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Daniel E. Timm
Alaska Department of Fish and Game

Michael L. Wege
u.s. Fish and Wildlife Service

David S. Gilmer
u.s. Fish and Wildlife Service

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Daniel E. Timm
Alaska Department of Fish and Game, Anchorage

Michael L. Wege and David S. Gilmer
U.S. Fish and Wildlife Service, Dixon, California

Introduction

Since large, dark tule white-fronted geese (*Anser albifrons gambelli* Hartlaub) were first described in Texas over a century ago by Hartlaub (1852), and again 65 years later in California by Swarth and Bryant (1917), tule geese have been the subject of at least 14 studies in California and 8 attempts to locate summering birds in the Artic. Central questions of these efforts have been: Is the tule goose a distinct subspecies? What is their range and population size? How can the birds be identified? and What threatens their existence?

The purpose of this paper is to present the current status of tule geese, including taxonomy, distribution, population size, and management challenges, and to provide management recommendations. Intensive work on tule geese in Calfornia by the U.S. Fish and Wildlife Service since 1978 and in Alaska by the Department of Fish and Game since 1979 has provided the basis for this paper.

Taxonomy

Verification of Nesting Grounds

During 1980 and 1981, morphological data were obtained from 88 molting whitefronts in Redoubt Bay and Susitna Flats, Cook Inlet, Alaska (Figure 1). Measurements for adults with young ($N=49$) were combined with those without ($N=39$) because there was no significant difference ($P>0.01$) for any data set.

Comparisons of culmen, diagonal tarsus, and nare to bill tip lengths (Baldwin et al. 1931) for both sexes of *gambelli* from Cook Inlet and California showed no differences ($P>0.05$). Differences in these measurements between *gambelli* from Cook Inlet and Pacific whitefronts (*A. a. frontalis*) from California were highly significant for both sexes ($P<0.001$). All *gambelli* captured at Redoubt Bay exhibited the diagnostic chocolate brown head and neck and blackish back described by Bauer (1979) and Krogman (1979).

During the two winters 1979–80 and 1980–81, 200 *gambelli* and about 1,000 *frontalis* (C. Ely, personal communication) were individually marked in California with plastic collars. After known losses, a maximum of 178 collared *gambelli* could have been observed during the following summers, of which 44 (24.7 percent) were positively identified in Cook Inlet in 1980 and 1981. One marked and two unmarked *frontalis* were seen summering in Cook Inlet.

Subspecies classification would have been inappropriate had there been a homogeneous mix of large and dark whitefronts with smaller and lighter birds on the

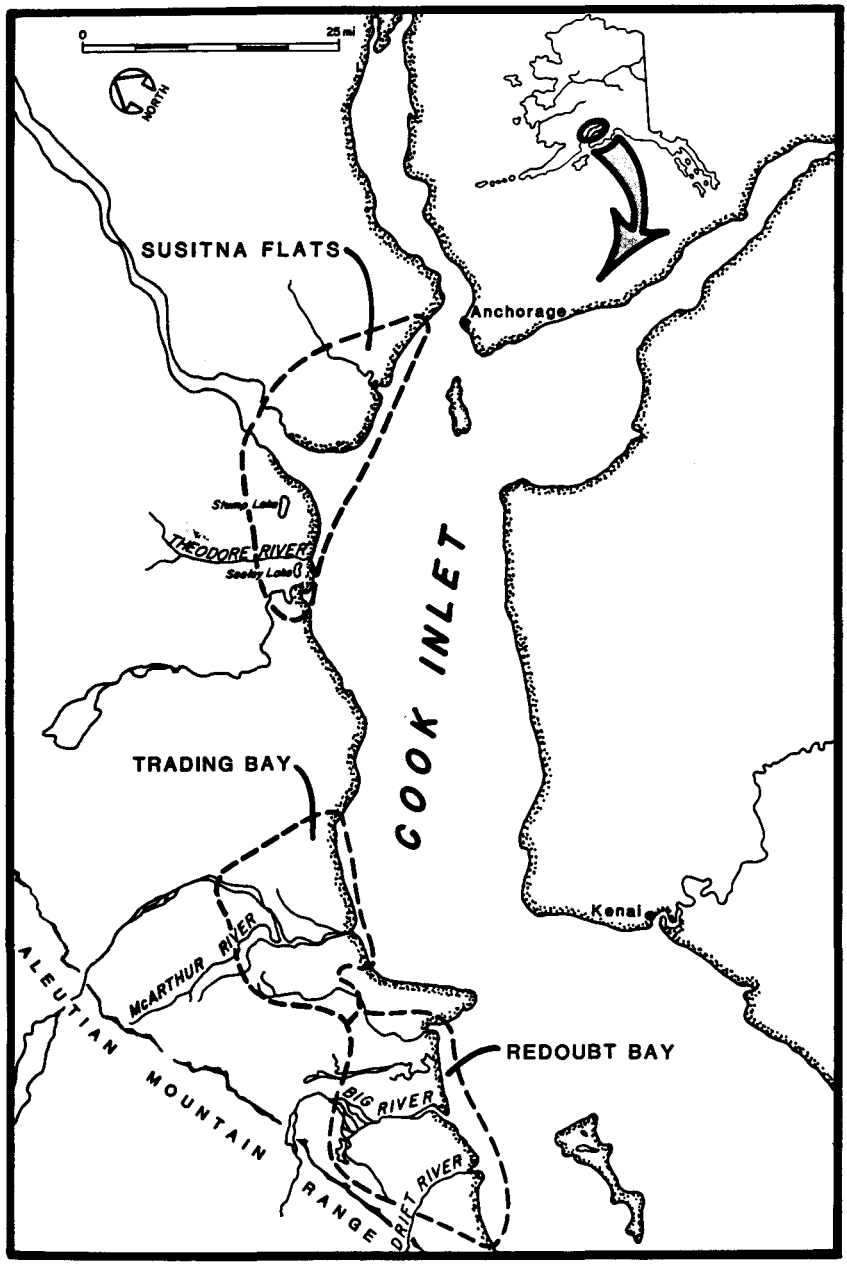

Figure 1. Upper Cook Inlet, Alaska.

breeding grounds. Sympatry with *frontalis* would have warranted full species classification whereas an allopatric relationship would dictate subspecific recognition (Ratti 1980).

We consider *gambelli* to be a distinct subspecies based on its geographical isolation from other whitefronts on the breeding grounds (Gabrielson and Lincoln 1959, D. Timm, unpublished data), distinctive morphological traits, and distribution and behavior of marked birds on migration and wintering areas (tule geese tend to segregate from other whitefronts).

Nomenclature

Elgas (1970) presented morphological data for eight relatively large and dark whitefronts he captured in Old Crow Flats of northwestern Yukon, about 600 miles (960 km) northeast of Cook Inlet. Since recoveries of smaller, lighter colored birds banded there came from the Central Flyway, Delacour and Ripley (1975) believe that the large dark birds from Old Crow Flats are the ones described in Texas by Hartlaub (1852). Consequently, they called tule geese wintering in California *elgasi*, and those in Texas *gambelli*.

In our opinion, a third subspecies has not been substantiated, particularly in view of morphological data from about 1,550 whitefronts captured at 34 locations in 14 regions of Alaska and Canada (Lensink and Timm, in preparation). Although relatively large and small individuals are found in a given area, significant differences in average size of morphological characteristics may occur between areas that are relatively close geographically. Whitefronts from coastal tundra are generally smaller than those found in interior taiga and boreal forest regions. Whitefronts from one area of central Alaska were (except for weight) as large as but lighter colored than *gambelli* from Cook Inlet.

Three of 258 (1.2 percent) *gambelli* marked in Cook Inlet were reported in the Central Flyway, compared to 3 of 687 (0.4 percent) *frontalis* recovered there that were banded on the Yukon-Kuskokwim Delta of Alaska (Timm and Dau 1979). The "type" *gambelli* (Hartlaub 1852) from Texas could therefore have come from Cook Inlet, Alaska. Only one whitefront subspecies (*frontalis*) is presently recognized in Texas (American Ornithologists Union 1957:65).

Distribution and Migration

Summer

Nesting in Redoubt Bay has been documented only near the Big River drainage (Figure 1), despite ground searches for nests and aerial surveys for goslings in other parts of the Bay. In 1981, no nests were found in a 6.3 square mile (10.1 km^2) area searched north of Big River. Whitefronts have not been recorded summering in Cook Inlet outside of Redoubt Bay and Susitna Flats, except on rare instances (Gabrielson and Lincoln 1959:134, Timm 1980). However, a recent report (S. McDowell, personal communication) of tule geese summering in the upper McArthur River drainage (Figure 1) demands further investigation.

Redoubt Bay is characterized by a transition from intertidal mud to brackish marsh, fresh marsh, expanses of poorly drained sweet gale (*Myrica gale*) and dwarf

birch (*Betula nana*), alder-willow (*Alnus* spp.-*Salix* spp.) thickets, aspen-spruce-birch (*Populus* spp.-*Picea* spp.-*Betula* spp.) forest, and alluvial glacial plain terminating at rugged mountains and glaciers within 12 miles (19.3 km) of saltwater. Although over 100 goslings were seen in the upper brushy and tree covered areas of the Big River drainage at least 9 miles (14.4 km) from salt water, no nests were found there in 1981 in a 1.3 square mile (2.1 km^2) area. In 1980 and 1981, 11 nests were discovered in a 9.6 square mile (15.5 km^2) area of lower Big River in brackish and freshwater marsh. Nest sites were typical of other whitefronts (Ely 1979).

Nests have not been located on Susitna Flats, although goslings were seen near Stump Lake and on Seeley Lake (Figure 1). According to a local fisherman (C. Brauch, personal communication), tule geese nest near Seeley Lake on brackish marsh flats, similar to habitat in Redoubt Bay, and near beaver ponds 0.5 to 1.5 miles (0.8 to 2.3 km) up the Theodore River. Adults reportedly bring young downriver from these ponds to Seeley Lake for rearing, a behavior we have observed in Redoubt Bay.

In 1980, nest initiation (date first egg laid) was during May 9–May 16, and hatching occurred June 10–June 16 ($N=7$). Nesting was initiated about one week earlier in 1981 because of an earlier thaw.

In Redoubt Bay, family groups congregate near the mouth of Big River for brood rearing. Other brood rearing and the primary area for molting of nonproducing adults and subadults occurs farther up the Big River and its tributaries in large expanses of shallow glacial and rain water. The first flightless nonbreeders were seen June 19, 1981, and by July 27 about 95 percent of the nonbreeding adults and 50 percent of the breeders could fly.

Migration

Neck collaring of 200 and 342 *gambelli* on the wintering and summering grounds, respectively, has enabled us to identify major use areas. Over 20,000 observations of these birds have been made in three years.

Several hundred tule geese had arrived at Redoubt Bay by April 23 and April 20 in 1980 and 1981, respectively, when investigators arrived. Major departures of tule geese from the Klamath Basin in California occurred April 8, 15–16, and 28–29, 1980, and April 10 and 20–22, 1981. Three marked individuals traveled about 1,900 miles (3,050 km) between northern California and Redoubt Bay in a maximum of four days.

Tule geese begin to leave the Big River area by mid-August, based on locations of radio transmitter-equipped birds (8 in 1980 and 20 in 1981). Aerial and ground surveys in 1980 and 1981 indicated that only 100–150 tule geese in Redoubt Bay and 300–350 on Susitna Flats remained until September 1 (opening of hunting season).

Tule geese first arrived at Summer Lake, Oregon (a major fall staging area), on August 28 and 30, 1980 and 1981, respectively (S. Denney, personal communication). First arrivals in the Malheur National Wildlife Refuge (NWR) vicinity occurred August 26 and 25 in 1980 and 1981, respectively (S. Thompson, personal communication). Tule geese had departed both Summer Lake and Malheur NWR by October 1, 1981.

Observations of neck-collared *gambelli* revealed that, unlike *frontalis*, appar-

ently over half of all tule geese overfly the Klamath Basin and are early arrivals at Sacramento NWR. C. Ely (personal communication) has observed up to 1,500 tule geese in the Klamath Basin during early October. Tule geese concentrate on Lower Klamath NWR, unlike Pacific whitefronts that prefer Tule Lake NWR. Tule geese depart the Klamath Basin by early December.

Of the three tule geese (two locals, one yearling) marked in Alaska and reported in the Central Flyway the first year after banding, one bird was seen December 15 on the Kirwin NWR in northcentral Kansas, and two were shot in southeastern Texas on November 25 and December 27.

Locations of neck-collared birds reported throughout North America are presented in Figure 2.

Winter

Tule geese arrive at Sacramento and Delevan NWR's during mid-September, and by late October 1981 they had peaked at about 3,500 birds. By late September they arrive at Grizzly Island State Wildlife Management Area (SWMA), where up to 1,500 individuals occur during the hunting season. Some birds travel between the Sacramento Valley and Grizzly Island throughout the winter.

Although a few neck-collared birds have been observed on Colusa and Sutter NWRs and in the Butte Sink, the primary wintering areas are the Sacramento and Delevan NWRs and Grizzly Island SWMA. Unconfirmed reports indicate that a few tule geese occur in the San Joaquin Valley of California and in western Mexico, although no marked birds have been reported from these regions.

From arrival in September until the opening of hunting season, tule geese feed primarily in harvested rice fields throughout the Sacramento and Delevan NWRs. Roosting and loafing occur in areas of open water and stands of bulrush (*Scirpus* spp.) and cattail (*Typha* spp.). After the hunting season opens on portions of these Refuges, tule geese shift to off-refuge harvested rice fields and to closed portions of refuges containing primarily flooded unharvested rice.

If winter rains flood uplands and fallow rice fields that contain bulrush, some birds will feed, loaf and roost in these fields. The use of these areas is delayed or nonexistent without adequate rainfall. When the hunting season ends in mid-January, the geese increase their use of off-refuge rice fields.

Tule geese begin to leave the Sacramento Valley in early February, and by early March 1,500 to 2,000 birds will have arrived in the Klamath Basin. The rest of the population (apparently most subadults) use an as yet undiscovered spring migration staging area(s).

Population Status

Recruitment

Based on winter surveys, young comprised an estimated 30 percent ($N = 2,500$) of the population in 1979, 34 percent ($N = 2,500$) in 1980, and 37 percent ($N = 2,300$) in 1981. In comparison, at Redoubt Bay during late May 1980, young comprised 29 percent ($N = 762$), and April 20 through late May 1981, 34 percent ($N = 1,284$), of the population.

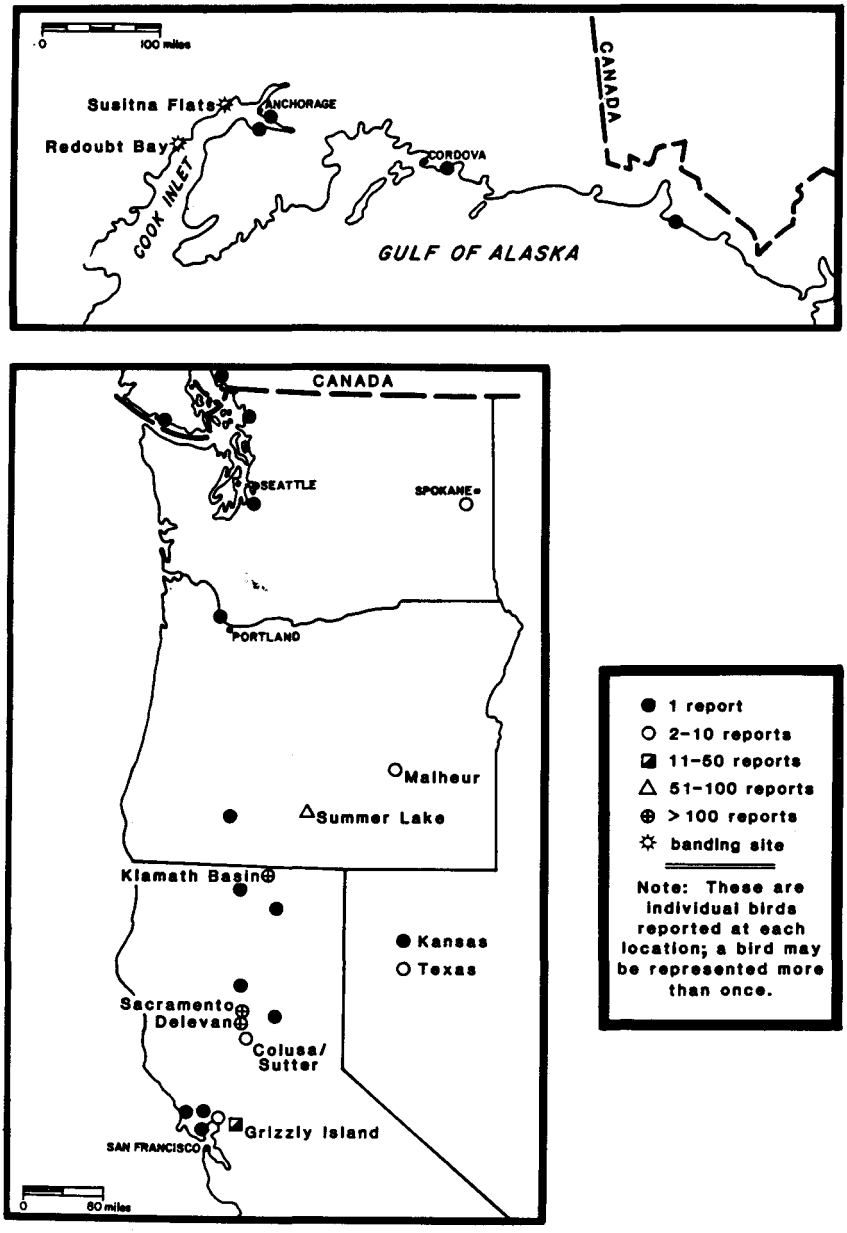

Figure 2. Reports from 342 tule geese neck-collared in 1980 and 1981, upper Cook Inlet, Alaska.

Survival and Mortality

Of 291 tule geese neck-collared in Alaska in 1980, 258 (88.7 percent) were reported within 18 months after banding. An annual collar loss rate of 19 percent (D. Timm, unpublished data) was measured for Canada geese (*Branta canadensis*) with glued neck collars. If a collar loss rate of 12 percent is assumed for tule geese, virtually all marked birds were reported.

In 1980, 45 adults and 78 locals were collared in family groups. Of these, 28 adults (62.2 percent) and 49 locals (62.8 percent) were seen alive after the 1980–81 hunting season. If 12 percent of the geese lost their collars the first year, survival of both adults and locals was 71 percent. Of 168 geese captured in flocks of subadults and unsuccessful breeders, 73 (43.5 percent) were seen alive after the hunting season. An additional 60 (35.7 percent) were seen before the season but not after, adding evidence that undiscovered spring staging area(s) are used primarily by subadults. Substantially greater mortality of subadults was unlikely since their direct band recovery rate was identical to that of older birds.

Direct band recovery rates for 78 locals, 98 yearlings, and 115 older geese neck-collared in Alaska were 11.5 percent, 12.2 percent, and 12.2 percent, respectively. Hunting recoveries (35) were from California (74 percent), Alaska (20 percent), and Texas (6 percent).

Of 70 tule geese neck-collared in California during the winter of 1979–80, a maximum of 59 birds were alive after that hunting season. Again assuming 12 percent collar loss, at least 43 (83 percent survival) were alive after the 1980–81 season.

Considering (1) the difficulty of observing geese that disperse after the hunting season, but a minimum 71 percent survival of locals, (2) band recovery rates that indicate only modest hunting mortality, assuming high reporting rates of collared birds, and (3) annual survival of at least 83 percent for geese marked in California, we conclude that population survival was 80 percent or more the first year after banding.

Reductions in the bag limit for white-fronted geese and shortened hunting seasons resulted in a large decrease of both whitefront subspecies harvested at Sacramento and Delevan NWRs during the 1979–80 and 1980–81 seasons. For example, during the 1978–79 season, 812 birds were taken compared with 111 and 148 during the following two hunting seasons. The proportion of tule geese in the total white-fronted goose harvest increased from 38 percent of the harvest in 1978, to 60 percent in 1979 and 46 percent in 1980. Despite this increase, the proportion of immature tule geese in the harvest remained constant (36 to 40 percent) during all three seasons. Except in 1980, the proportion of immature Pacific whitefronts in the harvest was about twice that of tule geese (76 percent in 1978, 70 percent in 1979, 47 percent in 1980).

Population Size

Coordinated surveys on September 14 and 21, 1981 were made on Summer Lake SWMA, and near Malheur, Klamath Basin, Sacramento and Delevan NWRs. Population estimates from these surveys indicated at least 3,500 tule geese. Most of the geese were seen at Summer Lake (2,130 on September 14 and 1,930 on September 21). Previous estimates of tule geese ranged up to 2,500 (Bauer 1979).

Some geese were likely still north of Oregon on the 14th, since one collared bird was shot at Susitna Flats, Alaska on September 12, 1981. Others were undoubtedly scattered outside of the count areas. After considering these factors, we conclude that the subspecies numbers at least 3,500 geese and likely over 4,000. Based on our field observations of relative abundance in California from 1978 through 1981, we believe that the tule goose population has approximately doubled in size, probably in response to reduced harvest in California.

During late July aerial surveys in Cook Inlet, 35mm photos revealed 1,537 birds in 1980 and 1,146 in 1981. In Redoubt Bay we counted 1,273 adults and 146 goslings in 1980, and 927 adults and 131 young in 1981.

Although birds are missed during aerial counts, the disparity between wintering ground estimates (>3,500 geese including >30 percent young) and breeding ground estimates (1,550 geese including 15 percent young) is disconcerting. However, based on extensive fixed-wing and helicopter surveys throughout upper Cook Inlet in 1980 and 1981, and on ground searches in Redoubt Bay, the production of tule geese in upper Cook Inlet occurs only in the Big River drainage of Redoubt Bay and on western portions of Susitna Flats. Although it is unlikely that >2,500 tule geese summer on these two areas, the recent report of whitefronts in the upper McArthur River drainage cannot be discounted. Apparently all tule geese molt in Redoubt Bay and Susitna Flats also, except for a one time use of Trading Bay by 110 adults in 1974.

During spring 1980, 59 (3.6 percent) of 1,652 tule geese checked for neck collars in Redoubt Bay had been marked in California. Using the Lincoln Index we estimated a spring population of 1,450 birds in Redoubt Bay. Field-age ratios indicated yearlings comprised 26 percent of the observed geese, compared with 24 percent yearlings in the collared sample.

Reports of whitefronts nesting in Tuxedni Bay, 30 miles (48 km) southwest of Big River (H. Keiser, personal communication), and of several hundred white-fronted geese in 1981 in Chinitna Bay, 65 miles (104 km) southwest of Big River in lower Cook Inlet (R. Haeg, personal communication), indicate that these areas should be searched.

Nesting populations of tule geese may exist outside of Cook Inlet. For example, apparently at least one other population of large, dark whitetronts is located in the Old Crow Flats, and populations of large whitefronts occur elsewhere in Alaska (see section on *Taxonomy*). The Arctic is large and at best moderately explored for whitefronts.

Habitat Status

Most major tule goose concentration areas are managed by State conservation agencies or the U.S. Fish and Wildlife Service. These include: Susitna Flats; Summer Lake SWMA; Malheur (substantial use also occurs in surrounding private lands), Lower Klamath, Tule Lake, Sacramento, and Delevan NWRs; and Grizzly Island SWMA. The obvious exception is Redoubt Bay.

There have been intermittent attempts to classify Redoubt Bay as a State Game Refuge since 1977. In 1980, an administration-sponsored bill did not leave subcommittee, and the bill will probably meet a similar fate in the near future. Public displeasure in Alaska over passage of the 1980 Alaska National Interest Lands

Conservation Act will not soon wane, and this displeasure has influenced consideration of Redoubt Bay for refuge status. Complicating the issue is the future status of privately owned cabins that have been built illegally on State lands. The Alaska Department of Fish and Game is, however, pursuing refuge classification for Redoubt Bay.

Cook Inlet has Alaska's largest producing natural gas field and the State's second largest producing oil field. The Alaska Department of Natural Resources, in response to requests from the Department of Fish and Game and the National Audubon Society, recently withdrew Redoubt Bay from two oil and gas lease sales. Redoubt Bay will be excluded from additional sales through 1983, when sufficient information should be available to protect the birds from exploratory and possible developmental activities.

An underground oil pipeline parallels the east side of Redoubt Bay about 3 miles (4.8 km) inland. The line carries oil from 14 platforms in Cook Inlet, located 17 to 50 miles (27.2 to 80 km) northwest of Big River, to the Drift River storage and tanker loading facility 5 miles (8 km) south of Big River (Figure 1). There has not been a major on or offshore oil spill since this field was opened in the mid-1960s. However, oil companies have been notified of the concern for tule geese, and they will afford special protection to Redoubt Bay if a spill occurs (A. Cline, personal communication).

No further surface entry for oil and gas drilling or permanent roads will be allowed in the Seeley Lake area of Susitna Flats where tule geese occur. Minimum aircraft altitude and other restrictions are also required during oil and gas exploration activities. However, nesting locations there and up the Big River remain unidentified.

The west side of Cook Inlet will experience extensive development in the future, including agriculture, coal and gold mining, new roads, timber harvest, oil and gas, hydroelectric projects, and conversion of State lands to private ownership. However, if all key lands are placed in refuge status or otherwise protected, we believe that the tule goose in Cook Inlet will not suffer a significant population decline. Long-term habitat protection for Redoubt Bay is, however, a paramount need.

Although tule geese concentrate on protected areas in California during the hunting season, pre- and post- season use of private lands is substantial. Gilmer et al. (1982) discussed concerns for tule geese and other waterfowl wintering in California's Central Valley.

Challenges

Obvious management and research challenges include better assessment of tule goose population size and distribution during migration, summering, and wintering periods; protection of key use areas; and resolution of the *Anser albifrons* taxonomic enigma. Other complicating factors include hunting and potential designation of tule geese under endangered or threatened species status.

In response to a suspected Pacific whitefront population decline exceeding 50 percent the past 10 years (O'Neill 1979, Timm and Dau 1979), the Pacific Flyway Council recommended in 1979, and the States of California and Oregon adopted, certain restrictive hunting regulations that resulted in harvest reductions of over

50 percent in California (California Department of Fish and Game, unpublished data; U.S. Fish and Wildlife Service, unpublished data). A concomitant decrease of at least that magnitude occurred in harvest of tule geese. Although it was desirable to increase the number of tule geese, future challenges of harvest management may occur when either whitefront population requires independent actions to meet population objectives.

In 1981, the International Council for Bird Preservation petitioned the U.S. Fish and Wildlife Service to list the tule goose as an endangered species. Although the Service requested public comment on the petition, they do not plan to list the birds (J. Sheppard, personal communication). The International Union for the Conservation of Nature lists the tule goose in their *Red Book* as a subspecies of concern.

If tule geese were classified as endangered, hunting of whitefronts in California and Cook Inlet would essentially cease. Declining goose populations, restrictive seasons, and shrinking habitat have all contributed to a more than 30 percent reduction in waterfowl hunters during the past 10 years in California. The loss of whitefront hunting would be a major blow to wetland preservation in California, which is supported by the sale of duck stamps and hunting licenses. Incentives to retain privately-owned wetlands, which comprise the bulk of Central Valley waterfowl habitat (Gilmer et al. 1982), would also diminish.

Endangered status would essentially place land management and development of most coastal marshes in Cook Inlet and key tule goose areas elsewhere under Federal purview, in view of the Endangered Species Act and Section 404 of the Clean Water Act. Clearly, it is in the best interest of all concerns to insure the birds' welfare. Endangered or threatened status would limit management flexibility and do little that is not already being done to protect the subspecies.

Examination of Trading Bay in 1981 indicated that tule geese could potentially nest there. Range extension from natural expansion or by transplants is an exciting challenge for the future.

Recommendations

The Pacific Flyway Waterfowl Technical Committee has drafted a Tule Goose Management Plan that is under agency review. Recommendations include a pre-hunting season population of 5,000 birds, surveys to better define range and population size, and actions to insure habitat protection for Redoubt Bay. We believe that adoption of that Plan is desirable for coordinated and effective management.

Locating unknown major spring staging areas, and nesting areas in Susitna Flats and Redoubt Bay, is imperative. Continuation and expansion of fall and mid-summer surveys is desirable to monitor population size and to better define the summer distribution of tule geese in Alaska. Harvest should be monitored, and a technique developed for in-hand field identification of tule geese. Banding in Alaska should continue at least until all major use areas are identified. Research in California should continue at least until habitat use and movements by tule geese are quantified and behaviorial differences between whitefront subspecies are determined. Beyond direct management applications the tule goose presents a unique opportunity to investigate life history and population dynamics of whitefronts.

Although taxonomy of Canada geese is still argued, taxonomy of white-fronted

geese is presently far more obscure. A compilation and analysis of morphology and migration information for North American whitefronts is long overdue. Where data are inadequate, examination and marking of adults with young may be necessary before final judgement can be made on whitefront taxonomy.

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