PACIFIC FLYWAY COUNCIL

Management Plan: Emperor Goose

Adopted September 2016

Cover photograph: Emperor goose, © 2014 Milo Burcham.

This management plan is one of a series of cooperatively developed plans for managing various populations of migratory birds in the Pacific Flyway. Inquiries about this plan may be directed to member States of the Pacific Flyway Council or to the Pacific Flyway Representative, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, 1211 SE Cardinal Court, Suite 100, Vancouver, Washington 98683-9684. Information regarding the Pacific Flyway Council and management plans can be found on the Internet at PacificFlyway.gov.

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MANAGEMENT PLAN

FOR THE

EMPEROR GOOSE

Prepared for the

Pacific Flyway Council
U.S. Fish and Wildlife Service
Canadian Wildlife Service
Direccion General de Conservacion Ecologica de Recursos Naturales

by the

Emperor Goose Subcommittee
of the
Pacific Flyway Study Committee

and

Emperor Goose Subcommittee
of the
Alaska Migratory Bird Co-Management Council

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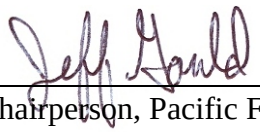
Approved by  September 30, 2016
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Pacific Flyway Study Committee, Emperor Goose Subcommittee members included:

Dan Rosenberg and Jason Schamber, Alaska Department of Fish and Game
Eric Taylor and Erik Osnas, U.S. Fish and Wildlife Service, Region 7
Todd Sanders, U.S. Fish and Wildlife Service, Headquarters

Alaska Migratory Bird Co-Management Council, Emperor Goose Subcommittee members included:

Brandon Ahmasuk, Kawerak, Inc.
Tim Andrew, Association of Village Council Presidents
Peter Devine, Aleutian/Pribilof Islands Association
Jack Fagerstrom, Kawerak, Inc.
Cyrus Harris, Maniilaq Association
Gayla Hoseth, Bristol Bay Native Association
Sonny Squartsoff, Sun'aq Tribe of Kodiak
Dan Rosenberg, Alaska Department of Fish and Game
Erik Osnas, U.S. Fish and Wildlife Service, Region 7
Eric Taylor, U.S. Fish and Wildlife Service, Region 7

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PREFACE

The Pacific Flyway Council is an administrative body that forges cooperation among public wildlife agencies for the purpose of protecting and conserving migratory birds in western North America. The Council is composed of the director or an appointee from the public wildlife agency in each state, province, and territory in the western United States, Canada, and Mexico. Migratory birds use four major migratory routes (Pacific, Central, Mississippi, and Atlantic flyways) in North America. Because of the unique biological characteristics and relative number of hunters in these regions, state and federal wildlife agencies adopted the flyway structure for administering migratory bird resources within the United States. Each flyway has its own Council.

Management plans are developed by Council technical committees and include biologists from state, federal, and provincial wildlife and land-management agencies, universities, and others. Management plans typically focus on populations, which are the primary unit of management, but may be specific to species or subspecies. Management plans identify issues, goals, and actions for the cooperative management of migratory birds among State and Federal agencies to protect and conserve these birds in North America. Management of some migratory birds requires coordinated action by more than one flyway. Plans identify common goals and objectives, establish priority of management actions and responsibility for them, coordinate collection and analysis of biological data, foster collaborative efforts across geo-political boundaries, document agreements on harvest strategies, and emphasize research needed to improve conservation and management. Population sustainability is the first consideration, followed by equitable recreational and subsistence harvest opportunities. Management plans generally have a 5-year planning horizon, with revisions as necessary to provide current guidance on coordinated management. Management strategies are recommendations and do not commit agencies to specific actions or schedules. Fiscal, legislative, and priority constraints influence the level and timing of management activities.

Management plans are not intended as an exhaustive compendium of information available, research needed, and management actions. Plans include summaries of historical data and information from recent surveys and research that help identify: (1) the current state of the resource (i.e., population and associated habitat), (2) desired future condition of the resource (i.e., population goals and objectives), (3) immediate management issues managers face, and (4) management actions necessary and assignment of responsibilities to achieve the desired future condition, including harvest strategies and monitoring to evaluate population status and management progress.

The first management plan for the emperor goose was adopted in May 1988. This document is the third revision of that plan. It was developed by the Emperor Goose Subcommittee of the Pacific Flyway Study Committee.

MANAGEMENT PLAN
FOR THE
EMPEROR GOOSE

INTRODUCTION

The emperor goose is a maritime bird with an annual range in coastal areas of Alaska and Russia that is mostly contiguous with the Bering Sea. Emperor geese winter primarily in the Aleutian Islands and Alaska Peninsula with smaller numbers at Kodiak Island and as far west as the Commander Islands in Russia (Figure 1). The majority of emperor geese breed in Alaska on the Yukon–Kuskokwim Delta (YKD, 80–90% of the total population; Eisenhauer and Kirkpatrick 1977) with the remainder nesting on the Seward Peninsula and the east and north coasts of the Chukotka Peninsula in Russia. Emperor geese migrate in spring and fall along coastal areas of the Alaska Peninsula and Bristol Bay (Figure 1; Appendix A).

The status of the emperor goose population has been measured annually using an aerial survey of spring migrants in southwest Alaska since 1981 (Wilson and Dau 2015). A 3-year running average of the survey count has been used as the population index for emperor goose management (Pacific Flyway Council 2006). In the early 1980s, the spring survey documented a

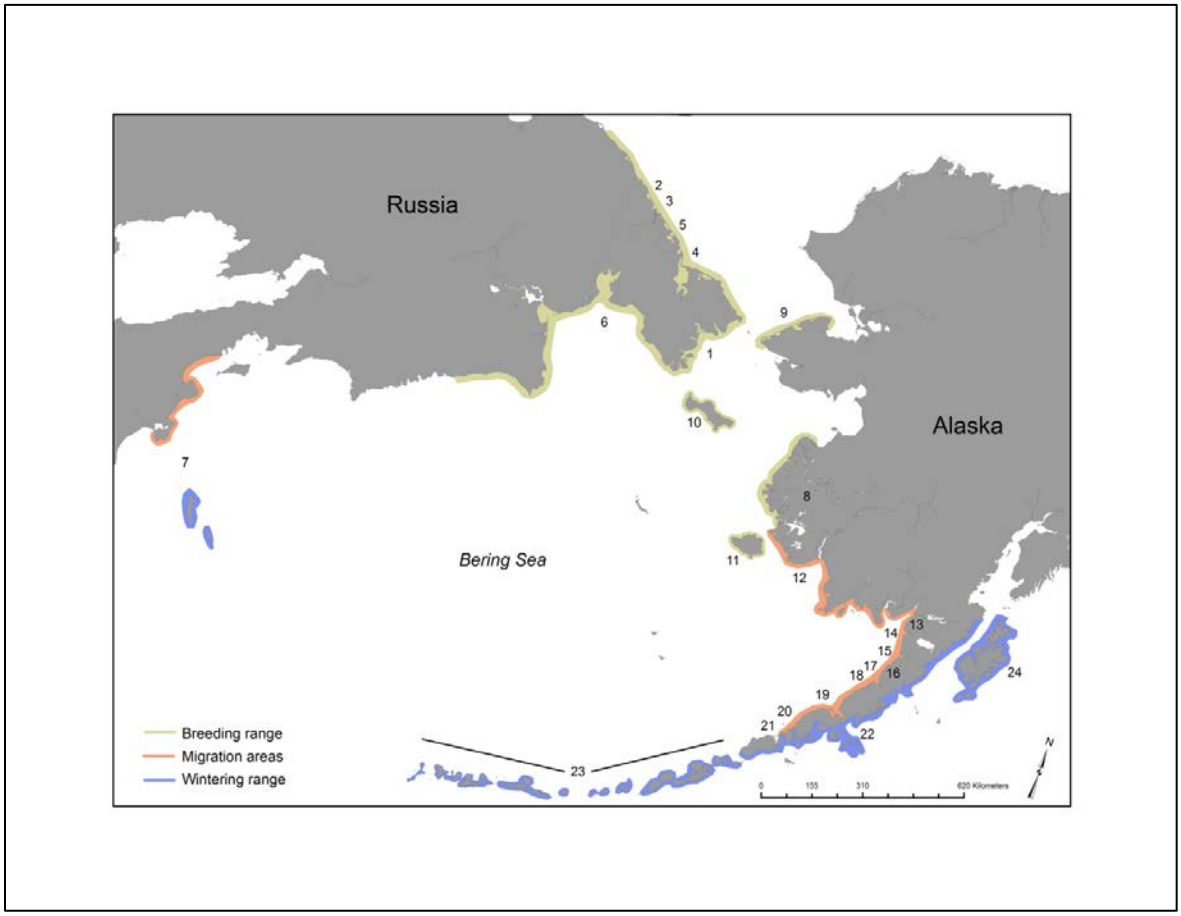


Figure 1. Annual range of the emperor goose (numbered locations referenced in Appendix 1)

population decline from a peak count of over 100,000 birds in 1982 to less than 45,000 birds in 1986 (Figure 2). Since then, annual survey counts fluctuated between 39,000 and 98,000 birds, but showed a slightly increasing long-term population trend. From 2005–2014 survey counts indicated increased population growth of ~3% per year (± 3%; Dooley et al. 2016). The most recent 3-year (2014–2016) average count of 85,795 birds was the highest recorded since 1983 (Safine 2016).

The apparent population decline in the early 1980s and an estimated low adult annual survival rate during that time (Petersen 1992) elevated conservation concerns for emperor geese. Fall/winter harvest restrictions were implemented in 1985 that reduced the daily bag limit from 6 to 2 birds (Pacific Flyway Council 2006). In 1986, the 3-year average survey count dropped below the minimum level of 60,000 birds (Wilson and Dau 2015) to allow harvest. The fall/winter harvest was closed to emperor geese in 1986, and in 1987 a cessation of subsistence harvest was agreed to under terms of the Yukon-Kuskokwim Delta Goose Management Plan (YKDGMP 2010). The resumption of spring/summer subsistence and fall/winter harvest could be considered when the 3-year average count reached 80,000 birds, as it did in 2015.

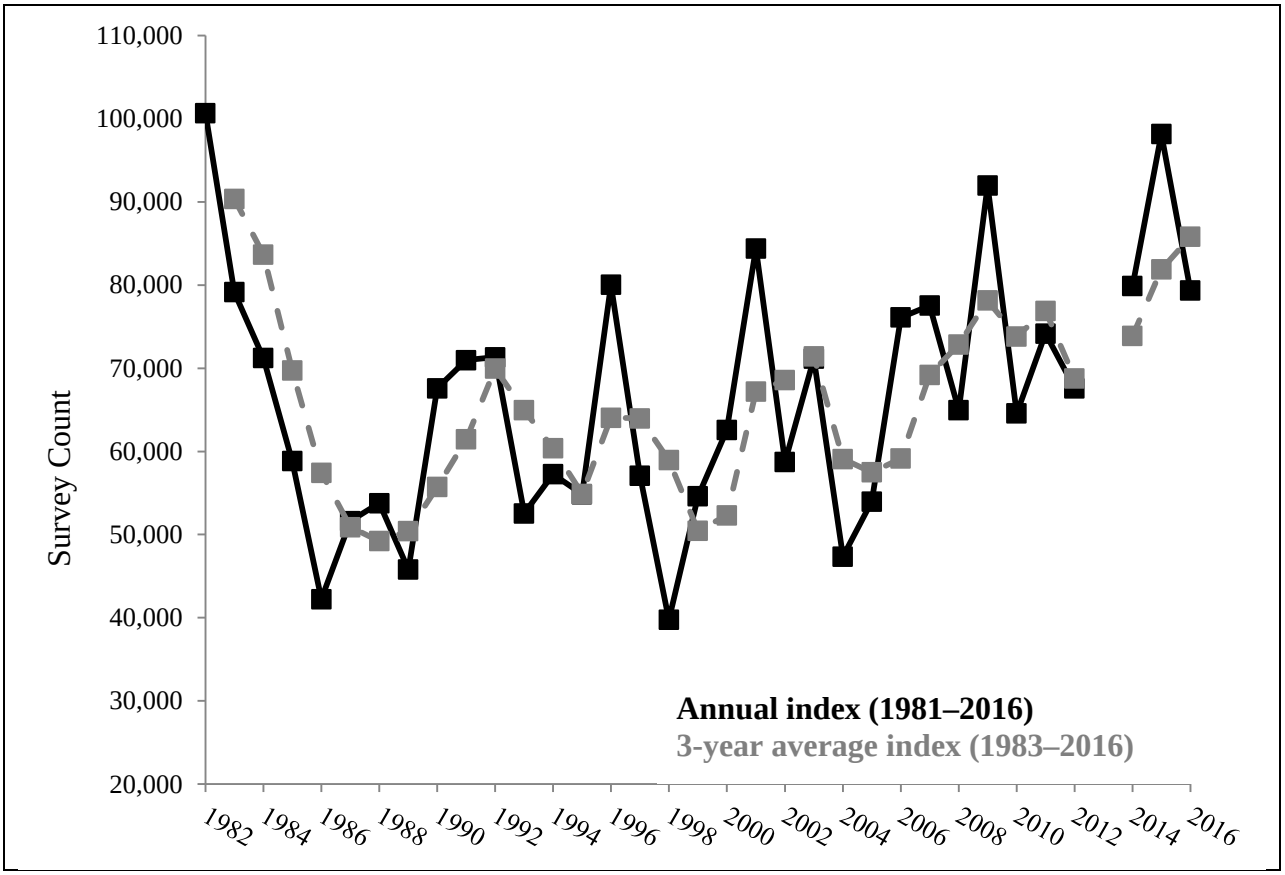


Figure 2. Annual index and 3-year average index of spring migrants at staging areas in southwest Alaska, 1981–2016.

The purpose of this revision of the Management Plan is to update established goals, objectives, and strategies from the previous version (Pacific Flyway Council 2006) to ensure responsible stewardship of emperor geese in the Pacific Flyway. This Management Plan identifies

management actions, information needs, and agency responsibilities until the next revision scheduled for 2021. This Management Plan will serve as a companion to the 2016 Alaska Migratory Bird Co-Management Council (AMBCC) Emperor Goose Management Plan, which specifies regulations for spring/summer subsistence harvest of emperor geese. The two Management Plans are intended to complement one another and contain identical population assessment methods, population objectives and regulatory harvest thresholds. Adoption of the Pacific Flyway Emperor Goose Management Plan by the Pacific Flyway Council is contingent upon the adoption of the AMBCC Emperor Goose Management Plan by the AMBCC.

The precedent for developing separate management plans for fall/winter and spring/summer subsistence harvest is supported by Article II(4)(2)(b)(ii) of the 1997 Protocol between the United States and Canada amending the 1916 Convention for the Protection of Migratory Birds. As noted, management bodies will be created to ensure an effective and meaningful role for indigenous inhabitants in the conservation of migratory birds. These management bodies will include Native, Federal, and State of Alaska representatives as equals, and will develop recommendations for, among other things: seasons and bag limits; law enforcement policies; population and harvest monitoring; education programs; research and use of traditional knowledge; and habitat protection. Management bodies involve village councils to the maximum extent possible in all aspects of management. This Article provides the basis for the two separate but complimentary Management Plans.

This Management Plan includes significant changes from the previous version (Pacific Flyway 2006) and represents a major shift in emperor goose management. From 1985–2016, emperor goose management was based on the 3-year average index of emperor goose abundance during a spring migration survey in southwestern Alaska. Based on this survey, the population objective was an index of 150,000 birds and harvest closed when the 3-year average index was below 60,000 birds. Harvest could be reconsidered once the 3-year average index exceeded 80,000 birds (YKDGMP 2010). This Management Plan replaces the spring survey index with a summer survey index of indicated total birds[1] (hereafter; total bird index) derived from aerial surveys of emperor goose abundance on the YKD (Yukon-Kuskokwim Delta) Coastal Zone Survey. The total bird index is less biased and more precise than the spring survey index and is based on statistical sampling theory. This Management Plan also includes a fall/winter harvest strategy that specifies a regulatory framework, recognizing the emperor goose population is of sufficient size to resume harvest.

Additionally, a new population objective was established as the 2016 total bird index of 34,000 from the YKD Coastal Zone Survey. This population objective is not intended to be used as the basis for harvest regulation. Rather, this population objective is a standard by which future population changes can be measured. The total bird index and population objective are viewed as interim strategies that will be reevaluated in 2019 while other population assessment models are further refined and agreement reached on the most appropriate short- and long-term survey protocols.

[1] Indicated total birds = 2 × (singles + number of pairs) + birds in flocks

The term of this Management Plan is for 2017–2021. This Management Plan is a significant departure from past management; thus, Council agrees to evaluate the emperor goose population response during the initial 3-year period in 2019. The Subcommittee, in cooperation with the AMBCC, will annually review available data (e.g., population status, harvest survey data, and other relevant information) and in 2019 will reevaluate the population objective, population assessment method and harvest strategy.

GOAL AND OBJECTIVES

The goal of this Management Plan is to ensure sustainable harvest and maintain key ecological functions throughout the range of emperor geese; and meet subsistence, recreational, educational, and scientific needs.

Objectives:

1. Maintain a population of emperor geese above an index of 23,000 birds, based on the total bird index from the YKD Coastal Zone Survey
2. Maintain a customary and traditional subsistence harvest
3. Provide for a fall/winter harvest
4. Protect and manage nesting and brood rearing habitats
5. Protect and manage staging and wintering habitats

STATUS

A. Abundance and Trends

Prior to the 1980s, little data were available on the population trend and distribution of emperor geese, but a few aerial surveys conducted during spring and fall migration in the 1960s and 1970s provide some historical information. In 1979, the U.S. Fish and Wildlife Service (USFWS) began annual survey counts of fall migrants at staging areas in southwest Alaska to provide a long-term consistent index to the population. In subsequent years, the surveys were expanded to index the population during other periods of the annual cycle. Since 1985, the USFWS has conducted surveys that: index the emperor goose population during the spring, summer, and fall; annually estimate the number of nests on the YKD; and estimate the proportion of young in the fall population. The data provide a unique, long-term perspective on seasonal abundance, trends, and distribution. In 2015 and 2016, two population models were developed based on these survey data: a Bayesian state-space model that integrated the 30-year dataset from these surveys to provide an estimate of the size and trend of the emperor goose population; and a theta-logistic population dynamics model that used data from the summer aerial survey, harvest surveys, and stakeholder values to derive harvest thresholds for emperor geese.

A brief description of these surveys, their trends, and the population models follow.

Historical Indices.— Initial assessments of the emperor goose population were conducted in the 1960s from a few aerial surveys of spring staging areas along the Alaska Peninsula (compiled by R. Stehn, USFWS MBM R7), where nearly the entire population of emperor geese is believed to stage during spring and fall migration. In 1963 and 1964, surveys were flown from March to May. These early survey counts were highly variable, in part owing to scheduling mismatched with timing of migration. Survey counts in late March, early April and mid-April in 1963 were nine, 43,000, and 69,000 respectively. In 1964, the survey count in early April was 68,000, but was ~139,000 in late May 1964 (King 1965). At the time of this particular 1964 survey, emperor geese were concentrated just south of the YKD because of unusually late snowmelt on the breeding area (King 1965); thus, relatively few birds were counted in more southern staging areas. This count may not be directly comparable to the standardized annual spring survey indices (see below) conducted since 1981 because of differences in survey timing and methodology; thus, there is uncertainty in the apparent population trend between these two time periods.

Additional aerial surveys of the Alaska Peninsula were conducted in the late 1960s and the 1970s during fall migration. The counts were highly variable, also due in part to difficulties timing the surveys relative to a protracted fall migration. The peak count was ~137,800 birds from a survey in fall 1969, similar to the spring count in 1964; but included an anomalous count at a staging area. The exploratory nature of these early spring and fall aerial surveys provided the basis for standardized long-term surveys conducted by the USFWS to monitor the emperor goose population.

Fall Aerial Index and Age Ratios.— The fall aerial survey of emperor geese at migratory staging areas in southwest Alaska began in 1979 to determine distribution and abundance, but in later years also included estimates of productivity based on aerial photography (Anderson et al. 2002). The survey originally included coastal habitats from Kuskokwim Bay south along the north and south side of the Alaska Peninsula, but in recent years the survey boundaries were limited only to areas flown for productivity estimates (see below). Since 1985, data from this survey were used to expand photographic estimates of productivity based on the distribution of the population across fall staging areas (Stehn and Wilson 2014). Annual survey counts of geese were less variable than the spring survey, with numbers ranging between 58,000 and 110,000 from 1979–2013 (Appendix B). The long-term growth rate was stable at 1.00 with an average count of 74,700 birds (Stehn and Wilson 2014).

In 1985, comprehensive aerial photographic surveys in estuaries on the north side of the Alaska Peninsula were begun (Butler et al. 1985) to provide annual estimates of the proportion of juveniles in the fall staging population as an index to production. The count-weighted proportion (weighted by the proportion of the total fall population observed in regions where counts occurred; Stehn and Wilson 2014) of juveniles was variable, ranging from 0.09–0.35 during 1985–2014 (Appendix E). The 30-year average count-weighted proportion of juveniles was 0.19.

In addition to the aerial photographic survey, ground-based observations of family groups have been conducted at Izembek Lagoon and Cold Bay, Alaska since 1966 (Izembek National

Wildlife Refuge, unpubl. data, Pacific Flyway Council 2006). The proportion of juveniles in the ground count survey was comparable to the aerial photographic surveys. Average estimates of fall age ratio and family group size at Izembek Lagoon and Cold Bay since 1966 were 23.1% juveniles and 2.8 juveniles per family (Appendix F).

Spring Aerial Index.— Beginning in 1981, the USFWS used standardized aerial surveys to annually monitor migrant emperor geese on spring staging areas in southwest Alaska (Wilson and Dau 2015). In 1988, the spring survey count (3-year average) was selected as the Pacific Flyway management index over the fall count because the population is concentrated during a shorter time period in spring than during fall when migration is more protracted (Pacific Flyway 1988). The spring survey counts indicated a population decline of ~58% between 1982 and 1986. During these initial years of the survey, variability in annual counts was relatively high, observer changes occurred more frequently than subsequent years, and observer training and survey timing was still being refined (Dooley, 2016). From 1987–2014, the spring count ranged from 39,000–91,000 birds with an average count of 64,000 birds (Appendix B). In 2015, the spring survey count was 98,155, resulting in a 3-year average of 81,875 (Wilson and Dau 2015).

YKD Coastal Zone Survey.— In 1985, the USFWS began annual aerial surveys to monitor waterbirds, including emperor geese on the YKD to provide indices to population abundance, trends, and distribution. The survey is conducted using a systematic transect design over a >12,000 km^2 area with transect spacing stratified in geographic regions roughly proportional to goose densities. Population indices of emperor geese are calculated as: indicated breeding birds = 2 × (singles + number of pairs) and indicated total birds = 2 × (singles + number of pairs) + birds in flocks (Appendix C), based on an assumption that a single goose signifies a pair (Platte and Stehn. 2015). The average annual population growth rate from 1985–2016 for indicated total birds was 1.020±0.003 (SE) and for indicated breeding birds was 1.026±0.003 (SE). The average (1985–2016) indicated total birds was 21,185 birds and indicated breeding birds was 13,639 birds.

The YKD Coastal Zone Survey (indicated total birds) was selected to replace the spring aerial survey as the interim Pacific Flyway management index for 2017-19. At present, this index is the most suitable for management decisions, while other population assessment methods (e.g., Bayesian state-space model, theta-logistic model) are being refined.

YKD Nesting Survey.— Prior to 1985, there were no comprehensive measures of the emperor goose nest population. Since 1985, intensive random ground plot surveys have been conducted on the YKD (Fischer et al. 2015) in conjunction with aerial surveys (Butler and Malecki 1986, Eldridge and Hodges 2004) to monitor nest populations and potential production. The abundance of nests was estimated annually from sampled plots within a 716 km^2 area. The estimated number of nests is expanded to the YKD, based on the ratio of the index of single birds observed outside the ground-sampled area (OUT) to the index within the ground-sampled area (IN) on the YKD Coastal Zone survey. The nest survey data indicated a long-term (1985–2014) average annual growth rate of 1.012 (90% CI=1.002–1.021) in the nesting population (Appendix D). The average estimated number of emperor goose nests on the YKD was 37,777 from 1985–2014.

Bayesian State-space Model.— In 2015, a Bayesian state-space model was developed that integrated 30 years of data from the 5 annual emperor geese surveys (spring aerial index, YKD coastal zone survey, YKD nesting survey, fall aerial index, and the age ratio survey) to provide a estimates of population size and trend. The data were used in a Bayesian hierarchical model and parameter estimates were derived using a population projection matrix model with four age classes. Model inputs (priors) were selected to be wide and uninformative. The model structure was based on a number of assumptions, but the model ensured that estimated demographic parameters (posterior distributions) such as population growth rate, population size, survival and productivity were coherent and consistent with all the available data from the five surveys. Parameter estimates were based on the median and 95% credible intervals of the posterior distribution of the Bayesian estimates.

Based on the data, model priors and assumptions, the averaged posterior median estimate of 30-year population growth in the June population was 1.010 (±0.008) with a higher increased rate (1.028±0.017) in the last 10 years. The posterior median estimates of population size in June averaged over 2007–2014 was 129,488 (±6,133 SD) birds. The model estimated median June population size in 2014 was 148,010 birds.

Theta-logistic Model[2].— In 2016, a theta-logistic population model and analysis was used to derive optimal harvest thresholds, given two statements of stakeholder values and considering the uncertainty in goose population dynamics and future harvest. Theta-logistic model parameter estimates were obtained using the YKD Coastal Zone Survey data and harvest data from Dooley et al. (2016). The model was fit using Bayesian Markov Chain Monte Carlo methods. Model priors were identical or consistent with the parameter distributions used in Dooley et al. (2016). Harvest decision thresholds were derived using population predictions from the theta-logistic model and associated parameter posterior distributions, utility functions of emperor goose population size elicited from two agency representatives, and harvest utility functions specified from perceived values of subsistence stakeholders.

Given the population model and utility functions, the optimal harvest policy, is to restrict or close the harvest season when the YKD Coastal Zone Survey index is lower than 26,000 birds, approximately. The harvest threshold is highly dependent on the shape of the utility functions and the reported harvest. The theta-logistic model was used to guide the closure threshold in the harvest strategy (see below).

B. Breeding Areas

In Alaska, approximately 90% of the emperor goose population nests along the coastal zone of the YKD (Palmer 1976, Bellrose 1980, King and Dau 1981, Petersen et al. 1994) with smaller numbers nesting on the Seward Peninsula (Kessel 1989) (Figure 1, Appendix A). Emperor geese also nest in Russia along the coast of the Chukotka Peninsula from Mallen Lagoon north and west to Cape Shmidt along the Chukchi Sea (Kistchinski 1973, Portenko 1981, Schmutz and Kondratyev 1995, Dorogoi and Beaman 1997).

[2] Code and associated files can be found at https://github.com/eosnas/Emperor-Goose-Harvest-Strategy.git

Emperor geese arrive on the YKD in early to mid-May, with large influxes occurring 2 to 16 days later (Petersen 1990, 1992a). The pre-laying period between arrival to the breeding areas and nest initiation is approximately 4–19 days (Hupp et al. 2006), which is dependent on individual arrival dates and the timing of snow-melt. Nest initiation dates for emperor geese on the YKD range from mid-May to early June (Petersen 1991, Petersen et al. 1994, Hupp et al. 2006) and on the Chukotka Peninsula from early to mid-June (Kistchinski 1972, Krechmar and Kondratyev 1982). Preferred nest sites include slough borders, pond shorelines, peninsulas, ericaceous tundra, and small islands (Kistchinski 1972, Mickelson 1975, Eisenhauer and Kirkpatrick 1977, Petersen 1985).

The nesting success of emperor geese is highly variable among years, ranging from 0.1% to 90.6% on the YKD (Petersen 1992a). Annual variation in nest success can be attributed to a number of factors, but is due primarily to variation in predation, especially by arctic foxes (Stickney 1989, Petersen 1992a). However, Petersen (1991) found that on average, 62% of clutches on the YKD were parasitized by other emperor goose females, and over 14% of goslings produced were from parasitic eggs. The cost of hosting parasitic eggs in a clutch was slightly reduced hatching success (- 4.5%) of host eggs.

The survival of emperor goslings to 30 days of age also varies considerably among years, from 33% to 71% on the YKD (Schmutz et al. 2001). The lower survival rates were primarily associated with cool, wet weather conditions after hatch and glaucous gull (*Larus hyperboreus*) predation. In 1994, glaucous gulls on the YKD consumed between 21,000 and 52,000 emperor goslings; more than for other goose species and exceeded the estimated 16,000 goslings surviving to early August (Bowman et al. 1997). Schmutz (1993) found that gosling survival was positively correlated with pre-fledging body mass; heavier goslings had significantly higher survival than lighter goslings between late pre-fledging and arrival to fall staging areas. Individual variation in pre-fledging body mass may be influenced by hatch date, forage quality, and inter-specific goose densities at foraging locations (Schmutz 1993, Lake et al. 2008).

Broods move to coastal salt marsh and estuarine habitats within one week of hatching. Laing and Raveling (1993) found that goslings selected vegetated mudflats in coastal salt marsh and spent over 80% of their feeding time there. Emperor goslings initially feed on salt marsh plants (Kistchinski 1972, Laing and Raveling 1993), as do cackling Canada geese and Pacific brant; but as goslings age, crowberries (*Empetrum nigrum*) also become important food (Mickelson 1975).

C. Molt migration

A molt migration consisting of mostly subadults and failed breeders occurs in early- to mid-June from the YKD to St. Lawrence Island and coastal lagoons of the Chukotka Peninsula (Murie 1936, Fay and Cade 1959, Fay 1961, Jones 1972, Kistchinski 1973, 1988). The number of migrating birds varies annually and is largely influenced by reproductive success. Hupp et al. (2007) estimated that in years with high reproductive success, approximately 20,000 birds are non- or failed-breeders. Migration from the YKD appears to be rapid. Most birds complete the transoceanic flight over St. Lawrence Island to Mechigmenan Bay on the Chukotka Peninsula

without stopping, while a portion of birds may stop for a brief period on St. Lawrence Island (Hupp et al. 2007).

Kistchinski (1976) suggested that up to 80% of emperor geese using Russia in summer were molting non-breeders. Historical population counts from late June aerial surveys in 1974 (Kistchinski 1976) indicated 12,000–15,000 emperor geese breeding and molting on the Chukotka Peninsula. In 1993–1995, Hodges and Eldridge (2001) estimated 5,079 emperor geese on the eastern Arctic coast of Russia between the Lena River Delta in the west and Kolyuchin Bay in the east. A more recent (2002) aerial survey of key coastal wetlands along the eastern Chukotka Peninsula counted 21,150 emperor geese (Hupp et al. 2007), which was likely a minimum count. The total population was speculated to be 25,000–30,000 birds (E. Syroechkovskiy, Jr., Russian Academy of Sciences, personal communication). The apparent two-fold increase in summering emperor geese on the Chukotka Peninsula from 1974–2002 may be related to a suspected shift in the 1980s of molting bird use from St. Lawrence Island to the Chukotka Peninsula (Murie 1936, Fay 1961, King and Derksen 1986, King and Butler 1987, Hogan and Rearden 1987, Eldridge and Bollinger 1988).

D. Fall Migration

Emperor geese migrate up to 2,200 km from molting sites to fall staging areas in southwest Alaska (Petersen et al. 1994, Izembek NWR unpublished data; Figure 2). Molt migrants arrive first from early to mid-August followed by successful breeders by late September. Banding and satellite telemetry data suggest most of the emperor goose population follows the Bering Sea coast of Alaska (Schmutz and Kondratyev 1995, Hupp et al. 2001, 2004). Few emperor geese are seen in fall along the Bering Sea coast of Kamchatka, likely because few geese winter there, or in the Commander Islands (Kistchinski 1973, Palmer 1976).

Most emperor geese are distributed among seven staging areas along the Alaska Peninsula during fall migration: Egegik Bay, Ugashik Bay, Cinder River Lagoon, Port Heiden, Seal Islands, Nelson Lagoon, and Izembek Lagoon (Figure 2, Appendix A). The remainder of the population likely uses three estuaries along the south coast of the Alaska Peninsula (Ivanof Bay, Chignik Lagoon and Wide Bay) and islands south of the Alaska Peninsula and Kodiak Island. Birds tend to spend much of their fall staging period at a single site, but use other staging areas while migrating to or from their primary site, generally moving toward a more southerly location (Schmutz 1992, Hupp et al. 2008). Individuals use fall staging areas for about 60–90 days (range = 1–126 days), but the length of stay varies annually and is related to winter location. Geese that migrate farther to the eastern or western Aleutian Islands stage for a longer duration than those that migrate to the south side of the Alaska Peninsula (Hupp et al. 2008). Emperor geese appear to exhibit a high degree of inter-annual fidelity to fall staging areas (Schmutz 1992).

During fall staging, Petersen (1983) observed emperor geese foraging on blue mussels (*Mytilus edulis*) and macoma clams (*Macoma* spp.) during low tide and roosting onshore at high tide. Schmutz (1994) reported that flocks with disproportionately more juveniles continued to feed during high tide due to greater nutritional demands. At Izembek Lagoon, emperor geese also feed on eelgrass (*Zostera* spp.) and crowberries (*Empetrum* spp.), roosting at high tides along beaches or adjacent uplands.

E. Wintering Areas

By early December, most emperor geese have migrated from fall staging areas to wintering sites throughout the Aleutian Islands, the south side of the Alaska Peninsula, and the Kodiak Archipelago. In mild winters, some birds remain in estuaries on the north side of the Alaska Peninsula, if ice-free habitat exists (Palmer 1976, Hupp et al. 2001, 2004). In Russia, emperor geese winter in the Commander Islands and along the southern Kamchatka coast.

Most birds arrive at winter locations by mid- to late-December. Arrival dates and length of stay are dependent on the region in which emperor geese spend the winter; a longitudinal pattern is apparent. Median arrival dates at winter regions were 28 September, 8 December, and 26 December for satellite-tagged geese wintering at the Alaska Peninsula, eastern Aleutian Islands, and western Aleutian Islands, respectively (Hupp et al. 2008). The average length of stay at winter sites was shorter for emperor geese that winter in the Aleutian Islands than for those that winter on the south side of the Alaska Peninsula (Hupp et al. 2008). Observations of marked birds suggest strong site fidelity to winter locations within and among years (Byrd 1989, Byrd et al. 1992, Hupp et al. 2001, 2004).

Little is known about the winter ecology of emperor geese. Wintering geese prefer shallow estuaries and shorelines for foraging and roosting. In the Aleutian Islands, large numbers use islands with extensive intertidal habitats, while others use conical volcanic islands with high energy beaches (J. Williams, USFWS, pers. comm.). The winter diet of emperor geese consists of *Fucus* spp., *Ulva* spp., eelgrass, kelp and various mollusks and other marine organisms associated with intertidal habitats. They also feed on vegetation including the shoots of *Elymus* spp. and rhizomes and herbaceous parts of *Equisetum* spp. (Murie 1959).

Estimates of adult monthly winter survival rate averaged 0.94±0.01 (SE), and estimates of juvenile monthly survival rate during their first winter period averaged 0.71±0.02 (SE), based on re-sighting collar-marked birds. Schmutz et al. (1994) speculate the lack of agricultural foods, and relatively high latitude and inclement weather of winter habitat contribute to high natural mortality rates for juvenile and adult emperor geese in comparison to other goose species.

F. Spring Migration

Emperor geese begin migrating from Aleutian Island wintering sites as early as March (Byrd et al. 1974, Byrd 1988) to staging areas on the Alaska Peninsula until making non-stop flights to the YKD in early May (Hupp et al. 2001, 2004). Birds migrating to more northerly breeding areas depart later. Many emperor geese return to the same primary staging areas they used in fall (Hupp et al. 2008). Emperor geese use spring staging sites for a shorter length of time (average 23 days) than in fall and many spend the majority of the spring staging period at a single site. Departure dates from spring staging sites vary annually, but are similar for emperor geese from different winter regions. Most geese depart for the YKD from Nelson Lagoon, Seal Islands, or Port Heiden and migrate directly across Bristol Bay.

Most Russia breeding birds migrate north along the western Alaska coastline, cross the Bering Strait, and arrive on the Chukotka Peninsula in early June (Kistchinski 1972, Krechmar and Kondratyev 1982). Birds wintering in the Commander Islands and southern Kamchatka are assumed to migrate along the western Bering Sea coastline to the Chukotka Peninsula (A. Kistchinski pers. comm.).

G. Banding and Survival Rates

Approximately 10,949 emperor geese have been banded and 177 encounters have been reported as of March 2016 (USGS Bird Banding Lab). Many of these encounters were recoveries that came from Alaska, and a few reports from British Columbia and Washington. Limited banding of molting emperor geese in Russia has resulted in two recoveries, both in Alaska; one near Cold Bay and one on St. Lawrence Island. Two birds with Russian bands were sighted in Cold Bay in the fall of 1993 (Schmutz and Kondratyev 1995). One young of the year bird banded on the YKD in August 1968 was recovered in July 1973 on the Chukotka Peninsula.

Two studies of annual survival of emperor geese were conducted using banding data from captures of nesting or flightless geese on the YKD. Petersen (1992b) used resights of neck-collared adult females to estimate annual survival from 1982 to 1985, prior to the closures of fall/winter and subsistence spring/summer harvest. The estimated average annual survival rate of 0.58±0.06 was low compared to other goose species (Petersen et al. 1994, Schmutz et al. 1994). Schmutz et al. (1994) used resights of neck-collared adults and juveniles at fall and spring staging areas to calculate seasonal and annual survival rates in the years 1988–1992, after harvest was closed. Adult annual survival was estimated at 0.62±0.02 (SE) and 0.63±0.02 (SE) after adjustment for collar loss; which was similar to the survival rate during 1982–1985 (Petersen 1992b, Schmutz et al. 1994), despite the change in harvest regulations between the two time periods.

In 1993–1998, Schmutz and Morse (2000) examined the effect of neck-collars on annual survival of emperor geese. Results indicated that average annual survival rates were higher for tarsal-only banded birds (0.80±0.14 SE) than for birds with large (0.59±0.18 SE) and small (0.69±0.15 SE) neck collars (Schmutz and Morse 2000). Thus, survival rates reported in prior studies based on neck collars (Petersen et al. 1994, Schmutz et al. 1994) may have been biased low. A recent study by Hupp et al. (2008a) estimated an annual adult female survival rate of 79–85% for radio-marked emperor geese on the YKD during 1999–2004, with 44–47% of all annual mortality occurring during the months of May and August.

H. Fall Harvest

The emperor goose daily bag limit during fall was reduced from six to two per day in 1985; the season has been closed since 1986. Estimates of annual fall harvest by the Alaska Department of Fish and Game (ADFG) from 1970–1980 (Appendix G) averaged 2,100 emperor geese (range = 1,400–3,000). Most fall harvest occurred at staging areas along the north side of the Alaska Peninsula, primarily at the Izembek State Game Refuge and Izembek National Wildlife Refuge.

I. Subsistence Harvest

In Alaska, the harvest of migratory birds and their eggs is a traditional and customary use (Wolfe et al. 1990). The governments of Canada, Mexico, and the United States amended the MBTA and the Mexico Convention in 1997 to allow for the harvest of migratory birds and their eggs during the previously closed period of March 10 to September 1. As part of the amendment, the Alaska Migratory Bird Co-Management Council (consisting of Alaska Native, USFWS and ADFG representatives) was established in October 2000 to recommend subsistence harvest regulations to the Service Regulation Committee for implementation in Alaska.

Prior to the MBTA amendment, the YKDGMP was signed in 1984 by Alaska Natives of the YKD (Association of Village Council Presidents), the USFWS, the ADFG, and other Pacific Flyway state agencies as an agreement to reduce harvest and increase populations of four species of Arctic nesting geese, including emperor geese. In 1987, the terms of the YKDGMP prohibited the taking of emperor geese at any time.

The first legal subsistence hunt of migratory birds took place in 2003. In that year, the AMBCC followed agreements from the YKDGMP (see below) and recommended a closed subsistence harvest season for emperor geese that continued through 2016. The AMBCC also established a Harvest Technical Committee to provide guidance on design and implementation of statewide migratory bird harvest surveys for all species open to subsistence hunting and an Emperor Goose Subcommittee was formed to address species-specific issues.

An integral part of the YKDGMP was the establishment of annual household surveys to document the number, seasonal use, and species composition of birds and eggs harvested for subsistence in the YKD region (Wentworth and Wong 2001). Surveys began in 1985 and continued through 2002. Surveys were expanded to the Bristol Bay region and conducted biennially in 1995–2002. In 2004, the AMBCC Harvest Assessment Program was implemented and was based on the earlier YKDGMP surveys in the YKD and Bristol Bay regions, but also expanded to cover subsistence harvest in other Alaska regions. The survey was revised in 2008–2009 to restructure data collection, analysis, and reporting (Naves et al. 2008). The revised survey was used from 2010–2014 (Naves 2015). In 2015, the survey design underwent another revision (Otis et al. 2016) with planned implementation in 2016.

Despite season closures, harvest of emperor geese continued to be reported in surveys (1985–2002 and 2004–2014; Wentworth and Wong 2001, Wolfe et al. 1990, Wolfe and Paige 2002, Naves 2015). Approximately 70% of the subsistence harvest of emperor geese occurs during the spring and summer months (Wentworth and Wong 2001). From 1985–2002, harvest estimates averaged 2,057 emperor geese (range 818–4,031 geese across years) on the YKD (Appendix 8); however, these data may underestimate harvest because several villages where harvest is known to occur did not participate in the survey during most years (Wentworth and Wong 2001, Wentworth, unpubl. data) and some people may have been and still are reluctant (see 2005–2011 harvest data below) to report the harvest of a closed species. From 1995–2002, the average harvest of emperor geese in Bristol Bay was 308 (97–636 geese). From 2005-2011, the AMBCC revised harvest surveys reported average harvests of 1,637 (815–2,559 geese) on the YKD, 1,532 (1,250–1,860 geese) in the Bering Strait/Norton Sound region, and 45 (26–110 geese) in the Bristol Bay region (Appendix H).

J. Non–consumptive Use

The extent of non-consumptive use of emperor geese is unknown, but likely limited due to their remote distribution. Limited viewing and photographic opportunities exist near Kodiak, Cold Bay, Unalaska/Dutch Harbor, Shemya, and Adak, as well as near many villages throughout their range. A public information program on Arctic nesting geese (Teach About Geese), with an emphasis on emperor geese, prepared by the USFWS received limited use in schools throughout Alaska.

MANAGEMENT ISSUES

Issues identified here are addressed in the Recommended Management Actions section that follows.

1. Population Assessment. Identify the most appropriate method to annually estimate population status and trend. From 1981–2016, the emperor goose population was indexed using the spring aerial count during migration and used to guide regulatory actions. The spring index was replaced with the total bird index because the latter survey index is less sensitive to bias and is a more precise measure of the emperor goose population. However, a model (or expansion factor) is required to scale the index to total population size, and frequent regulatory action may result from annual variation in a single index. Two different population models have been developed (Bayesian state-space model and theta-logistic model) that may be used as the population assessment method over the current approach, but they require additional refinement or integration.

   Current and comprehensive information on the distribution and abundance of emperor geese in Russia is lacking. The distribution and abundance of emperor geese in the Arctic may be influenced by Arctic warming and associated changes in flora and fauna. Aerial and ground inventories of Russian breeding and molting habitats have not been conducted in many years and compromise our ability to fully assess emperor goose distribution and abundance. No methods are available to monitor birds over most of the winter range in Alaska or Russia.

2. Harvest Assessment. Subsistence harvest surveys conducted throughout much of the harvest closure period, report a substantial harvest, but the proportion of reported harvest to actual harvest is unknown. There has been much disagreement regarding the reliability of harvest surveys during this period. Regional surveys to reliably estimate timing and magnitude of subsistence harvest are needed, and must be fully funded and implemented locally.

   Harvest surveys are currently being redesigned, but it remains unclear whether this new design will provide useful information (precision, reporting bias) to satisfy management needs.

Harvest rates cannot be assessed from band returns due to the difficulties with banding sufficient numbers of birds that spend most of the year in remote regions.

We have little quantifiable information to assess the harvest of emperor geese in Russia. Annual harvest is assumed to be a few hundred birds. Funding and infrastructure to gather this information is not currently available.

3. Population Enhancement. Besides adjusting hunting regulations and implementing cooperative outreach and education programs, managers have few tools to influence population dynamics. Gull and fox predation have been hypothesized as factors limiting population growth of emperor geese; predator control could be used.

4. Habitat Dynamics. Habitat changes on the YKD, due to global or localized events, may alter emperor goose nesting and brood rearing habitat and impact production and gosling survival. We are unable to correlate population change with breeding habitat change.

   There are insufficient data on the wintering ecology of emperor geese. We are unable to correlate population change with winter habitat change or understand how population dynamics are influenced by changes in the quality of winter habitat.

5. Outreach and Education. The perceived status of the emperor goose population is ambiguous, in part due to a lack of trust and differing viewpoints between many residents of rural Alaska, and federal and state management agencies. Compliance with federal and state regulations is difficult to achieve and this may compromise the ability to collect accurate harvest information. Improved outreach and education programs relying on knowledge, input, and participation of local residents to develop, convey, and collect essential management information is crucial to this effort.

MANAGEMENT ACTIONS

The following management actions are recommended and assigned a priority rating. The degree and timing of their implementation may be influenced by human resource, fiscal and legislative constraints. Whenever possible, management actions in this Management Plan should be integrated with those in management plans for other Pacific Flyway goose populations, local and regional land use plans, and habitat conservation programs. Management actions should be accompanied by monitoring efforts to examine their effectiveness in meeting population and habitat objectives.

Agencies should involve local residents in management activities, where feasible, throughout the range of the species.

A. Population Assessment

1. Continue the current system of population index surveys (that may include spring, fall, and summer) during the 3-year period following implementation of the Management Plan.

   Responsibility: USFWS
   Priority: 1
   Schedule: Ongoing

2. Continue to refine or integrate the Bayesian state-space and theta-logistic models to improve population assessment.

   Responsibility: ADFG, USFWS
   Priority: 1
   Schedule: Annual

3. Work cooperatively with Russian agencies to obtain breeding, molting, and migration information throughout the range of emperor geese in eastern Russia. Arrange opportunities for cooperative aerial and ground surveys.

   Responsibility: USFWS, Russia
   Priority: 1
   Schedule: Continuing

4. Investigate the use of Unmanned Aerial Vehicles and other remote sensing methods to survey emperor geese at winter locations through coordination with universities and other government agencies.

   Responsibility: USFWS, ADF&G
   Priority: 2
   Schedule: Undetermined

B. Outreach and Education

1. Cooperatively develop outreach and educational materials for hunters to increase awareness of the harvest strategy and harvest regulations for spring/summer and fall/winter harvest. Continue to improve education and outreach programs in cooperation with the AMBCC; they should be designed as relevant to local residents, build consensus, and create awareness of activities that affect emperor goose populations.

   Responsibility: Native Caucus, USFWS, ADFG
   Priority: 1
   Schedule: Continuing

2. Promote cooperative educational and volunteer programs originally agreed to in the Yukon- Kuskokwim Delta Goose Management Plan with Alaska Native organizations. Expand education and information programs on emperor goose conservation to include villages in Bristol Bay, Alaska Peninsula, St. Lawrence Island, Seward Peninsula and Aleutian Islands.

   Responsibility: USFWS, ADFG, AVCP, AMBCC
   Priority: 1
   Schedule: Undetermined

C. Management and Research

1. Refine the YKD Nest Plot Survey to make statistically defensible inference from sampled areas to total nest numbers.

   Responsibility: USFWS
   Participating: USGS-ASC
   Priority: 1
   Schedule: 2017

2. Develop methods to estimate aerial detection rates on the YKD Coastal Zone Survey.
   Responsibility: USFWS
   Participating: USGS-ASC
   Priority: 1
   Schedule: 2017

3. Design and implement studies that assess the change in emperor goose egg and gosling mortality on the YKD as a result of removing foxes and gulls.

   Responsibility: USFWS
   Participating: USGS-ASC
   Priority: 2
   Schedule: Undetermined

4. Design and implement studies that improve our knowledge of emperor goose breeding and winter ecology to help interpret mechanisms of population change.

   Responsibility: USFWS, USGS-ASC
   Priority: 2
   Schedule: Undetermined

D. Harvest Management

1. Conduct annual subsistence harvest surveys in regions of Alaska that harvest emperor geese to estimate harvest magnitude and trends.

Responsibility: USFWS, ADFG, AMBCC
Priority: 1
Schedule: Annual

2. Continue support of the conservation measures listed in the 2005 Yukon-Kuskokwim Delta Goose Management Plan and support the newly adopted AMBCC Emperor Goose Management Plan.

   Responsibility: USFWS, USGS-ASC, AMBCC, AVCP, ADFG,
   Priority: 1
   Schedule: Continuing

3. Work cooperatively with Russian agencies to assess the magnitude of harvest.

   Responsibility: USFWS
   Priority: 1
   Schedule: Undetermined

HARVEST STRATEGY

The goal of the harvest strategy is to adopt regulations that are defensible, enforceable, well communicated, and sufficiently flexible to meet the needs of harvesters in rural Alaska concurrent with Management Plan objectives.

The harvest strategy is based on using a total bird index from the YKD Coastal Zone Survey to assess population status relative to a regulatory harvest threshold (see Figure below). The total bird index is a relative measure of population size based on the number of geese detected from aerial surveys on the YKD during the early nesting period.

Based on the total bird index, the harvest strategy defines a regulatory harvest closure threshold of 23,000 birds. This represents approximately 120,000 emperor geese based on a theta-logistic population model currently in development (USFWS, R7-Migratory Bird Management). The most recent 3-year average population index (2014–2016) is 30,965 birds; equivalent to approximately 161,000 emperor geese. The theta-logistic model and associated analysis was used to derive optimal harvest thresholds, which helped guide the selection of the harvest closure threshold.

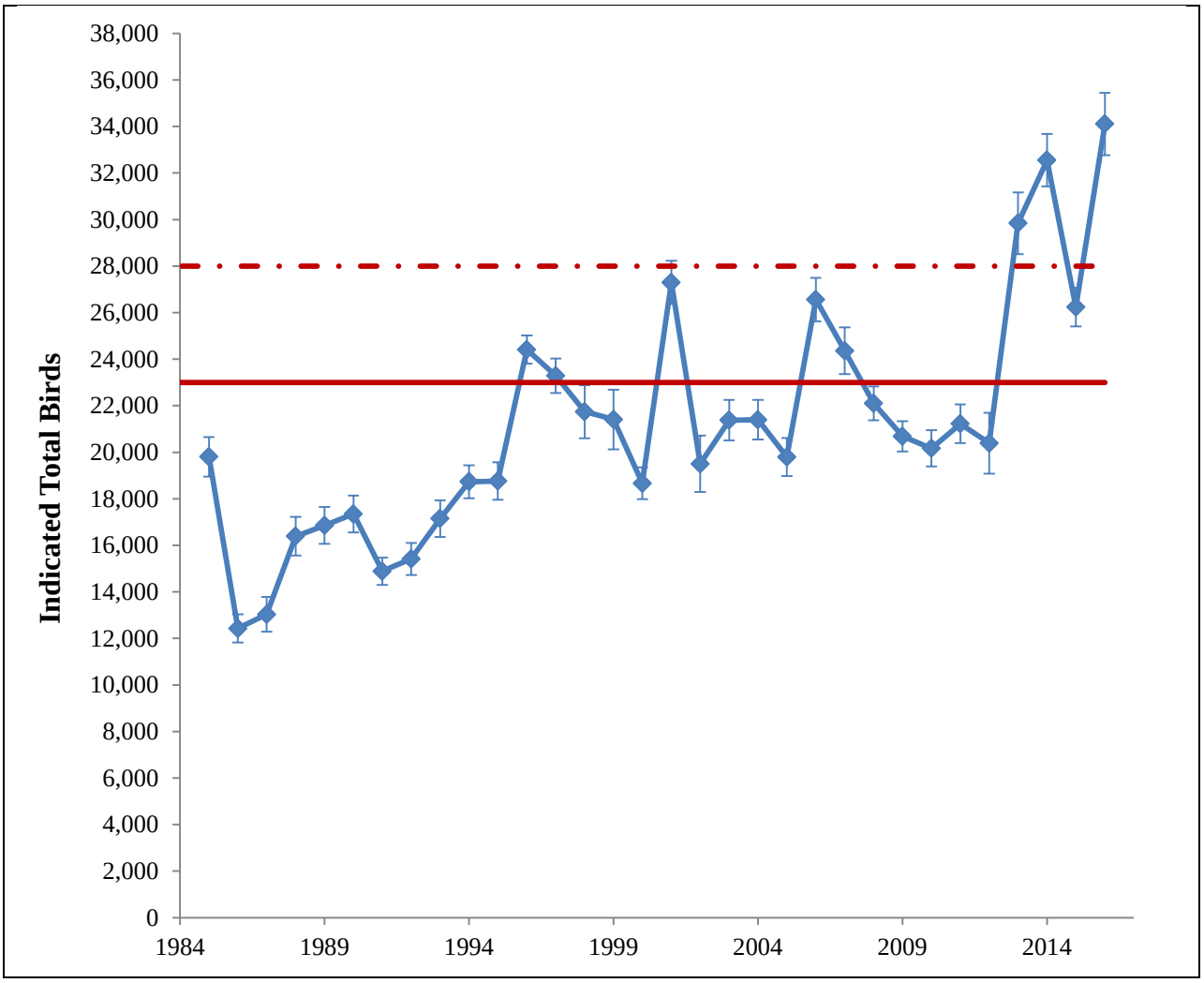
The term of this harvest strategy is the period of 2017-2021. However, during the 3-year period (2017–2019) following implementation, the Subcommittee in cooperation with the AMBCC will annually review available data (e.g., harvest survey data, population status and trend, and other relevant information), and consider the need for more restrictive regulations. After the 3-year period, the Subcommittee will conduct a thorough analysis of the available data to determine efficacy of the harvest strategy and will consider alternative strategies if warranted. Alternatives will be considered as amendments to the Management Plan and be effective for the remainder of the 5-year term. This harvest strategy is complementary to the spring/summer subsistence harvest strategy included in the AMBCC Emperor Goose Management Plan. In recognition that emperor geese are a shared resource, the Pacific Flyway Council has established the following fall/winter harvest guidelines:

1. The harvest strategy seeks to maintain a population of emperor geese above an index of 23,000 birds based on the total bird index from the most recent YKD Coastal Zone Survey.
2. Fall/winter harvest will be open with an annual 1000 bird quota (see Table below) if the total bird index from the previous year is greater than 23,000 birds. When the population index is less than 28,000 birds, a restrictive quota will be considered.
3. Fall/winter harvest will be closed if the total bird index from the previous year is less than 23,000 birds.

Alaska Zones and Regulation	Regulation Package		
	Open[1]	**Restrictive**	**Closed**
	1,000 bird quota	500 bird quota	No harvest
Gulf Coast			
Framework Dates	September 1 – December 16		
Open Areas	Game Management Unit 9		
Kodiak[2]			
Framework Dates	October 8 – January 22		
Open Areas	Game Management Unit 8		
Pribilof/Aleutian			
Framework Dates	October 8 – January 22		
Open Areas	Game Management Unit 10		
North			
Framework Dates	September 1 – December 16		
Open Areas	Game Management Unit 17, 18, 22, 23		

[1]Emperor goose harvest quota of 1,000 birds annually, to be administered by registration permit. A permit allows the harvest and possession of 1 emperor goose. Harvest reporting requirements will apply.

[2]Kodiak Island Road Area closed to hunting: the closed area consists of all lands and water (including exposed tidelands) east of a line extending from Crag Point in the north to the west end of Saltery Cove in the south and all lands and water south of a line extending from Termination Point along the north side of Cascade Lake extending to Anton Larsen Bay. Marine waters adjacent to the closed area are closed to harvest within 500 feet from the water's edge. The offshore islands are open to harvest, for example: Woody, Long, Gull and Puffin islands.



Indicated total bird index (±SE) from the Yukon-Kuskokwim Delta Coastal Survey (1985–2016) used as the interim Pacific Flyway management index of emperor geese. The solid horizontal line (23,000 total bird index) represents the threshold between open (above line) and closed (below line) regulation packages for fall/winter harvest. The dashed horizontal line (28,000 total bird index) represents a threshold below which more restrictive regulations will be considered.

ANNUAL PLAN REVIEW

The Subcommittee shall meet twice annually, or as needed, to review progress towards achieving the goal and objectives of this Management Plan, and to recommend actions and revisions. The Subcommittee shall report to the Pacific Flyway Council through its Study Committee on accomplishments and shortcomings of the cooperative management efforts. This Subcommittee shall coordinate management activities with those of the subcommittees on Pacific Greater White-fronted geese, cackling Canada geese, and Pacific brant. The Subcommittee will coordinate with the AMBCC Emperor Goose Subcommittee.

The Subcommittee shall be composed of a representative from the U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game. It shall be the responsibility of those members to assure that the objectives and procedures of this Management Plan are integrated and coordinated with those plans and activities of the various wildlife and land management agencies and local planning systems within their agency's venue. Chairmanship shall be appointed biennially and rotated among member agencies. The Subcommittee will exercise its prerogative to invite to attend and participate (*ex officio*) at meetings any individual, group, agency, or representative whose expertise, counsel, or managerial capacity is required for the coordination and implementation of management programs.

Agencies:	Subcommittee
Priority:	1
Schedule:	Twice annually -- at the March and September meetings of the Pacific Flyway Study Committee. The schedule for rotation of the chair, beginning January 1, is:

2016 – FWS Region 7
2017 – FWS Region 7
2018 – Alaska
2019 – Alaska
2020 – FWS Region 7

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APPENDICES

Appendix A. Important use areas of emperor geese in Russia and Alaska

	Area[1]	Use	Count[2]	Season	Ownership
	RUSSIA				
1	Chukotsk coastal areas	Breeding/Molting	3,000–8,000/21,000	Spring – Summer	
2	Tenkergynpilken Lagoon	Molting	21,000	Summer	
3	Ukouge Lagoon	Molting	2,000	Summer	
4	Kolyuchinskaya Bay	Breeding/Molting	Unknown/21,000	Spring – Summer	
5	Vankarem Lagoon	Breeding	Unknown	Spring – Summer	
6	Kresta Bay	Breeding	Unknown	Spring – Summer	
7	Kamchatka Peninsula/ Commander Islands	Wintering	Unknown	Winter	Nature Reserves
	ALASKA				
8	Yukon-Kuskokwim Delta	Breeding/Molting	80–90% of pop	Spring – Summer	Yukon Delta NWR, 22(g) lands
9	Kotzebue Sound	Breeding	1,000	Spring – Summer	50% Bering Land Bridge NP
10	St. Lawrence Island	Breeding/Molting	300–1,000/3,000–10,000	Spring – Summer	Native Alaskan owned
11	Nunivak Island	Breeding/Staging	Unknown/2,000	Spring – Summer/Spring; Fall	Yukon Delta NWR, 22(g) lands
12	Egegik Bay	Staging	1,800; 2,300	Spring; Fall	Egegik State CHA
13	Ugashik Bay	Staging	4,275; 2,500	Spring; Fall	Pilot Point State CHA
14	Cinder River Lagoon	Staging	13,825; 24,000	Spring; Fall; Winter	Cinder River State CHA
15	Hook Lagoon	Staging	1,000; 2,000	Spring; Fall; Winter	Private Lands
16	Port Heiden	Staging	33,187; 28,600	Spring; Fall; Winter	Port Heiden State CHA
17	Seal Islands	Staging	14,000; 20,000	Spring; Fall; Winter	Private Lands
18	Nelson Lagoon	Staging	60,000; 39,400	Spring; Fall; Winter	Port Moller State CHA
19	Izembek Lagoon	Staging	18,300; 9,100	Spring; Fall; Winter	Izembek NWR/SGR, 22(g) lands
20	Unimak/False Pass	Staging	120; 4,000	Spring; Fall; Winter	Izembek NWR, 22(g) lands
21	Alaska Peninsula (south)	Staging	4,200; 9,600	Spring; Fall; Winter	AK Peninsula, Becharof, Izembek NWRs
22	Aleutian Islands	Wintering	Unknown	Winter	AK Maritime NWR, DOD lands
23	Kodiak Island	Wintering	Unknown	Winter	Kodiak NWR, 22(g) lands

[1]Areas mapped by accession number in Figure 1
[2]Areas 12–22 counts are averages for spring and fall aerial surveys

Appendix B. Population indices of emperor geese from spring and fall aerial surveys; 1979–2016

Year	Spring Survey[a]	Spring survey 3-yr Avg[a]	Fall Survey[b]
1979			59,808
1980			65,971
1981	91,267		63,156
1982	100,643		80,608
1983	79,155	90,355	72,551
1984	71,217	83,672	82,842
1985	58,833	69,735	59,790
1986	42,231	57,427	68,051
1987	51,633	50,899	65,663
1988	53,784	49,216	76,165
1989	45,800	50,406	70,729
1990	67,581	55,722	109,531
1991	70,972	61,451	75,295
1992	71,319	69,957	82,295
1993	52,546	64,946	71,051
1994	57,267	60,377	87,086
1995	54,852	54,888	91,009
1996	80,034	64,051	87,018
1997	57,059	63,982	86,669
1998	39,749	58,947	67,744
1999	54,600	50,469	60,226
2000	62,565	52,305	61,626
2001	84,396	67,187	59,987
2002	58,743	68,568	78,692
2003	71,160	71,433	77,290
2004	47,352	59,085	93,544
2005	53,965	57,492	73,212
2006	76,108	59,142	81,078
2007	77,541	69,205	73,531
2008	64,944	72,864	78,201
2009	91,948	78,144	79,647
2010	64,562	73,818	59,924
2011	74,166	76,892	62,561
2012	67,588	68,772	58,683
2013	No survey		78,100
2014	79,883	73,879	90,116[c]
2015	98,155	81,875	84,702[c]
2016[c]	79,348	85,795	

[a]Dau, C.P. and H.M. Wilson. 2015. Aerial survey of emperor geese and other waterbirds in southwestern Alaska, spring 2015. USFWS, Migratory Bird Management, Anchorage, Alaska

[b]Dau, C.P. and H.M. Wilson. 2013. Aerial survey of emperor geese and other waterbirds in southwestern Alaska, fall 2014. USFWS, Migratory Bird Management, Anchorage, Alaska

[c]Safine, D.E. 2016. Alaska Goose and Swan Population Status Report. Memorandum to Todd A. Sanders, Pacific Flyway Representative. US Fish and Wildlife Service, Migratory Bird Management, Anchorage, Alaska

Appendix C. Population indices of emperor geese from the Yukon-Kuskokwim Delta Coastal Zone survey, 1985–2016

Year	Indicated breeding birds[a]	SE	Indicated total birds[b]	SE
1985	9,542	852	19,805	1,960
1986	7,413	611	12,430	1,008
1987	9,312	746	13,035	1,121
1988	8,695	829	16,392	1,402
1989	10,737	791	16,855	1,220
1990	9,282	787	17,347	1,401
1991	7,758	590	14,888	1,284
1992	9,879	686	15,416	994
1993	10,183	787	17,147	1,230
1994	12,007	712	18,733	1,059
1995	12,892	806	18,764	1,072
1996	12,433	604	24,413	2,476
1997	12,820	741	23,287	1,451
1998	15,686	1,136	21,741	1,541
1999	16,208	1,285	21,406	1,591
2000	12,798	680	18,667	949
2001	17,112	926	27,297	1,473
2002	15,646	1,215	19,504	1,326
2003	12,141	869	21,378	1,746
2004	14,410	848	21,396	1,097
2005	14,490	817	19,798	1,190
2006	17,460	936	26,562	1,697
2007	14,562	1,004	24,362	1,508
2008	16,110	724	22,100	1,038
2009	13,563	646	20,684	1,092
2010	14,103	781	20,167	1,199
2011	14,730	828	21,223	1,284
2012	17,207	1,307	20,388	1,554
2013	19,372	1,326	29,840	2,222
2014	16,188	1,132	32,550	2,973
2015	14,647	832	26,235	1,581
2016	27,051	1,341	34,109	2,490

data from: Platte, R.M. and R.A. Stehn. 2015. Abundance and trends of waterbirds on Alaska's Yukon-Kuskokwim Delta coast based on 1988–2014 aerial surveys. USFWS, Migratory Bird Management, Anchorage, Alaska; and

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[a]Indicated breeding birds = 2 × (singles + number of pairs)

[b]Indicated total birds = 2 × (singles + number of pairs) + birds in flocks

Appendix D. Nesting population indices of emperor geese on the Yukon-Kuskokwim Delta, Alaska from nest plot surveys, 1985–2014

Year	# plots	Adj. # nests (IN)[a]	OUT:IN ratio[b]	Adj. # nests (OUT)[c]	Total nests index[d]	SE
1985	49	4,411	2.94	12,950	17,361	3,180
1986	46	6,096	2.97	18,129	24,225	3,387
1987	37	10,218	3.08	31,513	41,731	6,635
1988	32	5,942	3.37	20,045	25,988	4,650
1989	23	13,306	2.67	35,530	48,836	6,752
1990	33	12,490	2.79	34,836	47,326	6,618
1991	36	13,758	2.26	31,142	44,900	6,315
1992	42	11,906	2.17	25,868	37,774	4,743
1993	47	11,571	2.02	23,357	34,928	4,436
1994	41	15,561	1.87	29,020	44,581	4,794
1995	50	11,389	2.22	25,316	36,706	4,052
1996	54	12,866	1.92	24,636	37,502	3,571
1997	72	8,461	2.12	17,926	26,387	2,613
1998	64	10,719	1.87	20,086	30,806	3,089
1999	53	11,794	2.48	29,221	41,015	4,243
2000	80	11,185	2.65	29,672	40,856	4,200
2001	81	5,209	2.15	11,188	16,398	1,608
2002	84	10,142	3.15	31,898	42,040	4,994
2003	83	8,311	2.42	20,149	28,461	3,295
2004	81	11,051	2.34	25,813	36,865	3,521
2005	83	12,588	2.44	30,697	43,285	3,994
2006	75	10,648	2.50	26,624	37,272	3,716
2007	79	11,688	2.19	25,601	37,288	3,814
2008	82	11,103	2.29	25,457	36,561	3,092
2009	81	15,369	2.45	37,704	53,073	4,661
2010	66	11,873	2.56	30,340	42,213	4,427
2011	82	11,945	2.81	33,576	45,521	4,506
2012	77	10,851	2.87	31,131	41,981	4,859
2013	59	10,993	3.86	42,376	53,369	5,749
2014	76	8,832	3.31	29,221	38,053	3,994

data from: Fischer, J.B. and R.A. Stehn. 2014. Nest population size and potential production of geese and spectacled eiders on the Yukon-Kuskokwim Delta, Alaska, 2013. Unpubl. Rep., USFWS, Anchorage, Alaska

[a]nest index corrected for nest detection rate

[b]ratio of indicated breeding pairs from aerial observations outside vs. inside the ground sampled area (plots)

[c]extrapolated to areas outside the plots using the OUT:IN ratio and corrected for nest detection

[d]Adjusted # nests (IN) + Adjusted # nests (OUT)

Appendix E. Proportion juvenile emperor geese in photographic samples from fall aerial surveys on the Alaska Peninsula

Year	% juveniles (count weighted)	SE	No. Geese Classified	No. Photos
1985	16.5	0.026	3,193	155
1986	25.4	0.051	6,380	311
1987	23.5	0.008	10,177	703
1988	24.4	0.009	11,180	483
1989	21.9	0.011	12,718	390
1990	24.1	0.009	13,541	474
1991	23.2	0.009	14,569	412
1992	15.6	0.008	14,832	403
1993	24.2	0.014	5,735	255
1994	22.7	0.010	16,881	479
1995	25.7	0.012	11,664	361
1996	18.5	0.017	10,793	182
1997	10.7	0.007	11,138	205
1998	11.7	0.007	16,544	336
1999	17.8	0.010	13,489	392
2000	11.4	0.009	7,748	263
2001	11.5	0.008	11,186	365
2002	17.8	0.010	6,458	402
2003	09.4	0.008	8,686	421
2004	11.2	0.007	6,237	370
2005	18.9	0.012	6,563	500
2006	35.2	0.013	9,773	469
2007	17.4	0.008	12,134	398
2008	24.8	0.010	10,207	625
2009	15.7	0.008	12,404	607
2010	19.2	0.009	20,876	436
2011	19.5	0.010	19,432	441
2012	18.4	0.021	13,109	378
2013	20.4	0.011	11,269	224

[a]Stehn, R.A. and H.M. Wilson. 2014. Monitoring emperor geese by age ratio and survey counts, 1985–2013. USFWS, Migratory Bird Management, Anchorage, Alaska

Appendix F. Emperor goose fall productivity indices from ground counts at Izembek Lagoon and Cold Bay, AK, 1966–2014

	Grouped Birds			Family Groups		
Year	Adults	Juveniles	% Juveniles	No. Families	No. Juveniles	Juveniles/Family
1966	699	265	27.5	132	331	2.51
1967	1,457	585	28.6	66	215	3.26
1968	1,195	585	32.9	40	112	2.80
1969	4,149	2,980	41.8	161	530	3.29
1970	9,722	4,933	33.7	383	1,115	2.91
1971	1,842	3,458	29.8	484	1,318	2.72
1972	4,680	2,270	32.7	210	641	3.05
1974	2,025	377	15.7	50	130	2.60
1975	744	405	35.2	51	149	2.92
1976	1,923	324	14.4	207	567	2.74
1977	996	683	40.7	108	302	2.80
1978	1,395	495	26.2	62	188	3.03
1979	841	113	11.8	53	175	3.30
1980	1,777	586	24.8	40	93	2.33
1981	1,067	495	31.7	181	571	3.15
1982	1,653	140	7.8	32	85	2.66
1983	1,058	393	27.1	192	612	3.19
1984	2,753	795	22.4	80	230	2.88
1985	2,245	503	18.3	125	354	2.83
1986	3,283	1,381	29.6	266	794	2.98
1987	2,926	1,523	33.8	186	577	3.10
1988	3,884	1,242	24.2	200	616	3.08
1989	3,811	1,136	23.0	145	455	3.14
1990	4,002	1,068	21.1	97	309	3.19
1991	8,599	2,882	25.1	147	487	3.31
1992	9,291	1,347	12.7	151	451	2.99
1993	13,976	2,176	13.5	161	441	2.74
1994	4,658	792	14.5	301	703	2.34
1995	6,434	1,618	20.1	99	319	3.22
1996	3,128	631	16.8	125	330	2.64
1997	1,345	144	10.0	43	114	2.65
1998	1,595	432	21.4	97	239	2.46
1999	2,395	527	18.0	82	200	2.44
2000	1,870	410	18.0	105	229	2.18
2001	1,232	228	15.6	42	103	2.45
2002	4,789	1,842	27.8	260	696	2.68
2003	5,744	785	12.0	218	439	2.01
2004	4,600	1,288	21.9	235	568	2.42
2005	2,844	1,139	28.6	131	365	2.79
2006	3,360	2,062	38.0	476	1,074	2.26
2007	5,124	1,146	18.3	179	387	2.16
2008	3,739	1,323	26.1	250	687	2.75
2009	2,114	743	26.0	148	340	2.30
2010	1,688	455	21.2	27	65	2.41
2011	2,065	389	15.9	27	51	1.89
2012	883	142	13.9	16	36	2.25
2013	1,366	370	21.3	79	210	2.66
2014	1,199	298	19.9	71	175	2.46

compiled in Groves, D.J. 2012. Alaska productivity surveys of geese, swans, and brant, 2011. USFWS, Migratory Bird Management, Anchorage, Alaska

Appendix G. Reported sport harvest of emperor geese in Alaska, 1970–1986

Year	Harvest[a]
1970	1,400
1971	715
1972	1,840
1973	2,373
1974	2,067
1975	2,891
1976	2,592
1977	2,198
1978	2,968
1979	2,055
1980	2,306
1981	700
1982	1,770
1983	1,674
1984	1,188
1985	835
1986–Present	Closed

[a]Harvest information based on ADF&G mail questionnaire surveys (1970–76 and 1982–85) and USFWS harvest surveys (1977–81)

Appendix H. Emperor goose harvest estimates by region excerpted from Alaska migratory bird subsistence harvest surveys conducted during the spring, summer, and fall periods; 1985–2014

Year	Alaska Region					
	Northwest Arctic	Bering Strait Norton Sound	Yukon-Kuskokwim Delta	Bristol Bay	Kodiak	Aleutian/Pribilof Islands
1985	-	-	4,031	-	-	-
1986	-	-	3,091	-	-	-
1987	-	-	1,352	-	-	-
1988	-	-	-	-	-	-
1989	-	-	1,616	-	-	-
1990	-	-	3,440	-	-	-
1991	-	-	2,394	-	-	-
1992	-	-	2,669	-	-	-
1993	-	-	2,602	-	-	-
1994	-	-	1,493	-	-	-
1995	-	-	2,041	439	-	-
1996	-	-	2,374	97	-	-
1997	-	-	1,469	320	-	-
1998	-	-	1,899	636	-	-
1999	-	-	818	422	-	-
2000	-	-	1,351	261	-	-
2001	-	-	1,078	123	-	-
2002	-	-	1,250	167	-	-
2003	-	-	-	-	-	-
2004	-	1,860	1,151	*	-	-
2005	-	1,487	815	47	-	*
2006	*	-	2,425	*	*	-
2007	-	1,250	1,608	26	-	*
2008	-	-	1,490	0	-	109
2009	-	*	2,559	-	-	-
2010	-	*	2,094	-	0	-
2011	-	*	952	110	-	-
2012	*	*	-	-	-	-
2013	-	-	*	-	-	-
2014	-	-	-	-	-	-

-: Region not surveyed

*: Region harvest estimates not produced because <75% of households represented in sample