Maintenance of population structuring in sympatric-wintering populations of Greater White-fronted Geese *Anser albifrons*: behaviour, ecology and landscapes

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I present information on the distribution and ecology of three morphologically distinct populations of Greater White-fronted Geese that breed in Alaska and winter primarily in the Pacific Flyway states of California and Oregon, and western Mexico. The breeding areas of the three populations are the Cook Inlet Basin (CIB) for the Tule Greater White-fronted Goose *A. a. elgasi*, the Yukon-Kuskokwim Delta (YKD) for the Pacific Greater White-fronted Goose *A. a. frontalis*, and the Bristol Bay Lowlands (BBL) for the Bristol Bay Greater White-fronted Goose (currently considered a form of *A. a. frontalis*). Observations of neck-banded geese indicated that structuring among these populations is maintained through temporal and geographic segregation, as well as via ecotypic differences in habitat selection. The population most likely to be negatively affected by resource competition was the most allopatric during winter. Resource partitioning also likely contributed to structuring, as CIB geese, whose large body size is adapted to aquatic foraging, were primarily marsh feeders during autumn and spring migration, in contrast to YKD and BBL geese that fed on farmlands. Foraging habits appeared linked to migration behaviour. The more sedentary CIB geese likely expended relatively little energy locating relatively poor quality, but predictable food sources and had a short migration to breeding areas, whereas the smaller-bodied YKD and BBL populations flew out daily to search for high quality, but somewhat more unpredictable foods, and migrated farther to breeding areas in far western Alaska. Conservation of population structuring in these birds will likely depend upon on the conservation of wetlands favoured by CIB geese, and the ability of birds to adapt to climate-induced perturbations in migration and breeding schedules.

Key words: Greater White-fronted Goose *Anser albifrons*, subpopulations, behaviour, ecology, ecotype, population structure.

1. Introduction

Population structuring, although most common in sedentary organisms (Arguedas & Parker 2000), is well documented in migratory birds, including waterfowl (Zink 1996). In polytypic species it is generally presumed that phenotypic variation, and some level of population genetic structuring, is an outcome of natural selection, with different forms adapted to specific environments or habitats (niches). Identification and quantification of "ecotypes" is a priority among conservationists and resource managers, as maintenance of genetic diversity is a common goal in wildlife conservation (Avise & Hamrick 1996). Once distinctive forms are identified then it becomes imperative to discover the mechanisms sustaining population structure with the objective of enhancing long-term persistence.

There is little empirical data on the behaviour and distribution of sympatric wintering subspecies or populations of waterfowl or documentation of potential isolating mechanisms. In North America, research on gene flow and population structuring among various forms of the Mallard *Anas platyrynchos* have focused on comparisons with the more geographically restricted, and habitat-dependent Black Duck *Anas rubripes*; Merendino *et al.* 1993; Morton 1998), and genetic differentiation among "Mallard-type" sibling species/subspecies, including the Mottled Duck *A. fuvigula*, and the Mexican Duck *A. diazi*, the latter two forms of which are non migratory, and exhibit a high degree of population structuring (McCracken *et al.* 2001). Although the evolution of the above forms is somewhat premised on a degree of allopatry, the same is not true of many of the different subspecies of Canada Geese *Branta canadensis* subsp. and Cackling Geese *Branta hutchinsii* subsp., many forms of which winter sympatrically (Bellrose 1976), but whose comparative wintering ecology has been little studied.

Of interest in the present paper is the Greater White-fronted Goose, a species of Holarctic distribution that has recently been shown to exhibit considerable morphological variation throughout their breeding range (Ely *et al.* 2005). In the Pacific Flyway of western North America three identifiable populations overlap in migratory pathways and winter distribution, but not in breeding range (Orthmeyer *et al.* 1995; Ely & Takekawa 1996; Ely *et al.* 2005). The three populations are morphologically different in size, and range in size from the smallest North Ame-

Fig. 1: Photograph of Pacific Flyway Greater White-fronted Geese from three different breeding areas. Photo was taken at a moulting site on Innoko National Wildlife Refuge in interior Alaska, a known moulting site for geese from the Cook Inlet Basin (large dark bird in centre of photo), and the Yukon-Kuskokwim Delta (comparable in appearance to the small bird in lower right, although often lighter in colour). The bird in the lower left is likely from interior Alaska, but is very similar in size and colour to birds from the Bristol Bay Lowlands. - Photo von Blessgänsen aus drei verschiedenen Brutgebieten des Pazifischen Flugweges. Das Photo wurde am Mauserplatz des Innoko National Wildlife Refuge im Inland von Alaska genommen. Das Gebiet ist ein bekanntes Mausergebiet für Gänse vom Cook Inlet Basin (großer dunkler Vogel im Zentrum des Bildes), und vom Yukon-Kuskokwim-Delta (im Erscheinungsbild vergleichbar mit dem kleinen Vogel unten rechts, obwohl häufig heller gefärbt). Der Vogel links unten kommt wahrscheinlich aus dem Inland Alaskas, ist aber in Größe und Farbe den Vögeln von der Bristol-Bay-Niederung sehr ähnlich.

rican form on the Yukon-Kuskokwim Delta (YKD; 2,100 g moulting mass) to the Bristol Bay Lowlands (BBL) birds (2,180 g) to the world's largest Greater White-fronted Goose from the Cook Inlet Basin (CIB), the Tule Goose (2,670 g; Fig. 1). Although there has been prior documentation of the winter distribution of CIB Geese (Wege 1984) and a detailed study of the differences in migration and winter distribution of geese from the YKD and the BBL regions of Alaska (Ely & Takekawa 1996), until now there has not been a simultaneous analysis of the wintering ecology of birds from the three breeding areas, or an assessment of factors possibly maintaining presupposed reproductive isolation among these groups despite their seemingly broad overlap in migration and wintering range. Here I present information on factors contributing to geographic, ecological, and behavioural segregation among these ecotypes based on observations of individually recognisable geese during the winter period.

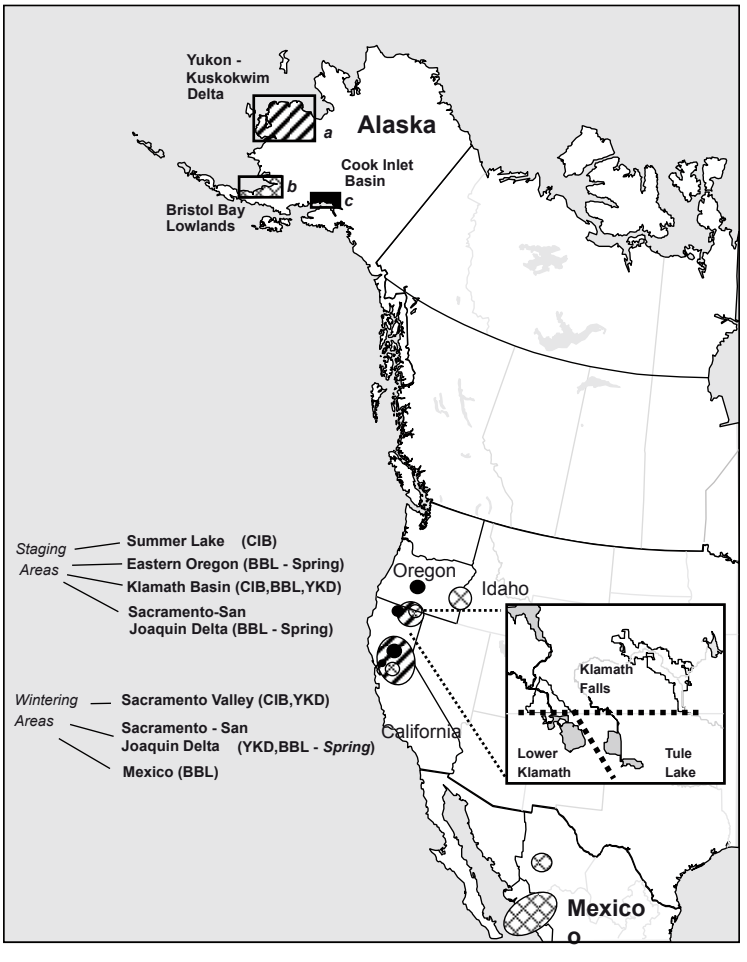

Fig. 2: Distribution of three populations of Greater White-fronted Geese in the Pacific Flyway, including A. a. frontalis from (a) the Yukon-Kuskokwim Delta, and (b) the Bristol Bay Lowlands, and (c) A. a. elgasi from the Cook Inlet Basin. Inset: The Klamath Basin, showing areas used by different breeding populations during autumn and spring. - *Verbreitung der drei Populationen der Blessgans des Pazifischen Flugweges, einschließlich A. a. frontalis vom (a) Yukon-Kuskokwim-Delta, und von der (b) Bristol-Bay-Niederung sowie (c) A. a. elgasi vom Cook-Inlet-Basin. Einsatz: das Klamath Basin mit den Gebieten, die im Herbst und Frühjahr durch die verschiedenen Brutpopulationen genutzt werden.*

2. Methods

2.1. Study area

Research was conducted from 1979–1982 on the primary staging and wintering areas of Greater White-fronted Geese in the Pacific Flyway, which includes the Klamath Basin of North California/South Oregon, and the Sacramento Valley and Sacramento-San Joaquin Delta of North California (Bellrose 1976; Fig. 2). Geese were studied from the time they arrived from Alaska in early September until they flew north again in early May. To examine temporal variation in distribution and habitat use of geese I divided the study period into six sampling periods: Early Autumn – 1st Sept. to mid Oct. (opening of hunting season); Late Autumn - mid Oct. to 30th Nov.; Early Winter – 1st Dec. to mid Jan. (end of hunting season); Late Winter - mid Jan. to March; Early Spring - March; Late Spring - April to departure of birds (usually by 7th May).

2.2. Distribution

Birds were monitored by tracking the movements of individuals fitted with coded plastic neck bands (Ely 1990). Geese were captured and marked during autumn, winter, and spring in California and Oregon, and during summer on the Yukon-Kuskokwim (Y-K) Delta, Alaska (Ely 1992), representing breeding populations from the Y-K Delta, and the Bristol Bay Lowlands, Alaska. Birds from the Bristol Bay Lowlands migrate through the Klamath Basin in early autumn, before YKD birds arrive (Ely & Raveling 1989; Ely & Takekawa 1996), so birds marked in the Klamath Basin before 23 September were assumed to have originated from the Bristol Bay Lowlands and those captured afterward from the Y-K Delta (Orthmeyer *et al.* 1995). Tule Geese, which breed in the Cook Inlet Basin, Alaska, were fitted with collars during winter in the Sacramento Valley (subspecies identification based on morphology) and on the breeding grounds during summer (Wege 1984). I monitored the distribution and density of staging and wintering geese by conducting local censuses of the number of neck-banded geese in the population (Ely 1992; Schmutz & Ely 1999). The distribution of marked geese closely approximated the true population distribution, as neck collared geese tended to be uniformly dispersed within the unmarked population (Schmutz & Ely 1999; C. Ely, unpubl. data).

I estimated the proportion of each population wintering in Mexico based on the distribution of recoveries of leg banded geese reported to the U.S. Geological Survey Bird Banding Laboratory. Distribution information based on leg band recoveries is mainly restricted in time to the harvest period (September to mid January).

2.3. Habitat use and Diet

I monitored habitats used by geese throughout the day, either by following them to foraging sites during morning and evening feeding periods, or at roost sites (Ely 1992; Alisauskas & Ankney 1992). When a flock was encountered, I mapped the location, determined the habitat, and counted the number of birds in each flock. Habitats that were similar in appearance were aggregated, such as stubble from cereal grains in the Klamath Basin, as well as different types of green vegetation, including irrigated pasture lands and winter-planted grain.

Food items eaten by YKD geese were determined by collecting (by shooting) birds at or near foraging sites during autumn and spring in the Klamath Basin, and during winter in the Sacramento Valley and the Sacramento-San Joaquin Delta (SSJD) during 1980-81 (see Ely & Raveling 1989 for details). Nutrient content of foods eaten by BBL geese was based on birds collected during winter on the SSJD. Assessment of the diet of CIB geese was restricted to springtime in the Klamath Basin, where they fed nearly exclusively on tubers of Alkali Bulrush *Bolboschoenus maritimus*, which were collected from feeding sites. Food items were sorted by species, rinsed with water to eliminate digestive mucosa, freeze-dried to constant weight, and then ground in a Wiley mill to pass a 40-mesh sieve. Nitrogen content, lipid, cell wall fraction, and mineral content (ash) were determined by proximate analysis (Horowitz 1975; Alisauskas & Ankney 1992).

2.4. Data Analysis

Differences among means were tested with analysis of variance (general linear models; PROC GLM, SAS Institute Inc. 1999); type III sums of squares were used to test hypotheses. I treated population as an independent variable in ANOVA models with arrival dates as dependent variables. Least significant difference (LSD) tests were used for follow-up comparisons (Sokal & Rohlf 1981). Chi-squared contingency tests were used for comparing the distribution of birds at staging and wintering areas. Means ± SE are presented, unless otherwise noted. All tests were two-tailed, and differences were considered significant at $P \leq 0.05$.

3. Results

3.1. Distribution and Timing

Geese from the three different breeding areas in Alaska all used the Klamath Basin in northern California and southern Oregon during autumn migration (Fig. 2), but the timing of use differed significantly among populations ($F_{2,656} = 147.2$, $p < 0.0001$). BBL geese were the first to arrive to the Klamath Basin ($\bar{x} = 16.6 \pm 0.6$ SE September), followed CIB geese ($\bar{x} = 22.3 \pm 1.3$ September) and 3 weeks later, YKD geese ($\bar{x} = 16.3 \pm 0.71$ October). Timing of arrival of CIB and BBL geese did not differ significantly ($p > 0.05$). Although BBL and CIB geese used the Klamath Basin at the same time, they were geographically segregated, as most (87.8%, n = 139) CIB geese were found on the Lower Klamath side of the basin (Fig. 2), while BBL and YKD geese predominantly used the east side of the basin (all observations of BBL geese [n=13] and 91.9 % of YKD geese [n=505]; $\chi^2 = 375.1$, $p < 0.0001$, 2 df, Fig. 2 and 3). BBL and CIB geese also departed the Klamath Basin well in advance of YKD geese ($\bar{x} = 22.7 \pm 2.4$ SE and 24.5 $\pm$ 1.3 September for BBL and CIB geese, respectively, vs. $\bar{x} = 2.2 \pm 0.66$ November for YKD geese; $F_{2,767} = 386.3$, $p < 0.0001$).

After departing the Klamath Basin, CIB and YKD geese migrated south to winter in the Sacramento Valley of California, while most BBL geese largely bypassed the Sacramento Valley and flew directly to western Mexico, as indicated by band return data (45 of 86 BBL birds recovered in Mexico, vs. 61 of 810 YKD geese and 2 of 158 CIB geese; $\chi^2 = 185.9$, 2 df; $P < 0.0001$). Of the BBL geese not recovered in Mexico, most were harvested in the San Joaquin Valley and Sacramento-San Joaquin Delta of California in late December and January after wintering in Mexico (Fig. 2, 3).

Migration patterns of geese during spring were somewhat different than during autumn. Although YKD geese returned to the Klamath Basin for spring staging, they were more broadly distributed in the Basin than in autumn, and used small wetlands in southern Oregon as well as in California (the "Klamath Falls" region in Fig. 2, 3). Many BBL geese remained on the Sacramento-San

Joaquin Delta until late spring, while others migrated north to areas in eastern Oregon and far western Idaho. Areas north of the Klamath Basin were not closely monitored during this study, although there were incidental sightings of BBL geese in the Malheur Basin in eastern Oregon. As in autumn, CIB geese were found almost exclusively in the Lower Klamath portion of the Basin during spring, and thus, were geographically isolated from BBL geese.

3.2. Habitat Use

There were major differences in habitats used by geese from the different breeding areas that were primarily dictated by population distribution. During autumn migration, BBL birds spent little if any time in the Sacramento Valley, but migrated to the west coast and Central Highlands of Mexico before migrating back to the Sacramento-San Joaquin Delta, where they fed primarily on maize. In contrast, CIB and YKD geese wintered predominantly in the Sacramento Valley of California where they fed on harvested rice, often using the same fields (although even then, subflocks remained somewhat segregated). During spring, CIB geese were found primarily on marsh habitats in the Klamath Basin (78.1 %; 25 of 32 flocks composed predominantly of CIB geese) where they roosted and fed, as opposed to YKD geese that flew out twice a day from water roost sites to feed on surrounding agricultural fields (7.8 % of 486 flocks foraging on wetlands vs. in fields; $\chi^2 = 138.9$, 1 df, $P < 0.0001$). The diets of geese using these two strategies were remarkably different, with wetland-foraging CIB geese feeding primarily on the submerged rhizomes of Alkali Bulrush, a food source much lower in protein and digestible carbohydrates than the agricultural foods ingested by YKD geese (Tab. 1).

4. Discussion

4.1. Dynamics of Distribution

Findings from this paper are complementary to earlier research by Wege (1984) who presented distribution and population data for CIB geese, and Ely & Takekawa (1996), who tracked radio-marked geese that elucidated differences in migration behaviour and winter distribution of BBL and YKD geese. Ely & Takekawa (1996) found that BBL geese were temporally isolated from YKD geese during autumn, whereas these new findings show that BBL geese were on a similar autumn migration schedule as CIB geese, but were geographically isolated from CIB geese.

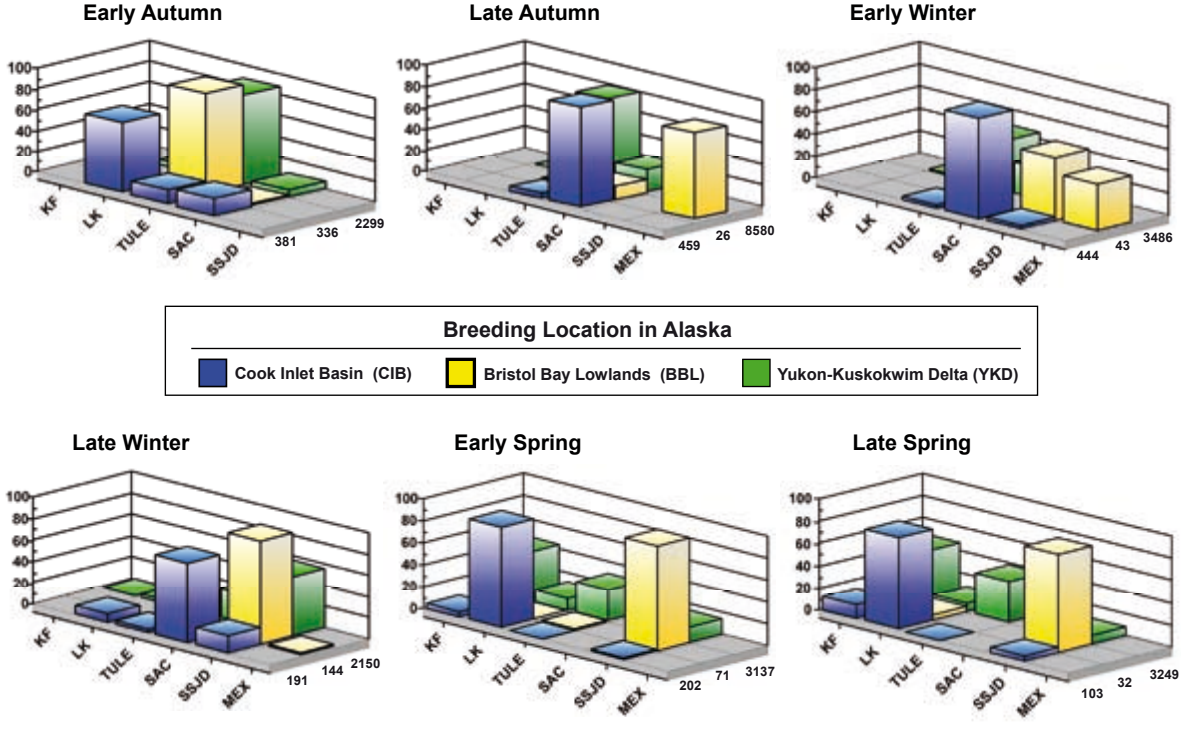

Fig. 3: Differences among populations of Greater White-fronted Geese in timing of use of different migration and wintering areas in the Pacific Flyway. Data are observations of neck-collared birds, except for BBL geese in Late Autumn and Early Winter, where proportions are based on the distribution of leg band recoveries (see Methods). Numbers in margins of each figure represent the total number of observations of collared birds observed from each population during the respective time period (except as above). Abbreviations for locations are: KF = Klamath Falls, LK= Lower Klamath, TULE = Tulelake, SAC = Sacramento Valley, SSJD = Sacramento-San Joaquin Delta, MEX = Mexico. - Unterschiede zwischen den Populationen der Blessgans im Zeitablauf der Nutzung der verschiedenen Rast- und Wintergebiete entlang des Pazifischen Zugweg. Die Daten basieren auf Beobachtungen von Vögeln, die mit Halsringen markiert sind, mit Ausnahme der BBL-Gänse im Spätherbst und Frühwinter; hier basieren die Anteile auf den Rückmeldungen von Fußringen (siehe Methods). Die Zahlen in der Marge der einzelnen Grafiken geben die Zahl der Beobachtungen markierter Vögel der jeweiligen Population in der jeweiligen Periode an (Ausnahme wie oben). Die Kürzel für die einzelnen Gebiete bedeuten: KF = Klamath Falls, LK= Lower Klamath, TULE = Tulelake, SAC = Sacramento Valley, SSJD = Sacramento-San Joaquin Delta, MEX = Mexico.

CIB and BBL geese remained mostly spatially segregated during winter and throughout spring as well. The greatest geographic overlap among populations was between YKD and CIB geese, which shared common wintering areas in the Sacramento Valley and during spring in the Klamath Basin. However during spring, YKD and CIB geese were ecologically segregated via resource partitioning.

BBL geese have previously been reported to winter primarily on the west coast and northern Highlands of Mexico (Ely & Raveling 1989; Ely & Takekawa 1996). These areas in Mexico may be of greater importance to wintering BBL geese than represented by band recovery data, because recovery and reporting rates of birds are likely lower in Mexico than in the United States due to reduced hunting pressure, and language and cultural barriers that impede submission of leg band data to the U.S. Bird Banding Laboratory. It is probably not coincidental that the population with the geographically most disjunct wintering area is also the form intermediate in body size and hence most likely to be affected by resource competition (see below).

Table 1: Nutrient content (% dry weight) of predominant spring foods used by two subspecies of Greater White-fronted Geese in the Klamath Basin during spring in the Pacific Flyway1. – *Nährstoffgehalt (in % Trockengewicht) der wichtigsten Frühjahrsnahrungspflanzen der beiden Subspezies der Blessgans im Klamath-Becken entlang des Pazifischen Flugweges im Frühjahr1.*

Subspecies /Diet – *Unterart/Nahrung*	Protein – *Eiweiß*	Lipid – *Lipid*	Ash – *Rohasche*	Cell wall (NDF) – *Zellwände*	Cell solubles – *Zelllösung*
Tule Greater White-fronted Goose *Anser albifrons elgasi*					
Alkali bulrush – *Bolboschoenus maritimus* (Gemeine Strandsimse)	4.7	3.5	4.7	60.9	26.2
Pacific Greater White-fronted Goose *Anser albifrons albifrons*					
Seeds[2] – *Samen*	14.0	3.1	13.2	34.3	35.6
Potatoes – *Kartoffeln*	7.3	0.6	12.5	15.6	64.3
Green vegetation – *grüne Pflanzenteile*	22.8	2.5	13.9	38.1	22.7
Mean[3] – *Mittelwert*	14.7	2.1	13.2	29.3	40.9

[1] Data from Ely and Raveling, unpubl. data, [2] Mean of oats and barley, [3] Assumes equal consumption of all three food types

Although the overall winter range of the different populations of geese has changed little since the time of the present study, there have been some changes in the relative importance of different areas. Most YKD geese now bypass the Klamath Basin in autumn and fly directly to the Sacramento Valley of California. Analysis of band recovery data (restricted to the hunting period from mid October to mid January) indicates a significant ($\chi^2 = 35.44$, 1*df*) increase in the proportion of CIB harvested in Oregon, from 3.8 % prior to 1990 ($n = 157$ total recoveries) to 31.0 % since then ($n = 87$ total recoveries), which indicates a northward shift in autumn distribution. The distribution of CIB geese has also changed in spring. Whereas during this study and Wege's (1984) nearly all CIB geese used the Klamath Basin during spring, they are now primarily found on wetlands in central Oregon, including Summer Lake (M. S. Louis, pers. comm.); an area reported by Wege (1984) to be used only during autumn.

4.2. Habitat use and resource partitioning

Our findings that CIB geese (Tule Geese) fed on harvested rice during winter similar to YKD geese, is somewhat in contrast to early reports stating they were primarily marsh feeders (Swarth & Bryant 1917). However, since Swath and Bryant's study, there has been continued and substantial wetland loss in the Sacramento Valley of California, and it appears that CIB geese have been able to adapt to this alternative food source, at least during winter when energy and nutritional demands are at a minimum (Ely & Raveling 1989). It is unknown whether CIB geese, whose large body size and length of extremities adapts them to foraging on aquatic foods, would be able to adapt to similar changes in habitat on spring staging areas. The reliance of CIB geese on submerged aquatic vegetation is well suited to (or dictates) their sedentary, nearly non-volant behaviour during spring staging. It is not surprising that exploitation of a relatively low quality food resource in spring is reflected in only nominal increases in body mass compared to YKD geese (C. Ely and J. Takekawa, unpubl. Data; Ely *et al.* 2007), and illustrates the diversity of adaptation within the species. Indeed, Ely & Raveling (1989) postulated that BBL geese may have a different annual energy cycle than YKD geese, based on differences in body mass and composition at different times during the winter.

4.3. Behaviour

The traditional definition of a subspecies as "an aggregate of phenotypically similar populations of a species, inhabiting a geographic subdivision of the range of a species, and differing taxonomically from other populations of the species" was an extension of the biological species concept (Mayr 1969). The definition has been more recently modified by adding that valid subspecies "should come from the concordant distribution of multiple, independent, genetically based traits" (Avise & Ball 1990), and "share a unique geographic range or habitat, a group of phylogenetically concordant phenotypic characters, and a unique natural history relative to other subdivisions of the species" (O'Brien & Mayr 1991). Differences documented here pertaining to BBL geese seemingly indicate they may merit subspecies status, especially given their profoundly disjunct wintering range. However, without more pronounced differences in morphology (they are statistically distinguishable from CIB and YKD geese, but there is still considerable overlap; Orthmeyer *et al.* 1995), such a designation would be tenuous without confirmation of genetic differentiation. BBL geese likely lay on a continuum between YKD and CIB geese in terms of morphology and life history characters.

Population structuring in Pacific Flyway Greater White-fronted Geese has likely persisted due to strong selection pressure for behavioural attributes optimising

timing of migration and breeding (which are tightly linked, if not inseparable events in geese; Ely *et al.* 2007) that constrain geese to choose mates on the same schedule. The implications of timing and location of pairing on genetic population structure has been well appreciated for ducks (Anderson *et al.* 1992) and geese (Ely & Scribner 1994). Recent work has revealed that within-species climate-induced differences in migration chronology can influence mate selection and potentially lead to speciation in migratory birds, especially if birds pair assortatively (Bearhop *et al.* 2005). While it remains to be seen if Greater White-fronted Geese pair assortatively (C. Ely and A. Fox, unpubl. data), it is clear that geese have a complex social system and behavioural attributes (e.g. Raveling 1979; Ely 1993) that predisposes them to forming sub-populations, or demes. Although "classic" allopatric mechanisms of speciation are undoubtedly important in contributing to the extant diversity of waterfowl (Ploeger 1968), it appears that in geese the juncture of temporal, spatial, and behavioural dimensions is the hinge to the door of speciation.

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5. Zusammenfassung

Ely, C.R. 2008: Erhalt der Populationsstruktur bei sympatrisch überwinternden Populationen der Blessgans *Anser albifrons*: Verhalten, Ökologie und Landschaft. Vogelwelt 129: 310–316.

In der vorliegenden Arbeit werden Informationen über die Verbreitung und Ökologie dreier morphologisch verschiedener Populationen der Blessgans, die in Alaska brüten und vornehmlich im Bereich des Pazifischen Zugweges in Kalifornien, Oregon und im Westen Mexikos überwintern, präsentiert. Die Brutgebiete der drei Populationen sind das Cook Inlet Basin (CIB) für die Tule-Blessgans *A. a. elgasi*, das Yukon-Kuskokwim-Delta (YKD) für die Pazifische Blessgans *A. a. frontalis* und die Bristol-Bay-Niederung (BBL) für die Bristol-Bay-Blessgans (gegenwärtig als eine Form von *A. a. frontalis* betrachtet). Beobachtungen von Gänsen mit Halsringen geben Hinweise darauf, dass die Populationsstruktur durch eine zeitliche und geographische Trennung der Populationen sowie durch ökotypische Unterschiede bei der Habitatselektion aufrechterhalten wird. Die Population, die wahrscheinlich am stärksten unter einer Konkurrenz um Ressourcen leiden würde, verhielt sich im Winter am stärksten allopatrisch. Die Aufteilung der Ressourcen hat wahrscheinlich auch zur Entwicklung der Populationsstruktur beigetragen, da die CIB-Gänse, die mit ihrer größeren Körpergröße an eine aquatische Nahrungsaufnahme angepasst sind, sich auf dem Herbst- und dem Frühjahrszug vornehmlich in Sumpfgebieten ernährten, wohingegen die YKD- und BBL-Gänse auf Agrarland fraßen. Zwischen den Ernährungsgewohnheiten und dem Zugverhalten scheint eine Verbindung zu bestehen. Die sesshafteren CIB-Gänse verbrauchten wenig Energie, um die qualitativ relativ schlechten, aber berechenbaren Nahrungsquellen zu finden, und hatten einen relativ kurzen Zugweg zu den Brutgebieten. Hingegen flogen die Angehörigen der beiden Populationen mit der geringeren Körpergröße täglich weite Strecken, um hoch qualitative, aber weniger berechenbare Nahrung zu finden. Zudem legen sie größere Entfernungen zu ihren Brutgebieten im westlichsten Teil Alaskas zurück. Die Erhaltung der Populationsstruktur dieser Vögel ist wahrscheinlich abhängig von der Erhaltung der von den CIB-Gänsen favorisierten Feuchtgebiete und von den Fähigkeiten der Vögel, sich an die klimabedingten Störungen des Zug- und Brutzyklus anzupassen.

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