south coastal population dynamics and levels of contaminant exposure.

The study is being done on the Chilliwack River, B.C. and involves colour banding and radio telemetry to learn more about the seasonal changes in population density as well as the patterns of spring movement. In addition, blood and feather samples from each bird caught are being used for metal and organic contaminant analysis to further be compared to invertebrate contaminant levels from active territories.

How habitat and water quality in south coastal B.C. streams affect the exposure of resident and transient dippers to contaminants (heavy metals and chlorinated hydrocarbons) is largely unknown. The American dipper has been considered a strong indicator of aquatic/ riparian habitat quality in the sub-alpine ecosystem and is likely a key species for monitoring the health of freshwater streams. By analysing the dynamics of the south coastal populations and their levels of contaminant exposure, the various regulatory agencies, habitat and population managers can better manage riparian habitat to preserve water quality.

5. The Riske Creek Field Station

CWE research in the Riske Creek area, southwest of William's Lake, is nearing completion, as PhD students Matt Evans and Brent Gurd complete their degrees. Their work focuses on waterfowl relationships with wetlands, forest, and rangeland, and how these relationships change with habitat alterations, particularly those related to forestry and water management. We worked in cooperation with Kathy Martin (UBC and CWS) and her "nest web" project, and Sean Boyd (CWS). Long-term funding obtained from Forest Renewal BC in July 1996 ended in mid-summer of 2001. As the CWE winds down its presence at Riske Creek, we turned over management of the field station to Kathy Martin, whose work at the site is ongoing.

Matt Evans completed his 5th field season at Riske Creek, including an experimental manipulation of nestbox availability. His first thesis chapter, comparing Barrow's Goldeneye and Bufflehead nesting in boxes *versus* natural cavities was accepted for publication. Additional thesis chapters consider the habitat variables associated with natural cavity sites, and how variation in pond productivity relates to duckling growth rates and survivorship through the first year of life. Matt's results indicated the importance of a combination of productive ponds and suitable forests to provide appropriate nest sites for the success of these species. Two final chapters will examine the effects of territoriality on waterfowl community structure, and make management recommendations arising from his work. Matt Evans has support from provincial and federal Industrial Fellowship awards for the final year of his program. This work overlaps and compliments CWS scientists Sean Boyd and André-Breault's longer-term research on these populations.

PhD student Brent Gurd is attempting to understand whether and how variation in invertebrate availability within ponds affects the abundance and distributions of dabbling duck species, an appropriate "bottoms-up" approach to waterfowl community ecology. He is testing alternative predictions from theories of resource partitioning that emphasize either bill structure or body size. He has completed fieldwork, including successful experimental manipulation of water levels to test hypothesized effects on invertebrate

6. Waterbirds in the North

Under the direction of Dan Esler, an array of studies are underway that address conservation issues about waterbirds in arctic and subarctic habitats along the Pacific

coast. The issues, species, populations, and, often, individuals being studied are shared concerns of CWE, CWS, and collaborators at higher latitudes.

a. Population change in sea ducks in Prince William Sound

Dan is continuing research initiated in 1995 addressing population-level responses of sea ducks (particularly Harlequin Ducks and Barrow's Goldeneyes) to the 1989 oil spill in Alaska. In collaboration with a research team of agency and university partners, Dan has documented that these sea ducks continued to be exposed to residual oil for more than a decade following the spill. Further, Harlequin Ducks have shown long-term demographic consequences of the oil spill, in contrast to the conventional wisdom that oil spill effects are short-lived for bird populations. These findings have important implications for understanding effects of large spills (e.g., Nestucca), low-level chronic releases, such as in boat harbors, and risks of large-scale industry (e.g., oil and gas exploration in northern BC waters). Current studies are examining the links between oil exposure and demography in Harlequin Ducks, including both field and captive approaches. Ongoing field work includes capture, biosampling, and radio-marking Harlequin Ducks to document, on individual and population-level bases, the relationship between exposure to oil and subsequent winter survival. Captive studies at the Alaska SeaLife Center involve exploration of the physiological and behavioural responses to oil exposure, as potential mechanisms that would lead to observed survival reductions in wild Harlequin Ducks in oiled areas.

b. Timing of reproduction in Greater Scaup

Another project initiated in collaboration with the U.S. Geological Survey addresses the relationships of nutrition and physiology to timing of reproduction by greater scaup in coastal Alaska. MSc student Kristen Gorman is leading the work; specific project details are described under the physiological studies section below.

c. Seaduck breeding and moulting biology off Alaska's North Slope

Research Assistant Debbie LaCroix, a recent MSc graduate from the CWE, is leading a study addressing common eider breeding biology on the north slope of Alaska,

in collaboration with the U.S. Geological Survey. The barrier islands, lagoons, and shallow continental shelf off of Alaska's north slope are important habitats for a variety of sea ducks during breeding and post-breeding wing molt portions of the annual cycle. These areas also contain significant oil reserves, and are being actively explored and developed. Hence, concerns have been raised regarding direct and indirect effects of oil field development on sea duck populations. Debbie's work will evaluate variation in breeding success of common eiders.

d. Foraging ecology of breeding Red-throated Loons

Numbers of red-throated loons have declined by over 50% in recent decades. Jeff Ball, MSc student, is considering the underlying causes of this population change by addressing the hypothesis that changes in forage fish quantity or quality have constrained the ability of parents to adequately provision chicks, resulting in subsequent depression of recruitment. Changes in the marine environment of the Bering Sea, where the loons forage, influence the abundance, distribution, and type of forage fish, which in turn has been demonstrated to influence productivity of many seabirds. In collaboration with U.S. agencies, Jeff will document variation in provisioning by Red-throated loons, and the subsequent effects on chick growth, survival, and behaviour.

e. Courtship and pair formation in Horned and Red-necked Grebes

Bonnie Stout continued her study of Horned and Red-necked Grebes in the Northwest Territories and on the wintering grounds in Boundary Bay from 1999 through 2001. Her work has uncovered a complex array of social patterns in both species that has not been adequately described or explained. While courtship begins at the wintering grounds and many grebes apparently arrive in pairs on the breeding grounds, exact timing and location of pair formation in these species remains uncertain. At wintering areas grebes display intense courtship behaviour but do not show consistent mate-guarding behaviour that would indicate the formation of stable pair bonds. In the absence of marked individuals, pair formation at wintering areas cannot be confirmed or ruled out. Staging areas en route to the breeding grounds or near breeding ponds may provide a site for pair formation in some grebes. Breeding territory acquisition follows pair formation, and pairs participate in joint male-female defense of breeding territories. This and other aspects of grebe biology may favor the strategy of pairing before reaching breeding

ponds. Pair bonds break down following breeding and males and females depart breeding ponds separately.

Marked birds have been observed on the breeding grounds for four breeding seasons near Yellowknife, NT. Red-necked Grebes regularly renew pair bonds over successive years; however, this is much rarer in Horned Grebes. Both males and females return to breeding areas in successive seasons. Red-necked Grebes were highly site faithful, while marked Horned Grebes were more flexible in their settling patterns with some returning to previously used ponds, and others moving to other study area ponds. In both species, mate fidelity sometimes occurred without pond fidelity. Both parents care for the young during the first 1 to 2 weeks of life, but then broods are divided between the two parents. Following brood division, Horned Grebes exhibit the interesting behavior of giving the most attention to the smallest chicks in sub-broods.

Following breeding, adults move to molt locations where they replace flight and body feathers, before proceeding to wintering locations. Known molt sites were also described as a part of this study. Evidence for Horned Grebe molt on lakes near breeding locations was observed near Yellowknife, NT, and was also discovered in records of banding in interior Alaska conducted by James King in the late 1950s and early 1960s. Red-necked Grebes appear to move to coastal locations before completing wing molt. Boundary Bay, BC is a molt location described in this study for Red-necked Grebe. Boundary Bay also appears to serve as a molt site for Western Grebes.

f. Parental care in eiders

Markus Öst, of the University of Helsinki, was a visitor at CWE in February and March 2002. He was working with Ron Ydenberg on a project modeling the evolution of cooperative parental care in eiders. Markus expects to return for another two month period sometime in 2003 to complete this project.

7. Physiological ecology of reproduction and migration

The main aims of CWE's research in physiological ecology are three-fold: 1) to obtain a better understanding of the fundamental mechanisms underlying individual and population-level variation in physiological traits in order to provide a solid basis for predicting how animals might respond to environmental change, 2) 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 and ecotoxicology. We continue to approach these aims through a combination of studies on basic physiology, often using tractable model systems (e.g. zebra finches, starlings), coupled with more applied, and more specific, goal-orientated projects (e.g. addressing current endocrine disrupter and ecotoxicological problems).

a. Reproductive physiology

i. **Zebra finches and starlings - model species for reproduction and ecotoxicology studies.** We are continuing our studies of basic reproductive physiology in captive-breeding zebra finches (*Taeniopygia guttata*) and nest-box breeding European starlings (*Sturnus vulgaris*). This work focuses on the causes and consequences of individual 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'). François Vézina (PhD student) has been investigating energetic costs of reproduction and, specifically, egg formation using respirometry (for BMR) and the doubly-labeled water technique (for DEE), and the relationship between body composition and energy expenditure. Katrina Salvante (PhD student) is working on a potential mechanism underlying "costs of reproduction": the conflict between the mother meeting her own energy needs (for maintenance etc) and those of provisioning the egg. In particular she is looking at the dynamics of lipoprotein metabolism in relation to reproduction under 'normal' and stressful conditions (e.g. low ambient temperature), and the hormonal basis of this relationship. Oliver Love (PhD student) will be continuing our work with starlings using hormonal manipulations to modify reproductive investment patterns in females (e.g. egg and clutch size, or offspring quality) to investigate the fitness consequences of variation in these traits. The techniques we have developed and utilised for this basic research, and the basic information generated on reproductive physiology have been invaluable in contributing to, and facilitating, our more applied work. One good example of this linkage is our work on development of indirect, physiological techniques to assess reproductive state and breeding chronology in rare or cryptic species (see below; Vanderkist *et al.* 1999, 2000).

ii. **Timing of nesting and reproductive physiology of Greater scaup.** Continental scaup populations have declined in recent years, and lowered productivity has

been suggested as an important contributing factor in this decline. Kristen Gorman (MSc, co-supervised by TDW and Dr Dan Esler) will be investigating physiological and nutritional attributes that influence timing of clutch formation in female greater scaup (*Aythya marila*). This work will have three components: 1) assessment of nutrient reserve dynamics (lipid, protein) during egg formation using more traditional methods of body composition analysis; 2) use of stable isotope analysis to determine the sources and relative contributions of nutrient reserves used in egg formation; and 3) validation of the use of an indirect, physiological method (plasma yolk precursor analysis) to determine reproductive state in free-living ducks. This project is funded by the US geological Survey in collaboration with Dr Paul Flint (USGS).

b. Endocrine disrupters and ecotoxicology

i. Reproductive and immunological effects in passerines of exposure to endocrine-disrupting compounds. Erinn Birmingham (MSc student) has been studying the effects of nonylphenol (a weak environmental estrogen) on zebra finch physiology and behaviour (using these as a model passerine for xenobiotic research). This involves assessment and validation of measures of immune function (wing web antigen test, organ weight, differential white blood cell counts), reproductive development (testes for histological analysis), and exposure to environmental estrogens (vitellogenin production). Erinn, together with Patti Dods (MET student) is also analyzing similar biological endpoints in field studies of tree swallows, both in Ontario and BC, while also assessing their exposure to nonylphenol and chlorinated organic compounds (through analysis of sediment, livers and insects to determine ambient nonylphenol levels). The goal of this project is to increase understanding of potential physiological and behavioural effects of endocrine-disrupting contaminants (particularly low-level xenoestrogens) in passerines. This work is funded by the Georgia Basin Initiative in collaboration with Dr John Elliott (Environment Canada).

ii. Effects of orchard pesticides on terrestrial and aquatic wildlife. This project, funded by Health Canada under their Toxic Substances Research Initiative, is being carried out by Tony Williams and Harpreet Gill (research assistant) in collaboration with Drs John Elliott and Christine Bishop (Environment Canada). The pesticide DDE is no longer routinely applied but it continues to be widespread as a contaminant in the environment. Other pesticides, such as the organophosphates, azinphos-methyl, and the

EBDC fungicide, mancozeb, are commonly being used currently in orchards applied alone or as mixtures. There is currently no data available on the toxicity of these pesticides themselves, or on how they may interact with DDE to produce synergistic effects. This project will examine the effects of exposure to DDE in combination with these current-use pesticides. We are using the Zebra finch (*Taeniopygia guttata*) as a model passerine, dosing birds prior to and during breeding with regimes that will mimic typical pesticide spray application in orchards. The focus of the study will be to detect subtle, sub-lethal effects on reproduction and health (e.g. immune status).

iii. Impact of use of MSMA (monosodium methanearsonate) for bark beetle control on cavity-nesting birds in B.C. forests. Bark beetles are considered among the most damaging of forest insect pests in western North America. Use of MSMA provides an alternative to direct harvesting in reducing losses to bark beetles. Typically pheromone baits are used to attract beetles to specific trees, and these infested trees are then treated with MSMA. This project will investigate a) the potential for secondary exposure to arsenic from MSMA in woodpeckers and other insectivorous forest birds, and b) possible relationships between AS exposure and health and reproductive success of birds (a collaboration between TDW and Drs John Elliott, Kathy Martin, Laurie Wilson and Pierre Mineau of Environment Canada (new project 2002).

iv. Heavy metals in migrating western sandpipers. In collaboration with Drs Leah Bendell-Young (SFU) and Chris Guglielmo (U Montana), Christine McFarland, an undergraduate student, has been investigating variation in tissue heavy metal levels of migrating western sandpipers in relation to age and stage of migration. Cadmium concentrations in kidney and liver tissue were dependent on age and sex: a) adult males have Cd concentrations than adult females (20-30 $\mu\text{g/g}$ vs. 10-15 $\mu\text{g/g}$); and b) juveniles during their first fall migration have very low Cd concentrations (< 5 $\mu\text{g/g}$). These preliminary data will hopefully form the basis of further work in this area.

c. Migration physiology of western sandpipers

i. Age-specific variation in digestive physiology and physiological state. One of the most interesting results from our earlier work is that juvenile western sandpipers have 30-40% larger gut size during their first Fall migration compared with adults. This is counter-intuitive if "guts don't fly" i.e. if birds should be trying to reduce wing loading

to increase flight efficiency. Will Stein (MSc student), has been investigating other aspects of digestive physiology (gut structure, histology, and digestive enzyme levels) and potential causes for this age differences gut size. His studies suggest that there is both an ontogenetic effect as well as a post-migration "training" effect on increased small intestine size. There were no seasonal differences in the sizes of specific digestive organs (proventriculus, gizzard, pancreas and small intestine) among adult migrants; however, Spring adults had higher intestinal maltase and aminopeptidase-N activities than Fall adults. During fall migration, however, juveniles had smaller proventriculi and lower total chitinase activity than adults did. Thus, although juveniles had longer small intestines, this did not result in additional intestinal enzymatic digestive capacity. These data suggest that adults and juvenile western sandpipers may adopt different foraging and/or digestion strategies during the first migration, e.g. juveniles might digest food less thoroughly than adults even though they have longer small intestines.

ii. **"Landscape physiology" - the use of physiological indicators for assessment of habitat quality.** With funding from the Marine Ecosystem Health Program (UC Davis), we have been investigating the application of plasma metabolite analysis for the assessment of the relative quality of habitats or sites used by migratory shorebirds. Site-specific variation in fattening rates should be important in determining habitat use which, in turn, is important to consider in land acquisition or stewardship decisions. Validation studies of captive birds have shown that plasma triglyceride and glycerol levels (obtained from blood samples) can predict mass change in western sandpipers (*Calidris mauri*) over time periods of 2-7 days. Dana Seaman (MSc) has been capturing and blood sampling western sandpipers at 6-9 sites in the Puget Sound/Georgia Basin region to determine inter-site variation in fattening rates, based on metabolite analysis. For each site we also obtain information on invertebrate prey availability (from mud cores), diet (from fecal samples), and foraging behaviour. The overall aim is to combine information from three very different approaches (metabolite analysis, invertebrate sampling, and foraging behaviour) to assess variation in the quality of migratory stopover sites. Captive birds will be used to investigate factors which might influence plasma metabolite levels (e.g. diet) and which might confound the use of this technique in free-living birds. This project is a collaboration between Dr Bob Elner (Canadian Wildlife Service), Dr Chris Guglielmo (U. Montana) and the US Fish & Wildlife Service in Washington State.

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 included (in roughly chronological order):

1. Scientific Meetings or Workshops

- i. The CWE has been well represented at the past few meetings of the American Ornithologists' Union (AOU). Lesley Evans Ogden, Cyndi Smith, Cindy Hull, Louise Blight, Pippa Shepherd, Connie Smith and Dov Lank presented papers and/or posters at the 1999 meeting at Cornell University in Ithaca, NY. Lesley received an award for best student presentation. In 2000 at Memorial University in Newfoundland, Matt Evans, Lesley Evans Ogden, Laura McFarlane Tranquilla, April Hedd, Dave Moore and Dov Lank gave oral and/or poster presentations. Fred Cooke gave a plenary talk entitled "To cull or not to cull: that is the question", concerning the debate over lesser snow goose population management. At the 2001 meeting in Seattle, WA, held jointly with the Society of Canadian Ornithologists (SCO), oral or poster presentations were given by practically everybody! Carina Gjerdrum, Christy Morrissey, Lesley Evans Ogden, Guillermo Fernandez, Matt Evans, Pippa Shepherd, Sam Iverson, Dov Lank, Will Stein, Doug Bertram, Silke Nebel, Falk Huettmann, Francois Vézina, Erinn Birmingham, Katrina Salvante, Tony Williams, Russ Bradley, Laura McFarlane Tranquilla, Dave Moore and Bonnie Stout all had something to say. Katrina Salvante received a Marcia Brady Tucker Travel Award from the AOU for this meeting, and Pippa Shepherd was awarded the best student presentation award by the SCO.
- ii. On a trip to Europe in Fall 1999, Fred Cooke attended several conferences and visited research institutions. He gave the keynote address at the "One Hundred Years of Bird Ringing" conference held at Helgoland, Germany and attended the Euring conference. He gave an invited presentation to the National Environmental Research Institute of Denmark at Rønne, Denmark.

- iii. Chris Guglielmo and Pippa Shepherd organized and hosted a Conservation Forum Seminar Series with weekly seminars on a range of wildlife conservation issues in 1999-2000.
- iv. CWE members have been active at the annual meetings of the Waterbird Society. At the 1999 meeting, held in Grado, Italy, Ron Ydenberg was a plenary speaker. Ron and Fred both organized symposium sessions, and Ross Vennesland, Rob Butler, Sean Boyd, James Burns and Debbie Lacroix presented papers. Lesley Evans Ogden gave a paper at the 2000 meeting in Plymouth, MA, and Dave Moore and Silke Nebel had papers at the 2001 meeting in Niagara Falls. Dave won the best student paper award at that meeting.
- v. Many members of the CWE have attended the annual meetings of the Pacific Seabird Group in the past few years. At the 2000 meeting, held in Napa, CA, Doug Bertram, Falk Huettmann, Cindy Hull, Louise Blight, Carina Gjerdrum, Russ Bradley, Sean Boyd, John Ryder, Fred Cooke and Laura McFarlane Tranquilla all presented papers. The 2001 meeting was held in Hawaii. Fred Cooke, Laura Tranquilla, Carina Gjerdrum, Russ Bradley, Falk Huettman, Peggy Yen, Nadine Parker and Debbie Lacroix presented papers. Debbie won the best Student presentation award, and Carina received Honourable Mention. At the 2002 meeting in Santa Barbara, CA, the CWE was represented by Russ Bradley, Laura Tranquilla, Falk Huettmann, Peggy Yen, Mark Hipfner, Doug Bertram and Sean Boyd.
- vi. CWE graduate students have made a strong showing at recent Pacific Ecology Conferences, which are organized and run by graduate students from universities in British Columbia, Washington and Oregon. Ten graduate students from the CWE attended and gave presentations at the 2000 PEC held in the San Juan Islands in 2000, four attended the 2001 conference held at Bamfield Marine Station on Vancouver Island and three attended the 2002 conference at Fort Warden in Port Townsend, WA.
- vii. Fred Cooke, Ron Ydenberg, Cyndi Smith, Michael Rodway, Heidi Regehr and Brian Arquilla participated in the 5th Harlequin Duck Symposium, held in Blaine, WA in March 2000.

- viii. Marbled Murrelet research findings were presented to user groups and interested scientists. A Conservation Science of Marbled Murrelet Recovery Team research workshop was held on Vancouver Island in March 2000 at which Falk Huettmann, Fred Cooke, Laura McFarlane Tranquilla and Russell Bradley made presentations.
- ix. Fred Cooke attended the Pacific Flyways Council meeting in March 2000 in Newport, OR.
- x. The 6th Western Sandpiper workshop was held in October 2000, hosted by CWE and organized by Dov Lank. Forty-one active researchers attended, including 24 speakers from Alaska, Mexico, Panama, New Brunswick, California, Saskatoon, Germany, the Netherlands, and UBC, CWS and SFU. Breeding, migration and survival strategies, physiological ecology and conservation of WESA were among the presentation topics, although a few Red Knots, Red-necked Stilts and Dunlin snuck in. Another workshop is being organized for Winter 2002-2003.
- xi. Matt Evans and Brent Gurd presented papers at the 2000 North American Duck Symposium, held 11-14 October in Saskatoon.
- xii. In January 2001, the CWE organized a very successful annual retreat for the Canadian Wildlife Service Pacific and Yukon Region. The theme of the meeting was the role of University research in CWS planning and management.
- xiii. Fred Cooke attended the second North American Bird Conservation Initiative (NABCI) meeting held Queretaro, México in February 2001.
- xiv. Members of CWE have presented papers at a wide variety of meetings and conferences since our last report: Lesley Evans Ogden and Matt Evans at the Cooper Society meeting (Riverside, CA, 2000); Lesley at Society for Conservation Biology meetings (Missoula, MT in 2000 and Hilo, Hawaii in 2001); François Vézina at the Société Québécoise pour L'étude Biologique du Comportement (Québec City, 1999 and Rimouski, 2000) and the Society for Integrative and Comparative Biology (Atlanta, GA, 2000); Silke Nebel spoke at an International Workshop on Biology and Conservation of Shorebirds (Ceuta, México, 2000), at the Wader Study Group Conference (Kollumerpomp, Netherlands, 2001), and to a US Congressional visit to the

to Smithsonian Tropical Research Institute (Panama City, 2002); James Burns and Sam Iverson at Animal Behaviour Society meetings (JB -Atlanta, GA, 2000; SI – Corvallis, OR 2001); and Kate Hagmeier at the North American Arctic Goose conference (Québec City, 2001).

- xv. In August 2001, the CWE hosted a conference entitled “The Application of Ecological Research to Conservation: East meets West”. This meeting was organized to discuss the relevance and application of basic science to conservation and management, and to mark the retirement of Dr Fred Cooke, the Senior Chair of CWE for its first 8 years. A wide range of international speakers, including university, government, and non-governmental researchers, were invited to speak at the conference. There was a poster session as well, in which most CWE graduate students participated. The conference ended with a workshop on university-government collaboration, with the aim of extending the Wildlife Ecology Chair concept to other Environment Canada regions and other universities. One of the high points of the conference was a banquet at the SFU Diamond University Centre, where Fred was “roasted” by his old friend and colleague, Graham Cooch, and Fred and Sylvia were wished a fond farewell and presented with a gift by members of the CWE.
- xvi. Tony Williams and several of his graduate students (Katrina Salvante, François Vézina and Oliver Love) attended the 2002 meeting of the Society for Integrative and Comparative Biology in Anaheim, CA. Katrina received a Dean of Graduate Studies Travel Grant to attend this conference.
- xvii. In February 2002, Dov Lank was invited to speak about the CWE work on Western Sandpipers at the Workshop on Animal Migration held in Lund, Sweden. Patrick O’Hara also attended this meeting, and presented a poster.
- xviii. In March 2002, Amanda Niehaus attended the 9th Alaska Bird Conference in Fairbanks, and won the best student poster award.

2. Awards, Honours and Appointments (alphabetically and chronologically)

- i. Fred Cooke was awarded the Career Achievement Award by the Confederation of University Faculty Associations/BC in June 1999.

- ii. Fred Cooke was selected as President-Elect of the American Ornithologists' Union at the August 2000 meeting in Newfoundland. He will begin his term at the annual meeting in New Orleans in October 2002.
- iii. In February 2001, Fred Cooke was appointed a Member of the Order of Canada, the highest honour granted in Canada for lifetime achievement. He received his insignia of membership from Adrienne Clarkson, the Governor General, at a ceremony in Rideau Hall in Ottawa in May 2001.
- iv. Fred Cooke 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 has played a major role in the development of the research plans of the organization, which has recently established a regional program in BC, under the direction of Dick Cannings, a leading BC naturalist and ornithologist. Stephanie Hazlitt, a recent CWE graduate, was the first employee of this program.
- v. Fred Cooke is on the executive of the Canadian Society of Ornithology and is also on the executive and Chair of the Nominations Committee of the XXII International Ornithology Congress, which will be held in Peking in 2002.
- vi. Fred Cooke was appointed to the Marbled Murrelet Recovery Team in February 2001.
- vii. Lesley Evans Ogden was selected to be the Society of Canadian Ornithologists' representative to the Ornithological Council of North America.
- viii. Guillermo Fernandez has been active in conservation programs directed towards Mexican shorebirds. He was an instructor for the 2nd International Training Workshop for Conservation and Management of Shorebirds held in Baja Santa Maria in February 2002, and also participated in the workshop to develop the Mexican Shorebird Conservation Plan organized by Ducks Unlimited and Ducks Unlimited México in late February 2002. His data on wintering shorebird population size has been instrumental in the designation of Bahía Santa Maria, México as a Western Hemisphere Shorebird Reserve Network (WHSRN) Hemispheric Site.

- ix. Falk Huettmann organized and presented DISTANCE sampling workshops at SFU, UBC, Acadia University and the University of Bayreuth, Germany, and presented a paper at the International DISTANCE Sampling Conference in St. Andrews, Scotland.
- x. Falk Huettmann was awarded a Killam Fellowship in 2002.
- xi. Dov Lank gathered information and provided an assessment of the population estimate for western sandpipers to be used for Canadian and US shorebird conservation plans.
- xii. Tony Williams was appointed to the Editorial Board of Ibis, the international journal of ornithology.

C. Community Involvement

- i. Several CWE members presented talks to naturalist and conservation groups about the work of CWE. Fred Cooke gave a talk for the BC Field Naturalists. Lesley Evans Ogden talked to the Boundary Bay Conservation Committee and to the Vancouver Natural History Society about use of agricultural land by Dunlin. Pippa Shepherd gave talks to the BC Field Ornithologists, the Rotary Club of Tsawassen, a Beach Grove Elementary school class, and at the 2001 Tofino Shorebird Festival about shorebird migration. Christy Morrissey talked about her work on Dippers to the Delta Field Naturalists, the Vancouver Natural History Society, the White Rock/Surrey Naturalists and the Squamish Estuary Conservation Society. Falk Huettmann discussed the Marbled Murrelet project with the Ahousaht Native Band and the Friends of Clayoquot Sound.
- ii. Brent Gurd and Patrick O'Hara served as volunteer judges at a Science Fair held at the Burnaby South Secondary School in February 2001.
- iii. Brent Gurd participated in the "Let's Talk Science" program in 2001 and made several visits to a Grade 4/5 classroom at Cleveland Elementary School.
- iv. Fred Cooke continued to conduct a monthly survey of the water birds of the western Boundary Bay with the Surrey and White Rock Naturalists.

- v. Fred Cooke was interviewed about the work of the CWE for a program broadcast on the Knowledge Network in February 2002.

D. Funding

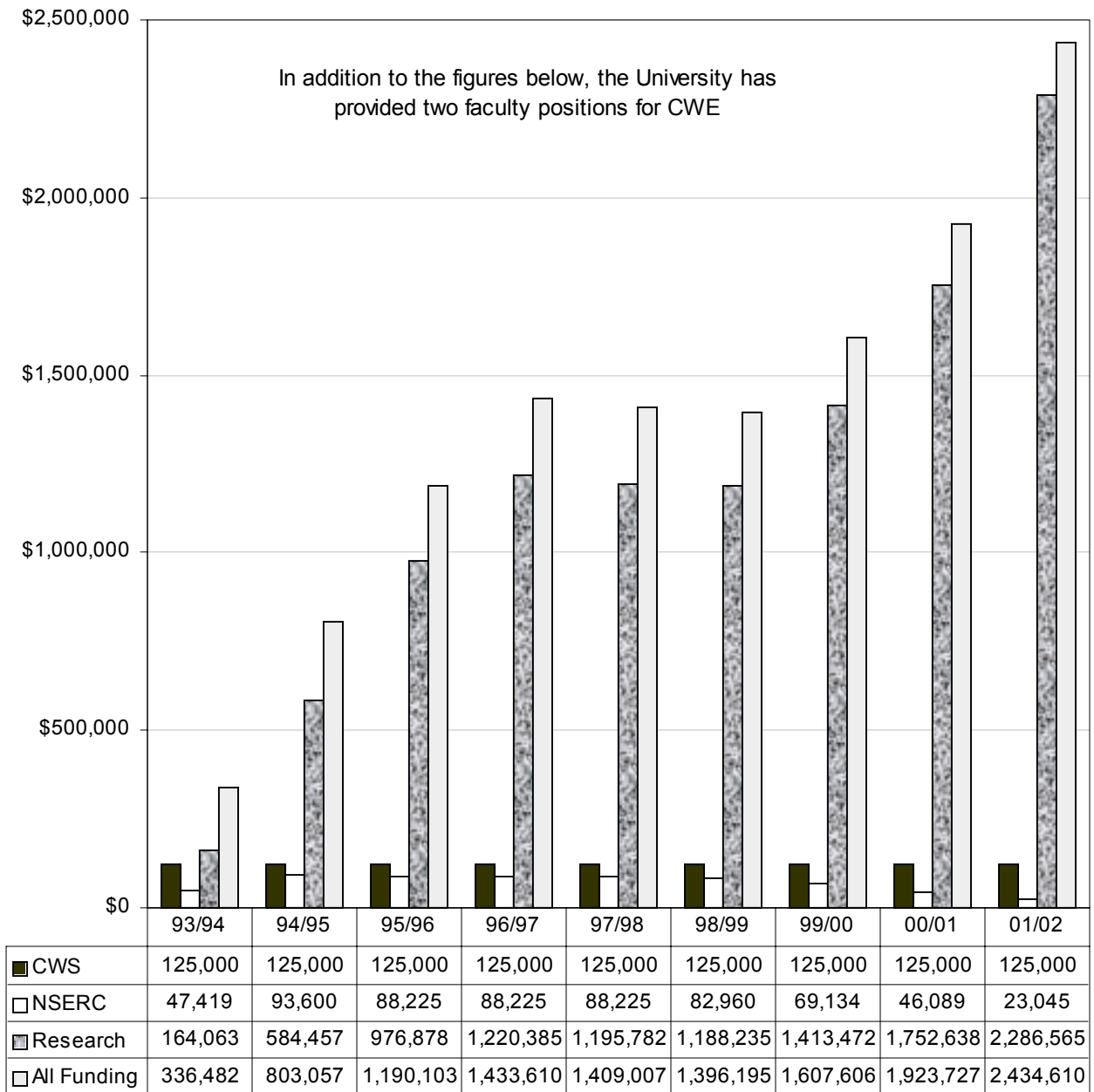
The Canadian Wildlife Service has contributed \$125,000 per year since the inception of the “Chair” in 1993/1994. In addition CWS has encouraged project collaboration and five CWS researchers have been granted adjunct status in the Department of Biological Sciences.

NSERC contributes annually, on a declining scale, to the salary of two CWE faculty members. This ten year gift concludes in March 2003.

The University’s contribution is the provision of two faculty positions (2002/2003 fiscal year will increase faculty positions to three). Our research staff base also includes three university research associates. The previously mentioned “core” SFU faculty positions, “core” CWS funding and “core” research staff have attracted continuously increasing research grant funding in each fiscal year as demonstrated in the following chart.

The two items following the chart identify all funding sources for the fiscal years 2000/2001 and 2001/2002.

Centre for Wildlife Ecology Funding History (March 2002)



1. Centre for Wildlife Ecology Funding History (Chart)

2. 2000/2001 fiscal year (1 April 2000 through 31 March 2001)

<i>Applicant</i>	<i>Source of Funding</i>	<i>Amount (per annum)</i>
	<u>Core Funding</u>	
Cooke, F.	Canadian Wildlife Service Contribution to Centre for Wildlife Ecology	\$125,000 (3rd of 5 yrs)
Cooke, F./ Williams, T.D	NSERC Contribution to Centre for Wildlife Ecology	\$46,089 (8 th of 10 yrs)
	Simon Fraser University Contribution to Centre for Wildlife Ecology	2 Faculty Positions
	Total 2000/2001 Core Funding	\$171,089
	<u>Generated Research Funding</u>	
	Graduate Research Fellowships (J. Burns, C. Gjerdrum, B. Gurd, S. Nebel, H. Regehr, M. Rodway, W. Stein, L. McFarlane Tranquilla, N. Wolfe)	\$55,000
	NSERC Undergrad Award: P. Yen	\$4,860
	NSERC Grad Research Fellowship: B. Gurd	\$19,140
	NSERC Grad Research Fellowship: C.Gjerdrum	\$19,140
Bertram, D.	Natural Resources Canada, Climate Change Action Fund “The Effects of Climate Change on Seabird Populations in Different Oceanographic Domains of British Columbia”	\$80,000 (2nd of 2 yrs)
Bertram, D.	Canadian Nature Federation “Conservation of seabird foraging zones within a Marine Protected Area around the Scott Islands IBA”	\$4,000
Bertram, D. /Mackas, D./Welch, D.	Nestucca Oil and Seabirds on Coastal Vancouver Island: The Power of Information for Impact Assessment and Response	\$95,000 (3rd of 5 yrs)
Bishop, C./ Williams, T.D./ J. Elliott	Health Canada (Toxic Substances Research Initiative) “Effect of pesticides on avian reproduction”	\$20,000 (2nd of 3 yrs)
Cooke, F.	BC Waterfowl Society Harlequin Duck wintering biology	\$7,000 (2nd of 2 yrs)
Cooke, F.	Canadian Wildlife Service Harlequin Duck Study – Strait of Georgia	\$15,000 (4th of 5 yrs)
Cooke, F.	Canadian Wildlife Service Georgia Basin Initiative	\$34,000 (4th of 5 yrs)

Cooke, F.	Canadian Wildlife Service “Marbled Murrelet research in Desolation and Clayoquot Sounds”	\$40,000
Cooke, F.	MacMillan Bloedel, Interfor and Timberwest MYA “Marbled Murrelet research in Desolation and Clayoquot Sounds”	\$262,195 (2nd of 4 yrs)
Cooke, F.	MacMillan Bloedel and Industry “Marbled Murrelet research in Desolation and Clayoquot Sounds”	\$80,000 (1 st of 3 yrs)
Cooke, F.	Science Council of B.C. – FRBC (Riske Creek) “Nesting Habitats, Abundance and Ecology of Marbled Murrelets on the B.C. Coast”	\$190,000 (5th 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 (5th of 5 yrs)
Cooke, F.	NSERC – Individual Operating Grant	\$90,000 (1st of 4 yrs)
Cooke, F.	NCASI “Marbled Murrelet Research in Desolation and Clayoquot Sounds”	\$72,500 (1st of 3 yrs)
Cooke, F.	Canadian Wildlife Service Surf Scoter Study – Strait of Georgia	\$15,000
Cooke, F.	Environment Canada, Science Horizons “Population Studies of Harlequin Ducks” – B. Arquilla “Monitoring of Moulting speed and Ecology of harlequin Ducks on the Moulting/Wintering Grounds” – B. Andres	\$24,000
Cooke, F./ Williams, T.D.	NSERC – CRD “Demographic and habitat studies of marbled murrelets”	\$311,787 (1st of 3 yrs)
Evans Ogden, L.	Wildlife Habitat Canada “The Importance of Agricultural Land to Over-Wintering Shorebirds in the Fraser River Delta, BC	\$12,000 (3rd of 3 yrs)
Fernandez, G.	CONACYT (Mexican Scholarship)	\$17,300 (3rd of 3 yrs)
Fernandez, G.	American Bird Conservancy	\$4,600
Fernandez, G.	Latin American Program	\$3,000
Lank, D.B.	First Jobs in Science and Technology Program, BC Gov’t	\$6,000
Lank D.B./ Cooke, F.	Skills Now Summer Works Program	\$4,500
Nebel, S.	Sigma Xi Grant	\$1,200
Williams, T.D./ J. Elliott	Environment Canada “Endocrine-disrupting chemicals and avian reproduction.”	\$12,500 (3rd of 3 yrs)

Williams, T.D.	NSERC Individual Research Grant “Intraspecific variability, physiological trade-offs and reproductive effort”	\$40,541 (3rd of 4 yrs)
	Total 2000/2001 Generated Research Funding	\$1,752,638
	Total All 2000/2001 CWE Funding	\$1,923,727

3. 2001/2002 fiscal year (1 April 2001 through 31 March 2002)

<i>Applicant</i>	<i>Source of Funding</i>	<i>Amount (per annum)</i>
Cooke, F.	<u>Core Funding</u> Canadian Wildlife Service Contribution to Centre for Wildlife Ecology	\$125,000 (4 th of 5 yrs)
Cooke, F./ Williams, T.D	NSERC Contribution to Centre for Wildlife Ecology	\$23,045 (9 th of 10 years)
	Simon Fraser University Contribution to Centre for Wildlife Ecology	Two Faculty Positions
	Total 2001/2002 Core Funding	\$148,085
	<u>Generated Research Funding</u>	
	Graduate Research Fellowships Ph.D. Fellowships: B. Gurd, C. Morrissey, S. Nebel, H. Regehr, M. Rodway, F. Vezina. M.Sc. Fellowships: R. Bradley, S. Iverson Special Graduate Entrance Scholarship: J. Heath Great Awards: M. Evans CD Nelson Memorial Graduate Scholarship: D. Seaman President’s Ph.D. Research Stipend: L. Evans Ogden, B. Stout, M. Evans, M. Rodway Grad Student Travel Support: K. Salvante	\$86,200
	NSERC USRA: P. Yen	\$4,000
	NSERC Industrial Grad Fellowship: M. Evans	\$18,000
	Ntl. Science Foundation Pre Doctoral: Niehaus, A.	\$25,872
	NSERC PGSB: K. Salvante	\$19,000
Bendell-Young, L.	NSERC Strategic Grant: “Towards a Sustainable Shellfish Aquaculture Industry”	\$65,500 (1 st of 5 years)

<i>Applicant</i>	<i>Source of Funding</i>	<i>Amount (per annum)</i>
Bertram, D. /Mackas, D./Welch, D.	Nestucca Trust Fund Oil and Seabirds on Coastal Vancouver Island: The Power of Information for Impact Assessment and Response	\$95,000 (4 th of 5 yrs)
Bishop, C./ Williams, T.D./ J. Elliott	Health Canada (Toxic Substances Research Initiative) “Effect of pesticides on avian reproduction”	\$20,000 (3 rd of 3 yrs)
Cooke, F.	Canadian Wildlife Service, Research for Surf Scoter, Harlequin Duck and Waterfowl of the Georgia Basin	\$38,800 (4 th of 5 yrs)
Cooke, F.	Weyerhaeuser, Western Forest Products, and Terminal Forest Products “Marbled Murrelet research in Desolation and Clayoquot Sounds”	\$80,000 (3 rd of 4 yrs)
Cooke, F Ydenberg, R.	Science Council of B.C. – FRBC “Nesting Habitats Requirements of Marbled Murrelets”	\$253,115 (1 st of 3 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”	\$50,000 (5 th of 5 yrs)
Cooke, F.	FRBC, Weyerhaeuser MYA “Demographic and Habitat Studies of Marbled Murrelets”	\$274,603 (1 st of 3 yrs)
Cooke, F.	NSERC – Individual Operating Grant	\$90,000 (2 nd of 3 yrs)
Cooke, F.	NCASI “Marbled Murrelet Research in Desolation and Clayoquot Sounds”	\$77,500 (2 nd of 3 yrs)
Cooke, F.	Environment Canada, Science Horizons Youth: “Causes of body mass declines in Western and Least Sandpipers” – A. Pomeroy “Predictability of Cassin’s Auklet foraging locations around the Scott Islands” – G. Blackburn “Colony size considerations when assessing the viability of the great blue heron in the Strait of Georgia” – J. Kenyon “Waterfowl species/habitat associations for the Georgia Basin Estuaries” – J. Ryder	\$48,000
Cooke, F./ Williams, T.D.	NSERC – CRD “Demographic and habitat studies of marbled murrelets”	\$215,532 (2 nd of 3 yrs)

<i>Applicant</i>	<i>Source of Funding</i>	<i>Amount (per annum)</i>
Esler, D.	Exxon Valdez Oil Spill Trustee Council – Harlequin Duck Population Recovery	\$354,000
Esler, D.	US Geological Survey – Red Throated Loons	\$33,962
Esler, D.	US Geological Survey – Greater Scaup	\$76,714
Esler, D.	US Geological Survey – Eiders, Long Tailed Ducks	\$71,867
Esler, D.	Sea Ducks Conference, Workshop Funding:	
	Ducks Unlimited USA	2,720
	Ducks Unlimited Canada	2,500
	Pacific Flyway Council	2,720
	Canadian Wildlife Service Prairie Region	\$5,000
	Canadian Wildlife Service Atlantic Region	\$10,000
	US Fish & Wildlife Service	\$15,840
	US Geological Survey	\$5,280
	Atlantic Flyway Council	\$2,720
Evans Ogden, L.	Canadian Wildlife Service “The Over-Wintering Ecology of Dunlin ... use of Agricultural Land in Delta, BC	\$2,260 2002/2003
Fernandez, G.	Lincoln Park Zoo Neotropical Research Fund	\$3,000
Fernandez, G.	CONACYT (Mexican Scholarship)	\$17,300
Gurd, B.	Delta Waterfowl and Wildlife Trust Fellowship	\$6,923
Hifpner, M.	Canadian Wildlife Service , Equipment for Triangle Island Project	\$10,000
Huettmann, F.	Royal Society of British Geographers	\$2,333
Lank, D.	University of Lund Travel Fellowship	\$1,307
Lank, D.	NSERC Individual Research Grant	\$21,000
Nebel, S.	Canadian Wildlife Service “Western Sandpipers”	\$4,900
O’Hara, P.	University of Lund Travel Fellowship	\$1,152
Stout, B.	Canadian Wildlife Service “Grebe Research”	4,990
Vezina, F.	FCAR (Quebec) Scholarship	6,000
Williams, T.D./ J. Elliott	Environment Canada “Endocrine-disrupting chemicals and avian reproduction.”	\$12,500 (3 rd of 3 yrs)
Williams, T.D./ Guglielmo, C.	Marine Ecosystem Health Program (UC-Davis) “Assessing habitat or site quality for migrating sandpipers”	\$41,914

<i>Applicant</i>	<i>Source of Funding</i>	<i>Amount (per annum)</i>
Williams, T.D.	NSERC Individual Research Grant “Intraspecific variability, physiological trade-offs and reproductive effort”	\$40,541 (4 th of 4 yrs)
Ydenberg, R.C./ DeFreitas, B.	Fisheries & Oceans , “Measuring Northern Abalone juvenile recruitment using artificial habitats.”	\$15,000 2002/2003
Ydenberg, R.C.	NSERC Individual Research Grant	\$51,000
	Total 2001/2002 Generated Research Funding	\$2,286,565
	Total All 2001/2002 CWE Funding	\$2,434,610

E. Publications

This list reflects those publications produced since our last report (publications that were “in press” or “submitted” for the last report are included and have been updated). We continue to publish actively and increasingly. The 20 publications in press and 29 submitted attest to this activity. Most of our publications relate to the research carried out in the main CWE programs and most refer to work carried out in the Pacific Northwest. We are however interacting with scientists throughout Canada and beyond and some of our publications reflect this. We include publications by scientists funded by our RNP program in addition to those within our group. The listing also includes the theses produced by graduate students in our group at SFU.

1. Papers in Refereed Journals

In press:

- Burns, J.G. and R.C. Ydenberg. In press. The effects of wing loading and gender on the escape flights of Least Sandpipers (*Calidris minutilla*) and Western Sandpipers (*Calidris mauri*). Beh. Ecol. Sociobiol.
- Esler, D., T.D. Bowman, K. Trust, B.E. Ballachey, T.A. Dean, S.C. Jewett and C.E. O'Clair. In press. Harlequin duck population recovery following the Exxon Valdez oil spill: progress, process and constraints. Mar. Ecol. Prog. Ser.
- Evans, M.R., D.B. Lank, W.S. Boyd and F. Cooke. In press. The breeding ecology of Barrow's Goldeneye and Bufflehead nesting in nest boxes versus natural cavities. Condor
- Guglielmo, C.G., N.H. Haunerland, P.W. Hochachka and T.D. Williams. In press. Seasonal dynamics of flight muscle fatty acid binding protein and catabolic enzymes in a migratory shorebird. Amer. J. Physiol.
- Guglielmo, C.G., P.D. O'Hara and T.D. Williams. In press. Extrinsic and intrinsic sources of variation of plasma lipid metabolites in free-living Western Sandpipers. Auk

- Guglielmo, C.G., T.D. Williams, G. Zwingelstein, G. Brichon and J.M. Weber. In press. Plasma and muscle phospholipids are involved in the metabolic response to long-distance migration in a shorebird. *J. Comp. Physiol.*
- Hakkarainen, H., E. Korpimäki, V. Koivunen and R.C. Ydenberg. In press. Survival of male Tengmalm's owls under temporally varying food conditions. *Oecologia*
- Hakkarainen, H., I. Yli-Tuomi, E. Korpimäki and R.C. Ydenberg. In press. Provisioning response to apparent predation danger by parental pied flycatchers. *Orn. Fenn.*
- Hazlitt, S. In press. Territory quality and reproductive performance of Black Oystercatchers in British Columbia. *Wilson Bull.*
- Hazlitt, S.L., R.C. Ydenberg and D.B. Lank. In press. Territory structure, parental provisioning, and chick growth in the Black Oystercatcher (*Haematopus bachmani*). *Ardea*
- Lougheed, C., L.W. Lougheed, F. Cooke and S. Boyd. In press. Local survival of adult and juvenile Marbled Murrelets and their importance for estimating reproductive success. *Condor*
- Lougheed, C., B.A. Vanderkist, L.W. Lougheed and F. Cooke. In press. Techniques for investigating breeding phenology in Marbled Murrelets, Desolation Sound, British Columbia. *Condor*
- Lozano, G.A. and R.C. Ydenberg. In press. Trans-generational effects of maternal immune challenge in tree swallows (*Tachycineta bicolor*). *Can. J. Zool.*
- Moore, D.J. and R.C. Ydenberg. In press. Variance-sensitive provisioning decisions of parent common terns (*Sterna hirundo*). *Ecology*
- O'Hara, P.D., D.B. Lank and F.S. Delgado. In press. Migration and wing feather moult trade-off in Western Sandpipers (*Calidris mauri*) wintering in Panama. *Ardea*
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- Ost, M., R.C. Ydenberg, K. Lindstrom and M. Kilpi. In press. Condition and coalition formation by brood rearing common eider females. *Behav. Ecol.*
- Rodway, M.S. and F. Cooke. In press. Use of fecal analysis to determine seasonal changes in the diet of wintering Harlequin Ducks at a herring spawning site in the Strait of Georgia, British Columbia. *J. Field Ornithol.*
- Rodway, M.S., H.M. Regehr and J.W. Chardine. In press. Status of the largest colony of Atlantic Puffins in North America. *Can. Field Nat.*
- Salvante, K.G. and T.D. Williams. In press. Vitellogenin dynamics during egg-laying: Daily variation, repeatability and relationship with egg size. *J. Avian Biol.*
- Torres, R., F. Cooke, G.J. Robertson and W.S. Boyd. In press. Pairing decisions in the Harlequin Duck: costs and benefits. *Waterbirds*

2002

- Blomqvist, D., B. Kempnaers, R.B. Lanctot and B.K. Sandercock. 2002. Genetic parentage and mate guarding in the arctic-breeding Western Sandpiper. *Auk* 119:228-233.
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- Bradley, R.W., L.A. McFarlane Tranquilla, B.A. Vanderkist and F. Cooke. 2002. Sex differences in provisioning rate in chick rearing Marbled Murrelets. *Condor* 104:178-183.
- Christians, J.K. and T.D. Williams. 2002. Effects of porcine follicle-stimulating hormone on the reproductive performance of female zebra finches (*Taeniopygia guttata*). *Gen. Comp. Endocrinol.* 125:121-131.

- Hedd, A., J.L. Ryder, L.L. Cowen and D.F. Bertram. 2002. Inter-annual variation in the diet, provisioning and growth of Cassin's Auklets at Triangle Island, BC: response to variation in ocean climate. *Mar. Ecol. Prog. Ser.* 229:221-232.
- Hull, C., B. Vanderkist, L.W. Lougheed, G. Kaiser and F. Cooke. 2002. Body mass variation in Marbled Murrelets in British Columbia: is it adaptive? *Ibis* 144:E88-E95.
- Lank, D.B., C.M. Smith, O. Hanotte, A. Ohtonen, S. Bailey and T. Burke. 2002. High frequency of polyandry in a lek mating system. *Behav. Ecol.* 13:209-215.
- Ydenberg, R.C., R.W. Butler, D.B. Lank, C.G. Guglielmo and M. Lemon. 2002. Trade-offs, condition dependence, and stopover site selection by migrating sandpipers. *J. Avian Biol.* 33:47-55.

2001

- Bertram, D.F., D. Mackas and S. McKinnell. 2001. The seasonal cycle revisited: interannual variation and ecosystem consequences. *Prog. Oceanogr.* 49:283-307.
-
- Bradley, R.W. and F. Cooke. 2001. Cliff and deciduous tree nests of Marbled Murrelets in southwestern British Columbia. *Northwestern Naturalist* 82:52-57.
- Burness, G.P., R.C. Ydenberg and P.W. Hochachka. 2001. Physiological and biochemical correlates of brood size and energy expenditure in tree swallows. *J. Exp. Biol.* 204:1491-1501.
- Burns, J.G. and S.L. Wardrop. 2001. The veloci-raptor: a bicycle-powered model raptor for realistic predator encounter experiments. *J. Field Ornithol.* 72:399-403.
- Butler, R.W., N.C. Davidson and I.G. Morrison. 2001. Global scale shorebird distribution in relation to productivity of near-shore ocean waters. *Waterbirds* 24:224-232.
- Challenger, W.O., T.D. Williams, J.K. Christians and F. Vezina. 2001. Follicular development and plasma yolk precursor dynamics through the laying cycle in the European starling (*Sturnus vulgaris*). *Physiol. Biochem. Zool.* 74:356-365.
- Christians, J.K. and T.D. Williams. 2001. Interindividual variation in yolk mass and the rate of growth of ovarian follicles in the zebra finch (*Taeniopygia guttata*). *J. Comp. Physiol.* 171:255-261.
- Christians, J.K. and T.D. Williams. 2001. Intraspecific variation in reproductive physiology and egg quality in the European starling (*Sturnus vulgaris*). *J. Avian Biol.* 32:31-37.
- Cooch, E.G., R.F. Rockwell and S. Brault. 2001. Retrospective analysis of demographic responses to environmental change: a lesser snow goose example. *Ecol. Monogr.* 71:377-400.
- Dale, J., D.B. Lank and H.K. Reeve. 2001. Signaling individual identity versus quality: a model and case studies with Ruffs, Quealeas and House Finches. *Am. Nat.* 158:75-86.
- Fernandez, G., H. de la Cueva and N. Warnock. 2001. Phenology and length of stay of transient and wintering Western Sandpipers at Estero Punta Banda, Mexico. *J. Field Ornithol.* 72:509-520.
- Guglielmo, C.G. and J.G. Burns. 2001. Avian forensics: predicting body fat and body mass from wing remains. *J. Avian Biol.* 32:198-203.
- Guglielmo, C.G., T. Piersma and T.D. Williams. 2001. A sport physiological perspective on bird migration: evidence for flight-induced muscle damage. *J. Exp. Biol.* 204:2683-2690.
- Gurd, D.B. and T. Nudds. 2001. Conservation of mammals in eastern North American Wildlife Reserves: how small is too small? *Conservation Biology* 15:1355-1363.

- Hazlitt, S. and R.W. Butler. 2001. Site fidelity and reproductive success of Black Oystercatchers in British Columbia. *Waterbirds* 24:203-207.
- Hull, C.L., G.W. Kaiser, C. Loughheed, L. Loughheed, S. Boyd and F. Cooke. 2001. Intra-specific variation in commuting distance of Marbled Murrelets (*Brachyramphus marmoratus*): ecological and energetic consequences of nesting further inland. *Auk* 118:1036-1046.
- Hull, C.L., B.A. Vanderkist, L.W. Loughheed, G. Kaiser and F. Cooke. 2001. Morphometric variation in Marbled Murrelets, *Brachyramphus marmoratus*, in British Columbia, Canada. *Northwestern Naturalist* 82:41-51.
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- Bennett, K., T.D. Williams, J.E. Smits, M. Wayland, S. Trudeau and L.I. Bendell-Young. Submitted. Impact of oil sands based wetlands on the growth of mallard (*Anas platyrhynchos*) ducklings. *Ecol. Appl.*
- Bertram, D.F., T. Golumbia, G.K. Davoren, A. Harfenist and J. Brown. Submitted. Short visit reveal consistent patterns of interyear and intercolony variation in seabird nestling diet and performance. *Can. J. Zool.*
- Butler, R.W., P.C.F. Shepherd and M.J.F. Lemon. Submitted. Individual site choice by migrating Western Sandpipers, *Calidris mauri*. *Wilson Bull.*
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- Egeler, O., D. Seaman and T.D. Williams. Submitted. The influence of diet on fatty acid composition of depot fat in Western Sandpipers, *Calidris mauri*. *Auk*
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- Evans Ogden, L.J., K.A. Hobson and D.B. Lank. Submitted. Blood isotopic (C13 and N15) turnover and diet-tissue fractionation factors in captive dunlin: implications for dietary assessment of wild birds. *Auk*
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- Gjerdrum, C. Submitted. Regulation of provisioning and nesting departure decisions: a supplementary feeding experiment in Tufted Puffins (*Fratercula cirrhata*). *Anim. Behav.*
- Guglielmo, C.G. and T.D. Williams. Submitted. Phenotypic flexibility of body composition in relation to migratory state, age and sex in the Western Sandpiper (*Calidris mauri*). *Physiol. Biochem. Zool.*
- Huettmann, F., E. Cam, R. Bradley, L. Lougheed, L.M. Tranquilla, C. Lougheed and F. Cooke. Submitted. Breeding habitat selectivity by Marbled Murrelets in a fragmented old-growth forest landscape. *J. Wildl. Manage.*
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- Lozano, G.A. and D.B. Lank. Submitted. Immunocompetence and testosterone-dependent condition traits in male ruffs (*Philomachus pugnax*). *Auk*
- McFarlane Tranquilla, L. Submitted. Stress response in Marbled Murrelets. *Auk*
- McFarlane Tranquilla, L.A., R.W. Bradley, T.D. Williams, L. Lougheed and F. Cooke. Submitted. Are brood patches reliable for assessing reproductive status in Marbled Murrelets? *Condor.*
- McFarlane Tranquilla, L., F. Huettman, C. Lougheed, L.W. Lougheed, G. Kaiser and N. Parker. Submitted. Sightings of vagrant Pacific alcids in Desolation Sound, BC, Canada. *Can. Field Nat.*
- McFarlane Tranquilla, L., T.D. Williams and F. Cooke. Submitted. Using physiology to examine interannual variation in breeding chronology of Marbled Murrelets in Desolation Sound, B.C. *Auk*
- Moore, D.J. and R.D. Morris. Submitted. The occurrence of second clutches in Common Terns (*Sterna hirundo*): proximate effects of reproductive timing and food supply. *Waterbirds*

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- Peterson, C.H., S.D. Rice, J.W. Short, D. Esler, J.L. Bodkin, B.G. Bue, D.B. Irons and B.A. Ballachey. Submitted. Emergence of ecosystem-based toxicology: long-term consequences of the Exxon Valdez oil spill. *Science*
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5. Theses

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- Moore, D. 2002. The provisioning tactics of parent Common Terns (*Sterna hirundo*) in relation to brood energy requirement. Ph.D., Simon Fraser University, Burnaby, BC. 202 pp.

- O'Hara, P. 2002. The role of feather wear in alternative life history strategies of a long-distance migratory shorebird, the Western Sandpiper (*Calidris mauri*). Ph.D., Simon Fraser University, Burnaby, BC.
- Burns, J. 2001. The ecological consequences of fuel storage in migrating *Calidris* sandpipers. MSc, Simon Fraser University, Burnaby, BC.
- Gjerdrum, C. 2001. Nestling growth and parental provisioning of Tufted Puffins (*Fratercula cirrhala*) on Triangle Island, British Columbia. MSc, Simon Fraser University, Burnaby, BC. 117 pp.
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- Schamel, D.L. 2000. Female and male reproductive strategies in the red-necked phalarope, a polyandrous shorebird. Ph.D., Simon Fraser University, Burnaby, BC.
- Smith, C.M. 2000. Survival and recruitment of juvenile Harlequin Ducks. MSc, Simon Fraser University, Burnaby, BC.
- Vennesland, R.G. 2000. The effects of disturbance from humans and predators on the breeding decisions and productivity of the Great Blue Heron in south-coastal British Columbia. MSc, Simon Fraser University, Burnaby, BC. 109 pp.
- Guglielmo, C.G. 1999. Physiological and biochemical modulation for long-distance migration: the functional significance of intra-specific variation in the Western Sandpiper. Ph.D., Simon Fraser University, Burnaby, BC. 226 pp.
- Lougheed, C. 1999. Breeding chronology, breeding success, distribution and movements of Marbled Murrelets (*Brachyramphus marmoratus*) in Desolation Sound, British Columbia. MSc, Simon Fraser University, Burnaby, BC. 89 pp.
- Vanderkist, B.A. 1999. Sex ratio and physiological indicators of reproduction in the Marbled Murrelet (*Brachyramphus marmoratus*). MSc, Simon Fraser University, Burnaby, BC. 92 pp.

F. Personnel**1. Board of Directors**

<i>Name</i>	<i>Position</i>	<i>Affiliation</i>
Dr. Robert Elner	Head, Migratory Birds Conservation	<i>CWS</i>
Dr. Larry Dill	Professor	<i>SFU</i>
Dr. Elizabeth Elle	Asst. Professor	<i>SFU</i>
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Dr. Tony Williams	Assoc. Professor (non-voting)	<i>SFU</i>
Dr. Alton Harestad (SFU alt.)	Professor	<i>SFU</i>

2. Research Team*i. Faculty and Research Associates*

<i>Name</i>	<i>Position</i>
Dr. Fred Cooke	Senior Chair, emeritus
Dr. Ron Ydenberg	Director, CWE
Dr. Tony Williams	Associate Director
Dr. Dov Lank	University Research Associate
Dr. Dan Esler	University Research Associate
Dr. Mark Hipfner	University Research Associate

ii. Research Group

<i>Sabbatical Visitor</i>	<i>Postdoctoral Fellow</i>	<i>PhD (in progress)</i>	<i>MSc (in progress)</i>	<i>Others</i>
	James Dale	Matt Evans	Jeff Ball	Judy Higham
	Yuri Zharikov	Lesley Evans Ogden	Gwylim Blackburn	Jamie Kenyon
		Guillermo Fernandez	Harpreet Gill	Nadine Parker
		Silke Nebel	Kristen Gorman	John Ryder
		Brent Gurd	Kate Hagmeier	Connie Smith
		Oliver Love	Sam Iverson	Peggy Yen
		Heidi Regehr	Amanda Niehaus	
		Michael Rodway	Andrea Pomeroy	
		Katrina Salvante	Dana Seaman	
		Bonnie Stout		
		Francois Vézina		

	<i>Moved On</i>	<i>PhD(defended)</i>	<i>MSc (defended)</i>	
	Falk Huettman	Julian Christians	Kirsty Bennett**	
	Emmanuelle Cam	Chris Guglielmo	Erinn Birmingham	
	Marcus Öst	Dave Moore	Louise Blight	
		Patrick O'Hara	Russell Bradley	
		Doug Schamel	James Burns	
		Pippa Shepherd	Carina Gjerdrum	
			Debbie Lacroix	
			Cecilia Lougheed	
			Katrina Salvante	
			Cyndi Smith	
			Will Stein	
			Laura Tranquilla	
			Ross Vennesland	
			Nick Wolfe	

** co-supervised by Drs. Tony Williams and Leah Bendell-Young

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 modeling 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 that 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. 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.

IV. APPENDIX II. MISSION STATEMENT (April 2002 – R. Ydenberg)

A. History

In 1993, the National Sciences and Engineering Research Council of Canada, Simon Fraser University, and Environment Canada signed a 10 year agreement to create the NSERC/CWS Chair in Wildlife Ecology at SFU. The Centre for Wildlife Ecology (CWE) described here is a new structure based on the Chair. Under the Migratory Birds Convention and Canada Wildlife Acts, the mandate of the Canadian Wildlife Service is to protect and conserve migratory bird populations. In the 21st century, this historical mandate is broadening to encompass other environmental concerns such as species at risk, biodiversity, sustainability and endangered habitats. To meet these broad and varied responsibilities, Environment Canada depends on sound science, and participates in cooperative ventures, such as that with the CWE.

B. Mission Statement

The mission of the Centre for Wildlife Ecology (CWE) is to foster high quality, graduate training and research, conduct basic and applied research in wildlife ecology, and to provide knowledge and personnel that will help Environment Canada and other agencies meet the challenges of conservation in the 21st century. The central concept is to foster synergy between the mission-oriented research and management policies of the Canadian Wildlife Service (CWS) and the basic research agenda of the University. Information, ideas, expertise, resources and opportunity flow back and forth across this interface, giving government agencies access to a broad base of science capability that helps inform policy and decision making, while the university and its faculty and students benefit from enhanced opportunities for research and application of the ideas their disciplines generate.