A Summary of Brant Research and Monitoring Programs in British Columbia

W. Sean Boyd, Kate Hagmeier and André Breault

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A SUMMARY OF BRANT RESEARCH AND MONITORING PROGRAMS IN BRITISH COLUMBIA

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ABSTRACT

Brant (*Branta bernicla*) wintering in and migrating through British Columbia belong to two distinct groups: dark-bellied Black Brant and a lighter grey-bellied (Western High Arctic or WHA) Brant. Phenotypic, behavioural and genetic data suggest that these two groups should be treated separately for management purposes. This report provides an overview of recent work undertaken in B.C. to better understand and manage Brant populations. It describes ongoing efforts to determine patterns of abundance and distribution of Black and WHA Brant during winter and spring migration, identify population structure by describing breeding, wintering, and spring staging ground affiliations, evaluate the effects of a late-winter hunt on the Fraser River Delta (FRD), and assess body condition and fat accumulation rates at critical stopover sites during spring migration.

Approximately 2,500 Brant currently spend the winter in B.C. The FRD supports the largest wintering population, with approximately 2,000 individuals in 2004 (1,400 Black Brant and 600 WHA Brant). Up to 25% of the Pacific Flyway Brant population stages in the Strait of Georgia during spring migration. The Parksville-Qualicum area on Vancouver Island is a particularly important spring staging site; survey and mark-resight data suggest that up to 15,000 Brant use the area each year. The number of Brant harvested on the FRD in March accounts for only a small portion (<5%) of the overall Pacific Flyway sport harvest.

In recent years, Brant have experienced high levels of disturbance on their winter and spring staging areas in B.C., mostly from Bald Eagles (*Haliaeetus leucocephalus*), humans, and dogs. These disturbance rates are among the highest observed anywhere in the world. Observations of marked individuals suggest that fat deposition rates in spring, and hence body condition, vary among years. During the last four years (2001-2004) abdominal profile scores were lower than those recorded in 1999 and 2000. Reasons for these differences are unknown but possible mechanisms are changes to their preferred foods (eelgrass, Pacific Herring spawn) and the noted increase in disturbance rates.

Given the small size of Brant wintering populations in B.C., the presence of WHA birds, and the suspected importance of spring-staging areas for fat accumulation, we recommend that current winter and spring monitoring programs be continued and, in some cases, expanded. This should include detailed assessments of the interactions between Brant body condition and disturbance levels, and the associated implications for individual reproductive success and survival.

RESUMÉ

Les bernaches cravants (*Branta bernicla*) qui hibernent en Colombie-Britannique ou traversent la province durant leur migration appartiennent à deux groupes distincts, l'un formé d'individus à ventre sombre, et l'autre, d'individus à ventre gris plus pâle (ouest de l'Extrême-Arctique). Des données phénotypiques, comportementales et génétiques portent à croire que ces deux groupes devraient être traités séparément à des fins de gestion. Dans le présent rapport, nous passons en revue les travaux entrepris récemment en Colombie-Britannique en vue de mieux comprendre et gérer les populations de bernaches cravants. Nous analysons les travaux en cours visant à déterminer les fluctuations d'abondance et la distribution des bernaches cravants noires et des bernaches cravants à ventre gris en hiver et durant leur migration printanière, à caractériser la structure des populations en décrivant les associations dans les aires de reproduction, les aires d'hivernage et les haltes migratoires printanières, à évaluer les effets de la chasse pratiquée à la fin de l'hiver dans le delta du Fraser et à estimer l'état et le rythme d'engraissement des bernaches à diverses haltes essentielles durant la migration printanière.

Environ 2 500 bernaches cravants hivernent actuellement en Colombie-Britannique. Le delta du Fraser abrite la plus importante population hivernante, évaluée à quelque 2 000 individus en 2004 (1 400 bernaches noires et 600 bernaches à ventre gris). Jusqu'à 25 % des bernaches cravants qui empruntent la voie migratoire du Pacifique font halte dans le détroit de Georgie durant leur migration printanière. La région de Parksville-Qualicum sur l'île de Vancouver est une halte migratoire printanière particulièrement importante, car selon des relevés et des études de marquage-réobservation, jusqu'à 15 000 bernaches cravants feraient halte dans la région chaque année. Le nombre de bernaches cravants récoltées en mars dans le delta du Fraser ne représente qu'une faible portion (<5 %) du nombre total prélevé par les amateurs de chasse sportive parmi la population empruntant la voie migratoire du Pacifique.

Depuis quelques années, les bernaches cravants sont exposées à des niveaux de perturbations intenses dans leurs haltes migratoires hivernales et printanières en Colombie-Britannique. Les principales sources de perturbations sont les pygargues à tête blanche (*Haliaeetus leucocephalus*), les humains et les chiens. Ces niveaux de perturbations sont parmi les plus élevés au monde. Des observations effectuées chez des individus marqués laissent croire que le rythme d'accumulation des graisses au printemps et, par conséquent, l'état d'engraissement, varient d'une année à l'autre. Les indices d'adiposité abdominale mesurés au cours des quatre dernières années (2001-2004) étaient plus faibles que ceux enregistrés en 1999 et en 2000. Les facteurs à l'origine de cette disparité sont inconnus, mais des modifications de la disponibilité des sources de nourriture préférées (zostère, œufs de hareng du Pacifique) et l'augmentation notée des niveaux de perturbations pourraient être en cause.

Compte tenu de la faible taille des populations de bernaches cravants hivernant en Colombie-Britannique, de la présence de bernaches cravants à ventre gris et de l'importance présumée des haltes migratoires printanières pour le stockage des graisses, nous recommandons la poursuite et, dans certains cas, l'élargissement des programmes de surveillance hivernale et printanière en cours. Il faut notamment étudier en détail les interactions entre l'état d'engraissement des bernaches et les niveaux de perturbations et les répercussions de ces interactions sur les taux individuels de succès de la reproduction et de survie.

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1 INTRODUCTION

1.1 General Introduction

Approximately 120,000 – 130,000 Brant (*Branta bernicla*) overwinter on the Pacific Coast, from Alaska to Mexico (Pacific Flyway Council 2004). British Columbia supports only about 2,500 winter residents which are largely restricted to the Fraser River Delta (FRD) and the Queen Charlotte Islands (QCI) (Campbell *et al*. 1990). These areas, in addition to the east coast of Vancouver Island (ECVI), support much larger numbers of Brant each spring, as up to 25% of all Pacific Flyway Brant stage in the Strait of Georgia (SoG) during their northern migration.

Brant in B.C. are comprised of two recognizable forms. Most are the dark-bellied Pacific Black Brant (*Branta bernicla nigricans),* which breed primarily in Alaska, the low Arctic of western Canada, and northeastern Russia (Banikov *et al*. 1983, Palmer 1976) and winter along the Pacific coast from Alaska to Mexico. The remainder are a grey-bellied form, similar in appearance to Atlantic Brant (*Branta b. hrota*), which nest in the Canadian Western High Arctic (WHA; including Prince Patrick, Melville, and Eglington Islands) and winter in a very restricted area in the northern Puget Sound area of Washington (Reed *et al*. 1989a) and, in recent years, also on the FRD (CWS *unpubl. data*).

Over the past century, the abundance and distribution of Brant has changed considerably along the Pacific Coast, including B.C. (Campbell *et al.* 1990). The causes underlying these changes are unknown, although factors such as over-hunting, increased disturbance, and habitat degradation have been suggested. The Canadian Wildlife Service (CWS) and partner agencies have undertaken a number of monitoring and research activities to better understand Brant population dynamics and habitat use in B.C. The purpose of this report is to summarize relevant information from these studies and to make recommendations on monitoring and research activities needed to manage Brant into the future.

1.2 Morphological Differences

WHA and Black Brant are phenotypically distinct (Boyd and Maltby 1979). WHA Brant tend to have lighter coloured belly/breast feathers (hence the term grey-bellied), with a sharp contrast between the neck and belly/breast feathers (Figure 1). Additionally, the white band of neck feathers, termed the necklace by Boyd and Maltby (1979), is broken at the front in WHA Brant whereas in Black Brant it is complete.

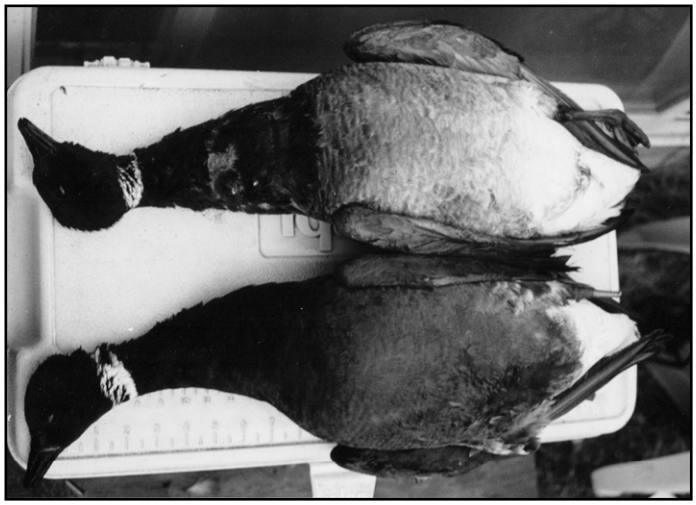

Figure 1. Western High Arctic Brant (above) and Black Brant (below).

1.3 Breeding and Wintering Ranges

Black and WHA Brant appear to be demographically distinct population segments. They exhibit little or no geographic overlap on the breeding grounds and minimal overlap in winter. Approximately 80% of Black Brant nest on the Yukon-Kuskokwim River delta in Alaska, with smaller populations breeding on the North Slope of Alaska around Teshepuk Lake and Prudhoe Bay, and in the Canadian Arctic around the Mackenzie River delta and on Banks Island (Sedinger *et al.* 1994; Figure 2). Most Black Brant (ca 80%) winter in Mexico, with smaller aggregations occurring at coastal locations between California and Alaska (Sedinger *et al.* 1994). WHA Brant breed mainly on Prince Patrick, Eglington, and Melville Islands in the western Canadian Arctic Archipelago and winter almost exclusively in Padilla and Samish Bays in the northern Puget Sound area of Washington State (Brewer *et al.* 1999; Figure 2). In recent years, however, a small proportion of the WHA population has started to winter on the FRD.

1.4 Genetic Differences

Analyses of mitochondrial DNA suggest that WHA Brant are sufficiently distinct from Black Brant and Atlantic Brant to be a separate stock (Shields 1990). Although subspecies designation has not yet been made the magnitude of genetic divergence between Black and WHA Brant is similar to that which separates Snow Geese and Ross' Geese, which are classified as separate species.

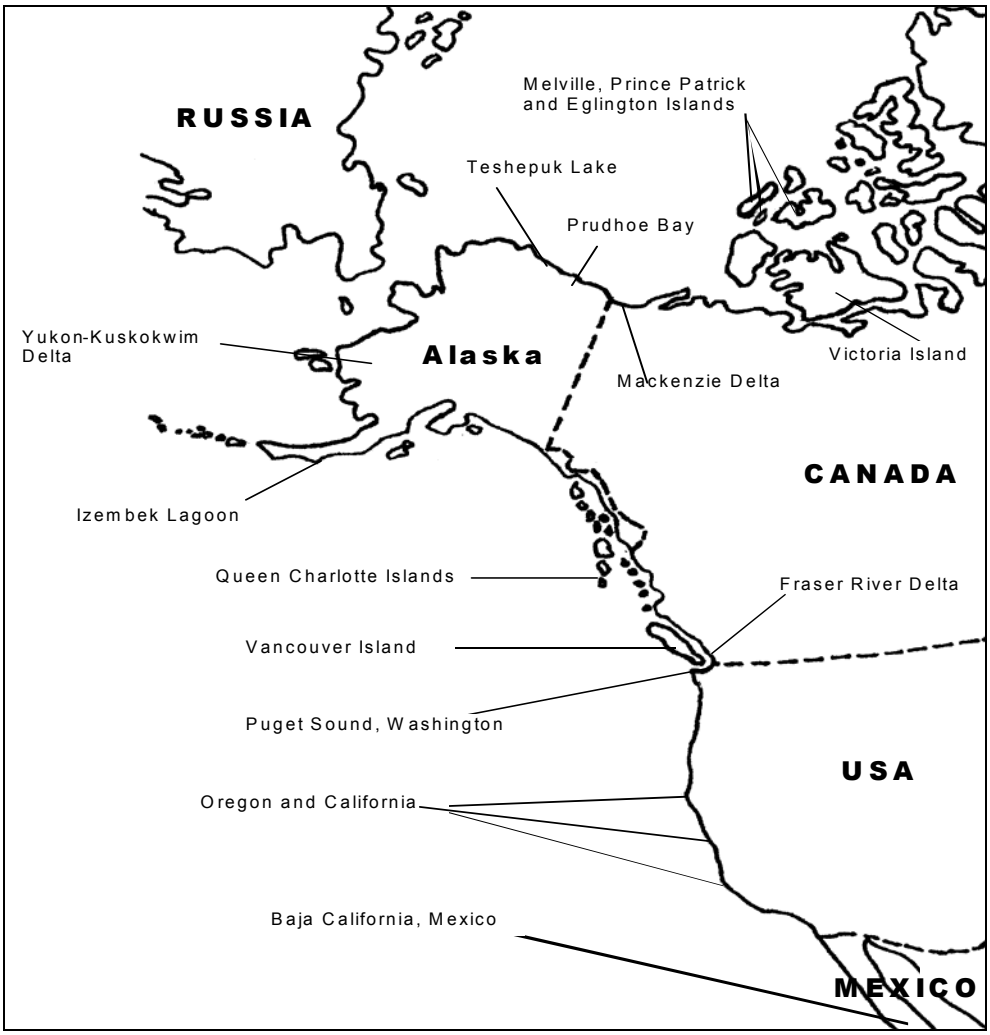

Figure 2. Important breeding, moulting, wintering, and spring staging areas for Black Brant and WHA Brant in North America.

The CWS, Washington State Department of Fish and Game, U.S. Geological Service, U.S. Fish and Wildlife Service and Pacific Flyway Council have recently initiated a collaborative study to further define the degree of genetic distinctiveness between WHA and Black Brant. Blood and tissue samples from WHA birds captured in family and moulting groups in the Arctic and from birds harvested by sport hunters on the FRD are being analysed at the U.S. Geological Service Science Center in Anchorage, Alaska.

1.5 Brant Abundance in the Pacific Flyway

In the Pacific Flyway, the status of Brant is assessed annually via surveys conducted on breeding, moulting, and staging grounds in Alaska, as well as on wintering grounds throughout the range. Data from the mid-winter waterfowl survey are typically used to track changes in Brant abundance for management purposes. Results of this survey indicate a long-term population decline between 1960 and 2002 (Figure 3), although substantial regional differences are apparent. For example, in the 1990's Brant populations increased in Alaska and B.C., decreased in Oregon, and fluctuated substantially in Washington and Mexico (Table 1).

The mid-winter waterfowl survey does not distinguish between Black Brant and WHA Brant. Most birds inventoried are presumed to be Black Brant so our understanding of the status and trend for the WHA population is limited. Derksen and Ward (1993) estimated that approximately only 2,000 WHA Brant nested on Melville and Prince Patrick Islands. During the non-breeding season, it is thought that nearly all of the Brant wintering in Padilla and Samish Bays (WA) are WHA birds (Reed *et al.* 1998). The mid-winter index for these areas suggests a WHA population varying between 5,000-15,000 birds (Table 1).

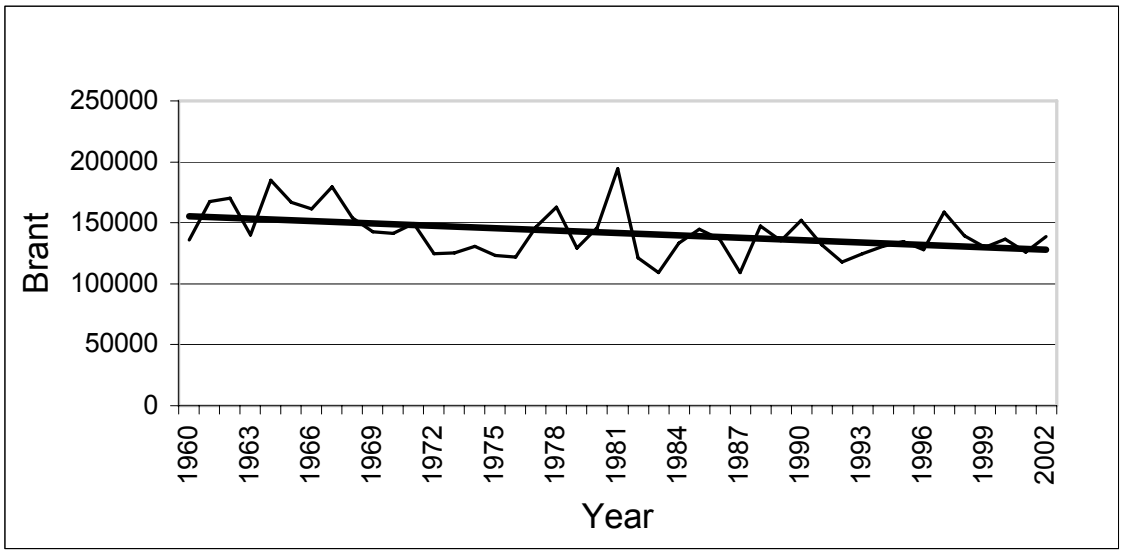

Figure 3. Pacific Flyway Brant Population Index (1960-2002) based on mid-winter aerial surveys.

Table 1. Pacific Flyway Brant Population Index (1991-2001). Region abbreviations: AK = Alaska, BC = British Columbia, WA = Washington, OR = Oregon, CA = California, MX = Mexico. Site abbreviations: FRD = Fraser River Delta, VI = Vancouver Island, QCI = Queen Charlotte Islands, GB = Areas traditionally considered as Grey-bellied WHA Brant wintering grounds, Other = Areas traditionally considered to hold a mixture of Black and WHA Brant (Pacific Flyway Council 2002, Breault 2004).

Region	Site	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02
BC	**FRD**	26	192	382	363	634	500	619	985	1238	1254	1483
	VI	10	2	0	0	0	0	5	2	7	11	65
	QCI	247	25	253	348	426	204	529	55	464	7	200
	Total	283	219	635	711	1060	704	1153	1042	1709	1272	1748
WA	**GB**	9520	10840	11240	16900	4885	4990	6340	9215	7915	4881	8964
	Other	3985	2218	2355	3331	2056	3763	4541	6037	5944	5316	4514
	Total	13505	13058	13595	20231	6941	8753	10881	15252	13859	10197	13478
OR		1397	1254	666	708	644	669	580	645	523	695	552
CA		2424	9415	2299	3987	2008	3598	6091	4296	3389	4197	4092
MX		93185	92724	100265	96815	107485	130738	112105	100760	108440	91860	105050
AK		7200	8008	13221	11978	9795	13147	8773	8255	8833	17790	13576
Flyway Total		117994	124678	130681	134430	127933	158567	139611	130254	136753	126011	138492

1.6 Management

Phenotypic, distributional, and genetic data suggest that Black Brant and WHA Brant are distinct population segments, if not subspecies (Reed *et al.* 1989b, Shields 1990). Also, the relatively small size of the WHA population (currently <10,000 individuals) suggests that it is one of the smallest goose stocks in the world (Grue, *in press*). This report recognizes the unique status of WHA Brant and supports recommendations to develop stock-specific management strategies in B.C.

2 ABUNDANCE AND DISTRIBUTION

2.1 Introduction

In British Columbia, Brant have historically wintered on the Fraser River Delta (FRD), along the east coast of Vancouver Island (ECVI) and in the Queen Charlotte Islands (QCI) (Campbell *et al.* 1990). On the FRD, Brant were abundant winter residents during the late 1800's (ca. 10,000 individuals; Fannin 1891). However, by the mid 1940's the wintering population was estimated at only 500–1,000 individuals (Campbell *et al.* 1990). Further declines were documented during the 1960's and 1970's; for example, Christmas Bird Counts conducted in Ladner, B.C., suggested a decline from 600 birds in 1960 to completely "absent" in 1980 (Campbell *et al.* 1990).

Recent estimates indicate a wintering population of approximately 2,500 Brant in B.C.. The largest aggregation of wintering Brant is on the FRD (more specifically the Boundary Bay-Roberts Bank area), with a smaller wintering group in the QCI. A few Brant (<25) also have wintered on the ECVI in recent years (Breault 2004, G. Monty *pers. comm*.).

During spring migration, up to 15,000 Brant have been observed on the ECVI, primarily in the Parksville-Qualicum area (Nygren *unpubl. report*s, Hagmeier 2002). Brant also stage in smaller numbers on the FRD, in the QCI, and on the west coast of Vancouver Island.

This section describes programs designed to track long-term trends in Brant abundance during winter and spring migration on the FRD, ECVI, and where data are available, the QCI.

2.2 Methods

Brant distribution and abundance on the FRD and ECVI have been tracked by Canadian Wildlife Service staff as well as graduate students, contractors, and volunteers (Reed 1997, Gowans *unpubl. report*, Hagmeier 2002, Martin *et al. unpubl. report*s, Monty *unpubl. data*, and Nygren *unpubl. report*s). Data collected include information on total abundance, adult to young ratios, WHA to Black Brant ratios, and resightings of alpha-numeric tarsal bands originally affixed on breeding areas. These data have been used to: (1) index mid-winter population size, (2) quantify spring migrant use of the ECVI and FRD, (3) index recruitment and the relative abundance of WHA and Black Brant, and (4) determine affiliations between breeding and non-breeding areas for Brant populations that winter in and migrate through B.C.

2.2.1 Mid-Winter Index of Brant Abundance on the Fraser River Delta

Between 1993-94 and 2000-01 survey data were used to calculate a mid-winter index of Brant abundance on the FRD. Surveys were comprised of daily counts conducted

between 15 December and 31 January each winter in the Boundary Bay-Roberts Bank area. Reed (1997) determined that the wintering population on the FRD is largely closed, meaning that there is no movement of birds into or out of the population within the winter period. Thus, the maximum number of Brant observed during any single survey during the monitoring period can be used as an index of minimum abundance.

In 2002-03, Brant expanded their winter range to include Semiahmoo Bay in northern Puget Sound, Washington. This area had not been used on a regular basis since prior to 1980. Following this recent range expansion, two sets of mid-winter indices have been estimated. The first was restricted to the Boundary Bay-Roberts Bank area, and was designed to yield data directly comparable to the 1993-94 through 2000-01 surveys described above. The second incorporated the Semiahmoo Bay data to provide a more complete index of total abundance on the FRD.

In addition to peak abundance, mean daily abundance estimates also were used to track changes in Brant wintering populations on the FRD, using only survey data conducted between 10-31 January each year.

Trends in abundance were examined by fitting quadratic equations to both peak and mean daily abundance estimates (excluding Semiahmoo Bay data). The level of association between peak and mean daily abundance estimates of population size was evaluated using Pearson coefficient of correlation (r).

2.2.2 Spring Use of the Fraser River Delta and East Coast Vancouver Island

Distribution and abundance of spring migrants on the FRD and the ECVI were assessed using both ground counts and aerial surveys. Aerial surveys were conducted on the ECVI in 1958 and 1964 (Blood and Smith 1966) and throughout the Strait of Georgia (SoG) in 1990, 1991 (Nygren *unpubl. report*), and 2004 (Monty *unpubl. data*). Ground counts were conducted annually in the Parksville-Qualicum area from 1989-2004 (with the exception of 1996) and in the Boundary Bay-Roberts Bank area from 1994-2004 (with the exception of 1996).

Daily abundance counts could not be used to estimate the number of geese using a spring-staging area because of the constant turnover of individuals during migration. Instead, we generated two indices to estimate spring abundance: (1) goose-days and (2) goose-volume. Goose-days are defined as the sum of the number of days in which individual geese were present in the study area. Goose-day estimates are presented for the full spring migration period, as well as the period of peak migration (1-30 April), each year.

Volumes (or total numbers) of Brant using the FRD and the Parksville-Qualicum area of ECVI in spring were estimated using two years of abundance and tarsal-band data (spring 1999 and 2000) incorporated into a mark-resight model in Program MARK (Frederiksen *et al.* 2001). The mark-resight model used arrival and departure

probabilities in combination with abundance estimates to infer average lengths of stay and the volume of birds at each site (see Hagmeier 2002 for detailed methodology).

2.2.3 Estimating Recruitment and Relative Abundance of Black and WHA Brant

Age and stock composition of Brant flocks using the FRD and Parksville-Qualicum area were assessed using data from ground counts. Hatch year Brant were distinguished from adults by the white edges on their wing coverts and secondary feathers. WHA Brant were distinguished from Black Brant by breast and necklace plumage as described in Boyd and Maltby (1979). Count data were converted to proportion estimates using a jackknife technique (Cochran 1977) and these proportions were then applied to peak mid-winter counts to produce annual recruitment and relative abundance indices.

2.2.4 Breeding Ground Affiliations of Winter Resident and Spring Migrant Brant

Between 1985 and the present, a substantial number of Black Brant were captured and marked with alpha-numeric, colour-coded tarsal bands on their breeding and moulting grounds (Bollinger *unpubl. data*). Additionally, WHA Brant were marked on their breeding and moulting grounds in the summers of 2000 and 2002. Each tarsal band has a unique colour and code corresponding to a specific breeding area. Using high-power spotting scopes, observers have been recording the presence of banded Brant on winter and spring staging areas in B.C. since1989. Most of the observations have taken place in the spring in the Parksville-Qualicum area of ECVI, but data have also been collected on the FRD during winter and spring, and in the QCI during winter.

By comparing tarsal band sightings made in coastal B.C. to the Pacific Flyway database (Ward and Sedinger, *unpubl. data*) breeding ground affiliations of Brant that winter in and migrate through B.C. were determined. In this report we summarize the results of resightings made in FRD, ECVI, and QCI, and use estimates of the number of individuals observed at more than one winter or spring staging location to infer the degree of isolation among Brant populations during the non-breeding season.

2.3 RESULTS

2.3.1 Fraser River Delta Mid-winter Population Index

Mid-winter counts indicate that the Brant population on the FRD has increased from between 200-400 birds in 1993-94 to >1,800 individuals in 2003-2004 (Table 2; Figure 4). Although peak and mean counts are highly correlated (r = 0.98 for 15 December-31 January data; r = 0.76 for 10-31 January data) trend results are somewhat equivocal. Peak counts have steadily increased between 1993 and 2003 (Figure 4), whereas mean counts appear to have levelled off during winters 2002-03 and 2003-04 (Figure 5).

Table 2. Peak and mean daily abundance counts for Brant during winter on the Fraser River Delta between 1993-94 and 2003-04. Source data are given in Appendix 1.

	15 December – 31 January					10-31 January				
Year	**N**	**Peak Count**	**Mean**	**SD**	**95% CI**	**n**	**Peak Count**	**Mean**	**SD**	**95% CI**
1993-94	15	382	150	108	60	11	226	106	20	44
1994-95	45	363	180	85	25	21	363	193	97	44
1995-96	-	634	310	-	-	-	-	-	-	-
1996-97	-	500	235	-	-	-	-	-	-	-
1997-98	14	619	226	191	110	7	515	166	161	150
1998-99	25	985	502	273	112	14	985	539	268	154
1999-00	25	1238	682	289	119	12	962	663	266	169
2000-01	26	1254	756	299	121	14	1254	785	232	134
2001-02	-	-	-	-	-	8	1483	782	378	316
2002-03	-	-	-	-	-	14	849	621	247	143
2003-04	-	-	-	-	-	11	1883	581	635	427
2002-03*	-	-	-	-	-	5	1103	879	183	227
2003-04*	-	-	-	-	-	10	2117	759	691	494

*Data for 2002-03 and 2003-04 including Semiahmoo Bay.

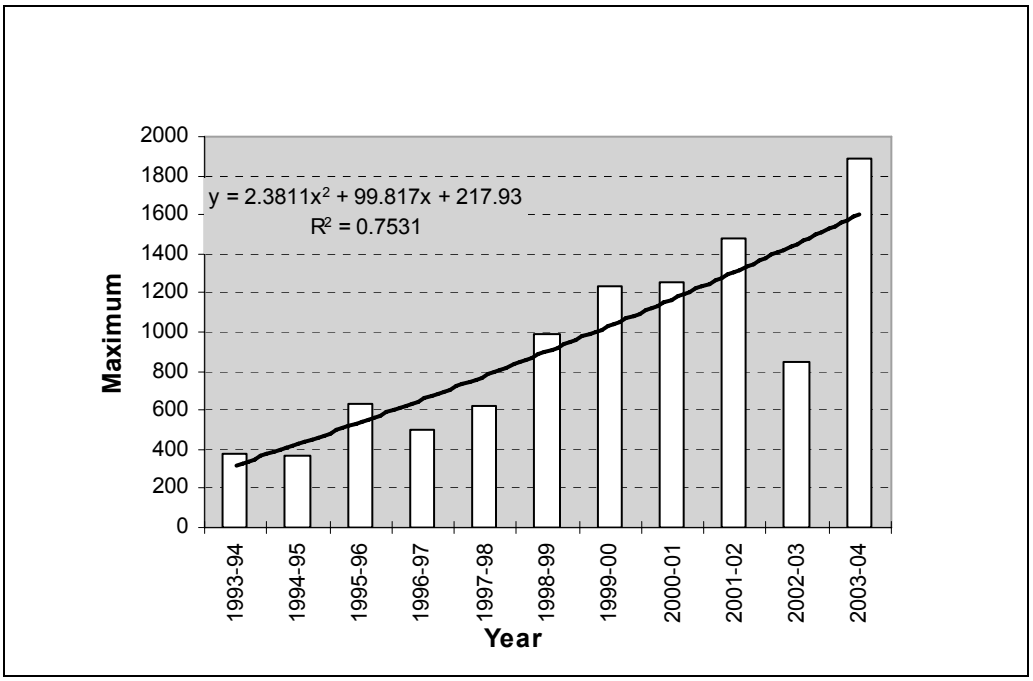

Figure 4. Peak abundance counts for Brant wintering on the Fraser River Delta, 1993-94 through 2003-04 (Semiahmoo Bay data excluded).

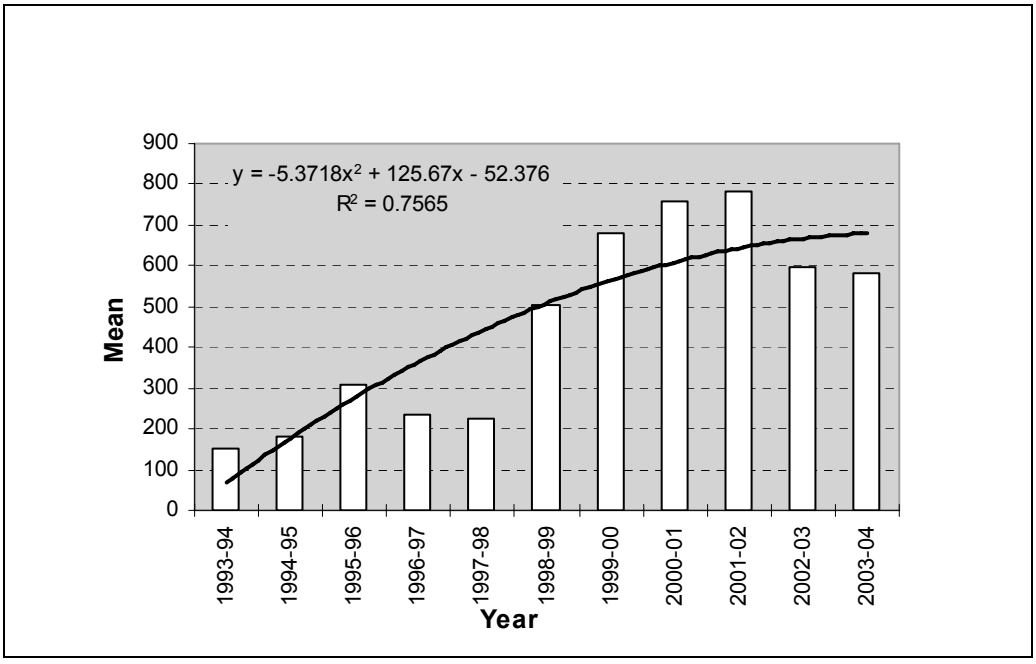

Figure 5. Mean daily abundance counts for Brant wintering on the Fraser River Delta, 1993-94 through 2003-04 (Semiahmoo Bay data excluded).

2.3.2 Spring Migrant Use of the Fraser River Delta and East Coast Vancouver Island

The FRD and ECVI supported thousands of Brant during spring migration (Table 3). Peak count estimates have ranged from 2,646 birds in 1992 to 12,794 birds in 2002 for the ECVI and 2,428 in 2000 to 5,347 in 1999 for the FRD (Table 3).

Migration patterns on the ECVI suggest a gradual increase in Brant numbers throughout March, with peak abundance occurring in late March/early April (Figure 6a). On the FRD, this build-up was less apparent due to the larger number of wintering birds already present at the site when migrants arrived. The peak of spring use by Brant appears to be a few days later at FRD than ECVI (Figure 6b). A long-term trend in peak abundance of spring migrants was not evident between 1989 and 2004 on the ECVI (linear regression, $r^2 = 0.01$, $p = 0.73$; Figure 7).

Table 3. Peak abundance counts for Brant during spring migration on the Fraser River Delta (FRD) and in the Parksville-Qualicum area (PQ) of the east coast Vancouver Island 1989-2004. Source data are given in Appendices 1 and 3.

Spring	FRD		PQ	
	Peak	Date	Peak[1]	Date
1989	-	-	9184	April 5
1990	-	-	4280	April 6
1991	-	-	3720	April 7
1992	-	-	2646	April 17
1993	-	-	4749	April 19
1994	-	-	5550	April 9
1995	-	-	6267	April 3
1996	-	-	-	-
1997	-	-	3689	April 14
1998	4763	April 23	4550	April 1
1999	5347	April 16	6900	April 1
2000	2428	April 18	5415	March 29
2001	-	-	5888	April 11
2002	-	-	12794	April 2
2003	-	-	3770	April 8
2004	3475	April 10	3100	April 3

[1] Note that these peak count estimates may not accurately reflect Brant use of the PQ area in any given spring. Peak abundance values, such as those in 1989 and especially 2002, were influenced by a large group of birds staging at only one site for one day.

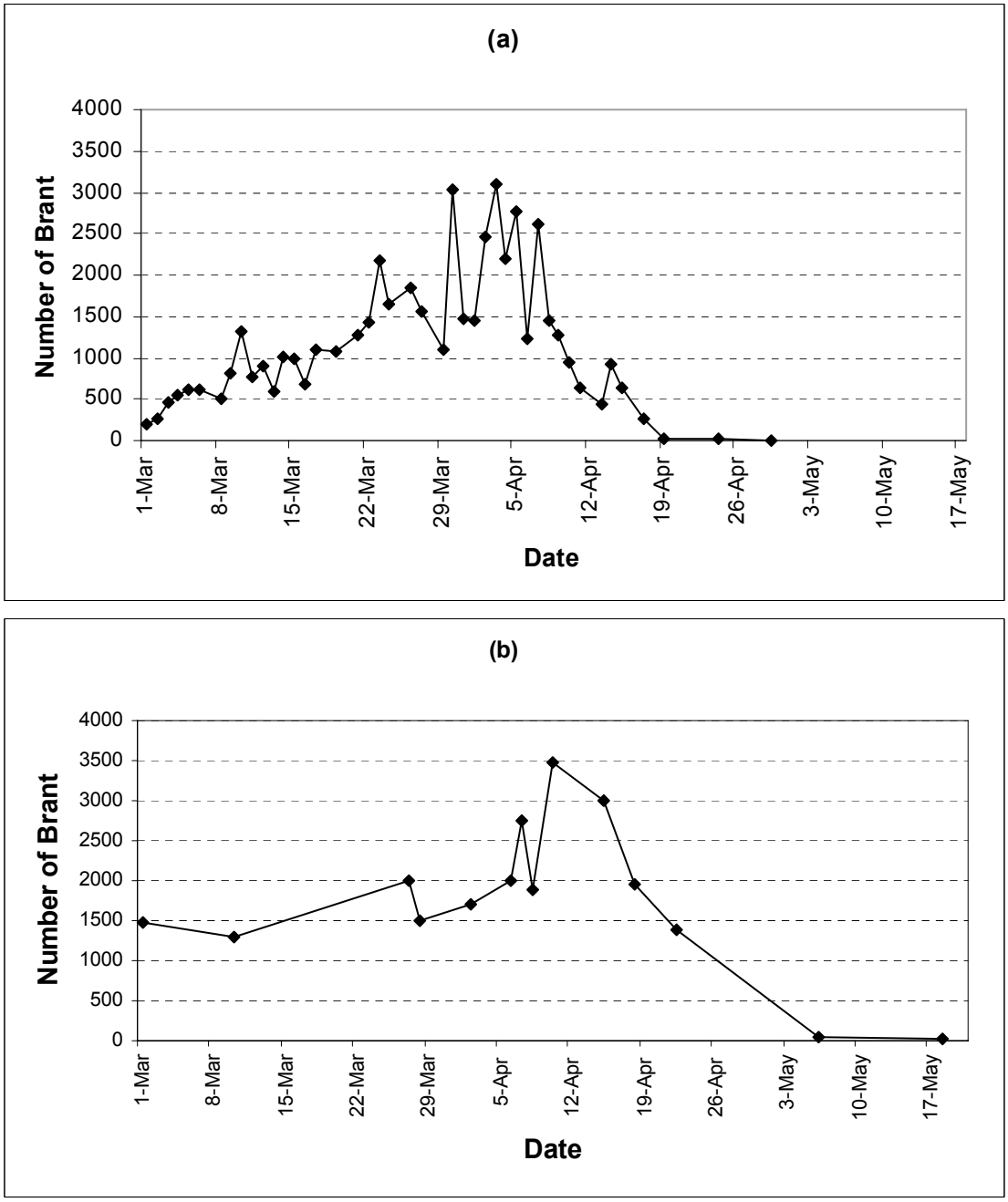

Figure 6. Peak counts of Brant abundance during spring migration in 2004 for (a) the Parksville-Qualicum area and (b) the Fraser River Delta. Figures are presented to illustrate seasonal arrival patterns. Additional source data for other years are included in Appendices 1-4.

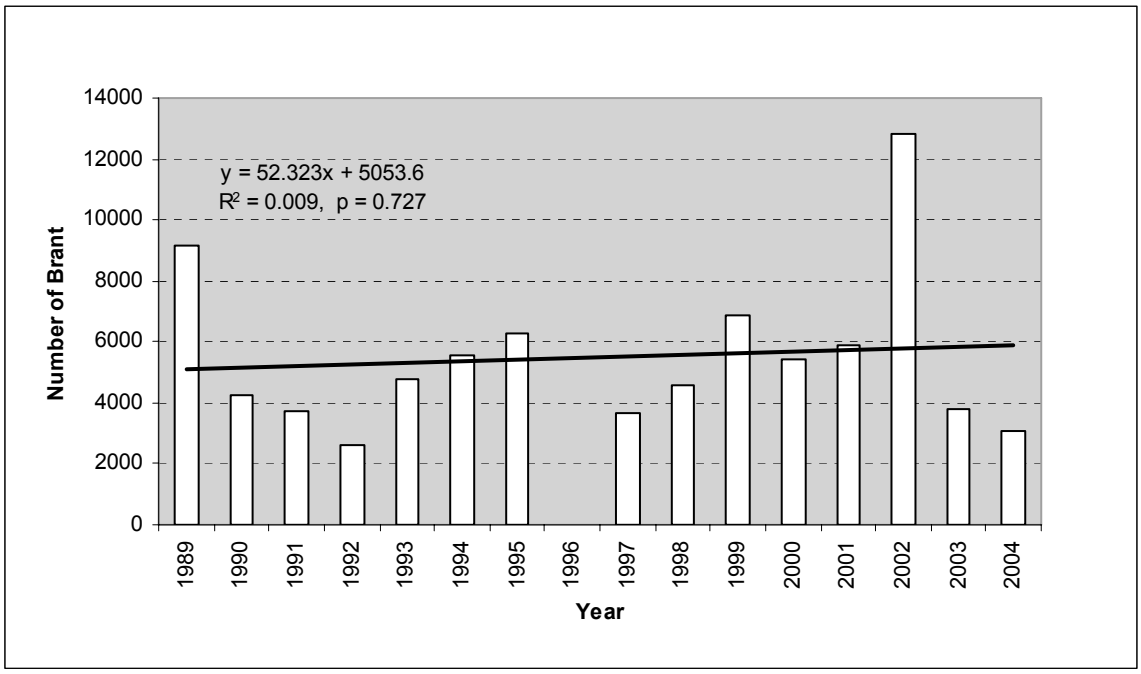

Figure 7. Peak abundance counts during spring migration 1989-2004 in the Parksville-Qualicum area. Note that no data were collected in 1996. Also, note that the peak count estimates for 1989 and especially 2002 were influenced by a large group of birds staging at only one site for one day.

Aerial and ground surveys suggest that the overall abundance of Brant in the SoG during spring, as well as the total number of goose-days, have declined between 1958 and 2004 (Tables 4 and 5). Although the 1958 and 1964 aerial surveys covered only the ECVI portion of the SoG, their resulting counts were higher than those from 1990, 1991, and 2004 when the entire SoG was surveyed (Table 4). The highest concentrations of spring staging birds have consistently occurred in the Parksville-Qualicum area of ECVI and Boundary Bay and Roberts Bank on the FRD (see Appendix 5).

Table 4. Aerial survey estimates of the abundance of Brant during spring on the east coast of Vancouver Island (ECVI) and the Strait of Georgia (SoG).

Year	Area	Survey Date	Peak Number	# Surveys
1958	ECVI	April 21, 1958	20 160	1
1964	ECVI	April 06, 1964	9 007	1
1990	SoG	April 17, 1990	8 295	12
1991	SoG	April 15, 1991	11 406	5
2004	SoG	April 08, 2004	7 131	9

Table 5. Goose-day estimates calculated using ground-counts in the Parksville-Qualicum (PQ) area and aerial surveys in the Strait of Georgia (SoG) during spring migration, 1989-2004.

	PQ Ground Counts		SoG Aerial Counts	
Spring	April	Total	April	Total
1989	68 567	99 179	-	-
1990	49 066	72 357	200 400	252 300
1991	76 980	101 990	222 400	-
1992	58 322	86 418	-	-
1993	57 118	-	-	-
1994	74 023	-	-	-
1995	84 337	140 000	-	-
1996	No data	No data	-	-
1997	58 488	78 265	-	-
1998	69 390	117 460	-	-
1999	92 859	130 001	-	-
2000	64 638	148 016	-	-
2001	56 915	106 975	-	-
2002	75 206	110 546	-	-
2003	49 088	87 456	-	-
2004	23 326	57 043	119 700	134 800

2.3.3 Estimating spring use from Goose-days and Goose Volume

Between 60,000 and 150,000 goose-days were supported each spring in the Parksville-Qualicum area from 1989-2004 (Figure 8, Table 5). The numbers of goose-days in April alone ranged from 20,000-90,000 birds (Figure 8). While variation among years was apparent, long-term trends in total spring goose-days and April goose-days were not evident over the course of this study (Total spring goose-days: $r^2 = 0.07$, $p = 0.84$; April goose-day: $r^2 = 0.07$, $p = 0.34$; Figure 8). However, when restricted to the period 1999-2004 both indices showed significant declines (Total spring goose-days: 55% decline, $r^2 = 0.83$, $p = 0.01$; April goose-days: 75% decline: $r^2 = 0.72$ $p = 0.03$).

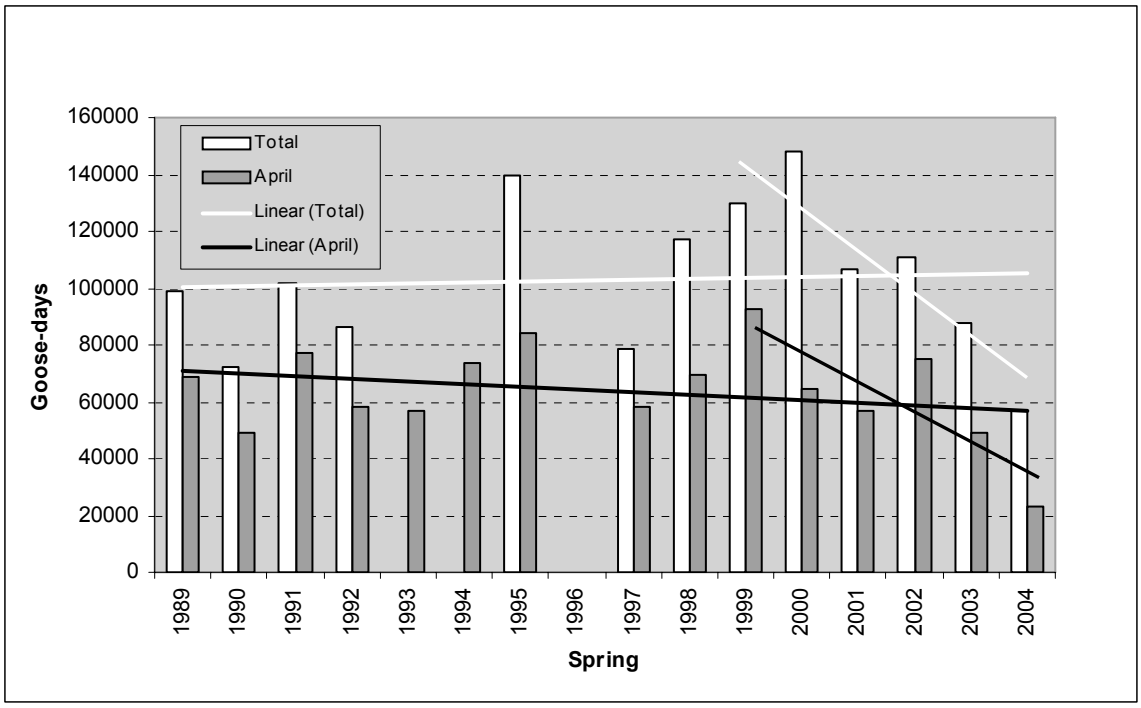

Figure 8. Number of goose-days estimated for the Parksville-Qualicum (PQ) area during the full spring migration period and for the peak migration period in April. Regression lines are for trend data collected between 1989-2004 and 1999-2004, respectively.

Goose volume estimates were similar among years on the ECVI; however, a declining trend was apparent on the FRD (Table 6). In 1999 and 2000, midwinter indices for the entire Pacific Flyway Brant population were ca. 120,000 and 128,000, respectively. For illustrative purposes, we have converted the goose-volume estimates given in Table 6 to proportions of the total Pacific Flyway Brant population in Table 7.

Table 6. Goose-volume estimates, adjusted for 5%, 10% and 20% sampling error when estimating Brant abundance at three levels of uncertainty owing to unknown error in transition probabilities (see Hagmeier 2002 for detailed methodology).

Uncertainty in Transition Parameters	Volume Estimate	FRD 1999			FRD 2000			ECVI 1999			ECVI 2000		
		5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Underestimate	Total	17562	17641	18040	10421	10858	11119	14025	14111	14356	14727	14828	15072
	S.D.	1437	1587	2069	456	603	982	494	734	1449	980	1170	1731
Intermediate	Total	16783	16876	17242	10645	10685	10898	13838	13921	14210	14242	14304	14603
	S.D.	315	628	1416	195	356	832	299	617	1383	289	619	1309
Overestimate	Total	10987	11037	11206	7460	7492	7710	5388	5420	10841	8135	8150	7940
	S.D.	215	429	912	138	261	594	132	231	1109	167	343	699

Table 7. Goose-volume estimates as a percentage of the total Pacific Flyway Brant population at each of the three proposed levels of measurement error and transition probability uncertainty (see Hagmeier 2002 for detailed methodology).

Uncertainty in Transition Parameters	Volume Estimate	FRD 1999			FRD 2000			ECVI 1999			ECVI 2000		
		5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Underestimate	Total	14.6	14.7	15.0	8.7	9.0	9.3	11.7	11.8	12.0	12.3	12.4	12.6
	S.D.	1.2	1.3	1.7	0.4	0.5	0.8	0.4	0.6	1.2	0.8	1.0	1.4
Intermediate	Total	14.0	14.1	14.4	8.9	8.9	9.1	11.5	11.6	11.8	11.9	11.9	12.2
	S.D.	0.3	0.5	1.2	0.2	0.3	0.7	0.2	0.5	1.2	0.2	0.5	1.1
Overestimate	Total	9.2	9.2	9.3	6.2	6.2	6.4	4.5	4.5	9.0	6.8	6.8	6.6
	S.D.	0.2	0.4	0.8	0.1	0.2	0.5	0.1	0.2	0.9	0.1	0.3	0.6

2.3.4 Breeding Ground Affiliations of Winter Resident and Spring Migrant Brant

Brant wintering on the FRD and using the FRD and ECVI during spring migration were originally banded on breeding areas in Alaska, including Prudhoe Bay, the Yukon-Kuskokwim River delta, and the North Slope, Canada, including Arctic Canada and the Western High Arctic, and Russia (Figure 9-11).

With the exception of the WHA Brant observed in 2000 and 2002, the relative proportion of individuals from different breeding grounds has remained consistent across years on the FRD (winter and spring; Figure 9-10) and on the ECVI (spring; Figures 11). On the FRD, the proportion of WHA Brant tends to be lower in spring than in winter due to the influx of Black Brant from more southerly wintering areas (Figure 10).

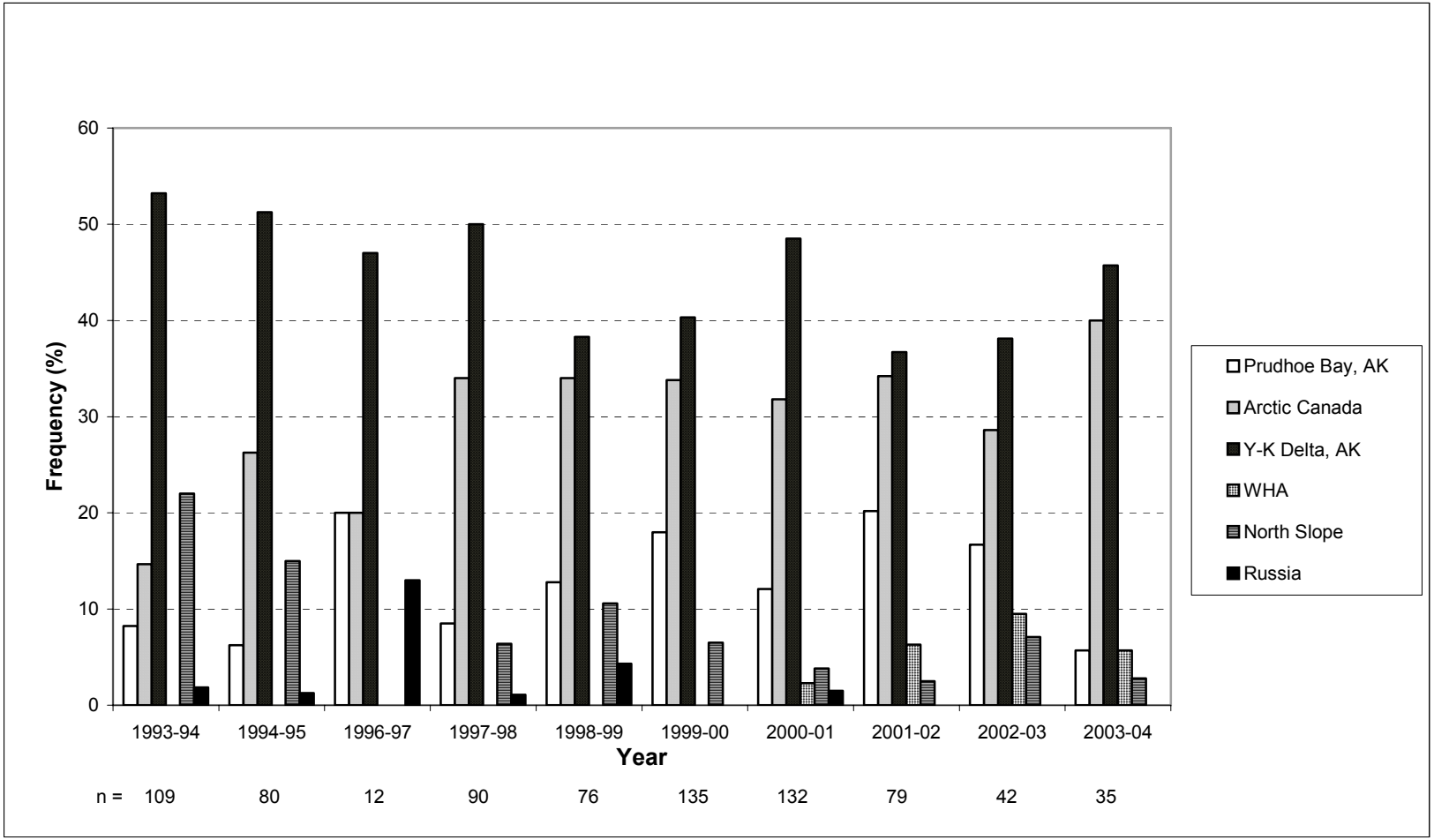

Figure 9**.** Breeding ground affiliations of Brant wintering in the Fraser River Delta. Frequency distribution bars denote the parentage of tarsal bands affixed in different breeding areas. The number of observations (n) made each year are listed below the x-axis. Note that no data were collected in 1995-96 and WHA Brant were only banded in 2000 and 2002.

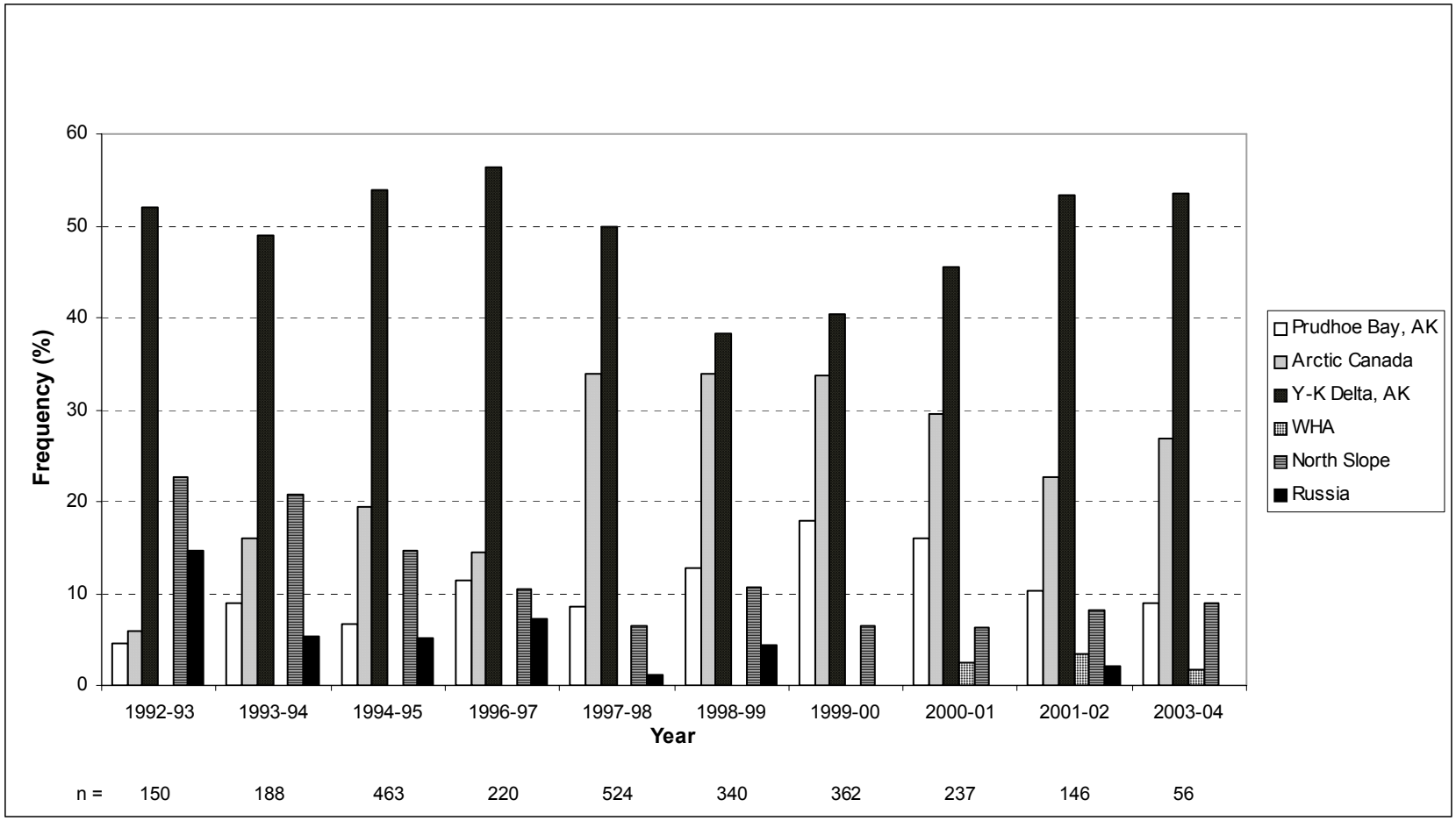

Figure 10. Breeding ground affiliations of Brant using the Fraser River Delta during spring migration. Frequency distribution bars denote the parentage of tarsal bands affixed in different breeding areas. The number of observations (n) made each year are listed below the x-axis. Note that no data were collected in 1995-96, WHA Brant were only banded in 2000 and 2002, and 1992-93 = spring 1993, etc.

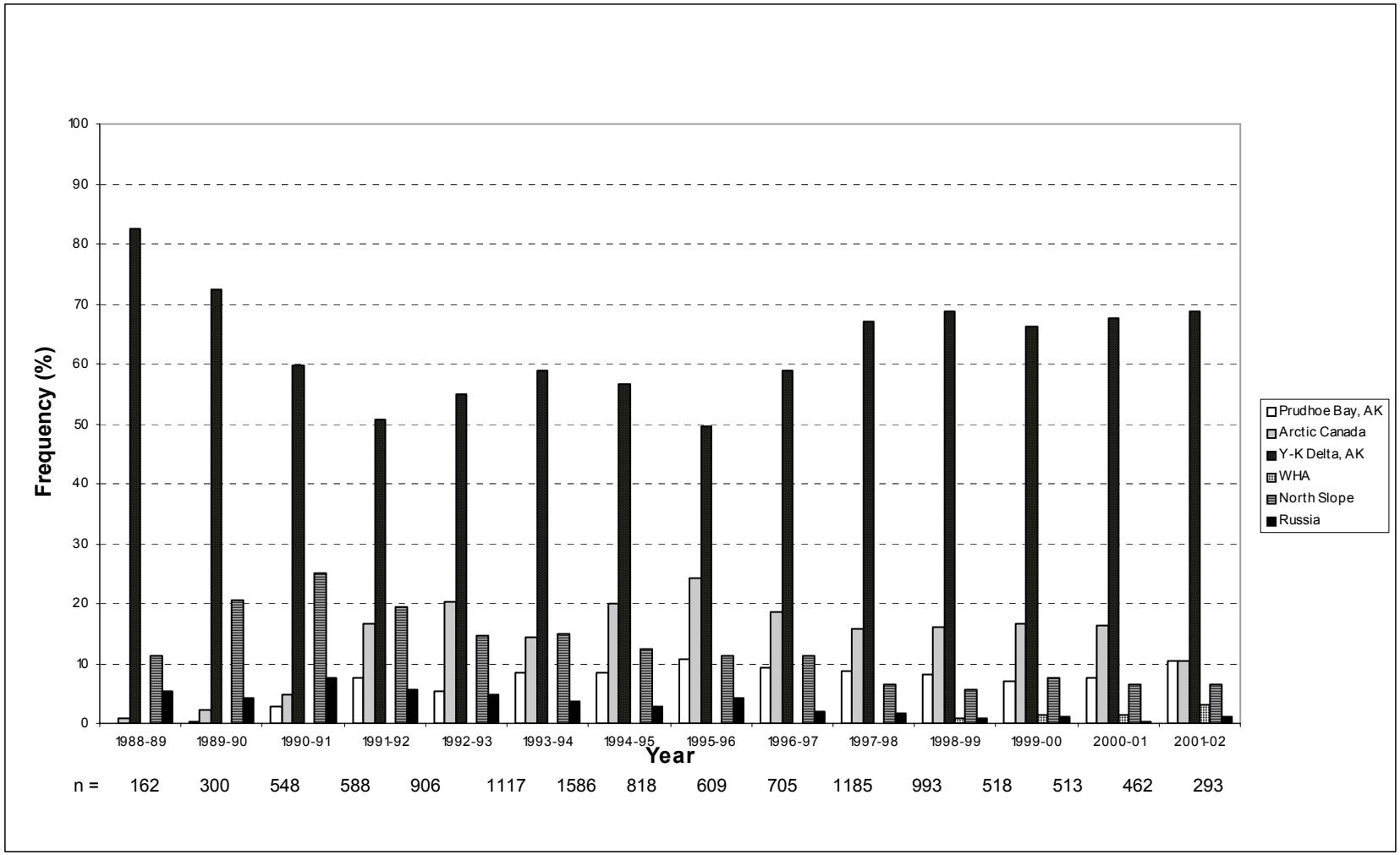

Figure 11. Breeding ground affiliations of Brant using the east coast of Vancouver Island during spring migration. Frequency distribution bars denote the parentage of tarsal bands affixed in different breeding areas. The number of observations (n) made each year are listed below the x-axis. Note that WHA Brant were only banded in 2000 and 2002 and 1988-89 = spring 1989, etc.

2.3.5 Recruitment of Black and WHA Brant on the Fraser River Delta

The proportion of WHA Brant in the FRD wintering population increased from 2-3% in 1994-1995 to over 30% in 2003-04 (Table 8). However, during spring migration, less than 1% of all Brant observed in the Parksville-Qualicum area were WHA birds (Table 8).

Percentages of hatch year Brant in the FRD wintering flock have ranged between 5-21% and 3-40%, respectively, for Black and WHA Brant from 1994-95 to 2003-04. In spring, the proportion of hatch year birds at Parksville-Qualicum has ranged from 3-13% during the period 1999-2000 through 2003-04 (Table 8).

Table 8. Stock composition and age ratios for Black and WHA Brant on the Fraser River Delta (FRD) during winter and in the Parksville-Qualicum (PQ) area during spring migration, 1994-95 through 2003-04.

	FRD (winter)						PQ (spring)					
	All Brant WHA/Total		Black Brant HY/Total		WHA Brant HY/Total		All Brant WHA/Total		Black Brant HY/Total		WHA Brant HY/Total	
Year	%	%			%	SD	%	SD	%	SD	%	SD
1994-95	2.9	2.6	5.3	-	-	-	-	-	-	-	-	-
1995-96	5.2	2.5	21.0	-	-	-	-	-	-	-	-	-
1996-97	-	-	14.8	-	-	-	-	-	-	-	-	-
1997-98	13.4	3.6	7.3	0.7	-	-	-	-	-	-	-	-
1998-99	11.1	2.2	17.2	2.6	-	-	0.3	0.2	5.7	0.4	-	-
1999-00	18.1	1.5	18.3	1.1	28.6	6.7	0.3	0.3	12.5	0.7	-	-
2000-01	15.9	3.1	20.7	0.8	39.6	2.4	0.0	-	6.9	0.3	-	-
2001-02	18.0	2.7	11.5	2.1	12.6	3.6	0.0	-	2.6	0.3	-	-
2002-03	20.8	3.8	4.9	1.3	3.2	1.2	<1.0	-	4.4	0.5	-	-
2003-04	31.9	4.6	12.1	2.4	7.5	4.6	<1.0	-	6.9	0.3	-	-

2.3.6 Identifying Distinct Brant Populations from Tarsal-band Observations

Tarsal-band resight data from 1988-89 and 2003-04 in B.C. are summarized in Table 9. The number of tarsal bands sighted at more than one spring staging location was very low, suggesting that the three main staging areas host largely separate migrating populations (Hagmeier 2002; Table 10). The largest degree of overlap between winter and spring assemblages occurred on the FRD, where the wintering population remains for an extended period during spring migration.

Table 9. Number of alpha-numeric tarsal bands affixed in different breeding areas that were observed in British Columbia according to site and season.

Year	ECVI Spring		QCI Spring		FRD Winter		FRD Spring		Total	
	Unique codes	Total records	Unique codes	Total records	Unique codes	Total records	Unique codes	Total records	Unique codes	Total records
1988-89	162	296	-	0	-	0	-	0	162	296
1989-90	300	951	-	0	-	0	-	0	300	951
1990-91	548	1447	-	0	-	0	-	0	548	1447
1991-92	588	2001	140	209	-	0	-	0	722	2210
1992-93	906	2781	121	386	7	7	173	190	1195	3364
1993-94	1117	3265	139	304	109	223	188	214	1482	4006
1994-95	1586	4203	146	227	80	153	463	651	2162	5234
1995-96	818	1744	-	0	-	0	-	0	818	1744
1996-97	609	1696	-	0	12	13	153	200	765	1909
1997-98	705	1318	-	0	90	161	524	916	1266	2395
1998-99	1185	3633	-	0	76	124	340	547	1556	4304
1999-00	993	3579	-	0	135	257	362	708	1364	4544
2000-01	518	1235	-	0	132	245	237	351	817	1831
2001-02	513	1654	-	0	79	120	146	231	710	2005
2002-03	462	1329	-	0	42	59	-	0	502	1388
2003-04	293	649	-	0	35	40	56	71	369	760

Table 10. Number of alpha-numeric tarsal bands affixed in different breeding areas and observed at more than one location in British Columbia, 1989 through 2004.

Year	ECVI/QCI		ECVI/FRD (winter)		ECVI/FRD (spring)		QCI/FRD (winter)		QCI/FRD (spring)		FRD (winter & spring)	
	Both locations	Total obs	Both locations	Total obs	Both locations	Total obs	Both locations	Total obs	Both locations	Total obs	Both locations	Total obs
1989	-	-	-	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-
1992	6	722	-	-	-	-	-	-	-	-	-	-
1993	4	1023	1	912	3	1073	0	128	0	294	1	179
1994	11	1245	18	1208	30	1275	1	247	0	327	19	278
1995	8	1724	8	1658	57	1992	0	226	1	608	80	463
1996	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	0	621	7	755	-	-	-	-	3	162
1998	-	-	6	789	19	1210	-	-	-	-	29	585
1999	-	-	5	1256	20	1505	-	-	-	-	23	393
2000	-	-	28	1100	45	1310	-	-	-	-	35	462
2001	-	-	8	642	12	743	-	-	-	-	53	316
2002	-	-	4	588	3	656	-	-	-	-	21	204
2003	-	-	2	502	-	-	-	-	-	-	-	-
2004	-	-	5	323	3	346	-	-	-	-	7	91

2.4 DISCUSSION

Black Brant comprise over 80% of B.C.'s wintering Brant population and over 99% of its spring staging population. These birds are associated with all major Brant breeding areas of Alaska, Canada and Russia. WHA Brant, which breed on Prince Patrick, Eglington and Melville islands in the far north, are much rarer and they occur primarily on the FRD in B.C. and adjacent areas in Washington (i.e., Padilla and Samish Bays).

During the mid-winter period (mid December - late January) the population of Brant on the FRD is largely closed (Reed 1997) and ground counts have been used to develop population indices. Peak abundance, which corresponds to the minimum number of wintering birds present, is a useful index, but it can be misleading due to unknown numbers of missed birds or individuals that are counted more than once. Mean abundance also is useful, but is subject to the same counting errors. Nevertheless, the two indices are highly correlated and demonstrate that the FRD population has increased substantially since 1993-94. The population also has expanded into Semiahmoo Bay, an area that had not been used by Brant since prior to 1980 (CWS *unpubl. data*).

Between 1993-94 and 1999-2000, both the peak and mean abundance counts increased on the FRD, with an annual rate of increase exceeding 20% (Hagmeier 2002). Fitting a quadratic model to the peak abundance data up to and including 2003-04 suggests that the overall rate of increase has remained high. However, when mean abundance is modeled in the same way, the population appears to have levelled off, although the current population is still much smaller than historic numbers (estimated at ca. 10,000 birds).

The mean annual recruitment rate of 13% (range = 5-21%) cannot account for the 20%+ growth rate in the wintering FRD Brant population between 1994-95 and 2003-04. Rather, both annual productivity and immigration of WHA Brant have contributed to this local population increase (Hagmeier 2002).

Monitoring abundance is helpful for tracking the timing of migration and the distribution of Brant at traditional areas like PQ. However, unlike the closed FRD winter population, spring-staging birds are continually arriving and departing and counts alone are insufficient for calculating the total number of birds passing through the area. Goose-days and goose-volumes should result in more accurate assessments. We estimated goose-days from both ground and aerial counts, where data were sufficient. While estimates derived from the ground counts suggest that the number of Brant staging in the Parksville-Qualicum area has remained relatively constant from 1989 to 2004, goose-days have declined considerably over the last 6 years (1999 to 2004). The latter may simply be due to short-term, natural variation in Brant population dynamics. However, goose-days estimated from the few available aerial counts conducted between 1990 and 2004 throughout the SoG suggest that the number of staging Brant has declined. These results argue for more thorough monitoring of staging areas in the Strait in addition to developing a more powerful index for detecting trends.

A more powerful index describing Brant use of the SoG is the total volume of birds moving through the area. Such an index was generated using abundance and tarsal band data (Frederiksen *et al.* 2001, Hagmeier 2002) and results were found to be comparable to estimates made in other studies. For example, Nygren (*unpubl. report*) used mean length of stay to calculate goose volume and estimated that approximately 12,000 and 14,000 Brant staged in the Parksville-Qualicum area during the springs of 1990 and 1991, respectively. Our volume estimates suggest that between 13-27% of the entire Pacific Flyway Brant population staged on the Fraser River Delta and Parksville-Qualicum in 1999 and 2000. The volume estimates have wide confidence intervals. More precise estimates can be obtained by running the model with the entire 15-year data set and exclusion of smaller staging areas, such as Denman Island, Sidney Spit and Texada Island. By including areas that host only small spring staging populations considerable estimation error is added to the model.

Tarsal-band observations also were useful to assess population structure. Analyses of tarsal band observations indicate that Brant wintering or staging in the FRD and ECVI originate from all major breeding areas, and that there is little interchange between wintering and spring staging areas from one year to the next.

3 SPORT HARVEST

3.1 INTRODUCTION

The Pacific Flyway Brant Population has declined from the 1960s to the present (see Figure 3, Sedinger *et al.* 1994). Wintering populations were virtually wiped out throughout British Columbia, with the exception of the Queen Charlotte Islands (Campbell *et al.* 1990). Over-harvest was implicated as one potential cause and this resulted in hunting restrictions being implemented throughout the Pacific Flyway. Currently, Brant hunting in B.C. occurs only on the Fraser River Delta (FRD) from 1-10 March. The duration of this hunt was limited to a 10-day interval and timed to occur in late-winter to protect the small over-wintering population that resides in the Boundary Bay-Roberts Bank area. By reducing the duration and switching the timing of the hunt it was hoped that migrant individuals would be targeted rather than residents (see Chapter 2 for more information on migration chronology).

Of the estimated 120,000 Brant in the Pacific Flyway (Chapter 2), approximately 5,000 are taken by sport hunters each year (Pacific Flyway Council 2002). An additional 5,000-7,000 Brant are harvested by First Nations groups in Alaska (Sedinger *et al.* 1994). In this section we summarize current and historic harvest data for Black and WHA Brant, with an emphasis on how changes in hunting regulations in B.C. have affected the winter resident population on the FRD, as well as the Pacific Flyway Brant population as a whole.

3.2 METHODS

Pacific Flyway harvest data were obtained from the 2002 Pacific Flyway Council data report (U.S. Fish and Wildlife Service). B.C. harvest data were obtained from unpublished reports (Hagmeier 2002, Breault 2004) and from data collected by the Canadian Wildlife Service and the B.C. Ministry of Water, Land and Air Protection (formerly B.C. Ministry of Environment, Lands and Parks).

To determine the impact of the B.C. hunt on the Pacific Flyway Brant population, tarsal-band data collected in the FRD were compared to data collected elsewhere in the Flyway from 1998-2000. Composition profiles, based on wintering ground affiliations, were then constructed using 10 day intervals before, during and after the FRD hunt to determine which wintering populations were most affected. Winter residency determinations were made on the basis of observations conducted between November and January each year. Because Brant movements are extremely limited during winter, a single tarsal band observation during this November-January period was considered sufficient to define individuals as being residents of B.C., Washington, Oregon, California, or Mexico.

3.3 RESULTS

3.3.1 Sport Harvest of Brant in British Columbia

In the early 1950's, thousands of Brant were harvested on Vancouver Island and on the FRD annually (Table 11). However, this sport harvest was greatly reduced in the 1960's and 1970's and in 1979 the Vancouver Island hunt was closed entirely (Table 11). The only remaining hunt in the province is the aforementioned spring hunt on the FRD.

On the FRD, the number of Brant harvested ranged from 88-260 birds during the period 1995-2004 (Table 11). The WHA portion of the FRD harvest is very low (only 3 birds in 2004, 4 birds in 2003, and 18 birds in 2002; Breault, *unpubl. data*). Raw data for the B.C. Brant harvest from 1950 to the present are presented in Appendix 6.

3.3.2 Sport Harvest of Brant in the Pacific Flyway

Prior to the 1990's, 6-16% of the Pacific Flyway Brant population was harvested annually (Pacific Flyway Council 1978). This proportion decreased to between 2-5% of the population in the early 1990's (Pacific Flyway Council 2002). Over the last 10 years, the sport harvest of Brant (Black and WHA combined) has ranged from 2,100 to 4,700 birds annually (Table 12). Sport hunting takes place in all of the U.S. Pacific coastal states, but the vast majority of the harvest occurs in Mexico (Table 12). Over the last 10 years, the B.C. sport harvest has accounted for 2-6% of the total Pacific Flyway harvest (Table 12).

The harvest of WHA Brant in Washington State has declined substantially since the 1970's, largely in response to restrictive regulations implemented in the 1970's and 1980's (Pacific Flyway Council 2002). Between 1991 and 2000, the number of WHA harvested annually in Washington fluctuated between zero, when the season was closed in 2001-2002, to, 1,347 birds in 1994-1995 (Table 12). The B.C. harvest of WHA birds is quite low, amounting to <1% of the total WHA harvest (CWS *unpubl. data*; Table 12).

Table 11. Sport harvest estimates for Vancouver Island and the Fraser River Delta (MELP *unpubl. data*, CWS *unpubl data* and Reed 1997). Harvest data were not available for the Queen Charlotte Islands, where hunting was allowed until 1985-86. Dashes indicate no data.

	Harvest Estimates	
Year (Spring)	Vancouver Island	Fraser River Delta
1950	3360	2500
1951	5800	3700
1952	1488	1400
1953	832	1800
1954	500	600
1955	1100 combined	
1956	1350	677
1957	1000	-
1958	500	-
1959	-	-
1960	-	150
1961	-	390
1962	-	150
1963	-	350
1964	-	500
1965	1233	500
1966	516	460
1967	1053	855
1968	772	460
1969	191	235
1970	575	397
1971	-	221
1972	-	294
1973	-	469
1974	-	335
1975	-	141
1976	-	400
1977	-	-
1978	-	250
1979	Closed	125
1980	Closed	450
1981	Closed	390
1982	Closed	255
1983	Closed	335
1984	Closed	275
1985	Closed	208
1986	Closed	559
1987	Closed	281
1988	Closed	358
1989	Closed	162
1990	Closed	224
1991	Closed	300
1992	Closed	250
1993	Closed	115
1994	Closed	220
1995	Closed	210
1996	Closed	260
1997	Closed	150-200
1998	Closed	150-200
1999	Closed	150-200
2000	Closed	150-160
2001	Closed	156
2002	Closed	101
2003	Closed	88
2004	Closed	90-100

Table 12. Sport harvest estimates in the Pacific Flyway from 1991-92 to 2000-01. GB denotes Brant harvested from areas traditionally considered as Grey-bellied Brant wintering areas in Washington, asterisk denotes instances when data were not available (Pacific Flyway Council 2002, CWS *unpubl data*, MELP *unpubl data*).

		1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	99-2000	2000-01
BC	**FRD**	250	115	220	210	260	~175	~175	~175	160	156
WA	**GB**	790	950	1347	825	918	1493	597	570	581	0
	Other	55	27	60	23	44	41	59	18	86	108
	Total	845	977	1407	848	962	1534	656	588	667	108
OR		98	97	86	197	106	55	34	0	5	29
CA		343	750	550	680	500	500	430	500	750	450
MX		867	1611	1300	1500	*	1192	1361	1277	1710	990
AK		*	392	309	550	494	369	504	*	1400	400
Flyway Total		*	3942	3872	3985	*	3825	3160	*	4692	2133

3.3.3 Impact of the 10-day Fraser River Delta Hunt on the Wintering Population

Composition profiles derived from tarsal-band observations before, during, and after the FRD spring hunt indicate that most migrating Brant had arrived in the area prior to the hunting season in 1998. However, this was not the case in 1999 and 2000, when 50-77% of the Brant observed during the hunt were winter residents. This percentage decreased to 35-67% of the total population during the 10-day period after the hunt (Table 13). Our data suggest that a majority of the ca. 150-200 Brant shot each year on the FRD are resident birds (Table 14). Further details on these calculations are presented in Appendix 7.

Table 13. Flock composition of Brant on the Fraser River Delta by location of winter residency before, during, and after the 1-10 March sport hunt.

Interval	Winter residency	1998		1999		2000		3-Year Mean
		#	%	#	%	#	%	%
Before	MX	11	36.7	1	12.5	1	3.1	17.4
	CA	4	13.3	0	0.0	0	0.0	4.4
	OR	0	0.0	0	0.0	0	0.0	0.0
	WA	0	0.0	0	0.0	0	0.0	0.0
	BC	15	50.0	7	87.5	31	96.9	78.1
	Total	30	100.0	8	100.0	32	100.0	100.0
During	MX	11	42.3	3	23.1	2	10.5	25.3
	CA	2	7.7	0	0.0	0	0.0	2.6
	OR	0	0.0	0	0.0	0	0.0	0.0
	WA	0	0.0	0	0.0	3	15.8	5.3
	BC	13	50.0	10	76.9	14	73.7	66.9
	Total	26	100.0	13	100.0	19	100.0	100.0
After	MX	25	58.1	2	33.3	20	48.8	46.8
	CA	3	7.0	0	0.0	3	7.3	4.8
	OR	0	0.0	0	0.0	0	0.0	0.0
	WA	0	0.0	0	0.0	1	2.4	0.8
	BC	15	34.9	4	66.7	17	41.5	47.7
	Total	43	100.0	6	100.0	41	100.0	100.0

Table 14. Estimated number of Brant harvested during the 1-10 March hunt on the Fraser River Delta (FRD) according to location of winter residency.

Total number of tarsal bands observed before and during the FRD hunt						
	MX	CA	OR	WA	BC	Total
1998	22	6	0	0	28	56
1999	4	0	0	0	17	21
2000	3	0	0	3	45	51
Total	29	6	0	3	90	128
Proportion Vulnerable (%)[1]	22.7	4.7	0.0	2.3	70.3	100
Estimated number shot	34-45	7-9	0	3-5	105-140	150-200

[1] Proportion of local resident population vulnerable to hunting

3.4 Discussion

The number of Brant harvested on the FRD accounts for less than 5% of the entire Pacific Flyway sport harvest. Hence, the FRD spring hunt has had a negligible impact on the population dynamics of the Pacific Flyway Black and WHA Brant. Given that the FRD winter population has increased in recent years, the late-winter Brant hunt appears to be sustainable. Continued monitoring of this harvest is needed, however, to ensure the long-term conservation and management of the population.

4 DISTURBANCE

4.1 Introduction

To meet the high energetic demands associated with egg-laying and brood-rearing, Brant accumulate endogenous (fat and protein) reserves prior to their arrival on the breeding grounds. Several studies have described the link between body condition, winter and spring staging areas and reproductive success in Arctic-nesting geese (e.g. Madsen 1994, Rowe *et al.* 1994, Bety *et al.* 2003, Prop *et al.* 2003). Repeated interruptions due to disturbance can negatively affect body condition and reduce individual fitness (Madsen 1985, Bélanger and Bédard 1989).

Brant diet consists primarily of eelgrass in winter (*Zostera spp*.; Cottam *et al.* 1944, Einarsen 1965, Charman 1977) and eelgrass, algae and Pacific Herring (*Clupea pallasi*) spawn in spring. Reliance on these food sources means that Brant must forage near shore, in intertidal areas where disturbance can play an important role in time allocation decisions and energetics. Disturbance is defined as any event that inhibits the ability of an individual to obtain essential resources (White and Pickett 1985), and can include both natural and human-related sources. In this chapter we discuss the effects of disturbance on the foraging behaviour of Brant during the spring staging period on the east coast of Vancouver Island and on the Fraser River Delta (FRD).

4.2 Methods

The amount of disturbance experienced by Brant was measured on several wintering and spring staging areas. Data were collected in the Parksville-Qualicum area in 1996-1999 and 2001-2003 (Martin, *unpubl. report*), on Sidney and Stubbs Islands during spring 1996 (CWS *unpubl. data*), on the Queen Charlotte Islands in 1991 (Vermeer *et al.* 1991) and 1992 (Goudie and Hearne 1997), and on the FRD in 1997 (Gowans *unpubl. report*), 1998, and 2000 (Hagmeier 2002). Disturbance events were classified according to whether or not they elicited avoidance flights by Brant. Our classification scheme should be considered a conservative one, as events that caused only alert, walking, or swimming behaviours were excluded. The source of each disturbance was assigned to one of three categories: human-related, natural, or unknown. Human-related disturbances included cases where Brant took flight in response to the approach of a pedestrian, dog, aircraft, or boat. Natural disturbances were caused primarily by Bald Eagles (*Haliaeetus leucocephalus*) and other raptors.

Disturbance was quantified by calculating the number of disturbance events per hour. Although human activities are often correlated with factors such as time of day, weekend vs. weekday, weather conditions, etc. we present results only for raw (unadjusted) data.

4.3 Results

Disturbance rates at the four spring staging sites we investigated ranged from 0.9-3.4 disturbances per hour (n=9). At the wintering sites, disturbance rates ranged from 1.3-3.2 disturbances per hour (n=4; Table 15). The lowest rate of disturbance recorded was in the Queen Charlotte Islands whereas the highest was in Parksville-Qualicum (Table 15).

In the Parksville-Qualicum area, natural causes were responsible for 47.9% of all disturbance events. The remainder was apportioned in nearly equal amounts to human and unknown causes (26.7% and 25.4%, respectively; Table 16). There was no significant difference in the overall rate of disturbance ($r^2 = 0.33$, $F = 1.98$, $p = 0.23$), human disturbance ($r^2 = 0.06$, $F = 0.31$, $p = 0.60$), or Bald Eagle disturbance ($r^2 = 0.05$, $F = 0.28$, $p = 0.63$) among years.

Table 15. Disturbance rate (avoidance flights per hour) for Brant in British Columbia. (QCI = Queen Charlotte Islands, PQ = Parksville-Qualicum, ST = Stubbs Island, SI = Sidney Island, BB = Boundary Bay on the Fraser River Delta, RB = Roberts Bank on the Fraser River Delta).

	1991	1996	1997	1998	1999	2000	2001	2002	2003
QCI (spring)	0.9								
PQ (spring)		3.4		2.7	2.4		3.1	2.0	2.6
ST (spring)		2.3							
SI (spring)		1.2							
BB (winter)			3.2	2.1		2.1			
RB (winter)						1.3			

Table 16. Causes of disturbance to spring-staging Brant in Parksville-Qualicum, Vancouver Island, 1996-2003. Data were not collected in 2000.

	1996		1997		1998		1999		2001		2002		2003		Mean	
	n=615		n=145		n=134		n=232		n=214		n=289		n=330		n=7	
Cause	**%**	**SE**	**%**	**SE**	**%**	**SE**	**%**	**SE**	**%**	**SE**	**%**	**SE**	**%**	**SE**	**%**	**SE**
Pedestrians	31.2	1.9	10.3	2.5	14.9	3.1	13.8	2.3	22.4	2.9	14.2	2.1	12.4	1.8	17.0	2.8
Dogs	8.1	1.1	6.2	2.0	2.2	1.3	3.9	1.3	8.4	1.9	10.0	1.8	8.8	1.6	6.8	1.1
Observer	0.0	0.0	1.4	1.0	1.5	1.0	1.7	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.3
Aircraft	3.3	0.7	1.4	1.0	1.5	1.0	0.9	0.6	0.0	0.0	2.4	0.9	2.1	0.8	1.6	0.4
Boat	0.0	0.0	1.4	1.0	0.7	0.7	0.0	0.0	0.0	0.0	0.7	0.5	0.0	0.0	0.4	0.2
Other human-related	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.5	0.0	0.0	0.1	0.1
Total human-related	42.6	2.0	20.7	3.4	20.9	3.5	20.3	2.6	30.8	3.2	28.0	2.6	23.3	2.3	26.7	3.1
Bald Eagle	31.9	1.9	53.8	4.1	52.2	4.3	34.9	3.1	41.6	3.4	43.6	2.9	51.2	2.8	44.2	3.3
Other natural	7.0	1.0	4.1	1.7	1.5	1.0	6.9	1.7	2.3	1.0	3.1	1.0	1.2	0.6	3.7	0.9
Total Natural	38.9	2.0	57.9	4.1	53.7	4.3	41.8	3.2	43.9	3.4	46.7	2.9	52.4	2.7	47.9	2.6
Unknown	18.5	1.6	21.4	3.4	25.4	3.8	37.9	3.2	25.2	3.0	25.3	2.6	24.2	2.4	25.4	2.3

In the Queen Charlotte Islands, natural causes were responsible for 77% of all disturbances in 1991 and 59% in 1992. Human causes accounted for the remaining 22.7% and 40.8%, respectively (Table 17). Bald Eagles were the most common source of disturbance for Brant on the Queen Charlottes, accounting for 75% and 51% of all disturbances in 1991 and 1992, respectively (Table 17).

On Sidney and Stubbs Islands a high proportion of disturbance events were from unknown causes (56% and 49%, respectively; Table 17). Human activity (mostly boat and aircraft) was the primary known cause of disturbance, accounting for 24% and 26% of all disturbance events for Sidney and Stubbs Islands, respectively. Natural-caused disturbance (primarily from Bald Eagle) accounted for 20% of all disturbances on Sidney Island and 25% of disturbances on Stubbs Island; Table 17).

In Boundary Bay, natural causes (primarily Bald Eagles) were responsible for 61-79% of disturbances in 1996-1998 (Table 17). Human-related causes accounted for 8-13% of disturbances) while 8-30% came from unknown sources (Table 17).

Most cases of disturbance observed on Roberts Banks in 2000 were from unknown causes (62%) while natural causes (primarily Bald Eagles) were the most important known cause of disturbance (27%; Table 17).

Table 17. Causes of disturbance to spring-staging Brant on the Queen Charlotte Islands (QCI), Sidney Island (SI) and Stubbs Island (ST) and to wintering Brant in Boundary Bay (BB) and Roberts Bank (RB) on the Fraser River Delta.

	QCI 1991 n=150		QCI 1992 n=49		SI 1996 n=267		ST 1996 n=282		BB 1997 n=325		BB 1998 n=91		BB2000 n=106		RB 2000 n=37	
Cause	**%**	**SE**	**%**	**SE**	**%**	**SE**	**%**	**SE**	**%**	**SE**	**%**	**SE**	**%**	**SE**	**%**	**SE**
Pedestrians	6.7	2.0	18.4	5.5	5.6	1.4	0.0	0.0	7.4	1.5	12.1	3.4	3.8	1.9	8.1	4.5
Dogs	4.0	1.6	2.0	2.0	0.7	0.5	0.0	0.0	0.3	0.3	1.1	1.1	1.9	1.3	0.0	0.0
Observer	0.0	0.0	4.1	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aircraft	10.7	2.5	4.1	2.8	6.4	1.5	13.5	1.4	3.7	1.0	0.0	0.0	0.9	0.9	0.0	0.0
Boat	0.7	0.7	0.0	0.0	9.4	1.8	12.8	1.3	0.0	0.0	0.0	0.0	0.9	0.9	2.7	2.7
Other human-related	0.7	0.7	12.2	4.7	1.9	0.8	0.4	0.2	0.3	0.3	0.0	0.0	0.9	0.9	0.0	0.0
Total human-related	22.7	3.4	40.8	7.0	24.0	2.6	26.6	1.8	11.7	1.8	13.2	3.5	8.5	2.7	10.8	5.1
Bald Eagle	75.3	3.5	51.0	7.1	18.0	2.4	20.9	1.6	68.8	2.6	71.4	4.7	59.4	4.8	27.0	7.3
Other natural	2.0	1.1	8.2	3.9	1.9	0.8	3.5	0.7	11.1	1.7	5.5	2.4	1.9	1.3	0.0	0.0
Total Natural	77.3	3.4	59.2	7.0	19.9	2.4	24.5	1.7	79.9	2.2	76.9	4.4	61.3	4.7	27.0	7.3
Unknown	0.0	0.0	0.0	0.0	56.2	3.0	48.9	2.0	8.3	1.5	9.9	3.1	30.2	4.5	62.2	8.0

4.4 Discussion

Brant experienced high levels of disturbance on most winter and spring staging habitats in B.C. The levels of disturbance observed in B.C. were among the highest observed for Brant anywhere in the world (Table 18).

Table 18. Disturbance rates to wintering and staging Brant.

Study	Season	Location	Rate of Disturbance (/hr)
Owens (1977)	Winter	Essex, UK	0.74
Stock (1993)	Spring	Wadden Sea, NL	2.19
Ward *et al.* (1994)	Spring	Izembek Lagoon, Alaska, USA	0.74
Riddington *et al.* (1996)	Winter	Norfolk, UK	0.83
This study	Winter	Fraser Delta, B.C	Range = 1.3 - 3.2
This study	Spring	Coastal B.C	Range = 0.9 – 3.4

The majority of the disturbances documented in this study were caused by Bald Eagles. Current data suggest that the wintering eagle population in B.C. has increased dramatically in recent years (Environment Canada 1998). B.C. has the highest winter abundance of Bald Eagles in North America, with the Georgia Basin alone supporting ca. 30,000 birds in the early 1990's (Blood and Anweiler 1994). Despite this large and increasing eagle population, disturbance rates to Brant in the Parksville-Qualicum area, while high, show no clear pattern of increase from 1996 to 2003. Further examination of eagle population dynamics might clarify the links between current and projected abundance and distribution in coastal areas and associated levels of disturbance on foraging Brant.

Although the human population in the Parksville-Qualicum area increased dramatically (approximately doubling in numbers between 1989 and 2004), we did not detect an increase in human-related disturbance to Brant between 1996 and 2003. One possible explanation for this is that the disturbance rates reported are underestimates. In most years, disturbance data were collected in conjunction with tarsal-band observations and counts. On occasion, observers prevented pedestrians from approaching birds so that the tarsal-band reading sessions were not jeopardized (Terri Martin *pers. comm*.). Furthermore, dog access restrictions, beginning in 2003 and enforced by conservation officers, led to a reduction of people and dogs at selected Parksville-Qualicum beaches (Terri Martin *pers. comm.*).

The impact of disturbance also can be evaluated from a metabolic perspective. When Brant are disturbed, not only do they forego a foraging opportunity, they also increase energy expenditure when forced to take flight. The energetic cost of flight has been estimated at 8-15 times Basal Metabolic Rate (BMR) (Hart and Berger 1972, Drent *et al.* 1978, Gauthier *et al.* 1984, Bélanger and Bédard 1990, and Riddington *et al.* 1996). This contrasts with much lower costs for activities such as resting (1.1 x BMR), foraging (1.7 x BMR), preening (2.3 x BMR) and socializing (6.4 x BMR) (Owen *et al.* 1992, Wooley and Owen 1978, Gauthier *et al.* 1984, Bélanger and Bédard 1990, Mooij 1992 and Riddington *et al.* 1996). Short flights tend to be more energy-demanding than long flights (Utter and Lefebvre 1970, Butler *et al.* 1977), and as a consequence, disturbance-related flights are considered 15 x BMR (Gauthier *et al.* 1984, Bélanger and Bédard 1990, and Riddington *et al.* 1996). On the Fraser River Delta, almost half (44.9% SE = 10.5%) of the estimated daily energy expenditure of Brant was used in responding to disturbance, even though this accounted for only 10.7% (SE = 2.5%) of the time-activity budget (Hagmeier 2002). Hence, relatively small amounts of disturbance can translate into substantial energy losses.

From a management perspective, high levels of disturbance in spring could have important implications for the long-term health of the Pacific Flyway Brant population. If staging areas in the SoG are indeed important for building nutrient reserves needed to fuel migration and for successful reproduction and if there is insufficient time and/or resources to make up for the energy lost in responding to disturbances, then the body condition of some individuals could be compromised. This could eventually lead to negative population level effects. Both human and eagle-caused disturbances should be

assessed on a regular basis to ensure that they do not result in significant changes in Brant behaviour, distribution, or abundance patterns (see Bélanger and Bédard 1989, Sedinger *et al.* 1994 for examples of this in other Arctic-nesting geese). Quantifying the effect of disturbance on Brant body condition will be especially important in this respect.

5 BODY CONDITION

5.1 INTRODUCTION

The ability to access food resources and store fat prior to breeding is critical to Arctic-nesting geese like Brant. Fat reserves are used to fuel migration and they also influence the timing of reproduction, clutch size, and incubation success (Rowe *et al.* 1994, Bety *et al.* 2003, Prop *et al.* 2003). The Parksville-Qualicum area and the Fraser River Delta (FRD) are used each spring by up to 25% of the total Pacific Flyway Brant population (Hagmeier 2002). This section presents data on spring body condition of Brant using these areas during the period 1999-2004.

5.2 METHODS

Brant body condition was assessed using an abdominal profile index (API) (see Owen 1981, Brown 1996, Therkildsen and Madsen 2000, Madsen *et al.* 2001, Prop *et al.* 2003). APIs were scored only for Brant marked with alpha-numeric tarsal bands, with individuals rated as either: 1) straight, 2) convex, 3) rounded or 4) sagging (Figure 12). Intermediate scores also were possible (i.e. 1.5, 2.5, 3.5) (see Owen 1981 for more details). APIs were scored only for birds that were out of the water and not extremely alert or in a head-down feeding position. All API data were collected using a 20-60x spotting scope, with feeding flocks generally within 150 m of observers. Scoring bias was assessed by comparing APIs recorded independently and simultaneously by different observers on the same marked birds. Mean API values were calculated each week beginning the third week in February, when early spring migrants begin to arrive in B.C.

5.3 RESULTS

Scoring bias was deemed to be negligible. Only 6% (4 of 70) of the API scores recorded simultaneously by observers differed and these varied by only up to 1 index point.

The API data suggests that body condition gradually increased over the course of spring migration in both the Parksville-Qualicum area (Figure 13) and on the FRD (Figure 14). Inter-annual variation in weekly mean API scores was apparent suggesting that Brant were more successful in building fat reserves in some years than in others. For example, Brant were in better body condition (i.e., accumulated more fat and at a higher rate) in the years 1999 and 2000 compared to the remaining years 2001-2004.

Figure 15 presents typical API data for a sample of marked Brant in the Parksville-Qualicum area in spring 2000. The figure, which shows that lean birds continue to arrive as fatter birds depart, suggests that some important trends in the API data might be masked by analysing on the basis of weekly means.

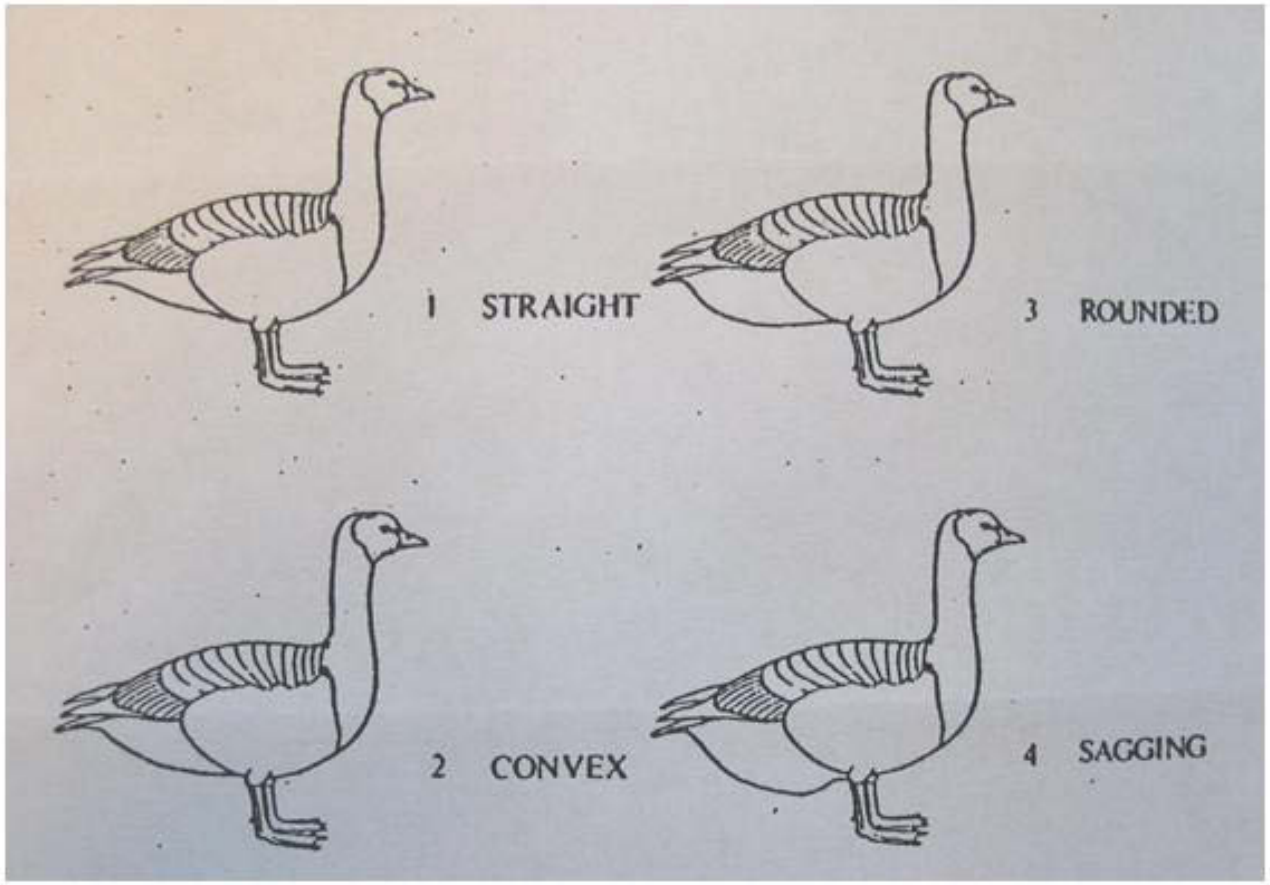

Figure 12. Abdominal profile index categories (1-4).

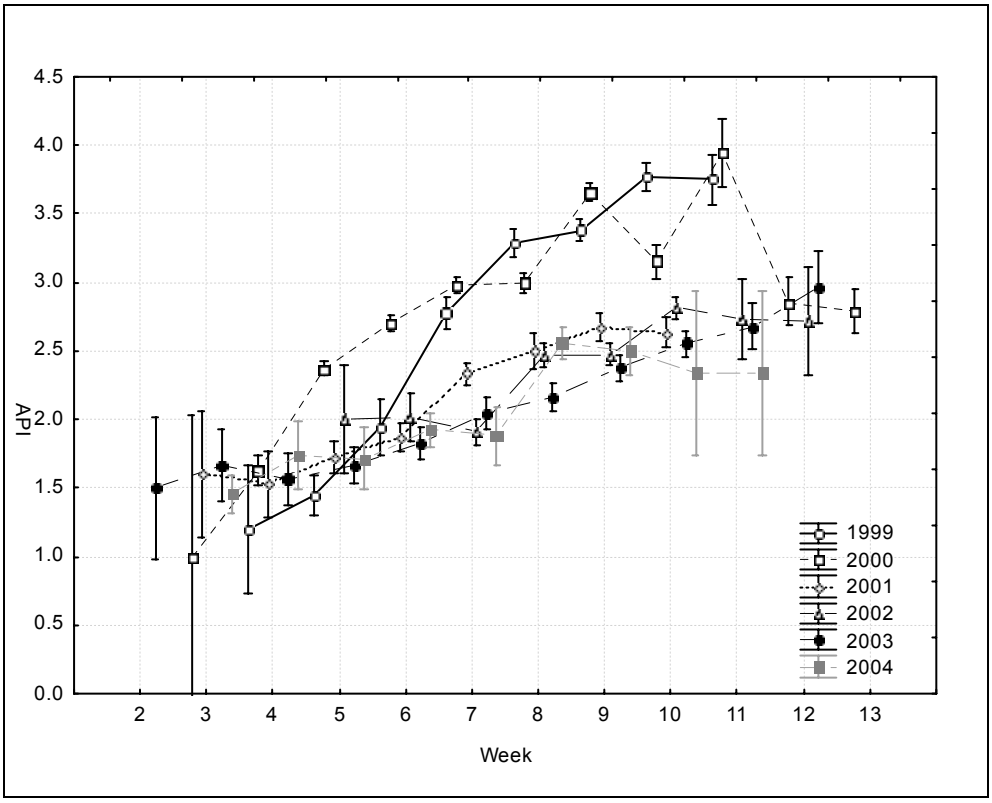

Figure 13. Mean abdominal profile index scores for Brant in the Parksville-Qualicum area during springs 1999-2004 (see Appendix 8 for source data).

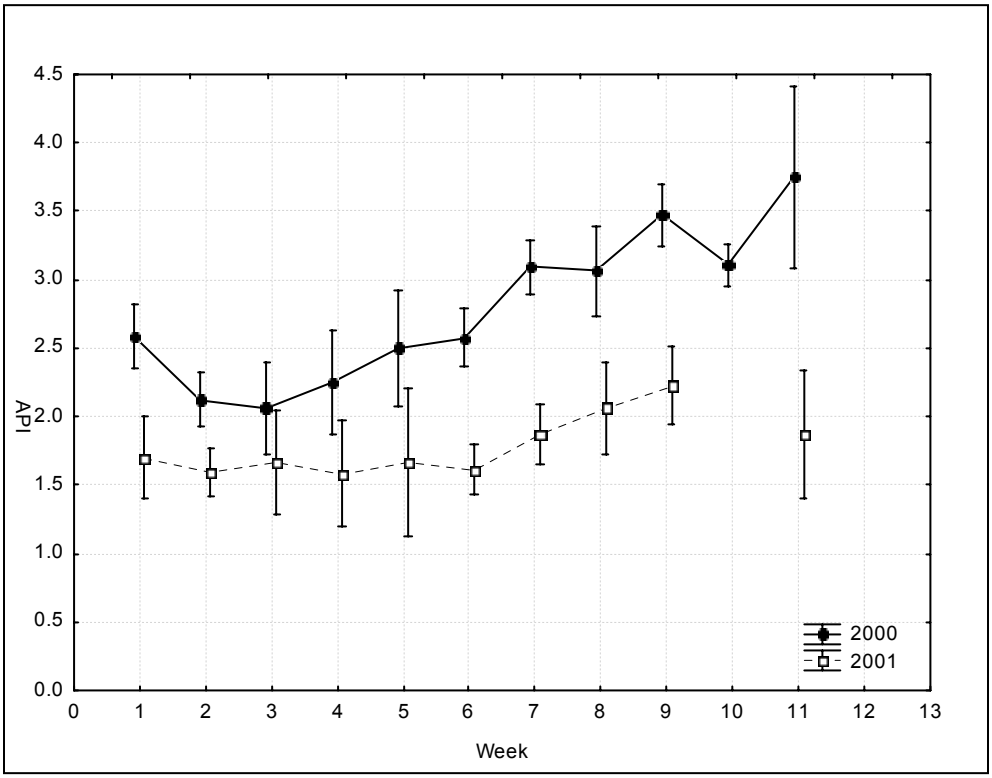

Figure 14. Mean abdominal profile index scores for Brant on the Fraser River Delta during springs 2000-2001 (see Appendix 9 for source data).

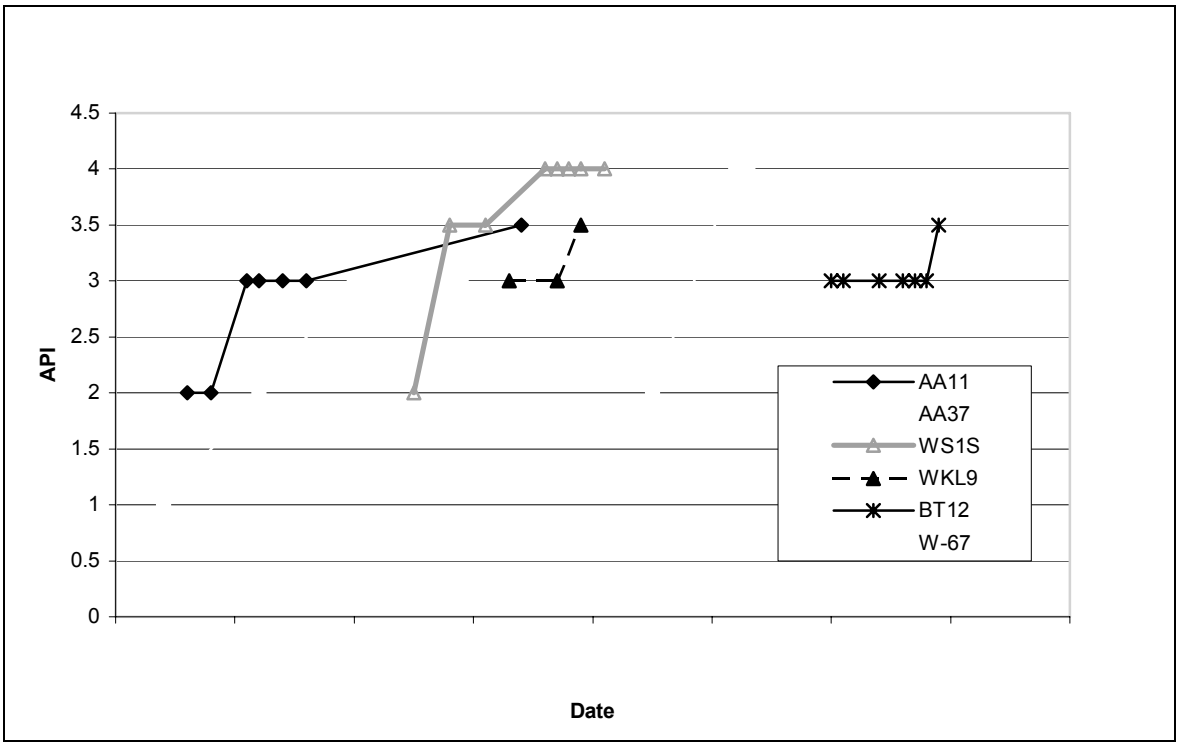

Figure 15. Abdominal profile index scores for individually marked Brant in the Parksville-Qualicum area during spring 2000.

5.4 Discussion

According to API scores, the body condition of Brant staging in the SoG in spring was elevated in 1999 and 2000 compared to that in the subsequent four years. Reasons for these annual differences are unknown, but likely relate to winter weather conditions, disturbance at staging sites, and/or to annual changes in the food supply on wintering or spring staging sites.

In both areas and in all years, weekly API scores showed a pattern of gradual increase. However, as noted above, averaging API scores on a weekly basis may have masked some patterns in the data. An in-depth analysis of individual API scores (or rates of change in these scores; see Figure 15) would help elucidate these patterns.

API data may help identify the food resources that are most important to migrating Brant. For example, each spring Pacific Herring spawn in the Strait of Georgia and one of the largest, most traditional sites is on the east coast of Vancouver Island near Parksville and Qualicum. The roe that is deposited in eelgrass and algal beds and collects along the shoreline is a valuable source of lipid and protein for migrating sea ducks and other marine birds (Haegele 1993, Vermeer *et al.* 1997). Brant are known to forage intensively on the eggs when present, and it has been suggested that herring

spawn is an important food. However, preliminary examination of historic spawn data suggests the relationship between spawn volume and mean API score is weak to non-existent (see Appendix 10). This suspected relationship is undermined even further by the fact that FRD API scores, where herring have not spawned for decades, were similar to those observed in the Parksville-Qualicum area (see Appendix 10). Clearly, this relationship needs to be studied in more detail.

6 RECOMMENDED MONITORING AND RESEARCH ACTIVITIES

This section outlines monitoring and research activities needed to further our understanding of Brant ecology in B.C. and to generate information needed to manage Brant populations into the future. Existing monitoring programs should be maintained and specific (applied) research studies implemented to ensure that current abundance/distribution patterns of wintering and staging Brant populations are maintained or enhanced under changing levels of harvest, disturbance and food resources and habitat declines that generally accompany expanding human populations.

6.1 Abundance and Distribution Patterns

The following basic activities are designed to monitor the abundance and distribution patterns of both the wintering and spring staging Brant populations:

- Continue regular ground counts on the FRD (December and January), and in the Parksville-Qualicum area (February to April) (annually).

- In conjunction with the ground counts, record tarsal bands on the FRD and especially in the Parksville-Qualicum area (annually if funding available).

- Implement a monitoring program for wintering and staging Brant in the Queen Charlotte Islands; conduct ground counts and record tarsal bands (periodically).

6.2 Brant Harvest

The following activities are needed to assess the impact of the 10-day hunt on the Pacific Flyway Brant population as a whole, and the FRD winter resident population in particular:

- Monitor the number of WHA and Black Brant harvested on the FRD through hunter checks (periodically).

- Monitor tarsal bands and the abundance of Brant on the FRD before, during and after the March hunt; analyse the data to determine the impact of harvest on the FRD resident population and other wintering groups (periodically).

6.3 Disturbance

The following activities are designed to assess the impacts of disturbance on Brant:

- Assess Brant time-activity budgets, as well as rates and causes of disturbance, on the FRD in winter and spring and in the Parksville-Qualicum area during spring migration (initiate research study within the next 1-2 years).

- Assess: 1) the abundance, distribution and behaviour of Bald Eagles during the winter and spring on the FRD and during spring in the Parksville-Qualicum area and 2) their effect on Brant time-activity budgets and energetics (integrate with above study).

6.4 Body Condition

The following activities are designed to understand the relationship between Brant body condition in spring and survival/reproductive success (all to be integrated with the above study):

- Together with ground counts and tarsal band recording in the Parksville-Qualicum area in spring, continue scoring APIs of marked birds.

- Determine the relationship between Brant body condition and the levels, rates and types of disturbance experienced, especially in the Parksville-Qualicum area in spring.

- Describe API patterns along the entire Pacific Flyway spring migration route (i.e., from wintering to breeding grounds) and the relative importance of the SoG with respect to overall body condition.

- For birds using the Parksville-Qualicum area in spring, assess the relationship between body condition (i.e., API rate and/or departure level) and reproductive success and survival rate.

- Assess the relationship between Brant body condition, migration chronology, length of stay, turnover rate, and food (eelgrass, algae, and herring spawn) abundance and availability in the SoG.

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APPENDIX 1

Brant Counts on the Fraser River Delta between 1992-93 and 2003-04. There are no data for 1995-96 and 1996-97.

FRD 1992-93	
Date	Count
22-Dec-92	100
23-Jan-93	71
25-Jan-93	109
27-Jan-93	121
28-Jan-93	96
01-Feb-93	19
04-Feb-93	129
05-Feb-93	68
12-Feb-93	179
18-Feb-93	24
19-Feb-93	23
20-Feb-93	122
21-Feb-93	33
03-Mar-93	59
20-Mar-93	125
21-Mar-93	64
23-Mar-93	200
24-Mar-93	318
25-Mar-93	174
26-Mar-93	238
28-Mar-93	21
29-Mar-93	45
30-Mar-93	59
01-Apr-93	247
02-Apr-93	356
03-Apr-93	300
04-Apr-93	36
05-Apr-93	163
07-Apr-93	36
08-Apr-93	232
09-Apr-93	212
10-Apr-93	95
12-Apr-93	67
13-Apr-93	46
16-Apr-93	168
18-Apr-93	230
19-Apr-93	380
20-Apr-93	826
21-Apr-93	140
22-Apr-93	320
23-Apr-93	750
23-Apr-93	1379

FRD 1993-94	
Date	Count
17-Nov-93	48
19-Nov-93	12
06-Dec-93	94
15-Dec-93	232
18-Dec-93	128
19-Dec-93	347
07-Jan-94	382
10-Jan-94	204
14-Jan-94	120
17-Jan-94	62
18-Jan-94	60
19-Jan-94	10
21-Jan-94	82
23-Jan-94	82
26-Jan-94	226
27-Jan-94	143
28-Jan-94	119
31-Jan-94	56
01-Feb-94	143
04-Feb-94	125
05-Feb-94	88
13-Feb-94	14
17-Feb-94	361
23-Feb-94	149
25-Feb-94	227
28-Feb-94	51
12-Mar-94	105
13-Mar-94	30
15-Mar-94	550
26-Mar-94	350
28-Mar-94	677
31-Mar-94	700
06-Apr-94	110
08-Apr-94	600
09-Apr-94	500
10-Apr-94	550
11-Apr-94	800
14-Apr-94	850
17-Apr-94	450
25-Apr-94	280

FRD 1994-95

Date	Count	Date	Count	Date	Count	Date	Count
01-Nov-94	26	21-Dec-94	122	07-Feb-95	135	29-Mar-95	17
02-Nov-94	43	22-Dec-94	95	08-Feb-95	100	30-Mar-95	400
03-Nov-94	12	23-Dec-94	224	09-Feb-95	284	31-Mar-95	45
04-Nov-94	0	25-Dec-94	273	10-Feb-95	192	01-Apr-95	1200
05-Nov-94	0	26-Dec-94	75	11-Feb-95	271	03-Apr-95	450
07-Nov-94	19	27-Dec-94	128	12-Feb-95	350	04-Apr-95	550
08-Nov-94	21	28-Dec-94	178	13-Feb-95	400	05-Apr-95	650
09-Nov-94	24	30-Dec-94	72	14-Feb-95	450	06-Apr-95	600
10-Nov-94	9	31-Dec-94	213	15-Feb-95	101	07-Apr-95	350
11-Nov-94	43	01-Jan-95	130	16-Feb-95	332	09-Apr-95	520
12-Nov-94	2	02-Jan-95	291	17-Feb-95	178	10-Apr-95	820
13-Nov-94	41	03-Jan-95	202	18-Feb-95	24	13-Apr-95	1800
14-Nov-94	31	04-Jan-95	267	19-Feb-95	600	17-Apr-95	1150
15-Nov-94	35	05-Jan-95	219	20-Feb-95	532	20-Apr-95	465
16-Nov-94	0	06-Jan-95	170	21-Feb-95	554	21-Apr-95	95
18-Nov-94	18	07-Jan-95	145	22-Feb-95	302	23-Apr-95	125
19-Nov-94	6	08-Jan-95	322	23-Feb-95	50	24-Apr-95	145
20-Nov-94	0	09-Jan-95	119	24-Feb-95	250	25-Apr-95	193
21-Nov-94	18	10-Jan-95	160	25-Feb-95	132	28-Apr-95	145
22-Nov-94	9	11-Jan-95	355	26-Feb-95	13	29-Apr-95	84
23-Nov-94	41	12-Jan-95	250	27-Feb-95	320	30-Apr-95	220
24-Nov-94	21	13-Jan-95	363	02-Mar-95	450		
25-Nov-94	62	14-Jan-95	50	03-Mar-95	400		
26-Nov-94	103	15-Jan-95	224	04-Mar-95	313		
27-Nov-94	73	16-Jan-95	110	05-Mar-95	81		
28-Nov-94	42	17-Jan-95	350	06-Mar-95	215		
30-Nov-94	55	18-Jan-95	260	07-Mar-95	500		
01-Dec-94	92	19-Jan-95	170	08-Mar-95	600		
02-Dec-94	102	20-Jan-95	107	09-Mar-95	600		
03-Dec-94	119	21-Jan-95	180	10-Mar-95	75		
04-Dec-94	119	22-Jan-95	273	11-Mar-95	860		
05-Dec-94	135	23-Jan-95	113	12-Mar-95	450		
07-Dec-94	157	24-Jan-95	40	13-Mar-95	1300		
08-Dec-94	174	25-Jan-95	90	14-Mar-95	550		
09-Dec-94	50	26-Jan-95	268	15-Mar-95	178		
10-Dec-94	89	27-Jan-95	149	16-Mar-95	1200		
11-Dec-94	160	28-Jan-95	251	17-Mar-95	1500		
12-Dec-94	230	29-Jan-95	116	19-Mar-95	290		
13-Dec-94	167	31-Jan-95	173	20-Mar-95	1000		
14-Dec-94	96	01-Feb-95	230	21-Mar-95	750		
15-Dec-94	124	02-Feb-95	128	22-Mar-95	2800		
16-Dec-94	47	02-Feb-95	250	23-Mar-95	1200		
18-Dec-94	160	03-Feb-95	400	24-Mar-95	500		
19-Dec-94	110	05-Feb-95	170	27-Mar-95	3603		
20-Dec-94	149	06-Feb-95	135	28-Mar-95	2000		

FRD 1997-98

Date	Count	Date	Count	Date	Count
10-Nov-97	38	27-Feb-98	645	27-Apr-98	4435
17-Nov-97	96	28-Feb-98	520	04-May-98	3392
18-Nov-97	150	01-Mar-98	137	06-May-98	142
19-Nov-97	100	02-Mar-98	246	07-May-98	217
20-Nov-97	58	03-Mar-98	12	08-May-98	1409
21-Nov-97	19	04-Mar-98	250	12-May-98	1264
24-Nov-97	116	05-Mar-98	155	20-May-98	250
25-Nov-97	171	06-Mar-98	135	22-May-98	265
27-Nov-97	263	07-Mar-98	225	23-May-98	172
28-Nov-97	20	08-Mar-98	165	24-May-98	31
01-Dec-97	290	09-Mar-98	133	25-May-98	27
03-Dec-97	6	10-Mar-98	325	27-May-98	104
04-Dec-97	288	11-Mar-98	427	28-May-98	28
05-Dec-97	160	12-Mar-98	507	28-May-98	122
07-Dec-97	413	13-Mar-98	213	29-May-98	121
08-Dec-97	186	14-Mar-98	267	05-Jun-98	34
09-Dec-97	400	15-Mar-98	404	16-Jun-98	20
11-Dec-97	80	16-Mar-98	259	17-Jun-98	24
12-Dec-97	350	17-Mar-98	235		
15-Dec-97	95	18-Mar-98	291		
17-Dec-97	300	19-Mar-98	162		
18-Dec-97	84	20-Mar-98	102		
19-Dec-97	480	23-Mar-98	1000		
23-Dec-97	619	24-Mar-98	417		
25-Dec-97	334	25-Mar-98	972		
06-Jan-98	92	26-Mar-98	1037		
14-Jan-98	59	27-Mar-98	795		
18-Jan-98	81	28-Mar-98	1400		
19-Jan-98	200	29-Mar-98	692		
19-Jan-98	145	31-Mar-98	1950		
27-Jan-98	89	01-Apr-98	1390		
29-Jan-98	515	05-Apr-98	127		
30-Jan-98	70	06-Apr-98	1858		
02-Feb-98	250	07-Apr-98	1714		
04-Feb-98	212	08-Apr-98	1450		
05-Feb-98	567	09-Apr-98	4072		
07-Feb-98	360	10-Apr-98	2656		
12-Feb-98	260	14-Apr-98	847		
14-Feb-98	278	15-Apr-98	3350		
17-Feb-98	175	16-Apr-98	733		
22-Feb-98	102	18-Apr-98	573		
23-Feb-98	82	20-Apr-98	4400		
24-Feb-98	246	23-Apr-98	4763		
25-Feb-98	342	24-Apr-98	3517		
26-Feb-98	424	26-Apr-98	2051		

FRD 1998-99

Date	Count	Date	Count	Date	Count
07-Nov-98	23	17-Jan-99	985	18-Apr-99	1057
09-Nov-98	65	19-Jan-99	468	19-Apr-99	4185
10-Nov-98	14	20-Jan-99	550	23-Apr-99	4751
11-Nov-98	42	21-Jan-99	775	27-Apr-99	4192
12-Nov-98	34	22-Jan-99	808	28-Apr-99	3218
14-Nov-98	9	24-Jan-99	555	29-Apr-99	1908
15-Nov-98	145	26-Jan-99	755	01-May-99	2958
19-Nov-98	141	30-Jan-99	825	02-May-99	494
21-Nov-98	58	31-Jan-99	458	04-May-99	1574
22-Nov-98	41	01-Feb-99	190	06-May-99	1580
23-Nov-98	308	02-Feb-99	148	10-May-99	667
24-Nov-98	37	04-Feb-99	206	12-May-99	386
26-Nov-98	76	06-Feb-99	861	13-May-99	481
28-Nov-98	470	09-Feb-99	236	15-May-99	179
29-Nov-98	170	10-Feb-99	659	19-May-99	44
30-Nov-98	573	12-Feb-99	43	20-May-99	30
01-Dec-98	450	13-Feb-99	100		
02-Dec-98	213	14-Feb-99	500		
03-Dec-98	945	15-Feb-99	335		
05-Dec-98	30	16-Feb-99	642		
06-Dec-98	930	17-Feb-99	858		
07-Dec-98	150	22-Feb-99	39		
08-Dec-98	158	23-Feb-99	209		
09-Dec-98	718	24-Feb-99	322		
10-Dec-98	214	25-Feb-99	250		
11-Dec-98	300	26-Feb-99	250		
12-Dec-98	270	01-Mar-99	556		
13-Dec-98	686	02-Mar-99	474		
14-Dec-98	600	04-Mar-99	542		
16-Dec-98	480	05-Mar-99	417		
18-Dec-98	486	10-Mar-99	214		
20-Dec-98	100	12-Mar-99	455		
22-Dec-98	500	15-Mar-99	433		
28-Dec-98	918	18-Mar-99	1249		
30-Dec-98	225	19-Mar-99	991		
01-Jan-99	263	22-Mar-99	1591		
02-Jan-99	820	25-Mar-99	1466		
04-Jan-99	210	26-Mar-99	1047		
06-Jan-99	200	29-Mar-99	1041		
09-Jan-99	801	01-Apr-99	2104		
10-Jan-99	243	03-Apr-99	1915		
11-Jan-99	101	06-Apr-99	3314		
12-Jan-99	130	09-Apr-99	2681		
15-Jan-99	400	12-Apr-99	4531		
16-Jan-99	501	16-Apr-99	5347		

FRD 1999-2000

Date	Count	Date	Count	Date	Count
28-Oct-99	0	11-Jan-00	785	26-Mar-00	893
29-Oct-99	56	13-Jan-00	440	27-Mar-00	226
30-Oct-99	25	14-Jan-00	931	28-Mar-00	1025
31-Oct-99	27	18-Jan-00	899	30-Mar-00	808
01-Nov-99	88	19-Jan-00	895	31-Mar-00	1061
02-Nov-99	45	20-Jan-00	962	01-Apr-00	1256
03-Nov-99	5	24-Jan-00	248	02-Apr-00	1627
05-Nov-99	206	25-Jan-00	755	04-Apr-00	549
06-Nov-99	108	26-Jan-00	823	05-Apr-00	1670
07-Nov-99	221	27-Jan-00	571	06-Apr-00	949
08-Nov-99	55	28-Jan-00	365	07-Apr-00	1786
09-Nov-99	75	31-Jan-00	283	10-Apr-00	1536
10-Nov-99	205	02-Feb-00	707	11-Apr-00	1173
13-Nov-99	170	03-Feb-00	310	13-Apr-00	700
14-Nov-99	224	04-Feb-00	400	14-Apr-00	966
15-Nov-99	281	08-Feb-00	665	15-Apr-00	1826
19-Nov-99	608	10-Feb-00	126	16-Apr-00	1732
20-Nov-99	524	11-Feb-00	658	17-Apr-00	2038
21-Nov-99	692	17-Feb-00	694	18-Apr-00	2428
22-Nov-99	339	18-Feb-00	488	20-Apr-00	1583
23-Nov-99	610	21-Feb-00	1058	22-Apr-00	1454
26-Nov-99	585	22-Feb-00	148	24-Apr-00	2342
30-Nov-99	576	23-Feb-00	436	25-Apr-00	1454
02-Dec-99	600	24-Feb-00	584	26-Apr-00	800
04-Dec-99	227	25-Feb-00	530	28-Apr-00	690
06-Dec-99	441	27-Feb-00	35	30-Apr-00	0
07-Dec-99	693	28-Feb-00	280	01-May-00	870
08-Dec-99	848	29-Feb-00	1119	02-May-00	399
09-Dec-99	842	01-Mar-00	258	03-May-00	477
11-Dec-99	928	02-Mar-00	209	04-May-00	177
13-Dec-99	936	03-Mar-00	373	05-May-00	32
14-Dec-99	901	06-Mar-00	450	06-May-00	92
16-Dec-99	936	07-Mar-00	543	07-May-00	90
17-Dec-99	1238	09-Mar-00	85	08-May-00	57
18-Dec-99	668	10-Mar-00	65	10-May-00	93
20-Dec-99	614	13-Mar-00	252	11-May-00	0
21-Dec-99	593	15-Mar-00	481	14-May-00	30
22-Dec-99	225	16-Mar-00	137	15-May-00	63
26-Dec-99	262	17-Mar-00	500	17-May-00	33
29-Dec-99	602	19-Mar-00	1193	18-May-00	29
30-Dec-99	410	20-Mar-00	1381	19-May-00	33
03-Jan-00	1128	22-Mar-00	805	20-May-00	33
04-Jan-00	814	23-Mar-00	262		
06-Jan-00	1052	24-Mar-00	650		
09-Jan-00	552	25-Mar-00	919		

FRD 2000-01

Date	Count	Date	Count	Date	Count
02-Nov-00	7	16-Jan-01	631	10-Mar-01	1400
03-Nov-00	3	19-Jan-01	645	11-Mar-01	1150
04-Nov-00	0	21-Jan-01	759	12-Mar-01	72
07-Nov-00	11	22-Jan-01	756	13-Mar-01	100
08-Nov-00	16	23-Jan-01	1074	14-Mar-01	0
09-Nov-00	11	24-Jan-01	858	15-Mar-01	537
11-Nov-00	11	26-Jan-01	614	16-Mar-01	110
12-Nov-00	0	29-Jan-01	614	19-Mar-01	147
13-Nov-00	25	30-Jan-01	540	20-Mar-01	0
17-Nov-00	106	31-Jan-01	946	21-Mar-01	367
19-Nov-00	67	01-Feb-01	448	23-Mar-01	664
20-Nov-00	96	02-Feb-01	565	26-Mar-01	1463
22-Nov-00	196	03-Feb-01	103	28-Mar-01	1818
23-Nov-00	236	05-Feb-01	686	29-Mar-01	5631
24-Nov-00	301	06-Feb-01	35	30-Mar-01	1142
27-Nov-00	261	07-Feb-01	53	31-Mar-01	549
28-Nov-00	582	08-Feb-01	1198	01-Apr-01	0
30-Nov-00	543	09-Feb-01	551	02-Apr-01	42
01-Dec-00	246	10-Feb-01	350	03-Apr-01	94
02-Dec-00	376	11-Feb-01	38	04-Apr-01	298
03-Dec-00	439	12-Feb-01	260	05-Apr-01	94
04-Dec-00	733	13-Feb-01	113	08-Apr-01	288
05-Dec-00	550	14-Feb-01	90	09-Apr-01	59
07-Dec-00	351	15-Feb-01	10	10-Apr-01	140
08-Dec-00	604	16-Feb-01	160	11-Apr-01	3386
10-Dec-00	108	17-Feb-01	16	12-Apr-01	505
11-Dec-00	595	18-Feb-01	134	13-Apr-01	125
13-Dec-00	765	19-Feb-01	300	18-Apr-01	0
14-Dec-00	813	20-Feb-01	95	19-Apr-01	405
15-Dec-00	107	21-Feb-01	225	20-Apr-01	400
17-Dec-00	509	22-Feb-01	217	21-Apr-01	1321
18-Dec-00	1177	23-Feb-01	177	22-Apr-01	226
26-Dec-00	1213	24-Feb-01	85	23-Apr-01	1774
27-Dec-00	705	25-Feb-01	85	01-May-01	828
28-Dec-00	1186	27-Feb-01	27	04-May-01	958
29-Dec-00	940	28-Feb-01	127	05-May-01	978
02-Jan-01	679	01-Mar-01	194	06-May-01	1069
03-Jan-01	551	02-Mar-01	87	07-May-01	50
04-Jan-01	612	03-Mar-01	156	08-May-01	659
07-Jan-01	156	04-Mar-01	15	09-May-01	120
08-Jan-01	835	05-Mar-01	0	10-May-01	163
10-Jan-01	1134	06-Mar-01	8	11-May-01	45
11-Jan-01	543	07-Mar-01	160	12-May-01	252
12-Jan-01	1254	08-Mar-01	243	20-May-01	43
15-Jan-01	627	09-Mar-01	109	21-May-01	30

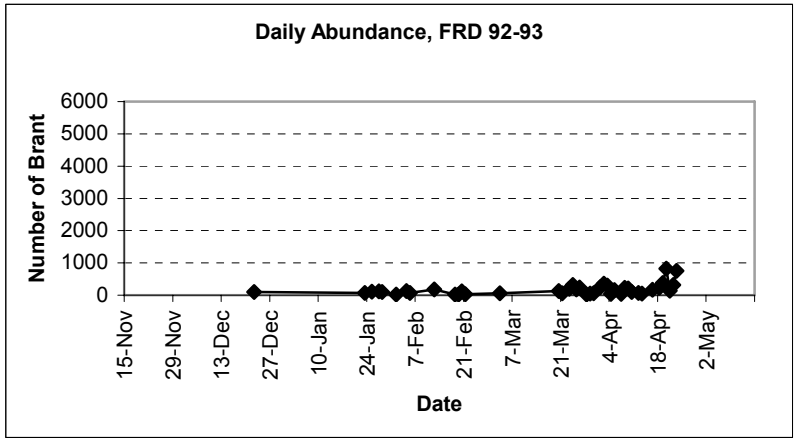
FRD 2001-02	
Date	Count
02-Jan-02	500
08-Jan-02	797
11-Jan-02	1483
14-Jan-02	159
18-Jan-02	783
21-Jan-02	724
22-Jan-02	843
25-Jan-02	970

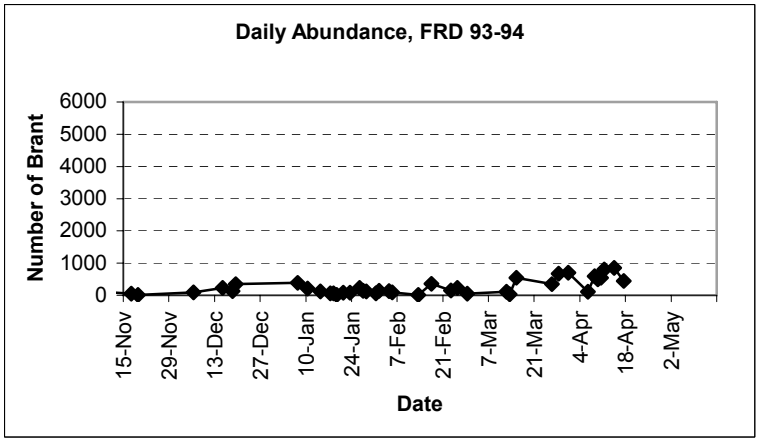
FRD 2002-03		
Date	Count	Include Semiahmoo Bay
20-Nov-02	96	
23-Nov-02	51	
24-Nov-02	23	
01-Dec-02	970	
13-Dec-02	1910	
30-Dec-02	500	
03-Jan-03	241	
10-Jan-03	537	
13-Jan-03	196	
14-Jan-03	737	800
16-Jan-03	825	
17-Jan-03	729	
20-Jan-03	727	998
21-Jan-03	793	867
22-Jan-03	773	
24-Jan-03	821	
25-Jan-03	6	
27-Jan-03	583	
28-Jan-03	849	1103
30-Jan-03	550	627
31-Jan-03	573	

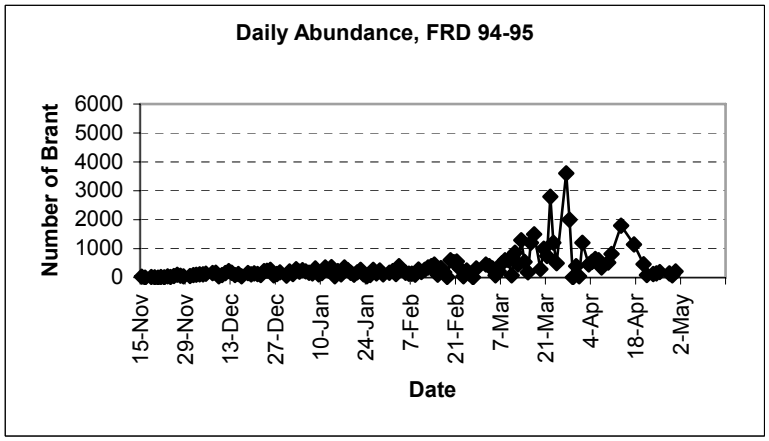
FRD 2003-04		
Date	Count	Include Semiahmoo Bay
10-Jan-04	423	450
11-Jan-04	215	317
12-Jan-04	39	181
13-Jan-04	299	245
14-Jan-04	480	516
15-Jan-04	1883	1949
17-Jan-04	444	720
18-Jan-04	1800	2117
30-Jan-04	173	
10-Feb-04	739	
11-Feb-04	864	
01-Mar-04	1477	
10-Mar-04	1300	
27-Mar-04	2000	
28-Mar-04	1500	
02-Apr-04	1700	
06-Apr-04	2000	
07-Apr-04	2750	
08-Apr-04	1888	
10-Apr-04	3475	
15-Apr-04	3000	
18-Apr-04	1956	
22-Apr-04	1393	
06-May-04	49	
18-May-04	26	

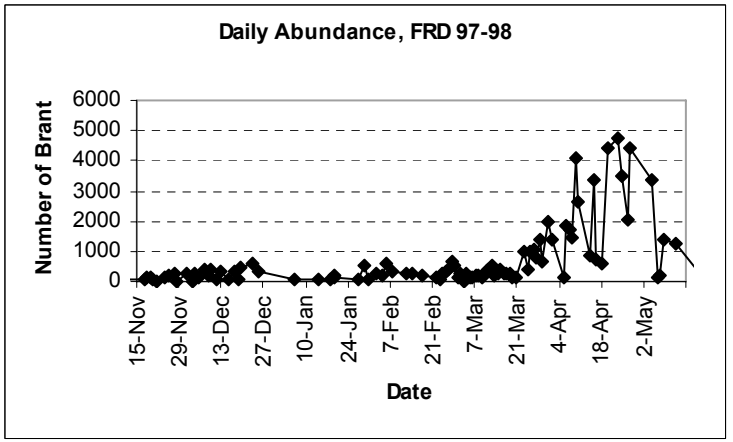
APPENDIX 2

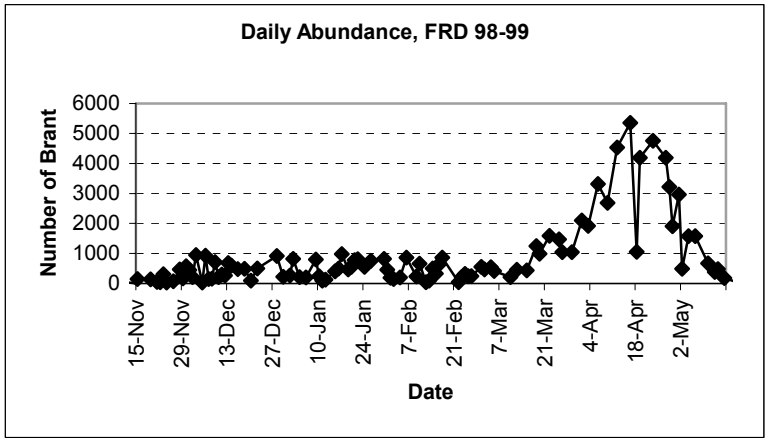
Daily abundance of Brant (winter and spring) on the Fraser River Delta from 1992-93 to 2003-04. Source data are in Appendix 1. There are no data for 1995-96 and 1996-97.

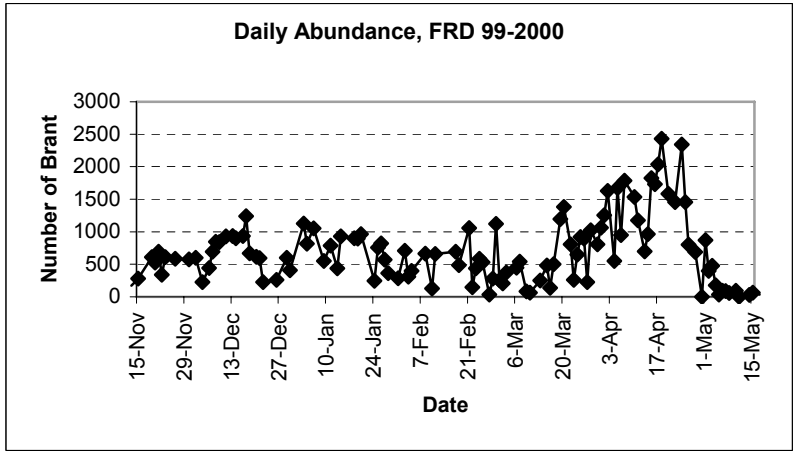


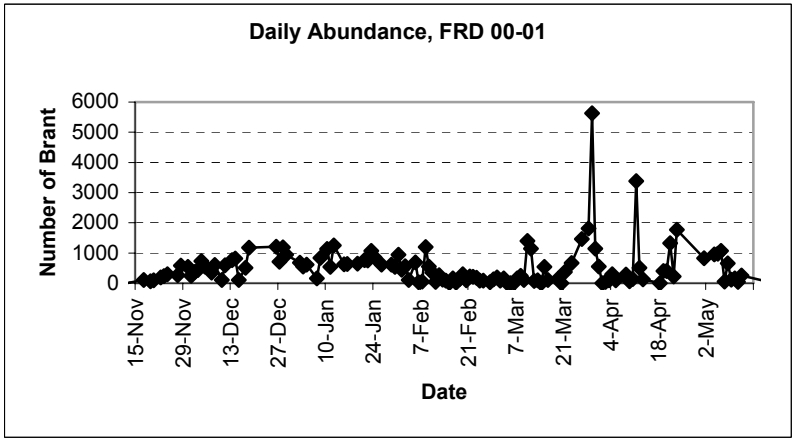


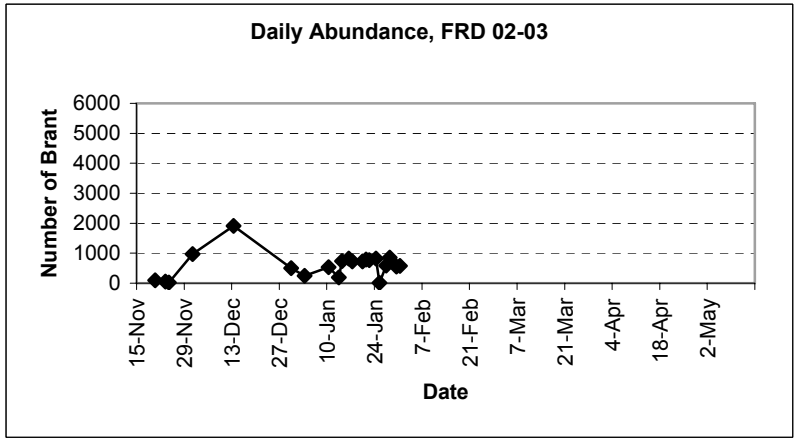


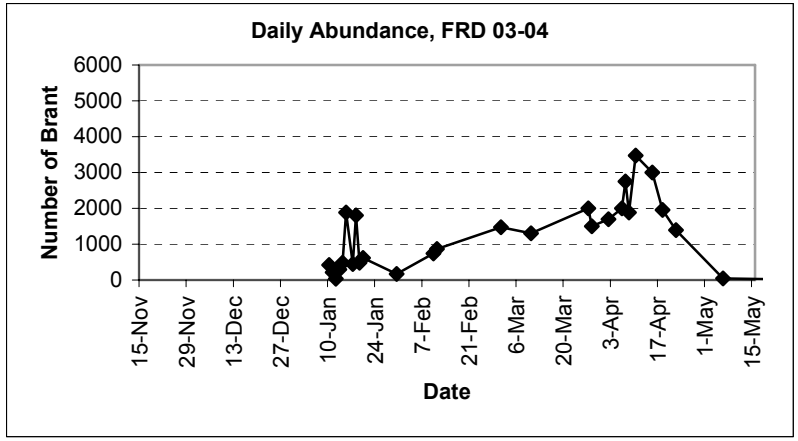



Daily Abundance, FRD 98-99
Number of Brant
6000
5000
4000
3000
2000
1000
0
15-Nov
29-Nov
13-Dec
27-Dec
10-Jan
24-Jan
7-Feb
21-Feb
7-Mar
21-Mar
4-Apr
18-Apr
2-May
Date


Daily Abundance, FRD 99-2000
Number of Brant
3000
2500
2000
1500
1000
500
0
15-Nov
29-Nov
13-Dec
27-Dec
10-Jan
24-Jan
7-Feb
21-Feb
6-Mar
20-Mar
3-Apr
17-Apr
1-May
15-May
Date


Daily Abundance, FRD 00-01
Number of Brant
6000
5000
4000
3000
2000
1000
0
15-Nov
29-Nov
13-Dec
27-Dec
10-Jan
24-Jan
7-Feb
21-Feb
7-Mar
21-Mar
4-Apr
18-Apr
2-May
Date


Daily Abundance, FRD 02-03
Number of Brant
6000
5000
4000
3000
2000
1000
0
15-Nov
29-Nov
13-Dec
27-Dec
10-Jan
24-Jan
7-Feb
21-Feb
7-Mar
21-Mar
4-Apr
18-Apr
2-May
Date


Daily Abundance, FRD 03-04
Number of Brant
6000
5000
4000
3000
2000
1000
0
15-Nov
29-Nov
13-Dec
27-Dec
10-Jan
24-Jan
7-Feb
21-Feb
6-Mar
20-Mar
3-Apr
17-Apr
1-May
15-May
Date

APPENDIX 3

Spring abundance counts for Brant in the Parksville-Qualicum area, 1989-2004.

PQ 1989

Date	Count	Date	Count
04-Mar-89	4	22-Apr-89	1086
09-Mar-89	57	23-Apr-89	1174
10-Mar-89	36	24-Apr-89	2477
11-Mar-89	61	25-Apr-89	3071
12-Mar-89	123	26-Apr-89	589
13-Mar-89	261	27-Apr-89	635
14-Mar-89	586	28-Apr-89	833
15-Mar-89	533	29-Apr-89	572
16-Mar-89	72	30-Apr-89	40
17-Mar-89	827	01-May-89	121
18-Mar-89	358	02-May-89	1155
19-Mar-89	890	03-May-89	517
20-Mar-89	803	04-May-89	11
21-Mar-89	1615	06-May-89	5
22-Mar-89	1357	07-May-89	0
23-Mar-89	2162	08-May-89	0
24-Mar-89	875	09-May-89	0
25-Mar-89	1331	10-May-89	0
26-Mar-89	415	11-May-89	29
27-Mar-89	3054	12-May-89	0
28-Mar-89	2519	13-May-89	0
29-Mar-89	1589	14-May-89	0
30-Mar-89	4659	15-May-89	0
31-Mar-89	4139	17-May-89	120
01-Apr-89	560	18-May-89	3
02-Apr-89	1527		
03-Apr-89	1075		
04-Apr-89	1231		
05-Apr-89	9184		
06-Apr-89	804		
07-Apr-89	7063		
08-Apr-89	2228		
09-Apr-89	765		
10-Apr-89	5602		
11-Apr-89	6778		
12-Apr-89	4367		
13-Apr-89	3609		
14-Apr-89	1169		
15-Apr-89	1964		
16-Apr-89	1842		
17-Apr-89	2090		
18-Apr-89	2374		
19-Apr-89	847		
20-Apr-89	1230		
21-Apr-89	1741		

PQ 1990

Date	Count	Date	Count
27-Feb-90	6	24-Apr-90	1098
04-Mar-90	26	25-Apr-90	460
11-Mar-90	130	26-Apr-90	649
12-Mar-90	111	27-Apr-90	500
13-Mar-90	457	28-Apr-90	622
14-Mar-90	347	29-Apr-90	793
15-Mar-90	473	30-Apr-90	582
16-Mar-90	602	01-May-90	360
17-Mar-90	663	02-May-90	587
18-Mar-90	260	03-May-90	351
19-Mar-90	722	04-May-90	383
20-Mar-90	445	05-May-90	100
21-Mar-90	1050	06-May-90	310
22-Mar-90	450	07-May-90	300
23-Mar-90	1370	08-May-90	364
24-Mar-90	880	09-May-90	184
25-Mar-90	1470	10-May-90	289
26-Mar-90	1762	11-May-90	189
27-Mar-90	1500	12-May-90	90
28-Mar-90	1000	13-May-90	52
29-Mar-90	870	14-May-90	42
30-Mar-90	2570	16-May-90	58
31-Mar-90	1792	17-May-90	76
01-Apr-90	2670	18-May-90	83
02-Apr-90	2850	25-May-90	27
03-Apr-90	3672		
04-Apr-90	2220		
05-Apr-90	2980		
06-Apr-90	4280		
07-Apr-90	1050		
08-Apr-90	2090		
09-Apr-90	2699		
10-Apr-90	1957		
11-Apr-90	2360		
12-Apr-90	2450		
13-Apr-90	1100		
14-Apr-90	2010		
15-Apr-90	1225		
16-Apr-90	1293		
17-Apr-90	1780		
18-Apr-90	1000		
20-Apr-90	1012		
21-Apr-90	690		
22-Apr-90	630		
23-Apr-90	750		

PQ 1991

Date	Count
26-Feb-91	40
01-Mar-91	8
03-Mar-91	28
05-Mar-91	40
06-Mar-91	55
08-Mar-91	90
09-Mar-91	153
10-Mar-91	179
14-Mar-91	280
16-Mar-91	206
18-Mar-91	336
19-Mar-91	325
20-Mar-91	642
21-Mar-91	571
22-Mar-91	918
23-Mar-91	1221
25-Mar-91	1136
26-Mar-91	1169
27-Mar-91	1790
28-Mar-91	1806
29-Mar-91	1874
30-Mar-91	2015
01-Apr-91	2046
04-Apr-91	3003
06-Apr-91	3430
07-Apr-91	3720
09-Apr-91	3112
11-Apr-91	2795
12-Apr-91	2734
14-Apr-91	1864
15-Apr-91	2746
19-Apr-91	1869
22-Apr-91	1777
24-Apr-91	2152
25-Apr-91	2680
29-Apr-91	2081
09-May-91	779
10-May-91	893
13-May-91	317
18-May-91	307
23-May-91	97

PQ 1992

Date	Count	Date	Count
09-Feb-92	8	17-Apr-92	2646
01-Mar-92	42	18-Apr-92	2575
02-Mar-92	23	19-Apr-92	2429
03-Mar-92	21	20-Apr-92	2391
04-Mar-92	11	21-Apr-92	2030
05-Mar-92	86	22-Apr-92	1994
06-Mar-92	52	23-Apr-92	1711
07-Mar-92	145	24-Apr-92	1800
08-Mar-92	93	25-Apr-92	1987
09-Mar-92	139	27-Apr-92	1532
10-Mar-92	146	04-May-92	971
11-Mar-92	110	05-May-92	1170
12-Mar-92	101	06-May-92	961
13-Mar-92	204	07-May-92	1083
14-Mar-92	323	08-May-92	730
15-Mar-92	198	09-May-92	584
16-Mar-92	339	10-May-92	345
17-Mar-92	358	11-May-92	429
18-Mar-92	630	12-May-92	276
19-Mar-92	677	13-May-92	147
20-Mar-92	620	15-May-92	208
21-Mar-92	397	16-May-92	158
22-Mar-92	591	17-May-92	144
23-Mar-92	636	18-May-92	113
24-Mar-92	1395	19-May-92	2
25-Mar-92	1485	20-May-92	10
26-Mar-92	1665	21-May-92	7
27-Mar-92	1992		
28-Mar-92	1702		
30-Mar-92	2070		
31-Mar-92	2531		
01-Apr-92	2063		
02-Apr-92	1968		
03-Apr-92	1489		
04-Apr-92	1844		
05-Apr-92	1946		
06-Apr-92	1731		
07-Apr-92	2096		
08-Apr-92	2179		
09-Apr-92	2263		
10-Apr-92	1887		
11-Apr-92	1319		
13-Apr-92	1305		
14-Apr-92	1700		
15-Apr-92	1826		

PQ 1993	
Date	Count
22-Mar-93	1680
23-Mar-93	1100
24-Mar-93	3072
25-Mar-93	2500
26-Mar-93	1900
27-Mar-93	1926
28-Mar-93	3074
29-Mar-93	1900
30-Mar-93	1648
31-Mar-93	2040
01-Apr-93	2542
02-Apr-93	1900
03-Apr-93	1418
04-Apr-93	2234
05-Apr-93	1192
06-Apr-93	2826
07-Apr-93	1181
08-Apr-93	1994
09-Apr-93	3304
10-Apr-93	1775
11-Apr-93	1650
12-Apr-93	2600
13-Apr-93	1165
15-Apr-93	1039
16-Apr-93	2854
17-Apr-93	3578
18-Apr-93	4550
19-Apr-93	4749
20-Apr-93	3696
21-Apr-93	2708
22-Apr-93	3130
23-Apr-93	1614
24-Apr-93	630
28-Apr-93	250

PQ 1994	
Date	Count
01-Apr-94	4194
02-Apr-94	3268
03-Apr-94	4176
04-Apr-94	2171
05-Apr-94	3373
06-Apr-94	3042
07-Apr-94	3506
08-Apr-94	3614
09-Apr-94	5540
10-Apr-94	3572
11-Apr-94	3051
12-Apr-94	2370
13-Apr-94	2856
14-Apr-94	3153
15-Apr-94	2310
16-Apr-94	2938
17-Apr-94	2205
18-Apr-94	2829
19-Apr-94	1999
20-Apr-94	2301
21-Apr-94	1940
22-Apr-94	1634
23-Apr-94	1587
24-Apr-94	1851
25-Apr-94	815
26-Apr-94	1011
27-Apr-94	670
28-Apr-94	639
29-Apr-94	484
30-Apr-94	462

PQ 1995	
Date	Count
12-Mar-95	1354
18-Mar-95	2834
23-Mar-95	4425
24-Mar-95	5816
25-Mar-95	2860
26-Mar-95	4640
30-Mar-95	2630
31-Mar-95	5795
03-Apr-95	6267
04-Apr-95	4768
05-Apr-95	5384
06-Apr-95	5246
07-Apr-95	3999
08-Apr-95	5000
09-Apr-95	3523
10-Apr-95	2193
11-Apr-95	2129
18-Apr-95	1389
19-Apr-95	1306
20-Apr-95	1366
21-Apr-95	1359
22-Apr-95	795

PQ 1996	
Date	Count
28-Feb-96	393
29-Feb-96	330
06-Mar-96	66
07-Mar-96	39
09-Mar-96	40
13-Mar-96	380
16-Mar-96	320
17-Mar-96	410
18-Mar-96	300
19-Mar-96	470
20-Mar-96	3020
23-Mar-96	1150
24-Mar-96	2060
26-Mar-96	1100
28-Mar-96	1300
29-Mar-96	2500
30-Mar-96	3726
31-Mar-96	3500
02-May-96	375

PQ 1997	
Date	Count
15-Jan-97	6
17-Feb-97	6
23-Feb-97	28
26-Feb-97	38
27-Feb-97	170
28-Feb-97	49
02-Mar-97	143
07-Mar-97	12
08-Mar-97	528
09-Mar-97	372
12-Mar-97	354
13-Mar-97	125
14-Mar-97	1466
16-Mar-97	920
19-Mar-97	1497
20-Mar-97	1004
21-Mar-97	1414
22-Mar-97	1287
23-Mar-97	2080
26-Mar-97	611
28-Mar-97	1936
29-Mar-97	1650
30-Mar-97	1508
31-Mar-97	2105
04-Apr-97	1206
05-Apr-97	2703
06-Apr-97	1622
07-Apr-97	3906
08-Apr-97	3490
09-Apr-97	2620
11-Apr-97	2656
12-Apr-97	1998
14-Apr-97	3689
15-Apr-97	2920
16-Apr-97	2572
17-Apr-97	1830
18-Apr-97	2576
21-Apr-97	1315
22-Apr-97	1282
23-Apr-97	260
26-Apr-97	445
27-Apr-97	320

PQ 1998	
Date	Count
30-Jan-98	41
09-Feb-98	128
14-Feb-98	348
26-Feb-98	728
27-Feb-98	860
04-Mar-98	580
09-Mar-98	610
11-Mar-98	330
20-Mar-98	2000
29-Mar-98	2550
30-Mar-98	2640
01-Apr-98	4550
02-Apr-98	3890
07-Apr-98	2860
08-Apr-98	3890
09-Apr-98	3050
14-Apr-98	2445
15-Apr-98	2000
16-Apr-98	2165
18-Apr-98	1195
24-Apr-98	1610
05-May-98	180
19-May-98	50

PQ 1999

Date	Count	Date	Count
15-Jan-99	16	02-Apr-99	3430
16-Jan-99	3	04-Apr-99	4570
09-Feb-99	5	05-Apr-99	4071
10-Feb-99	1	06-Apr-99	5317
11-Feb-99	10	07-Apr-99	4000
12-Feb-99	16	08-Apr-99	5083
13-Feb-99	8	09-Apr-99	4512
16-Feb-99	16	10-Apr-99	3200
18-Feb-99	40	11-Apr-99	3881
19-Feb-99	30	12-Apr-99	4016
23-Feb-99	117	13-Apr-99	6100
25-Feb-99	41	14-Apr-99	3859
26-Feb-99	30	15-Apr-99	4656
27-Feb-99	25	16-Apr-99	3970
28-Feb-99	12	17-Apr-99	2437
01-Mar-99	66	18-Apr-99	2500
02-Mar-99	58	19-Apr-99	2000
04-Mar-99	52	20-Apr-99	1600
05-Mar-99	96	21-Apr-99	2117
06-Mar-99	60	22-Apr-99	1036
07-Mar-99	215	23-Apr-99	1546
09-Mar-99	1	24-Apr-99	1079
10-Mar-99	125	25-Apr-99	1104
11-Mar-99	405	26-Apr-99	447
12-Mar-99	274	27-Apr-99	1422
13-Mar-99	64	28-Apr-99	1180
14-Mar-99	126	29-Apr-99	711
15-Mar-99	245	30-Apr-99	535
16-Mar-99	201	08-May-99	100
17-Mar-99	577	15-May-99	88
18-Mar-99	925		
19-Mar-99	1073		
20-Mar-99	1916		
21-Mar-99	632		
22-Mar-99	1226		
23-Mar-99	1730		
24-Mar-99	2871		
25-Mar-99	2959		
26-Mar-99	3192		
28-Mar-99	3064		
29-Mar-99	2573		
30-Mar-99	4088		
31-Mar-99	4330		
01-Apr-99	6900		
02-Apr-99	4380		

PQ 2000

Date	Count	Date	Count
19-Feb-00	11	14-Apr-00	2167
01-Mar-00	49	15-Apr-00	3855
02-Mar-00	24	16-Apr-00	2675
03-Mar-00	104	17-Apr-00	2300
04-Mar-00	361	18-Apr-00	885
05-Mar-00	507	19-Apr-00	1350
06-Mar-00	702	20-Apr-00	681
07-Mar-00	948	21-Apr-00	768
08-Mar-00	1206	22-Apr-00	1247
09-Mar-00	1688	23-Apr-00	927
10-Mar-00	2245	24-Apr-00	612
11-Mar-00	2750	25-Apr-00	622
12-Mar-00	2700	26-Apr-00	183
13-Mar-00	2750	27-Apr-00	232
14-Mar-00	2500	29-Apr-00	502
15-Mar-00	2700	01-May-00	209
16-Mar-00	3550	02-May-00	175
17-Mar-00	3455	03-May-00	181
18-Mar-00	3629	04-May-00	77
19-Mar-00	2732	05-May-00	87
20-Mar-00	3800	06-May-00	35
21-Mar-00	3658	07-May-00	58
22-Mar-00	4039	08-May-00	18
23-Mar-00	3889	09-May-00	52
24-Mar-00	3450	10-May-00	46
25-Mar-00	4763	11-May-00	66
26-Mar-00	3099	12-May-00	71
27-Mar-00	3075	13-May-00	64
28-Mar-00	3276	14-May-00	63
29-Mar-00	5415	15-May-00	20
30-Mar-00	5260		
31-Mar-00	4840		
01-Apr-00	5194		
02-Apr-00	4827		
03-Apr-00	4514		
04-Apr-00	4060		
05-Apr-00	3180		
06-Apr-00	3523		
07-Apr-00	2600		
08-Apr-00	2915		
09-Apr-00	2190		
10-Apr-00	3082		
11-Apr-00	2630		
12-Apr-00	2630		
13-Apr-00	2777		

PQ 2001

Date	Count	Date	Count
05-Jan-01	1	01-May-01	383
16-Jan-01	17	10-May-01	11
20-Feb-01	43	15-May-01	15
22-Feb-01	2		
24-Feb-01	8		
25-Feb-01	5		
26-Feb-01	76		
28-Feb-01	109		
02-Mar-01	71		
06-Mar-01	409		
08-Mar-01	138		
09-Mar-01	267		
12-Mar-01	951		
13-Mar-01	1093		
14-Mar-01	1030		
15-Mar-01	1211		
16-Mar-01	1971		
16-Mar-01	2038		
19-Mar-01	1707		
20-Mar-01	1558		
21-Mar-01	2588		
23-Mar-01	2401		
25-Mar-01	1576		
26-Mar-01	2622		
28-Mar-01	2699		
29-Mar-01	4208		
30-Mar-01	4675		
31-Mar-01	3837		
01-Apr-01	2869		
02-Apr-01	2510		
06-Apr-01	3969		
07-Apr-01	3090		
08-Apr-01	3092		
09-Apr-01	2750		
10-Apr-01	3114		
11-Apr-01	5888		
12-Apr-01	881		
13-Apr-01	3393		
16-Apr-01	1138		
17-Apr-01	1250		
18-Apr-01	1569		
19-Apr-01	1640		
20-Apr-01	1885		
22-Apr-01	1712		
27-Apr-01	30		

PQ 2002	
Date	Count
11-Mar-02	265
16-Mar-02	541
18-Mar-02	661
19-Mar-02	335
20-Mar-02	775
21-Mar-02	862
23-Mar-02	719
24-Mar-02	1312
25-Mar-02	1017
26-Mar-02	813
27-Mar-02	1993
28-Mar-02	2782
30-Mar-02	7706
31-Mar-02	1736
01-Apr-02	1850
02-Apr-02	12794
03-Apr-02	2232
04-Apr-02	3398
05-Apr-02	3840
06-Apr-02	3256
07-Apr-02	3024
08-Apr-02	3040
09-Apr-02	2689
10-Apr-02	2892
12-Apr-02	3440
15-Apr-02	3041
16-Apr-02	1915
17-Apr-02	2709
18-Apr-02	2596
19-Apr-02	3075
20-Apr-02	1553
23-Apr-02	1251
24-Apr-02	2110
25-Apr-02	1427
29-Apr-02	224
30-Apr-02	77

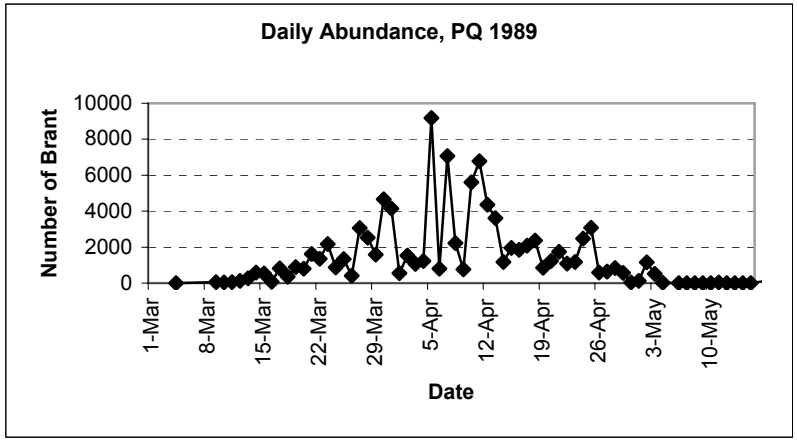
PQ 2003	
Date	Count
16-Feb-03	6
20-Feb-03	211
21-Feb-03	77
25-Feb-03	99
28-Feb-03	367
04-Mar-03	446
06-Mar-03	793
09-Mar-03	990
10-Mar-03	1892
13-Mar-03	409
14-Mar-03	487
17-Mar-03	1263
18-Mar-03	1122
19-Mar-03	1792
20-Mar-03	1171
22-Mar-03	918
25-Mar-03	2070
28-Mar-03	1980
29-Mar-03	2198
30-Mar-03	1723
31-Mar-03	1777
01-Apr-03	2557
03-Apr-03	2354
04-Apr-03	2786
05-Apr-03	2515
08-Apr-03	3770
09-Apr-03	3324
10-Apr-03	3406
11-Apr-03	1507
12-Apr-03	2350
13-Apr-03	1006
14-Apr-03	1759
15-Apr-03	2008
17-Apr-03	1407
18-Apr-03	1803
19-Apr-03	708
20-Apr-03	799
22-Apr-03	311
24-Apr-03	700
25-Apr-03	372
26-Apr-03	384
29-Apr-03	190
04-May-03	211
07-May-03	63

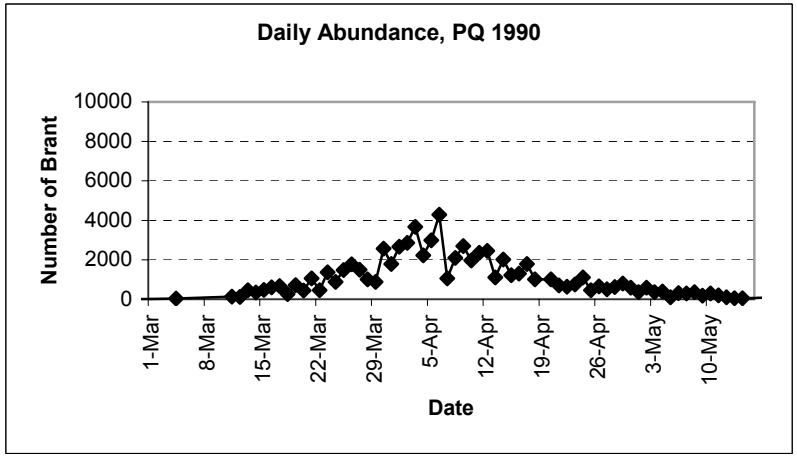
PQ 2004

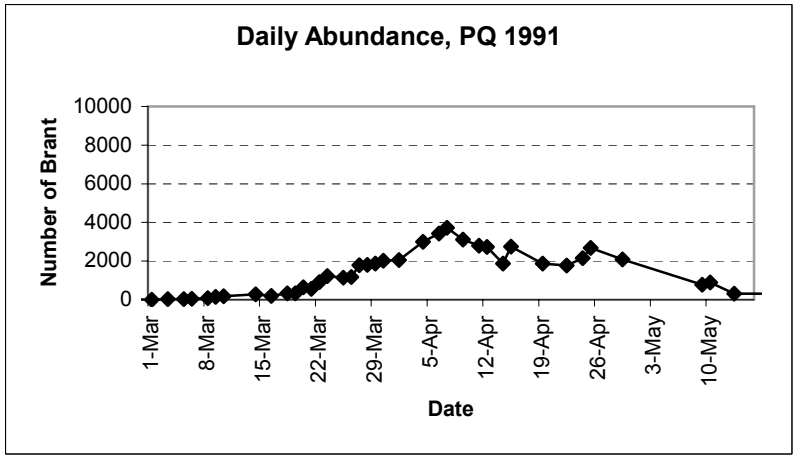
Date	Count	Date	Count
14-Feb-04	14	15-Apr-04	636
21-Feb-04	6	17-Apr-04	258
23-Feb-04	12	19-Apr-04	24
24-Feb-04	0	24-Apr-04	22
28-Feb-04	9	29-Apr-04	10
29-Feb-04	162		
01-Mar-04	206		
02-Mar-04	266		
03-Mar-04	463		
04-Mar-04	540		
05-Mar-04	606		
06-Mar-04	608		
08-Mar-04	497		
09-Mar-04	809		
10-Mar-04	1309		
11-Mar-04	775		
12-Mar-04	902		
13-Mar-04	585		
14-Mar-04	1015		
15-Mar-04	981		
16-Mar-04	671		
17-Mar-04	1091		
19-Mar-04	1078		
21-Mar-04	1280		
22-Mar-04	1426		
23-Mar-04	2172		
24-Mar-04	1639		
26-Mar-04	1842		
27-Mar-04	1560		
29-Mar-04	1105		
30-Mar-04	3027		
31-Mar-04	1482		
01-Apr-04	1442		
02-Apr-04	2472		
03-Apr-04	3100		
04-Apr-04	2189		
05-Apr-04	2763		
06-Apr-04	1237		
07-Apr-04	2612		
08-Apr-04	1446		
09-Apr-04	1265		
10-Apr-04	951		
11-Apr-04	644		
13-Apr-04	450		
14-Apr-04	925		

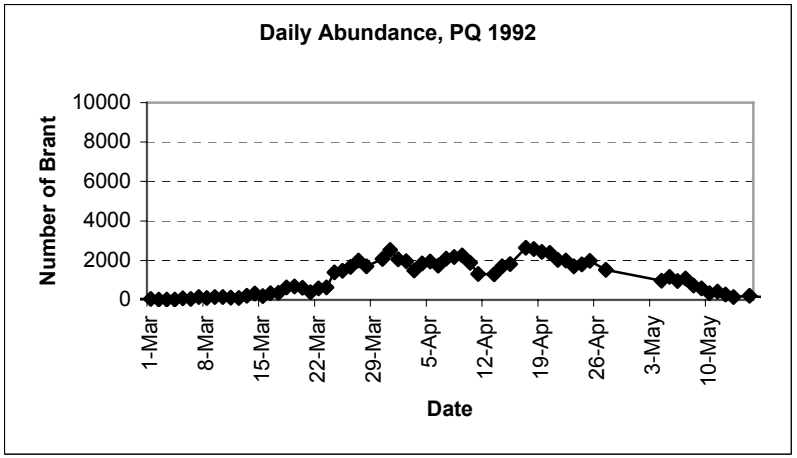
APPENDIX 4

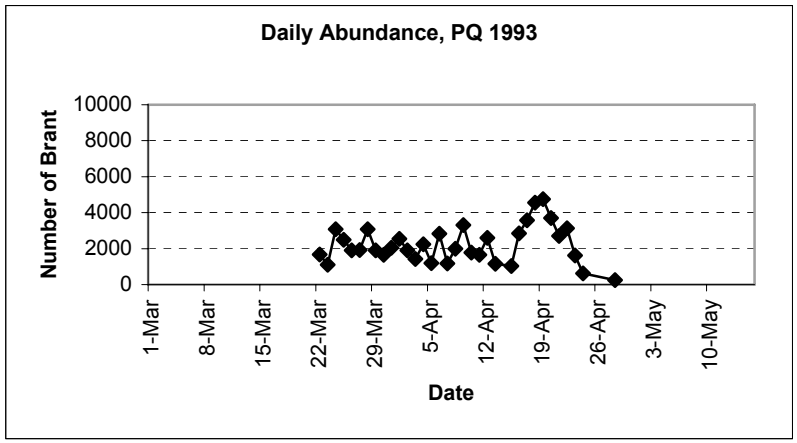
Daily abundance of Brant during spring staging, 1989-2004. Source data are in Appendix 3. Note in 2002 the peak count is 12,794, which is above the maximum value on the y-axis.

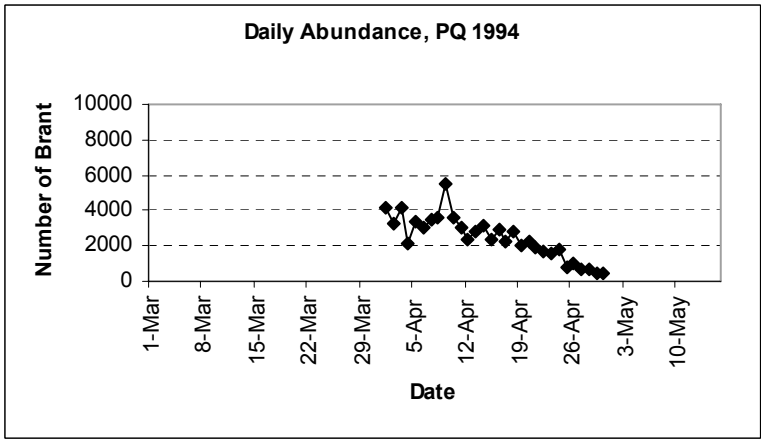


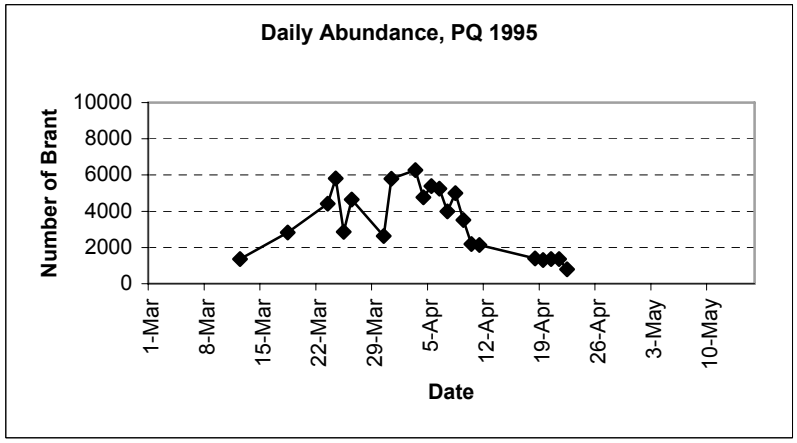


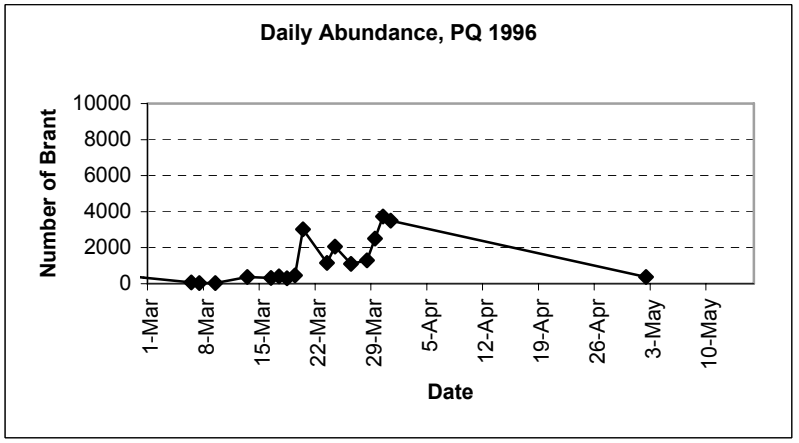


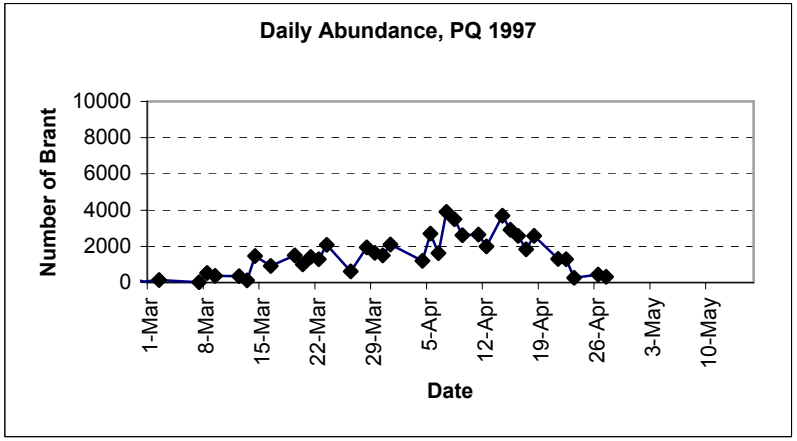


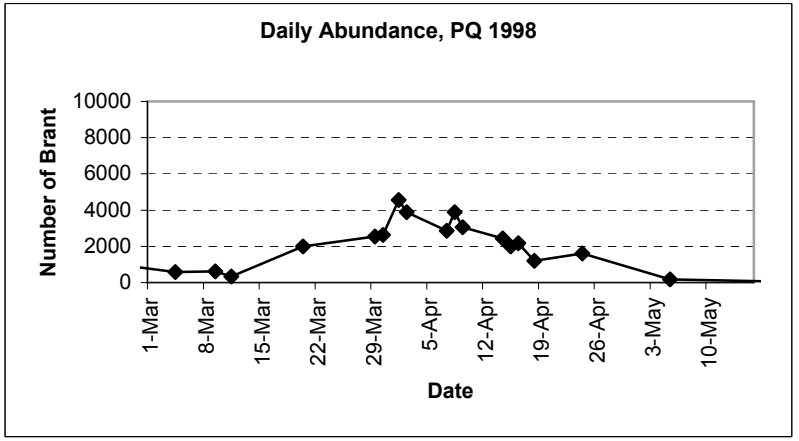

Daily Abundance, PQ 1993
Number of Brant
10000
8000
6000
4000
2000
0
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
Date

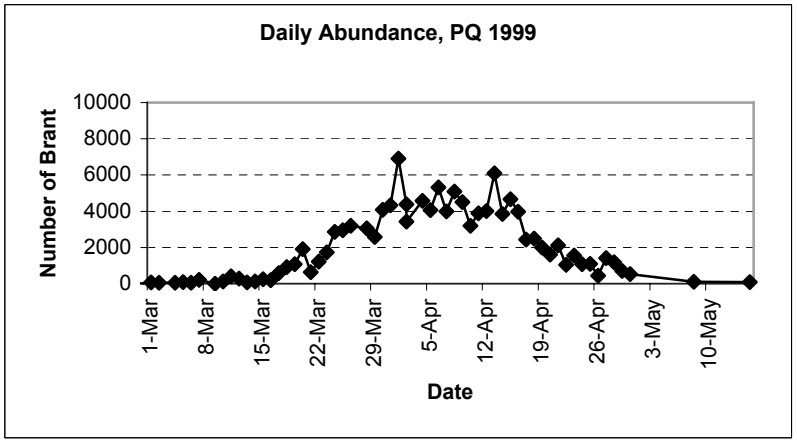

Daily Abundance, PQ 1994
Number of Brant
10000
8000
6000
4000
2000
0
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
Date

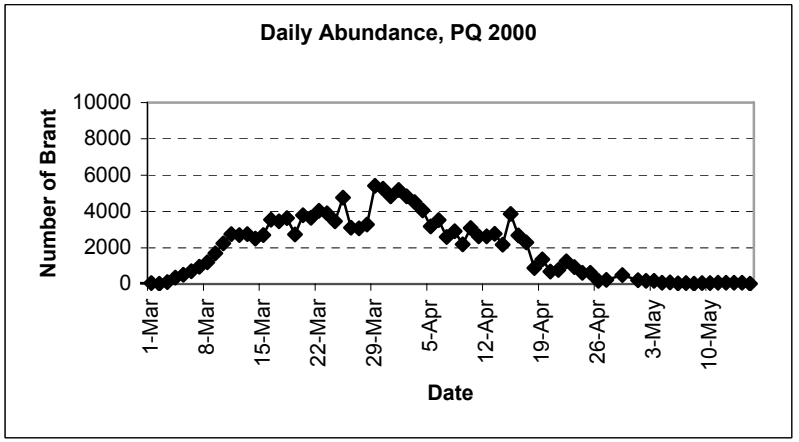

Daily Abundance, PQ 1995
Number of Brant
10000
8000
6000
4000
2000
0
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
Date

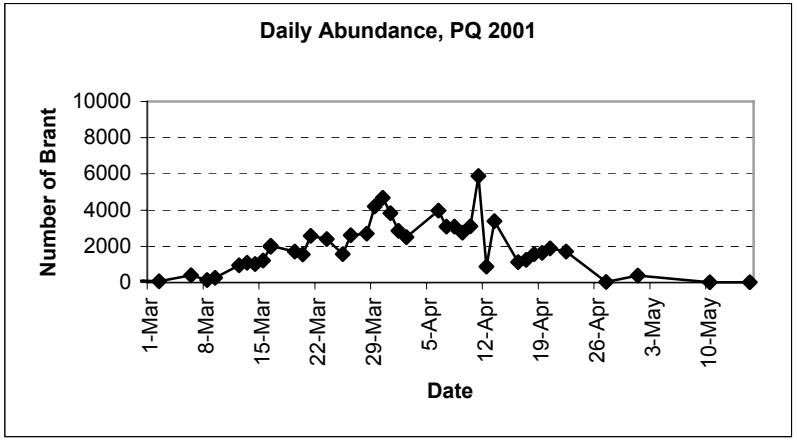

Daily Abundance, PQ 1996
Number of Brant
10000
8000
6000
4000
2000
0
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
Date

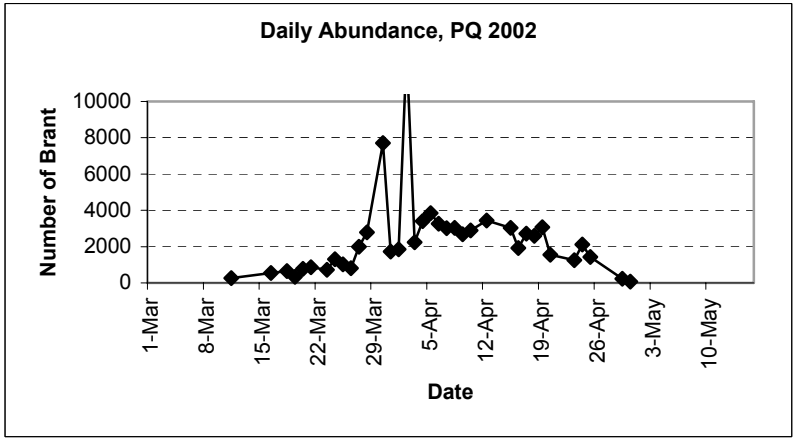

Daily Abundance, PQ 1997
Number of Brant
10000
8000
6000
4000
2000
0
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
Date

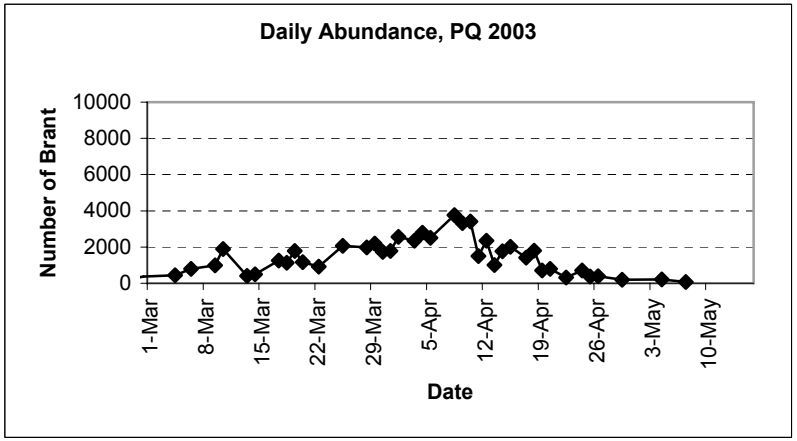

Daily Abundance, PQ 1998
Number of Brant
10000
8000
6000
4000
2000
0
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
Date

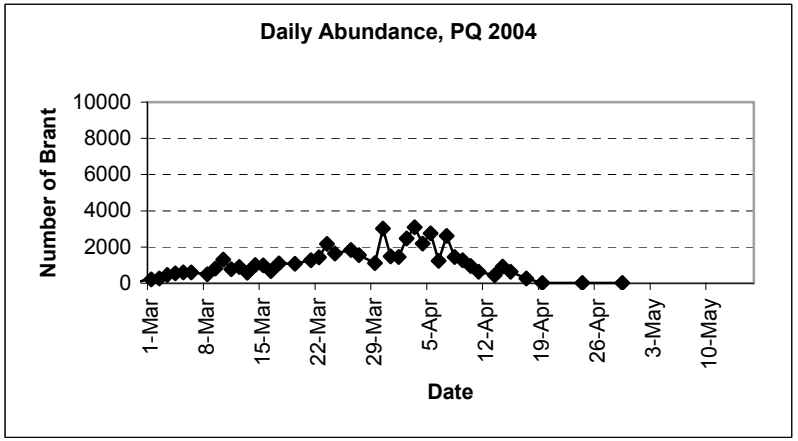

Daily Abundance, PQ 1999
Number of Brant
10000
8000
6000
4000
2000
0
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
Date


Daily Abundance, PQ 2000
Number of Brant
10000
8000
6000
4000
2000
0
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
Date


Daily Abundance, PQ 2001
Number of Brant
10000
8000
6000
4000
2000
0
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
Date


Daily Abundance, PQ 2002
Number of Brant
10000
8000
6000
4000
2000
0
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
Date


Daily Abundance, PQ 2003
Number of Brant
10000
8000
6000
4000
2000
0
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
Date


Daily Abundance, PQ 2004
Number of Brant
10000
8000
6000
4000
2000
0
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
Date

APPENDIX 5

Aerial survey data for Brant on the ECVI (April 6, 1964) and in the Strait of Georgia (SoG) (1990, 1991 and 2004). The 1958 aerial data were reported as a total count, so the numbers of Brant at specific locations are unavailable.

ECVI April 6, 1964

Location	Count
Snake Island	60
Nanoose Bay	575
Rathtrevor	400
Englishman River	420
French Creek	850
Qualicum Beach	350
Deep Bay	1075
Trent River	1405
Comox Bay	775
Willow Point	745
Seal Islets	700
Nanaimo Harbour	30
Ladysmith Harbour	135
Chemainus	200
Cowichan Bay	100
Island View Beach	337
James Island	595
Sidney Island	255
ECVI Total	**9007**

Strait of Georgia 1990

Location	26-Feb	14-Mar	20-Mar	24-Mar	27-Mar	3-Apr	10-Apr	17-Apr	24-Apr	1-May	10-May	15-May
Bazan Bay										254		
Big Qualicum River										180		
Boundary Bay		41		218	102	55	341	480	1105	120		
Cluxewe River												580
Columbia Beach			24		191		555	273	47			
Cortes Island									32			
Denman Island							10					
Discovery Islands							40					
Eve River												46
Goose Spit		166	200	277			900					
Harwood							5					
James Island									20			
Ladysmith Harbour							2					
Lantzville							20					
Lazo Cape										32		
Malcolm Island											6	
Mariana Island							39			4		
Mittlenatch Island							55	5				
Mud Bay (V. Isl.)							215	670	1188	120		
Nanaimo							20					
Niels Bight												20
Oyster River							50	213	77		30	60
Parksville Bay					700		136	398	139			
Qualicum Bay								100	206			
Qualicum Beach		188	180	204	614	2268	1355	407	128	92		
Rathtrevor			400	40	200	672	653	980	834	363		
Roberts Bank						640	1000	780	562	352		
Robson Bight											4	
Savory Island							3					
Seal Islets			200	245	536		633	255		83		
Shelter Point												15
Shushartie Bay												6
Sidney Spit		169		260	536	330	1146	1191	1244	108		
Snake Island					15							
Trent River						290	40	2369	2071	818	179	157
Willow Point					66			174	367	40		
SoG Total	**0**	**564**	**1004**	**1244**	**2960**	**4255**	**7218**	**8295**	**8020**	**2566**	**219**	**1768**

Strait of Georgia 1991

Location	1-Apr	9-Apr	15-Apr	22-Apr	29-Apr
Marina Island	0	25	0	6	0
Cortes Island	0	0	224	105	80
Hernando Island	0	0	339	0	264
Gillies Bay	70	51	98	69	12
Stories Beach	0	0	50	12	20
Oyster River	0	20	77	196	390
Miracle Beach	0	0	170	0	0
Little River	0	8	0	0	0
Cape Lazo	0	0	0	0	24
Goose Spit	300	30	8	463	247
Trent River	0	536	1709	1448	1134
Seal Islets	533	2151	40	224	406
Fillongley Park	150	0	1187	251	53
Hornby Island	0	0	678	132	0
Wilfred Creek	0	0	12	14	0
Mud Bay (V. Isl.)	0	0	291	349	12
Qualicum Bay	0	0	4	94	66
Big Qualicum River	0	0	441	734	1004
Little Qualicum River	923	820	610	561	697
French Creek	414	283	662	668	381
Parksville Bay	0	290	100	50	247
Englishman River Estuary	629	1049	251	10	603
Rathtrevor Park	80	670	1123	488	153
Nanoose Harbour	0	20	20	0	0
Lantzville	0	0	110	0	0
Chemainus River	0	0	20	0	0
Vesuvius Bay	0	0	7	0	0
Sidney Spit	240	267	230	466	46
James Island	0	0	0	0	12
Bazan Bay	100	0	30	6	112
Cordova Spit	84	64	90	34	321
Island View Beach	0	0	130	354	0
Discovery Island	3	0	0	0	0
Clover Point	0	0	5	0	0
Esquimalt Lagoon	0	0	65	0	0
Roberts Bank	700	100	515	328	549
Point Roberts	0	0	110	141	190
Boundary Bay	0	696	1950	672	2510
Ocean SoG	205	0	50	0	0
SoG Total	**4431**	**7080**	**11406**	**7875**	**9533**

Strait of Georgia 2004

LOCATION	27-Feb	6-Mar	12-Mar	28-Mar	1-Apr	8-Apr	18-Apr	30-Apr	7-May
Between Savary and Hernando Islands						103			
Black Creek									14
Boundary Bay				21					
Columbia Beach		3		4	280	42			
Deep Bay				36		29			
Englishman River						230			
Fillongley, Denman Island		4			17	18			
French Creek					77	36			
Ganges Harbour, Salt Spring Island					6				
Goose Spit, Comox					47	8	162		12
Myrtle Rocks, Powell River				28	13		9		3
Oyster River						21	67		
Parksville Bay		2	370	58	380	280		31	
Qualicum Bay						6			
Qualicum Beach			36	260	58	39	106		
Rathtrevor		570	46	45	90	480	65		10
Roberts Bank				131	1920	3726	1530	31	10
Sandy Island	22	16	60	6	32	32	22	8	
Snake Island				14	10				
Stories Beach								4	
Sidney Spit, Victoria				48	36	677	46		
Trent River						1400	37		
Whalebone Point						4			
White Rock							216	39	
Wilson Creek					79				
SoG Total	**22**	**595**	**512**	**651**	**3045**	**7131**	**2260**	**113**	**49**

APPENDIX 6

Dates and bag limits for Brant hunting season in British Columbia, 1950-51 to 2003-2004.

	Bag Limit		Location		
Year	Daily	Season or Possession Limits[1]	ECVI	QCI	FRD
1950-51	5	25	16 Dec – 28 Feb	16 Dec – 28 Feb	16 Dec – 28 Feb
1951-52	5	25	22 Dec – 29 Feb	22 Dec – 29 Feb	22 Dec – 29 Feb
1952-53	5	25	20 Dec – 28 Feb	20 Dec – 28 Feb	20 Dec – 28 Feb
1953-54	5	25	12 Dec – 28 Feb	12 Dec – 28 Feb	12 Dec – 28 Feb
1954-55	5	25	11 Dec – 28 Feb	11 Dec – 28 Feb	11 Dec – 28 Feb
1955-56	5	25	10 Dec – 07 Mar	10 Dec – 07 Mar	10 Dec – 07 Mar
1956-57	5	25	08 Dec – Feb 28	08 Dec – Feb 28	08 Dec – Feb 28
1957-58	5	25	07 Dec – 28 Feb	07 Dec – 28 Feb	07 Dec – 28 Feb
1958-59	5	25	06 Dec – 28 Feb	06 Dec – 28 Feb	06 Dec – 28 Feb
1959-60	3	18	16 Jan – 29 Feb	16 Jan – 29 Feb	16 Jan – 29 Feb
1960-61	3	6	14 Jan – 28 Feb	14 Jan – 28 Feb	14 Jan – 28 Feb
1961-62	3	6	13 Jan – 05 Mar	13 Jan – 05 Mar	13 Jan – 05 Mar
1962-63	3	6	12 Jan – 05 Mar	12 Jan – 05 Mar	12 Jan – 05 Mar
1963-64	3	6	18 Jan – 08 Mar	18 Jan – 08 Mar	18 Jan – 08 Mar
1964-65	3	6	16 Jan - 10 Mar	16 Jan - 10 Mar	16 Jan - 10 Mar
1965-66	3	6	15 Jan – 10 Mar	15 Jan – 10 Mar	15 Jan – 10 Mar
1966-67	4	8	01 Jan – 10 Mar	01 Jan – 10 Mar	01 Jan – 10 Mar
1967-68	4	8	30 Dec – 10 Mar	30 Dec – 10 Mar	02 Dec – 10 Mar
1968-69	4	8	28 Dec – 10 Mar	28 Dec – 10 Mar	07 Dec – 10 Mar
1969-70	4	8	27 Dec – 10 Mar	27 Dec – 10 Mar	06 Dec – 10 Mar
1970-71	4	8	26 Dec – 10 Mar	26 Dec – 10 Mar	05 Dec – 10 Mar
1971-72	4	8	01 Mar – 10 Mar	25 Dec – 10 Mar	04 Dec – 10 Mar
1972-73	4	8	01 Mar – 10 Mar	23 Dec – 10 Mar	02 Dec – 10 Mar
1973-74	4	8	01 Mar – 10 Mar	22 Dec – 10 Mar	01 Dec – 10 Mar
1974-75	4	8	01 Mar – 10 Mar	21 Dec – 10 Mar	30 Nov – 10 Mar
1975-76	4	8	01 Mar – 10 Mar	21 Dec – 10 Mar	29 Nov – 10 Mar
1976-77	4	8	01 Mar – 10 Mar	21 Dec – 10 Mar	04 Dec – 10 Mar
1977-78	3	6	01 Mar – 10 Mar	21 Dec – 10 Mar	01 Mar – 10 Mar
1978-79	3	6	Closed	21 Dec – 10 Mar	01 Mar – 10 Mar
1979-80	3	6	Closed	21 Dec – 10 Mar	01 Mar – 10 Mar
1980-81	3	6	Closed	21 Dec – 10 Mar	01 Mar – 10 Mar
1981-82	3 (2)*	6 (4)*	Closed	21 Dec – 10 Mar	01 Mar – 10 Mar
1982-83	3 (2)*	6 (4)*	Closed	21 Dec – 10 Mar	01 Mar – 10 Mar
1983-84	3 (2)*	6 (4)*	Closed	21 Dec – 10 Mar	01 Mar – 10 Mar
1984-85	3 (2)*	6 (4)*	Closed	21 Dec – 01 Jan	01 Mar – 10 Mar
1985-present	2	4	Closed	closed	01 Mar – 10 Mar

[1] Season limits were changed to possession limits in 1960-1961

*QCI had a bag limit of 2 and a possession limit of 4 from 1981-82.

APPENDIX 7

Methods for Harvest Estimates based on Tarsal-band Data

- Assumed 8-10% of the PFBP is banded and equally distributed along the Flyway
- Based on observations at Boundary Bay, Vancouver Island, Oregon and California
- Removed Grey-bellied Brant from analysis as Grey-bellied Brant were not banded at this time
- Estimated 3-year population mean for each wintering area

	Year			
Site	**1997-98**	**1998-99**	**1999-00**	**Mean**
FRD	619	985	1238	947
WA	4541	6037	5944	5507
OR	580	645	523	583
CA	6091	4296	3389	4592
MX	112105	100760	108440	107102

	Year			
Site	**1997-98**	**1998-99**	**1999-00**	**Total**
10 days before				
FRD	15	7	31	53
WA	0	0	0	0
OR	0	0	0	0
CAL	4	0	0	4
MX	11	1	1	13
10 days of hunt				
FRD	13	10	14	37
WA	0	0	3	3
OR	0	0	0	0
CAL	2	0	0	2
MX	11	3	2	16
Total				
FRD	28	17	45	90
WA	0	0	3	3
OR	0	0	0	0
CAL	6	0	0	6
MX	22	4	3	29

1) Combined the band data for 10 days before and 10 days of the hunt to establish the segments of the PFBP vulnerable to hunting.

2) Estimated population composition based on wintering ground affiliation

3) Estimated the number of birds in the harvest from each wintering ground based on a harvest of 150-200 Brant.

4) Estimated the % of birds harvested from each wintering population: B.C. = 11-15%, Washington < 1%, Oregon < 1%, California < 1%, and Mexico < 1%.

APPENDIX 8

Mean (with SD and n) weekly spring Brant API scores in the Parksville-Qualicum area 1999-2004. No Brant were present each year in week 1.

	2			3			4			5			6			7		
Spring Year	$\bar{x}$	**SD**	**n**	$\bar{x}$	**SD**	**n**	$\bar{x}$	**SD**	**n**	$\bar{x}$	**SD**	**n**	$\bar{x}$	**SD**	**n**	$\bar{x}$	**SD**	**n**
1999	-	-	-	-	-	-	1.2	0.3	5	1.4	0.3	47	1.9	0.4	25	2.8	0.6	77
2000	-	-	-	-	-	-	1.6	0.5	89	2.4	0.5	351	2.7	0.5	316	3	0.6	338
2001	-	-	-	1.6	0.4	5	1.5	0.5	18	1.7	0.5	76	1.9	0.5	98	2.3	0.5	152
2002	-	-	-	-	-	-	-	-	-	2	0.6	7	2	0.5	34	1.9	0.5	117
2003	1.5	0	4	1.7	0.4	15	1.6	0.4	31	1.7	0.4	65	1.8	0.4	76	2.1	0.5	78
2004	-	-	-	1.4	0.3	57	1.7	0.3	17	1.7	0.2	21	1.9	0.5	69	1.9	0.5	25

	8			9			10			11			12			13		
Spring Year	$\bar{x}$	**SD**	**n**	$\bar{x}$	**SD**	**n**	$\bar{x}$	**SD**	**n**	$\bar{x}$	**SD**	**n**	$\bar{x}$	**SD**	**n**	$\bar{x}$	**SD**	**n**
1999	3.3	0.4	100	3.4	0.5	157	3.8	0.4	99	3.8	0.4	34	-	-	-	-	-	-
2000	3.0	0.7	186	3.7	0.5	247	3.1	0.6	67	3.9	0.2	18	2.9	0.4	35	2.8	0.5	42
2001	2.5	0.5	59	2.7	0.5	94	2.6	0.6	84	-	-	-	-	-	-	-	-	-
2002	2.5	0.5	148	2.5	0.7	170	2.8	0.6	156	2.7	0.4	13	2.7	0.5	7	-	-	-
2003	2.2	0.5	109	2.4	0.6	121	2.6	0.6	112	2.7	0.7	39	3	0.7	15	-	-	-
2004	2.5	0.7	75	2.5	0.6	34	2.3	0.3	3	2.3	0.6	3	-	-	-	-	-	-

APPENDIX 9

Mean (with SD and n) weekly spring Brant API scores in the FRD 2000 - 2001.

	1			2			3			4			5			6		
Spring Year	$\overline{X}$	**SD**	**n**	$\overline{X}$	**SD**	**n**	$\overline{X}$	**SD**	**n**	$\overline{X}$	**SD**	**n**	$\overline{X}$	**SD**	**n**	$\overline{X}$	**SD**	**n**
2000	2.6	0.4	17	2.1	0.2	24	2.1	0.5	8	2.3	0.3	6	2.5	0.4	5	2.6	0.4	20
2001	1.7	0.3	10	1.6	0.4	27	1.7	0.4	6	1.6	0.7	6	1.7	0.3	3	1.6	0.6	27

	7			8			9			10			11			12		
Spring Year	$\overline{X}$	**SD**	**n**	$\overline{X}$	**SD**	**n**	$\overline{X}$	**SD**	**n**	$\overline{X}$	**SD**	**n**	$\overline{X}$	**SD**	**n**	$\overline{X}$	**SD**	**n**
2000	3.1	0.5	22	3.1	0.4	8	3.5	0.5	17	3.1	0.5	38	3.8	0.4	2	-	-	-
2001	1.9	0.7	19	2.1	0.4	8	2.2	0.7	11	-	-	-	1.9	0.5	4	-	-	-

APPENDIX 10

Relative ranks of overall API and spawn index[1]

Site[2]	Relative API Rank[3]	Number of Spawn Sites	Spawn Index[4]
FRD 2000	1	0	0
FRD 2001	2	0	0
PQ 1999	2	13	2685868
PQ 2000	1	12	3045227
PQ 2001	4	11	2912116
PQ 2002	3	11	1992279
PQ 2003	4	15	3719553

1. From: www.pac.dfo-mpo.gc.ca/sci/herring/herspawn
2. FRD = Fraser River Delta; PQ = Parksville-Qualicum area
3. Overall API score
4. A measure of herring roe biomass/density