Lieferschein

Universitaet Konstanz, Kommunikations-, Informations-, Medienzentrum
\50KIM\51

- Dokumentlieferung –
Postfach Postfach

D-78457 Konstanz

Tel.: ++49-7531-88-2824
Fax: ++49-7531-88-2809
Email: dokumentlieferung.kim@uni-konstanz.de

Empfänger

Max-Planck-Institut fuer Ornithologie

Bibliothek

D-82319 Seewiesen

Eberhard-Gwinner-Strasse

Angaben zur Bestellung:

Bestelldatum:	2019-01-15 20:12:05
Bestellnummer:	SUBITO:VE19011501298 E000298342
Name des Bestellers:	Max-Planck-Institut fuer Ornithologie
Benutzerkennung:	SLS08X00031
Lieferdatum:	2019-01-16 09:54:28
Lieferpriorität:	NORMAL
Aktueller Lieferweg:	Email
E-Mail Adresse:	bibliothek@orn.mpg.de

Bemerkungen zur Auslieferung:

Angaben zum Dokument:

Signatur:	bio 776:pm12/v27a
Autor:	Kees Vermeer
Titel:	The ecology, status, and conservation of marine and shoreline birds of the Queen Charlotte Islands
Jahr:	
Band / Jahrgang:	
Seiten:	123-130
Aufsatzautor:	Cooper
Aufsatztitel:	Populations, status, and biology of shorebirds 123 breeding near Masset, Queen Charlotte Islands
ISSN:	0662254708
ISBN:	
CODEN:	

Ihre Bemerkung zur Bestellung: Bulla

subito Urheberrechtshinweis

Die Bestellung und Nutzung der über subito gelieferten Aufsatzkopien unterliegen den urheberrechtlichen Bestimmungen. Mit der Registrierung bei subito verpflichten Sie sich, diese einzuhalten, d.h. insbesondere, dass die Kopien ausschließlich zum eigenen Gebrauch bestimmt sind und nicht an Dritte weitergegeben werden dürfen. Sie dürfen ohne Genehmigung des Verlags nicht zum Wiederverkauf, Wiederabdruck, zu systematischer Verteilung, Emailversand, Webhosting eingeschlossen institutionelle Repositorien/Archive oder jedweden anderen kommerziellen Zweck verwendet werden.

Sofern Sie eine Lieferung per Email oder FTP erhalten, dürfen Sie die Kopie nur einmal ausdrucken und müssen diese anschließend dauerhaft löschen.

Die Kopien sind mit einem Wasserzeichen versehen, welches ein Urheberrechtsvermerk enthält. Das von subito e.V. angebrachte Wasserzeichen darf nicht entfernt werden.

N7

SUBITO-Bestellschein KOPIE

Bestellart:	**Lieferweg: FTP**	
-	Eingang: 15.01.2019 - 20:12	Lieferung bis: **18.01.2019 - 14:00**

Subito-BestNr.: SUBITO:VE19011501298

Kundennummer: K000007502	Bestellnummer: **E000298342**	Benutzernr.: **SLS08X00031**

E-Mail: docdel-doc.de

Max-Planck-Institut fuer Ornithologie

Bibliothek

Eberhard-Gwinner-Strasse

82319 Seewiesen **DE**

Signatur:	**bio 776:pm12/v27a**
Titel:	The ecology, status, and conservation of marine and shoreline birds of the Queen Charlotte Islands
Jahrgang/Heft:	
Erscheinungsjahr:	1997
Seiten:	123-130
Autor:	Cooper
Artikel:	Populations, status, and biology of shorebirds 123 breeding near Masset, Queen Charlotte Islands

Weitere Angaben:

Bemerkung zum Dokument: **Bulla**

Kundennummer:

Bestellnummer

Kees Vermeer[1]
Ken H. Morgan[2]
(editors)

The ecology, status, and conservation of marine and shoreline birds of the Queen Charlotte Islands

Occasional Paper
Number 93
Canadian Wildlife Service

[1] Canadian Wildlife Service, Environment Canada, c/o Institute of Ocean Sciences, P.O. Box 6000, Sidney, B.C V8L 4B2.
[2] Pacific Wildlife Research Centre, Canadian Wildlife Service, Environment Canada, 5421 Robertson Road, RR # 1, Delta, B.C. V4K 3N2.

A member of the Environmental Conservation family

Cover photo: Ancient Murrelet forest, Rankine I. (Moria Lemon)

Published by Authority of the
Minister of Environment
Canadian Wildlife Service

Minister of Public Works and Government Services Canada, 1997
Catalogue No. CW69-1/93E
ISBN 0-662-25470-8
ISSN 0576-6370

Canadian Cataloguing in Publication Data

Main entry under title:

The ecology, status and conservation of marine and shoreline birds of the Queen Charlotte Islands

(Occasional paper, ISSN 0576–6370; no. 93)
Includes an abstract in French.
Includes bibliographical references.
ISBN 0-662-25470-8
Cat. no. CW69-1/93E

1. Shore birds — British Columbia — Queen Charlotte Islands — Ecology.
2. Sea birds — British Columbia — Queen Charlotte Islands — Ecology.
3. Marine biology — British Columbia — Queen Charlotte Islands.
I. Vermeer, Kees.
II. Morgan, Kenneth Henley.
III. Canadian Wildlife Service.
IV. Series: Occasional paper (Canadian Wildlife Service); no. 93.

The Canadian Wildlife Service

The Canadian Wildlife Service of Environment Canada handles wildlife matters that are the responsibility of the Canadian government. These include protection and management of migratory birds as well as nationally significant wildlife habitat. Other responsibilities are endangered species, control of international trade in endangered species, and research on wildlife issues of national importance. The service cooperates with the provinces, territories, Parks Canada, and other federal agencies in wildlife research and management.

The Occasional Papers series

Occasional Papers report the results of original research carried out by members of the Canadian Wildlife Service or supported by the Canadian Wildlife Service. Occasional Papers have been subjected to external peer review.

For more information about the Canadian Wildlife Service or its other publications, please contact:

Publications
Canadian Wildlife Service
Environment Canada
Ottawa, Ontario
K1A 0H3
(819) 997-1095
(819) 997-2756 (fax)
mark.hickson@ec.gc.ca

QL685.5B7E36 1997 598.3'3 C97–980058–7 97-03

Acknowledgements

The editors wish to thank A. Martell, formerly of the Canadian Wildlife Service, for his support of this synthesis on the ecology, status, and conservation of marine and shoreline birds of the Queen Charlotte Islands; and the authors for their patience and assistance throughout the preparation of this report. Besides the editors, the following persons reviewed manuscripts: Donald A. Blood, Hugh Boyd, Kenneth T. Briggs, Karen Burns, Robert W. Butler, G. Vernon Byrd, Alan Campbell, Dirk Derksen, John E. Elliott, Peter J. Ewins, J. Rod Forbes, Howard J. Freeland, Anthony J. Gaston, Cheri L. Gratto-Trevor, Harry M. Ohlendorf, Tim Parsons, Dennis Paulson, Alex Peden, Gerald A. Sanger, Rick E. Thomson, Nico A.M. Verbeek, Terence R. Wahl, and D. Vaughn Weseloh.

This publication was produced by the Scientific and Technical Documents Division of the Canadian Wildlife Service. The following people were responsible: Pat Logan — coordination and supervision; Sylvie Larose — layout; Marla Sheffer (Contract Editor) — scientific editing; and Mark Hickson — printing.

Populations, status, and biology of shorebirds breeding near Masset, Queen Charlotte Islands

John M. Cooper and Edward H. Miller

1. Abstract

The breeding biology of six shorebird species was studied near Masset, Queen Charlotte Islands, British Columbia, during 1984–1988. Chronology of breeding cycles, reproductive success, and the influence of predation and human disturbance are summarized. Reproductive success, measured as successful hatching of eggs, ranged between 0% for Short-billed Dowitcher *Limnodromus griseus* and 100% for American Black Oystercatcher *Haematopus bachmani*. Hatching success for the two most abundant species, Least Sandpiper *Calidris minutilla* and Semipalmated Plover *Charadrius semipalmatus*, was 58% and 55%, respectively. Predation was a significant cause of clutch loss (27% of 408 clutches with a known fate were depredated), particularly for Least Sandpiper, Semipalmated Plover, and Killdeer *Charadrius vociferus*. Disturbance by humans may be negatively impacting local populations of Semipalmated Plovers. Domestic cattle destroyed 8% of 344 Least Sandpiper clutches. One pair of American Black Oystercatchers successfully nested at a site frequently disturbed by humans.

2. Résumé

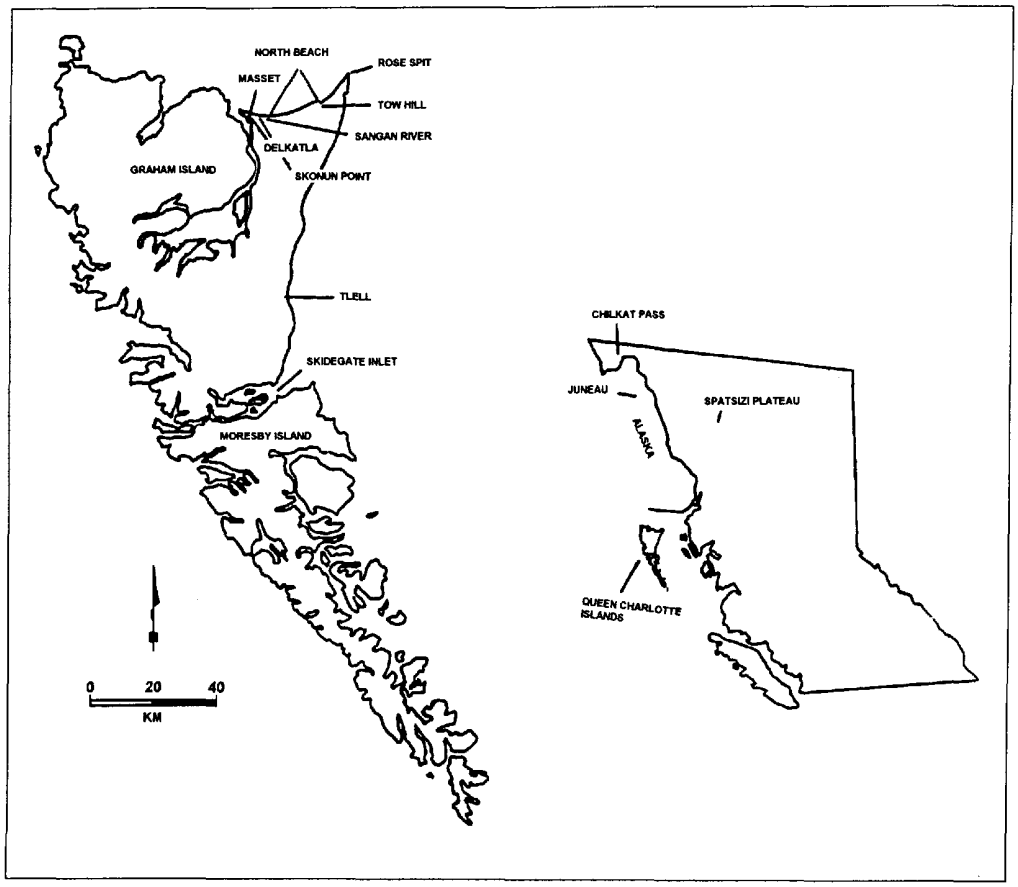
On a étudié la biologie de la reproduction de six espèces d'oiseaux de rivage près de Masset aux îles de la Reine-Charlotte en Colombie-Britannique de 1984 à 1988. On résume la chronologie des cycles de reproduction, le succès de la reproduction, et les répercussions de la prédation et des perturbations humaines. Le succès de la reproduction, mesuré par l'éclosion des oeufs, allait de 0 % chez le Bécasseau roux *Limnodromus griseus* à 100 % chez l'Huîtrier de Bachman *Haematopus bachmani*. Le succès de la reproduction chez les deux espèces les plus abondantes, le Bécasseau minuscule *Calidris minutilla* et le Pluvier semipalmé *Charadrius semipalmatus* était de 58 % et 55 % respectivement. La prédation était une cause importante des pertes de nichées (chez les 408 dont on connaît le sort, 27 % furent l'objet de prédation), particulièrement le Bécasseau minuscule, le Pluvier semipalmé et le Pluvier kildir *Charadrius vociferus*. Il se peut que les perturbations humaines aient des répercussions néfastes sur les populations locales de Pluviers semipalmés. Les bovins domestiques ont détruit 8 % des 344 nichées de Bécasseaux minuscules. Un couple d'Huîtriers de Bachman ont niché avec succès à un endroit souvent perturbé par les humains.

3. Introduction

Of the seven species of shorebirds known to breed on the Queen Charlotte Islands (Campbell et al. 1990), six species were studied in the vicinity of Masset (Fig. 1). Significant numbers of Least Sandpipers *Calidris minutilla* and Semipalmated Plovers *Charadrius semipalmatus* nest in Delkatla Wildlife Sanctuary (hereafter Delkatla) and along North Beach, respectively. Smaller numbers of Common Snipe *Gallinago gallinago*, Killdeer *Charadrius vociferus*, Short-billed Dowitcher *Limnodromus griseus*, and American Black Oystercatcher *Haematopus bachmani* also breed. Spotted Sandpipers *Actitis macularia*, which nested along open riverbanks, were not studied. This community of breeding shorebirds is the most diverse and abundant on the Pacific coast south of Alaska, with two species (Least Sandpiper and Short-billed Dowitcher) reaching the southern limit of their Pacific coast breeding range.

The Least Sandpiper, the most intensively studied of the above species, is a widely distributed breeder across low Arctic and sub-Arctic northern North America (American Ornithologists' Union 1983; Godfrey 1986; Cooper 1994). In northwestern British Columbia, they are known to breed in the vicinity of Chilkat Pass and on the Spatsizi Plateau (Campbell et al. 1990). Small numbers breed in the Alaskan Panhandle as far south as Juneau (Kessel and Gibson 1978). The population breeding at Delkatla was first discovered in 1983 (Miller 1986; Hamel 1989). Delkatla is the southernmost breeding locality in British Columbia and in North America west of Sable Island, Nova Scotia (Godfrey 1986; Campbell et al. 1990). This population is thought to represent the highest breeding density reported for the species (Jehl 1970; Miller 1977; Cooper 1993a; C. Gratto-Trevor, pers. commun.). In addition, the population is thought to have become established only after a change in habitat occurred following the construction of a road causeway in 1964 across the mouth of Delkatla Inlet, which caused Delkatla to change from a tidal marsh to a brackish marsh (Crippen Consultants Ltd. 1986; Cooper 1993a). It is anticipated

Figure 1
Map of the Queen Charlotte Islands, British Columbia, and Alaska, with localities mentioned in the text



that the causeway will be removed in the near future to restore Delkatla as a tidal marsh.

Semipalmated Plovers nest along sandy beaches on northeastern Graham Island, from Masset east to Rose Spit and south to Tlell. This population is the southernmost significant breeding area in western North America. Delkatla is also the southernmost breeding locality for Short-billed Dowitchers on the Pacific coast. The primary purpose of this paper is to document the breeding success of a diverse community of shorebirds, some nesting at the southern edge of their range on the Pacific coast.

4. Study area and methods

4.1 Study area

The study was conducted mainly in Delkatla and along North Beach near Masset, British Columbia (54°01'N, 132°08'W). Approximately 111 ha of mudflats and marshlands and 111 ha of upland meadows occur within Delkatla (Crippen Consultants Ltd. 1986). Upland areas are covered by open meadows of grass, sedges (*Carex* spp.), rushes (*Juncus* spp.), herbs, and mosses above the high tide line. Red alder *Alnus rubra* and Sitka spruce *Picea sitchensis* are encroaching along upland and creek edges. Delkatla is bordered on three sides by coniferous forest and by the Village of Masset to the west. Delkatla is used by many migrant and nesting species of shorebirds (Appendix 1).

North Beach is a sand dune beach, 20–100 m in width, between the high tide line and shoreline forest. It extends from Masset east to the Sangan River and discontinuously to Tow Hill. North Beach in the vicinity of Skonun Point was studied most intensively. Large drift logs are scattered along the beach. The dunes are sparsely to heavily vegetated with yarrow *Achillea millefolium*, beach pea *Lathyrus japonicus*, and sedges and are littered with large woody debris.

4.2 Methods

Preliminary surveys for nests of breeding shorebirds were conducted during June 1984 and May–June 1985. Intensive research was conducted between early May and early August from 1986 to 1988.

Systematic nest searches were conducted throughout the nesting season each year from 1986 to 1988 in Delkatla and at the nearby golf course (Cooper 1993a). Nests were monitored regularly until eggs hatched or were depredated, and broods were monitored until young fledged (capable of sustained flight). Breeding adults were caught on nests and colour-banded in all years. Chicks were banded with an aluminum U.S. Fish and Wildlife Service (USFWS) band during 1984–1986 and also unique combinations of colour bands during

1987–1988 before or shortly after they left the nest. All observations of known colour-banded individuals were noted during the year they were banded and during subsequent years. Nests of Semipalmated Plover, Killdeer, Common Snipe, and Short-billed Dowitcher were found incidentally to this work. Adult Semipalmated Plovers and Short-billed Dowitchers were captured on their nests and banded, as were Semipalmated Plover, Killdeer, and Common Snipe chicks.

Nests for all territorial pairs of Semipalmated Plovers were searched for along North Beach during 1986–1987 but less intensively during 1984, 1985, and 1988. Nests were monitored until eggs hatched or clutches were lost. Adults were captured on their nests and colour-banded. Chicks were colour-banded before or shortly after leaving the nest, but little effort was made to document survival of chicks. One pair of American Black Oystercatchers nesting at Skonun Point was monitored regularly from 1984 to 1988, and young were banded during 1987–1988. Local gravel pits were monitored occasionally, during all years, for nesting plovers.

Population estimates were derived from data on banded birds and by estimating the number of breeding pairs that were present but not banded.

5. Results

5.1 Least Sandpiper

5.1.1 Population

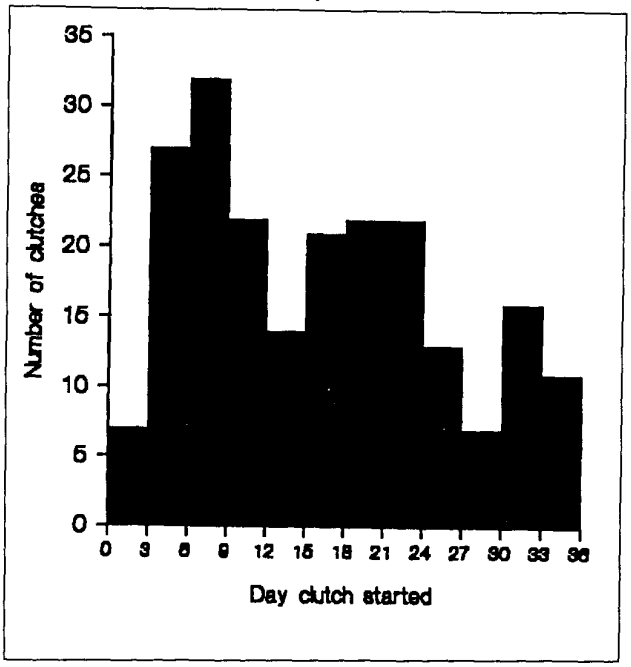
An estimated 85–90 pairs of Least Sandpipers nested in upland areas of Delkatla inside the causeway across Delkatla Inlet to Masset (Cooper 1993a). By 1988, about 80% of the adult breeding population had been banded. Density of breeding pairs was 0.81 pairs/ha of total upland in Delkatla. However, density in preferred nesting habitat was about 3–4 pairs/ha. About 85% of the population nested in the southern portion of Delkatla. Most nests were found in a moist strip of upland vegetation, dominated by sedges, mosses, and grasses, within 30 m of water. An additional 10–12 pairs were found nesting along drainage ditches and sand dune habitat 3 km east of Delkatla.

5.1.2 Breeding cycle and reproductive success

Dates of arrival are unknown, but males began aerial displays by the first week of May, and early pair formation began during the same period. Early breeders probably arrived in late April, and breeders continued to arrive through May.

Clutches were initiated between 11 May and 15 June. Median dates for first clutches over five years ranged between 18 May and 26 May, with an overall median of 23 May. Replacement clutches were laid between 1 and 3 June. Most first clutches were begun within the first three weeks of the egg-laying period. Three peaks of clutch initiation were evident during the egg-laying period (Fig. 2). The first peak represents first clutches laid by experienced breeders. The second peak represents first clutches laid by yearling breeders and replacement clutches laid by experienced pairs that had lost their first clutch during early incubation. The third peak represents replacement clutches laid by experienced

Figure 2
Numbers of clutches of Least Sandpipers initiated near Masset, British Columbia, 1986–1988. Data are the numbers of clutches started during each three-day interval, from the start of the earliest clutch initiation, in each year.



pairs that lost clutches during late incubation and replacement clutches laid by late-nesting yearlings.

The median clutch size was four eggs (Table 1). Replacement clutches were more likely to contain three eggs than first clutches ($t = 2.219$, $p = 0.041$). Eggs hatched between 6 June and 11 July, with most hatching during the last two weeks of June. Viability of eggs, in clutches where at least one chick hatched, did not vary annually between 1986 and 1988 ($F = 0.450$, $p = 0.772$, $n = 169$ clutches). In those clutches, 86.1% of 661 eggs laid hatched. During the entire study (1984–1988), 201 of 353 (56.9%) clutches hatched, with the remainder being depredated, destroyed by cattle, abandoned, or having an unknown fate (Table 2).

Prefledgling chicks were present from 6 June through the end of July. Most broods contained four chicks (Table 3). Chicks fledged between 24 June and 31 July. During 1987–1988, 78 of 103 (75.7%) broods produced at least one fledgling (Table 3). From these 78 clutches that produced fledglings, a mean of 2.23 fledglings/brood was produced. Nineteen of 46 (41%) broods that produced fledglings during 1987 produced at least one yearling (mean = 1.37) that returned to breed in 1988. Assuming 90 breeding pairs during 1987–1988, the population produced 1.92 chicks/pair per year, 1.02 fledglings/pair per year, and 0.29 yearlings/pair (1987 only).

Females whose clutches resulted in fledged chicks left the study area between 23 June and 8 July, whereas successful nesting adult males left between 30 June and 1 August. Fledged young departed between mid-July and mid-August.

Between 1984 and 1988, approximately 26% of 353 Least Sandpiper clutches were known or thought to have been depredated (Table 2). Predation rates were

Table 1
Clutch size of shorebirds nesting near Masset, British Columbia, 1984–1988

Species	n	Min.	Max.	Mean	SD	Median
Least Sandpiper						
First clutch	270	2	5	3.92	0.317	4
Replacement clutch	28	3	4	3.79	0.418	4
Semipalmated Plover	71	2	4	3.70	0.518	4
Killdeer	14	2	4	3.86	0.535	4
Common Snipe	5	2	4	3.40	0.894	4
American Black Oystercatcher	5	2	3	2.60	0.548	3
Short-billed Dowitcher	3	3	4	3.67	0.577	4

Table 2
Fate of shorebird nests near Masset, British Columbia, 1984–1988

	Fate of clutch[a]						
Species	Hatched	Depredated	Destroyed	Abandoned	Buried in sand	Unknown	Total
Least Sandpiper	201 (56.9)	93 (26.3)	28 (7.9)	22 (6.2)	0	9 (2.5)	353
Semipalmated Plover	26 (36.6)	12 (16.9)	1	4 (5.6)	4 (5.6)	24 (33.8)	71
Killdeer	2	5	0	1	0	6	14
Common Snipe	3	0	0	1	0	1	5
American Black Oystercatcher	4	0	0	0	0	1	5
Short-billed Dowitcher	0	0	0	1	0	2	3

[a] Percentages are given in parentheses.

Table 3
Frequencies of the number of chicks per brood of shorebirds breeding near Masset, British Columbia, for which the brood size could be determined

	Frequency of number of chicks per brood			
Species	1	2	3	4
Least Sandpiper	6	20	49	94
Fledglings/brood, 1987–1988[a]	23	15	30	10
Semipalmated Plover	1	2	9	11
Killdeer	1	0	0	1
Common Snipe	1	1	1	0
American Black Oystercatcher	1	1	2	0
Short-billed Dowitcher	0	0	0	0

[a] Frequencies of the number of fledglings/brood.

relatively high on incomplete clutches compared with definitive clutches (Table 4) and, during one year, on all nests located within 1 km of a nest of a Common Raven *Corvus corax* (Table 5). Predation by ravens had a significant impact on the breeding success of Least Sandpipers (Cooper 1993a). Seventy-four of 257 (28.8%) clutches found between 1986 and 1988 were thought to have been depredated by that one pair of ravens. Most nests listed as destroyed were crushed by domestic cattle (Table 2).

5.2 Semipalmated Plover

5.2.1 Population

Semipalmated Plovers breed along the sandy and gravel shorelines of northeastern Graham Island, from Masset east to Rose Spit and south to northern Moresby Island (Campbell et al. 1990). Along North Beach, nests were distributed along a strip of sand dune beach, mainly among drift logs above the high tide line. Nests were found on open sand or under the protruding ends of logs or planks. In Delkatla, and in nearby gravel pits, nests were on undisturbed patches of gravel. In the vicinity of Skonun Point, the distance between concurrently active nests in 1985 averaged 263 m (range 140–460 m, n = 7). About 30 pairs were estimated to breed along 7.5 km of North Beach between the Masset Airport and the Sangan River, by assuming a mean density of 4 pairs/km of beach. In addition, 1–4 pairs nested annually in gravel pits near Masset and in Delkatla. Thus, the total breeding population of Semipalmated Plovers was about 31–34 pairs.

5.2.2 Breeding cycle and reproductive success

Pairs were present on breeding areas when first surveyed in early May. Although the earliest clutch was initiated on 5 May, most North Beach clutches were started in mid- to late May. The clutch begun on 5 May was in an inland gravel pit, which may have influenced the early date of egg laying. Median clutch size was four eggs (Table 1). Clutch size did not vary with season ($r^2 = 0.003$, $p = 0.672$). During 1984–1988, 26 of 47 (55%) clutches with a known fate hatched chicks, with the remainder being depredated, abandoned for unknown reasons, covered with sand, or destroyed by humans (Table 2). New clutches, first found in July, were most likely replacement clutches.

Hatching date ranged between 13 June and 20 July. Most clutches hatched in late June and early July. The clutch begun on 5 May could have hatched as early as 31 May – 2 June, given the 23- to 25-day incubation period (Sutton and Parmelee 1955). Most broods contained three or four chicks (Table 3). Data on chick survival and fledging were not collected.

Predation caused the loss of 12 of 47 Semipalmated Plover nests of known fate (Table 2). In Delkatla, ravens took three of six clutches. For 24 other clutches, it could not be determined conclusively if they had hatched or were predated.

Table 4
Estimated predation rates (clutches per day) of Least Sandpiper nests in relation to clutch size. Data are from this study (1988) and from Sable Island, Nova Scotia (Miller 1983).

	Predation rate (clutches/day) at following clutch size:			
	1	2	3	4
Queen Charlotte Islands	0.25	0.33	0.24	0.03
(n)	(16)	(23)	(28)	(50)
Sable Island, Nova Scotia	0.45	0.12	0.07	0.04
(n)	(6)	(13)	(15)	(22)

Table 5
Clutch survival of Least Sandpipers relative to the distance from a Common Raven nest

	1988[a]		1987[b]	
Distance (km)	No. of nests	Mean survival (days)	No. of nests	Mean survival (days)
<0.5	18	12.4	12	19.4
0.5–1.0	29	12.9	28	20.4
1.0–1.5	13	21.8	13	21.8
>1.5	16	23.9	13	20.7

[a] 1988: chi-squared = 17.36, $p < 0.01$.
[b] 1987: chi-squared = 0.61, ns.

5.3 Killdeer

5.3.1 Population

Between five and eight pairs of Killdeer nested in the study area each year, with 1–3 pairs in Delkatla. Nests in Delkatla were found on small patches of gravel or on shortgrass areas. Isolated pairs nested in gravel pits and near North Beach.

5.3.2 Breeding cycle and reproductive success

Breeding activity had begun before surveys began in early May. Eggs were found between 8 May and 26 June. However, a chick that was estimated to be at least four days old was found on 8 May, again in a gravel pit, indicating that some clutches are initiated in early April. Prefledgling chicks were found between 8 May and 23 July.

The median clutch size was four eggs (Table 1). Of 14 clutches that were found, only two were known to hatch, producing one and four chicks. No data on fledging success were obtained. Five clutches were depredated, one was abandoned, and six had unknown fates (Table 2). Of six clutches with known fate in Delkatla, five were taken by ravens.

5.4 Common Snipe

Several pairs nested each year in Delkatla, but only nine clutches or broods were found during 1984–1988. Nests and broods were found in wetter parts of Delkatla, in areas dominated by common rush *Juncus effusus*. Eggs were found between 5 June and 10 July. Chicks out of the nest were found between 4 June and 14 July, suggesting that some clutches were started in early May.

The median clutch size was four eggs (Table 1). Of four clutches with a known fate, three hatched (Table 2) and produced one, two, and three chicks (Table 3). No data on fledging success were obtained.

5.5 Short-billed Dowitcher

One or two pairs nested in Delkatla each year. Nests were well hidden, and extremely difficult to find, in upland areas with rich growths of grasses and sedges. The median clutch size was four eggs (Table 1). Of three nests found, one was abandoned, one clutch disappeared after the eggs had pipped, apparently taken by a predator, and the third nest suffered an unknown fate.

5.6 American Black Oystercatcher

One pair of American Black Oystercatchers, suspected to be the same individuals, nested each year at Skonun Point. The nest site was unusual because it was located on a "mainland" (Graham Island) site, rather than on an offshore "island." The nest was situated each year on an open sand beach, a few metres above the high tide line. All nests were located within a 30-m section of beach at the tip of the point. Eggs were found as early as 16 May and hatched as early as 11 June. The clutch size ranged from two to three eggs (Table 1). Between 1985 and 1988, nine chicks hatched from 11 eggs. Fledging success was not determined in 1985 or 1986, but all chicks fledged in 1987 and 1988.

6. Discussion

A striking feature of the shorebirds on the Queen Charlotte Islands is their early nesting season. Least Sandpipers began laying eggs about two weeks earlier at Delkatla than on Sable Island, Nova Scotia (Miller 1983), although the Queen Charlotte Islands are about 10° latitude farther north. Clutches were initiated about three weeks earlier than in northern Manitoba (58°30′N; Jehl 1970) and extreme northwestern British Columbia (59°40′N; J.M. Cooper, unpubl. data).

These differences might be explained by the milder climate on the Queen Charlotte Islands than in other parts of the Least Sandpiper's breeding range (Jehl 1970; Miller 1983; Cooper 1993a), because northern shorebirds in general respond to local conditions and breed earlier in milder climates or years (Soikkeli 1967; Holmes and Pitelka 1968; Nettleship 1973). Similarly, the relatively long egg-laying period at Delkatla of 40 days (1.3 and 2.4 times as long as on Sable Island and northern Manitoba) is likely due to the long spring and summer seasons on the Queen Charlotte Islands. This extended nesting period likely resulted in relatively high overall nesting success, largely due to second clutches. To illustrate this point, nonfledged young were present in Delkatla during the main southbound wave of adult migration from more northern breeding populations.

Early nesting is thought to be correlated with higher breeding success in a wide range of bird taxa (e.g., Soikkeli 1967; Newton and Marquiss 1984; Wanless and Harris 1988). Therefore, it was predicted that early-nesting Least Sandpipers would have higher breeding

success. This prediction was not supported: for first clutches, there were no significant differences between early and late clutches in hatching, fledging, or return of yearlings. However, because of the length of the breeding season, there was a relatively long period in which replacement clutches could be laid.

Breeding success, as measured by the proportion of nests that hatched at least one chick, ranged from 0% for Short-billed Dowitchers to 100% for American Black Oystercatcher (Table 2). Breeding success of Least Sandpipers and Semipalmated Plovers was similar, being 58.4% and 55.3%, respectively. Breeding success for Least Sandpipers was lower than in northern Manitoba (69.6% of 56 clutches hatched; Jehl 1971) but higher than on Sable Island (46.8% of 62 clutches hatched; Miller 1983). Viability of eggs in clutches that produced at least one chick was similar to that in northern Manitoba, 86.1% (this study) vs. 87.3% (Jehl 1970).

During this study, a pair of ravens inflicted heavy losses upon Least Sandpipers, Killdeers, and Semipalmated Plovers at Delkatla. Depredation ceased after the raven young fledged and the family group moved to the local dump. Loss of Semipalmated Plover clutches to predators on North Beach was more difficult to pinpoint but was thought to be severe as well. Ravens, Northwestern Crows *Corvus caurinus*, or raccoons *Procyon lotor* were the most likely predators. This study confirmed the findings of other studies that nest destruction by predators is the primary cause of nest failure in shorebirds (Holmes 1971; Gratto et al. 1983; Oring et al. 1983; Colwell and Oring 1988).

Predation may have significant effects on local shorebird populations (e.g., Maxson and Oring 1978; Oring et al. 1983; Pienkowski 1984). For example, on Sable Island, Herring Gulls *Larus argentatus* were thought to be causing a decline in breeding Least Sandpipers (Miller 1983). Between 1984 and 1988, the timing of breeding of Least Sandpipers was not altered by predation (see Pienkowski 1984), nor were populations apparently affected from year to year. However, in 1993, populations seemed to be lower, probably owing to habitat changes caused by plant succession (Cooper 1993b). Similarly, in 1993, no noticeable changes in populations of Semipalmated Plovers on North Beach were observed, although it was noted that they did not nest in the gravel pits or on the gravel patches in Delkatla. Again, it was thought that encroachment by plants was the reason for the decline in breeding effort by Semipalmated Plovers (Cooper 1993b).

Considerable disturbance of incubating Semipalmated Plovers by humans was noted on North Beach. Although not quantified, disturbance by humans caused one nest loss directly and may have been a factor in the loss of many other nests.

Blowing sand buried four clutches on North Beach that were subsequently abandoned by the parent birds. The effect of blowing sand may have been greater than documented. For example, several nests disappeared with an undetermined fate, and some of these may have been buried.

The data on American Black Oystercatcher nesting are noteworthy because of the high breeding success and unusual nest location. All of the 53 pairs of oystercatchers breeding in Skidegate Inlet utilized small islands, whereas the pair at Skonun Point nested on Graham Island (Vermeer et al. 1992). Hatching success (38.3% vs. 91%) and fledging success (0.49 fledglings/pair vs. 3 fledglings/pair) were lower in Skidegate Inlet than for the pair at Skonun Point.

7. Acknowledgements

We would like to thank Dianne Cooper, Margo Hearne, Margie Purdy, Susan Skaalid, Michelle Linekin, Susan Sihikalo, and Michael McNall for their tireless and enthusiastic assistance in the field. Rob Butler, Cheri Gratto-Trevor, and Ken Morgan reviewed an earlier draft and provided significant improvements to the paper. Funding for this study was provided mainly by an NSERC (Natural Sciences and Engineering Research Council) Individual Operating Grant to EHM (University of Victoria), research grants from Friends of the Royal British Columbia Museum to EHM, and the Royal British Columbia Museum.

8. Literature cited

American Ornithologists' Union. 1983. Check-list of North American birds. Lawrence, Kansas. 877 pp.

Campbell, R.W.; Dawe, N.K.; McTaggart-Cowan, I.; Cooper, J.M.; Kaiser, G.W.; McNall, M.C.E. 1990. The birds of British Columbia. Vol. 2. Nonpasserines. Diurnal birds of prey through woodpeckers. Royal British Columbia Museum/Canadian Wildlife Service, Victoria. 636 pp.

Colwell, M.A.; Oring, L.W. 1988. Breeding biology of the Wilson's Phalarope in southcentral Saskatchewan. Wilson Bull. 100: 567–582.

Cooper, J.M. 1993a. The breeding biology of the Least Sandpiper on the Queen Charlotte Islands. M.Sc. thesis, University of Victoria, Victoria. 122 pp.

Cooper, J.M. 1993b. Preliminary impact assessment on migratory birds of the proposed causeway breaching at Delkatla Inlet, Masset, British Columbia. Unpublished report prepared for the Canadian Wildlife Service, Delta, B.C. 25 pp.

Cooper, J.M. 1994. Least Sandpiper. *In* A. Poole and F. Gill (eds.), The birds of North America. Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C. 28 pp.

Crippen Consultants Ltd. 1986. Report on increasing tidal flow in the Delkatla Wildlife Sanctuary. Unpublished report prepared for the Village of Masset, B.C.

Godfrey, W.E. 1986. The birds of Canada. National Museums of Canada, Ottawa. 595 pp.

Gratto, C.L.; Cooke, F.; Morrison, R.I.G. 1983. Nesting success of yearling and older breeders in the Semipalmated Sandpiper *Calidris pusilla*. Can. J. Zool. 61: 1133–1137.

Hamel, P.J. 1989. A bird population study of the Delkatla Wildlife Sanctuary, Masset, Queen Charlotte Islands. Pages 187–194 *in* G.G.E. Scudder and N. Gessler (eds.), The outer shores. Based on the Proceedings of the Queen Charlotte Islands First International Symposium, University of British Columbia, August 1984, Queen Charlotte Islands Museum Press, Skidegate, B.C.

Hamel, P.; Hearne, M. 1992. Bird list, Delkatla Wildlife Sanctuary. Published by authors.

Holmes, R.T. 1971. Density, habitat, and the mating system of the Western Sandpiper (*Calidris mauri*). Oecologia 7: 191–208.

Holmes, R.T.; Pitelka, F.A. 1968. Food overlap among coexisting sandpipers on northern Alaska tundra. Syst. Zool. 17: 305–318.

Jehl, J.R., Jr. 1970. Sexual selection for size differences in two species of sandpipers. Evolution 24: 311–319.
Jehl, J.R., Jr. 1971. Patterns of hatching success in subarctic birds. Ecology 52: 169–173.
Kessel, B.; Gibson, D.D. 1978. Status and distribution of Alaska birds. Stud. Avian Biol. No. 1, Cooper Ornithological Society, Los Angeles.
Maxson, S.J.; Oring, L.W. 1978. Mice as a source of egg loss among ground-nesting birds. Auk 95: 582–584.
Miller, E.H. 1977. Breeding biology of the Least Sandpiper, *Calidris minutilla* (Vieill.), on Sable Island, Nova Scotia. Ph.D. thesis, Dalhousie University, Halifax.
Miller, E.H. 1983. Habitat and breeding cycle of the Least Sandpiper (*Calidris minutilla*) on Sable Island, Nova Scotia. Can. J. Zool. 61: 2880–2898.
Miller, E.H. 1986. Components of variation in nuptial calls of the Least Sandpiper (*Calidris minutilla*; Aves, Scolopacidae). Syst. Zool. 35: 400–413.
Nettleship, D.N. 1973. Breeding ecology of turnstones *Arenaria interpres* at Hazen Camp, Ellesmere Island, N.W.T. Ibis 115: 202–217.
Newton, I.; Marquiss, M. 1984. Seasonal trend in the breeding performance of Sparrowhawks. J. Anim. Ecol. 53: 809–829.
Oring, L.W.; Lank, D.B.; Maxson, S.J. 1983. Population studies of the polyandrous Spotted Sandpiper. Auk 100: 272–285.
Pienkowski, M.W. 1984. Breeding biology and population dynamics of Ringed Plovers *Charadrius hiaticula* in Britain and Greenland: nest-predation as a possible factor limiting distribution and timing of breeding. J. Zool. 202: 83–114.
Soikkeli, M. 1967. Breeding cycle and population dynamics in the Dunlin (*Calidris alpina*). Ann. Zool. Fenn. 4: 158–198.
Sutton, G.M.; Parmelee, D.F. 1955. Breeding of the Semipalmated Plover on Baffin Island. Bird-Banding 26: 137–147.
Vermeer, K.; Morgan, K.H.; Smith, G.E.J. 1992. Black Oystercatcher habitat selection, reproductive success, and their relationship with Glaucous-winged Gulls. Colon. Waterbirds 15: 14–23.
Wanless, S.; Harris, M.P. 1988. The importance of laying date on breeding success of the guillemot *Uria aalge*. Ornis Scand. 19: 205–211.

Appendix 1
List of shorebirds that have occurred or nested (*) in Delkatla (some data from Hamel and Hearne 1992)

Black-bellied Plover	*Pluvialis squatarola*
American Golden-Plover	*Pluvialis dominica*
Semipalmated Plover*	*Charadrius semipalmatus*
Killdeer*	*Charadrius vociferus*
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Solitary Sandpiper	*Tringa solitaria*
Spotted Sandpiper	*Actitus macularia*
Upland Sandpiper	*Bartramia longicauda*
Whimbrel	*Numenius phaeopus*
Hudsonian Godwit	*Limosa haemastica*
Bar-tailed Godwit	*Limosa lapponica*
Marbled Godwit	*Limosa fedoa*
Red Knot	*Calidris canutus*
Sanderling	*Calidris pusilla*
Western Sandpiper	*Calidris mauri*
Least Sandpiper*	*Calidris minutilla*
Pectoral Sandpiper	*Calidris melanotos*
Sharp-tailed Sandpiper	*Calidris acuminata*
Rock Sandpiper	*Calidris ptilocnemis*
Dunlin	*Calidris alpina*
Curlew Sandpiper	*Calidris ferruginea*
Stilt Sandpiper	*Calidris himantopus*
Buff-breasted Sandpiper	*Tryngites subruficollis*
Ruff	*Philomachus pugnax*
Short-billed Dowitcher*	*Limnodromus griseus*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Common Snipe*	*Gallinago gallinago*
Wilson's Phalarope	*Phalaropus tricolor*
Northern Phalarope	*Phalaropus lobatus*