Segregation of Brent Geese *Branta bernicla* wintering and staging in Puget Sound and the Strait of Georgia

AUSTIN REED, MICHAEL A. DAVISON and DONALD K. KRAEGE

The distribution of Brent Geese from different breeding stocks was studied in Puget Sound and the Strait of Georgia from autumn 1987 to spring 1988. Breeding origins were determined from the belly colour of free-living and shot Brent, from sightings of colour-ringed birds, and from ring recovery information (including recoveries from pre-1987 bandings). The largest wintering flock (c.15,000) during 1987–88 inhabited Padilla Bay, Washington, and was made up almost exclusively of grey-bellied Brent from the western Canadian High Arctic. The few other wintering flocks were smaller (<100–1400), occurred almost entirely in Washington State, and were composed of dark-bellied birds (Black Brant) originating from the western Canadian Low Arctic and Alaska. During spring migration, Low Arctic Brent from Canada and Alaska staged along the east coast of Vancouver Island, British Columbia. This high degree of segregation between High and Low Arctic Brent will allow more refined management of the individual stocks.

Brent Geese *Branta bernicla* which migrate along the Pacific Coast of North America originate from breeding colonies spread over a large expanse of arctic and subarctic coastal areas of Alaska, the Northwest Territories, the Yukon, and northeastern USSR (Einarsen 1965, Bellrose 1980, Palmer 1976). During autumn most, if not all, stage in the vicinity of the Izembek Lagoon on the Alaska peninsula (Reed *et al.* 1989), from where an oversea migration is undertaken to wintering locations which are found from southern Alaska and the Queen Charlotte Islands, British Columbia, south to Baja California and the mainland coast of Mexico (Hansen & Nelson 1957). Mexico has long been the major wintering area and has taken on increased importance in recent decades (Smith & Jensen 1970), while other wintering areas have declined. However, areas in Washington, especially in Puget Sound, continue to harbour the most important wintering concentrations north of Mexico (Anon. 1980. Management plan for Pacific coast Brant. Pacific Waterfowl Flyway Council. 75 pp.).

The Pacific Flyway flock is made up of individuals of two recognizable forms. Most are of the black-bellied form (*B. b. nigricans* – Black Brant). A grey-bellied form is also present; it is characterised by generally lighter belly colour varying in individuals from dark- to light-grey (Boyd & Maltby 1979, Boyd *et al.* 1988). It can best be considered as a stock or race intermediate between *B. b. hrota* and *nigricans*. Earlier studies showed that most of the grey-bellied birds bred on Melville, Prince Patrick, and adjacent islands in the Canadian High Arctic and wintered in Puget Sound (Boyd & Maltby 1979). Most Black Brant nested in Alaska and the Canadian Low Arctic (southern Banks and Victoria islands and the mainland coast of Mackenzie district, Northwest Territ.), and wintered in Mexico, but appreciable overlap in the wintering range of the two forms was evident (Boyd & Maltby 1979).

In this paper we examine the composition of present-day wintering flocks in the vicinity of Puget Sound using recoveries of rings, sightings of colour-marked birds and documentation of belly colour in shot and free-living Brent. In so doing we assess the degree of stock segregation and provide information for refined management of Brent Geese along the Pacific Flyway.

Methods and Study Area

During August 1987 the senior author and collaborators captured and marked 902

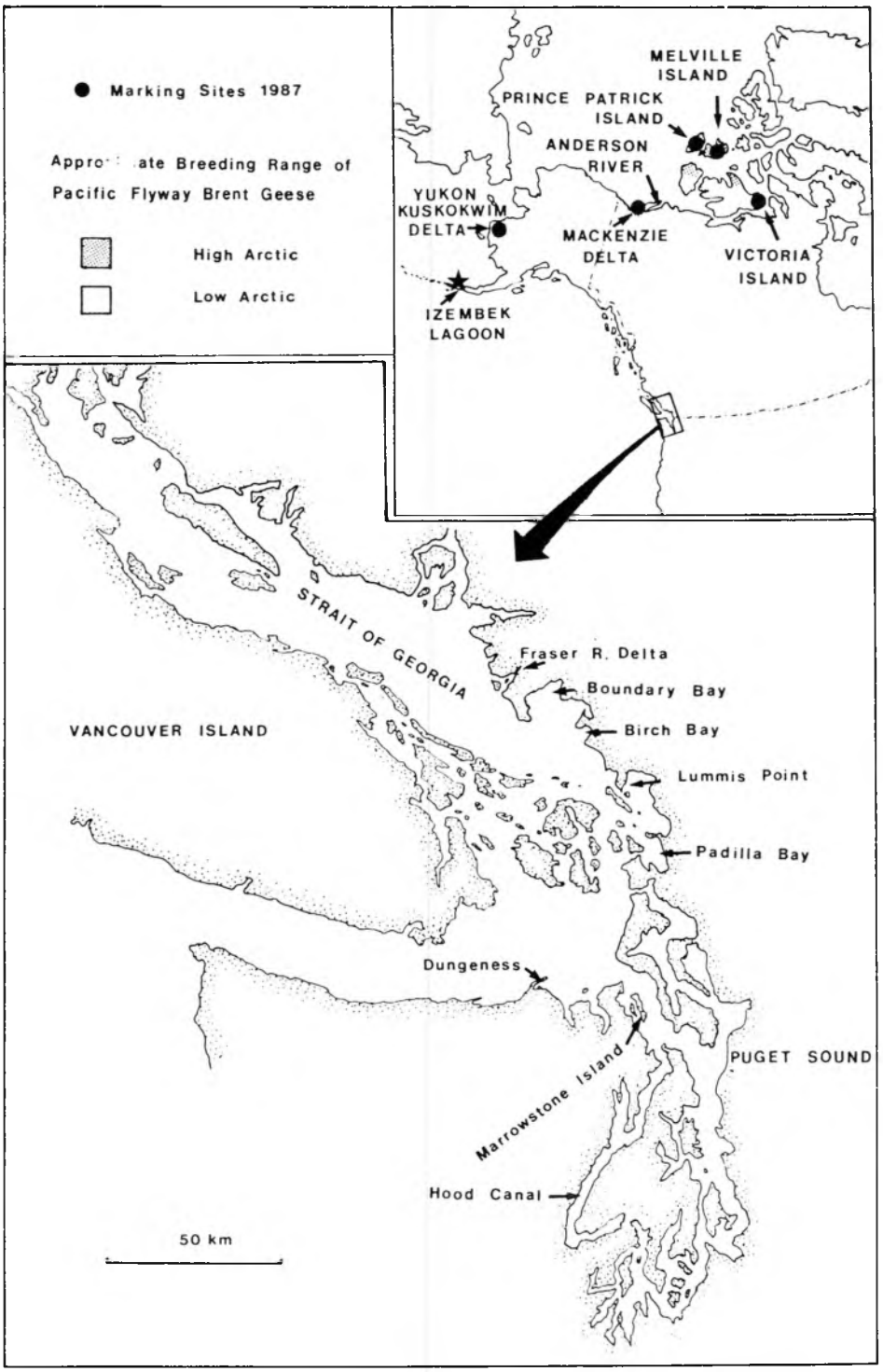

Figure 1. Puget Sound and the Strait of Georgia, and (inset) northwestern North America showing Brent Goose breeding and staging areas.

Table 1. Number of Brent Geese leg-ringed with metal and colour rings in the western Canadian Arctic and Alaska during 1987, and previously.

Ringing area	1987		pre-1987	
	metal	metal + colour	metal	metal + colour
High Arctic	134	709	1167	0
Low Arctic				
Anderson and Mackenzie Rivers	4	4	10969	0
Victoria Island	16	35	0	0
Alaska	0	2000	32424	570

Brent Geese in the Canadian Arctic (Fig. 1, Table 1). Most were marked with both standard metal leg rings and blue plastic leg rings inscribed with individual three-letter codes (blue rings on the left leg of High Arctic birds, on the right leg of Low Arctic birds). On the Yukon-Kuskokwim Delta, Alaska, J. Sedinger and collaborators similarly marked another 2000 Brent Geese in 1987 and 570 in 1986, using instead yellow plastic rings with alpha-numeric codes. Also, some adults were fitted with radio transmitters but since no signals were received in the study area they are not dealt with here.

The distribution of marked and unmarked Brent was studied in Puget Sound and the Strait of Georgia which, together, form a complex embayment of the Pacific Ocean near the Canada-USA border (Fig. 1). Observations were conducted from ground locations using telescopes with magnification up to 80x several days each month from October 1987 to April 1988 at the main wintering site in Padilla Bay (including the adjacent bays of Samish and Fidalgo) as well as in Boundary Bay. We emphasized the search for coloured leg rings and documentation of belly colour (see below). Periodic observations were conducted by us or collaborators at other sites during the course of the winter and spring. Aerial surveys were made from November to February in Padilla Bay and adjacent locations.

During hunting seasons in Padilla Bay (12–23 December 1987) and in Boundary Bay (1–10 March 1988) we checked hunter-shot Brent for rings and recorded data on age, sex and belly colour.

Belly colour of hunter-shot birds was determined using a colour chart (Munsell Soil Chart, sheet 10YR) to obtain a numeric value of the colour of contour feathers on the midline of the belly, approximately 2–3 cm posterior to the line of demarcation between the breast and the belly (Boyd & Maltby 1979, Boyd *et al.* 1988). On free-living birds a subjective evaluation was made for birds with their bellies exposed (flying overhead, standing on shore) according to the following scale: "Dark" – dark grey to black belly colour, showing no obvious line of demarcation with the black breast; "Light" – light to medium grey belly colour, showing a distinct demarcation with the breast; "Intermediate" – medium to dark grey belly colour, showing some demarcation with the breast. The latter method was used only under good lighting conditions (i.e. avoiding situations where dark shadows might mask underbody coloration) and when the midline of the belly was visible (i.e. frontal view – many birds with dark bellies appear lighter in side view).

We also analysed records of rings recovered from birds shot, found dead, and sighted within blocks (10 minutes N latitude x 10 minutes W longitude) throughout the study area during the months of November to March since 1949. Only recoveries from ringings in northern breeding and moulting areas were considered. To express the relative contributions of different northern sites to given winter or staging populations, we weighted the recoveries or sightings according to the number of birds marked at each northern site (Table 1).

Results

Padilla Bay

In 1987–88 the first Brent Geese were noted in late October and by 17 November almost 5000 were present. Through December and

January approximately 15,000 were present. In early February an increase was noted which continued to a maximum count of 19,800 by 25 February (Table 2). More than 15,000 were counted on 5 May, and on our last day of field observation, 5 June, 5000 were still present.

Table 2. Numbers of Brent Geese recorded in Padilla Bay, Washington, during aerial surveys conducted between November 1987 and February 1988.

Date of survey	*n* of Brent
17 November	4990
4 December	16290
18 December	14450
24 December	16110
4 January	15320
4 February	18120
25 February	19800

Visual evaluations of belly colour showed the flock to be dominated by dark-bellied birds in November. By December Brent with light and intermediate coloured bellies made up approximately 45% of the flock; subsequently light-bellied birds predominated (Fig. 2). The colour chart readings from hunter-killed Brent during December ranged from 2 (very dark) to 6 (light) for all age and sex categories, averaging 4.3 (SE = 0.07, n = 200). The adult values were similar (Kolmogorov-Smirnov $X^2 = 5.8$, $P = 0.06$) to those recorded on Melville and Prince Patrick Islands during ringing (Fig. 3, see also Boyd *et al.* 1988). Sightings of colour leg rings showed High Arctic Brent Geese to be present throughout the study period (Table 3), accounting for 94 to 100% of the weighted ring sightings from December to March. Low Arctic Brent (most from Alaska) were observed mainly during November and April, none being seen in February and March. During late December 48 ringed Brent were also examined in hunters' bags, 45 (94%) of which came from High Arctic ringings (39 from Melville Island, six from Prince Patrick Island) and three from the Low Arctic (all from the Yukon-Kuskokwim Delta, Alaska); excluding two of these birds which had been ringed prior to 1987 (one each from Alaska and Melville Island), and weighting the remaining recoveries, we estimated that the

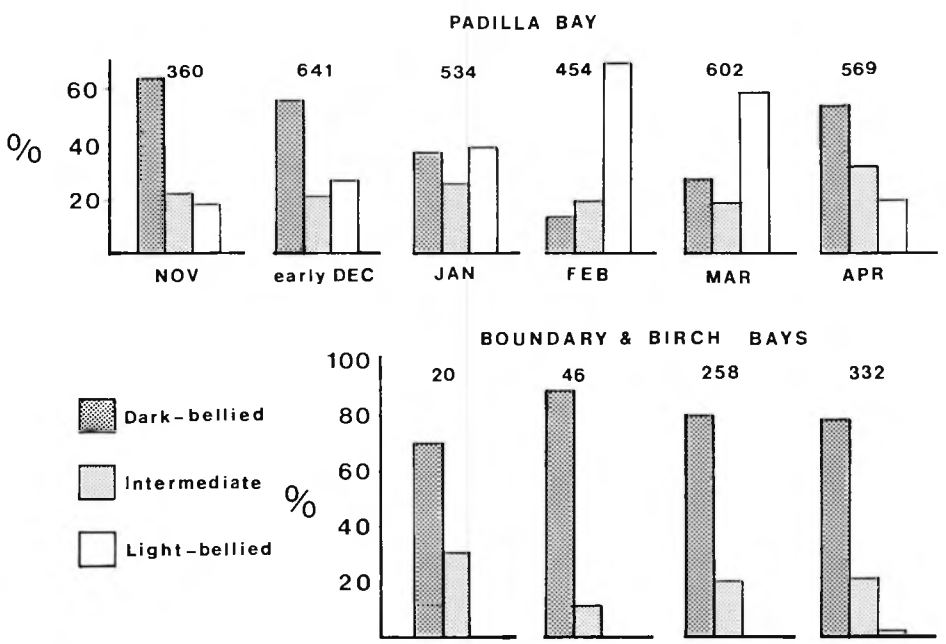

Figure 2. Belly colour of Brent Geese as determined by visual observation of free-living birds in Padilla Bay and Birch Bay, Washington, and Boundary Bay, British Columbia, November 1987 to April 1988. The sample sizes are indicated above each chart.

Table 3. Observations of colour-ringed Brent Geese in Padilla Bay, Washington, November 1987 to April 1988.

Month	Colour rings observed	Weighted percent[a] from ringing in:	
	n	High Arctic	Low Arctic[b]
November	14	77	23
December	10	97	3
January	67	94	6
February	20	100	0
March	14	100	0
April	8	67	33

[a] Ring sightings were weighted on the basis of the number of Brent colour-marked in each ringing area: High Arctic 709; Low Arctic, Alaska 2000 in 1987 and an assumed survival of 300 from 1986 markings, plus Canadian Low Arctic 39 = 2339.
[b] All from Alaska, except one Brent from the Canadian Low Arctic seen in January.

relative contributions to the kill were 98 High Arctic *v* two Alaskan Brent.

The pre-1987 ring recoveries ($n = 460$) in the four 10 minute blocks centring on Padilla Bay, represented the highest density of recoveries throughout the study area (Fig. 4). The weighted recoveries indicated that the High Arctic contributed many more birds than either Alaska or the Canadian Low Arctic (Table 4).

Boundary and Birch Bays

Aerial and ground surveys during November and December 1987 revealed fewer than 100 Brent, always near Birch Bay. Numbers increased slowly to a few hundred during January and February, with birds showing up periodically in Boundary Bay and the Fraser Delta foreshore. From mid-March to late April approximately 1500 Brent were present in several flocks spread out between Lummis Point and the Fraser Delta. Numbers decreased during late April and no birds were seen after 10 May.

Visual evaluation of belly colour from February to April 1988 indicated a strong domination of dark-bellied birds; only five light-bellied Brent were seen in 656 birds (Fig. 2). Of 156 Brent examined during the hunt in Boundary Bay (1–10 March) 149 had dark bellies (scores of 2 and 3) and seven had light bellies (scores of 4 and 5); the average score was 2.8 ± 0.04 (SE). The adult values were similar (Kolmogorov-Smirnov $X^2 = 1.8$, $P = 0.40$) to those recorded on Victoria Island, but different from those recorded in Padilla Bay ($X^2 = 111.1$, $P<0.001$, Figure 3).

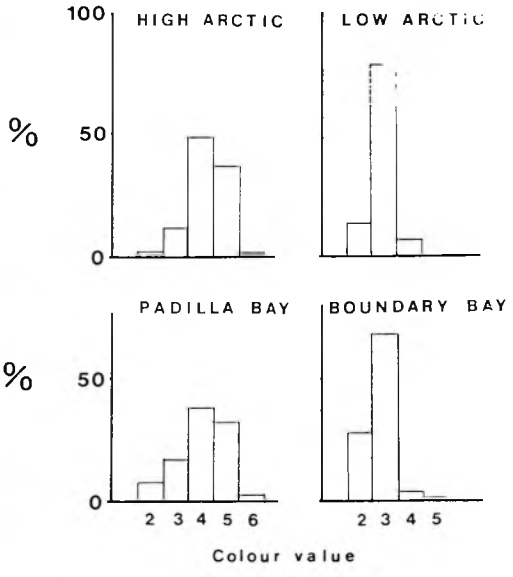

Figure 3. Belly colour of adult Brent Geese as determined using a colour chart with birds in the hand. The colour values grade from 2 (darkest) to 6 (lightest). The upper lefthand graph presents data from Melville and Prince Patrick Islands during August 1987 ($n = 431$ Brent, $\bar{x} = 4.2 \pm$ SE 0.03), the upper righthand data from Victoria Island in August 1987 ($n = 34$, $\bar{x} = 2.9 \pm 0.08$), the lower lefthand data from Padilla Bay, Washington, during December 1987 ($n = 99$, $\bar{x} = 4.0 \pm 0.10$) and the lower righthand data from Boundary Bay, British Columbia, during March 1988 ($n = 126$, $\bar{x} = 2.8 \pm 0.05$).

Six colour ringed Brent were seen in 1987–88, all from ringings in Alaska. All of the eight ringed Brent recovered during the

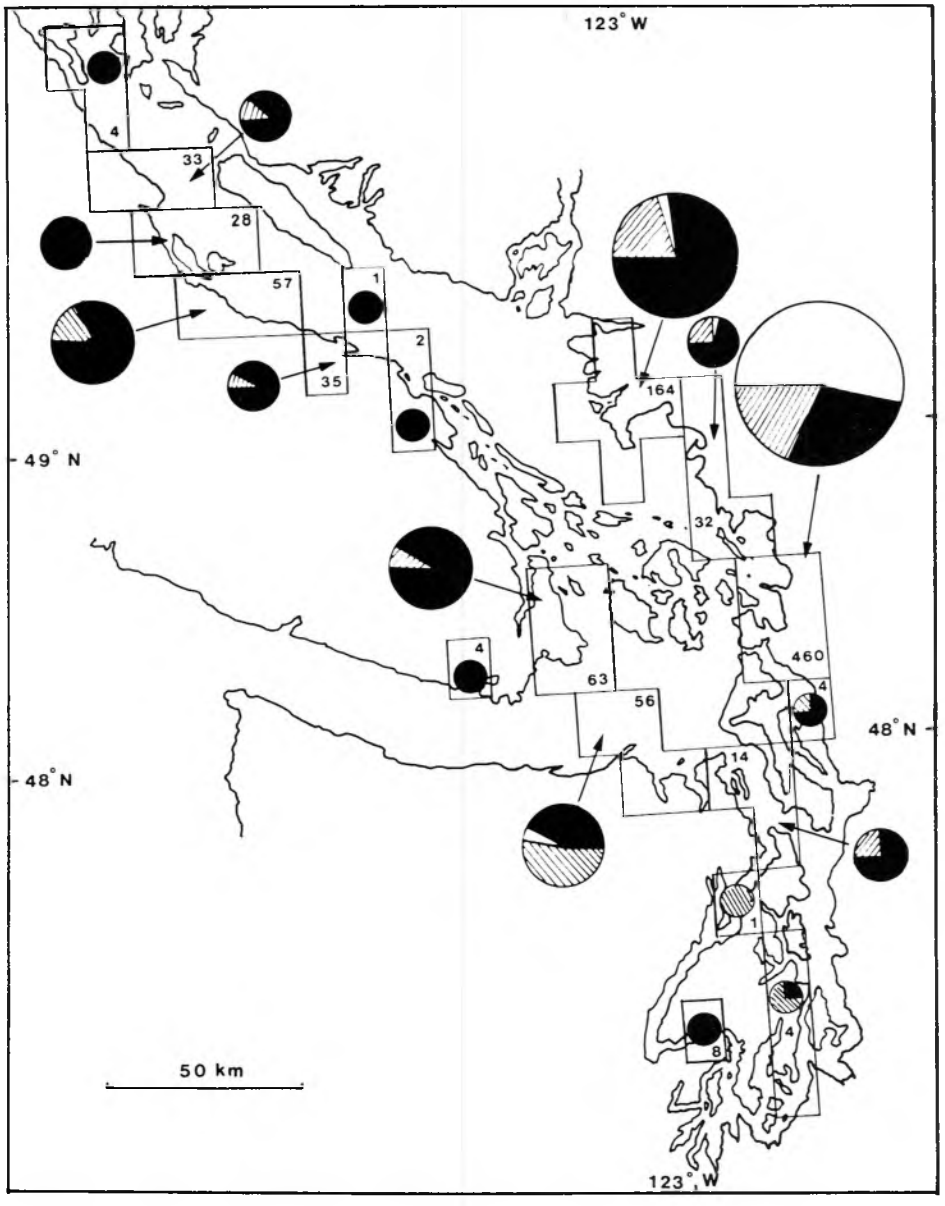

Figure 4. The distribution of 970 recoveries of ringed Brent Geese in Puget Sound and the Strait of Georgia, November to March, up to and including 1986. The number of recoveries are plotted by 10 minute blocks or groups of 2–5 adjacent blocks. The number of recoveries is indicated within each block; the proportion of those recoveries resulting from ringings in different and moulting areas is shown in the pie diagrams: black = Alaska, hatched = Canadian Low Arctic, and white = Canadian High Arctic.

1988 hunt during March were from the Low Arctic; after weighting, they suggested relative contributions to the kill of 65 Canadian Low Arctic Brent to 35 Alaskan birds.

Pre-1987 recoveries (Fig. 4), when weighted in relation to numbers ringed, suggested that similar proportions of Canadian Low Arctic, Alaskan, and High Arctic Brent were present (Table 4).

Table 4. Relative contributions of three breeding areas to winter populations of Brent Geese in Puget Sound and the Strait of Georgia, based on pre-1987 ring recoveries.

Winter[b] flock	Recoveries *n*	Weighted[a] % of recoveries from ringing in: High Arctic	Can. Low Arctic	Alaska
Padilla Bay	460	95	2	3
Boundary and Birch Bays	196	30	29	41
Dungeness	56	33	54	13
Vancouver Island	227	0	76	24
Puget Sd. and Hood Canal	31	0	50	50

[a] Weighting based on the number of bandings: see column 3 in Table 1.
[b] November to March.

Dungeness area

Approximately 620 Brent arrived on 18 November 1987, increasing soon after to 700. A wave of arrivals in mid-January brought the total to approximately 1400 birds. Spring migrants increased the total to almost 5900 by early April. Major departures occurred in late April and no Brent were observed after 11 May (U. Wilson pers. comm.).

On 6 February and 10 April 1988 scans of Brent (n = 389 birds) showed 87% to be dark-bellied and 13% of intermediate belly coloration; none was light-bellied. Ten sightings of colour leg rings were reported, all from Alaskan ringings.

The pre-1987 ring recoveries (Fig. 4), after weighting, suggested that the largest contribution from the three northern ringing locations was the Canadian Low Arctic, followed by the High Arctic, and then Alaska (Table 4).

East coast of Vancouver Island

This area harboured no regular wintering flock in 1987–88. Spring arrivals were noted on 22 February and numbers increased to a peak of 1500 by late March. All had left by 16 May (N. Dawe pers. comm.).

Belly colour was determined for 381 Brent Geese observed between 11 April and 11 May 1988: 57% were scored dark, 42 intermediate, and 1% light. Of 51 different colour ring codes read, all but one (a High Arctic bird) were from Alaskan ringings. Pre-1987 recoveries (Fig. 4) were widely distributed along the coast; after weighting, they indicated that the Canadian Low Arctic contributed more birds than Alaska (Table 4). No High Arctic birds were recovered.

Lower Puget Sound and the Hood Canal

Three other sites were reported to harbour Brent Geese over the 1987–88 winter months: Marrowstone Island with about 90 birds, the inner tip of the Hood Canal with 40–280 birds (usually about 100), and the upper Hood Canal with about 100 (A. McMillan, C. Merker, M. McMinn pers. comm.). In March, and especially April, Brent increased in numbers and were more widely distributed. All but a few stragglers had departed by about 12 May.

Five colour ringed Brent were observed: four from Alaska and one from the High Arctic (A. McMillan pers. comm.). Pre-1987 weighted ring recoveries (Fig. 4, Table 4) suggested equal contributions from the Canadian Low Arctic and Alaska; no High Arctic birds were recovered.

Discussion

In mid-winter 1987–88 the population was largely restricted to one large concentration (15,000–18,000 Brent) in the Padilla Bay area, a smaller one (*c.*1400) near Dungeness, and three or four small groups (mostly <100) near Birch Bay, the Hood Canal, and Marrowstone Island.

Identifying the breeding origins of the wintering and staging flocks was complicated by various biases and shortcomings with each data set. Belly colour was a good criteria for distinguishing between High

Arctic and Low Arctic birds but was not 100% accurate at the individual level (e.g. about 12% of the adults ringed in the High Arctic during 1987 were dark enough to be indistinguishable from Black Brant of the Low Arctic) nor to separate birds from different areas within the vast Low Arctic breeding range. Colour leg rings provided accurate identification of breeding origins (Yukon-Kuskokwim Delta *v* Mackenzie Delta/Victoria Island *v* Melville/Prince Patrick Islands) but they were often hidden from view and could provide independent records only when seen at close enough range for the codes to be read; they, like standard metal rings, could only provide information for the few northern areas in which marking was conducted. Also, a substantial proportion of the pre-1987 bandings involved moulting, rather than breeding flocks, which could have contained moult migrants from other breeding populations. Nevertheless, each data set provided a useful indication of the probable origin of the Brent Geese examined, and we have drawn on all of these indices in the conclusions which follow.

In Padilla Bay during November and early December 1987, light-bellied, dark-bellied and intermediate Brent Geese were present in large numbers (Fig. 2, Table 3). This, and the sightings of colour-ringed birds, suggested an intermixture of birds from High Arctic and Low Arctic areas. But the mean and frequency distribution of belly colour ratings of hunter-shot birds examined in late December were almost identical to those recorded from a sample of Brent examined in the High Arctic during August (Fig. 3). Rings recovered from the same December birds, and sightings of colour rings during January to March (Tables 3 and 4), confirmed the presence of many High Arctic birds and showed that they outnumbered massively Brent from other marked populations from Alaska and the Canadian Low Arctic. We conclude that from late December to February the Padilla Bay flock was composed almost entirely of birds from the western Canadian High Arctic stock. Influxes of migrants during March and April included many dark-bellied Brent, several wearing colour rings from Alaska. Analyses of pre-1987 ring recoveries also showed a strong dominance of High Arctic birds in the wintering population, and showed that both Canadian and Alaskan Brent were among the few Low Arctic birds.

The mid-winter population of approximately 1400 Brent near Dungeness contained mainly Low Arctic Brent and few, if any, High Arctic birds during 1987–88; pre-1987 ring recoveries showed that the Low Arctic birds came primarily from Canada, and that some High Arctic Brent were present. Similarly, the scattered small flocks wintering near Boundary Bay, the Hood Canal, and Puget Sound south of Padilla Bay were composed almost exclusively of Low Arctic Brent. Canadian Low Arctic birds appeared to outnumber Alaskan Brent in areas south of Padilla Bay (Dungeness, Hood Canal, lower Puget Sound) whereas Alaskan birds were relatively more abundant in areas to the north (Birch and Boundary Bays).

Of the 252 pre-1987 ring recoveries of High Arctic Brent within the study area, 98% occurred in Padilla Bay, 2% in areas to the north, and <1% to the south. The 324 recoveries of Alaskan-ringed Brent were more evenly distributed within the study area: 39% in Padilla Bay, 47% to the north, and 14% to the south. The 161 recoveries of Canadian Low Arctic Brent were also widely distributed: 54% in Padilla Bay, 22% to the north, and 24% to the south. Chi-square tests showed those differences in recovery distribution from the three northern areas to be highly significant ($P<0.001$) for all possible comparisons

The southeastern and eastern coasts of Vancouver Island were used almost exclusively by Low Arctic Brent, and only during spring migration. Formerly Brent were considered to be an important wintering species in southern British Columbia (Leach 1982) although most early references to abundance refer to December or March rather than to the mid-winter months.

Brooks (1904), Jewett *et al.* (1953), Einarsen (1965), and Palmer (1976) reported the occasional occurrence of grey-bellied Brent Geese on the coasts of Washington and British Columbia. Boyd & Maltby (1979) established the existence of a distinct stock of such birds and identified Puget Sound as their main wintering area; our observations confirm this, while highlighting the numerical importance of the wintering flock and its almost exclusive use of Padilla Bay.

Raveling (1979) showed that groups of

Canada Geese *Branta canadensis* from different breeding locations each used different staging and wintering areas. Brent Geese from the Pacific Flyway were similarly segregated in our study area, as well as on their principal staging area at Izembek Lagoon (Reed *et al.* 1989).

Our results now allow managers to relate local surveys of winter population, productivity, and harvest to specific stocks of Brent Geese. This is a distinct advantage because management concerns differ between stocks. Few Black Brant now overwinter north of the US-Mexico border (Smith & Jensen 1970) and numbers are declining on the Yukon-Kuskokwim Delta which was considered their principal nesting area (King & Derksen 1986). High Arctic Brent are of concern because of the relatively small size of the stock (probably <20,000 from a total Pacific Flyway wintering flock of approximately 150,000), and because they may experience breeding failure more frequently on their northern breeding grounds.

Hunting regulations for Padilla Bay will influence the kill of High Arctic Brent, most of which winter there, but regulations elsewhere in the study area will have little impact on that stock. In the study area Low Arctic Brent will be influenced mainly by regulations outside Padilla Bay, but the impact of the kill will be lessened by the relatively low proportion of the population wintering there; further research may, however, reveal subpopulations of Low Arctic Brent which are especially vulnerable to hunting in the study area. It is recommended that monitoring of winter populations and harvests be continued annually and that ringing be expanded to cover other breeding locations.

We thank T. Barry, H. Boyd and J. Hawkings (Canadian Wildlife Service (CWS)), R. Bromley (Northwest Territ. Dep. Renewable Resour.), and J. Sedinger (Univ. of Alaska, Fairbanks) for help in ringing Brent Geese on the breeding grounds during 1987. Ringing in Canada was made possible by the generous support from the Polar Continental Shelf Project and from the Inuvialuit Final Agreement Fund. T. Barry and L. Maltby (CWS) and C. Lensink (U.S. Fish and Wildl. Serv.) graciously allowed us access to recovery data from their pre-1987 ringings. We are grateful to T. Sullivan, R. Beach, E. Kramer, P. Miller, P. Thompson, J. Watson, M. Whalen, K. Dzinbal, P. Dye, U. Wilson, A. McMillan, C. Merker, M. McMinn, J. Atkinson, N. Dawe, and volunteers from the Arrowsmith Natural History Society, Parksville, British Columbia, for reporting observations or for assistance during bag checks. We also thank many Brent hunters for their collaboration. H. Boyd provided useful comments on an earlier draft of the manuscript. The senior author is grateful to A. Martell (CWS) for his support and encouragement throughout the study.

References

Bellrose, F.C. 1980. *Ducks, geese and swans of North America.* Third ed. Stackpole Books, Harrisburg, Pa. 540 pp.

Boyd, H. & Maltby, L.S. 1979. The Brant of the western Queen Elizabeth Islands. Pages 5–21 in R.L. Jarvis and J.C. Bartonek, Eds. *Management and biology of Pacific Flyway geese, a symposium.* OSU Book Stores, Corvallis, Oreg.

Boyd, H., Maltby, L.S. & Reed, A. 1988. Differences in the plumage patterns of Brant breeding in High Arctic Canada. *Can. Wildl. Serv. Prog. Note 174* 9 pp.

Brooks, A. 1904. British Columbia Notes. *Auk* 21:289–290.

Einarsen, A.S. 1965. *Black Brant: sea goose of the Pacific Coast.* Univ. Washington Press, Seattle. 142 pp.

Hansen, H.A. & Nelson, U.C. 1957. Brant of the Bering Sea – migration and mortality. *Trans. North Am. Wildl. Conf.* 22:237–254.

Jewett, S.G., Taylor, W.P., Shaw, W.T. & Aldrich, A.J. 1953. *Birds of Washington State.* Univ. Washington Press, Seattle. 767 pp.

King, J.G. & Derksen, D.V. 1986. Alaska goose populations: past, present and future. *Trans. North Am. Wildl. and Nat. Resour. Conf.* 51:464–479.

Leach, B.A. 1982. Waterfowl on a Pacific estuary. *British Columbia Prov. Museum Spec. Publ. No. 5.* Victoria, B.C. 211 pp.

Palmer, R.S. (Ed.) 1976. *Handbook of North American birds.* Vol. 2. Yale Univ. Press, New Haven, Conn. 521 pp.

Raveling, D.G. 1979. Traditional use of migration and winter sites by Canada Geese. *J. Wildl. Manage.* 43:229–235.

Reed, A., Stehn, R. & Ward, D. 1989. Autumn use of Izembek Lagoon, Alaska, by Brant from different breeding areas. *J. Wildl. Manage.* 53:720–725.

Smith, R.H. & Jensen, G.H. 1970. Black Brant on the mainland coast of Mexico. *Trans. North Am. Wildl. and Nat. Resour. Conf.* 35:227–241.

Austin Reed,[1] Canadian Wildlife Service, Box 340, Delta, British Columbia V4K 3Y3, Canada.
Michael A. Davison, Washington Department of Wildlife, 16018 Mill Creek Boulevard, Mill Creek, WA 98012, USA.
Donald K. Kraege, Washington Department of Wildlife, 600 N Capitol Way, Olympia, WA 98504, USA.

[1] Present address: Canadian Wildlife Service, 1141 Route de l'Eglise, Ste-Foy, Quebec G1V 4H5, Canada.