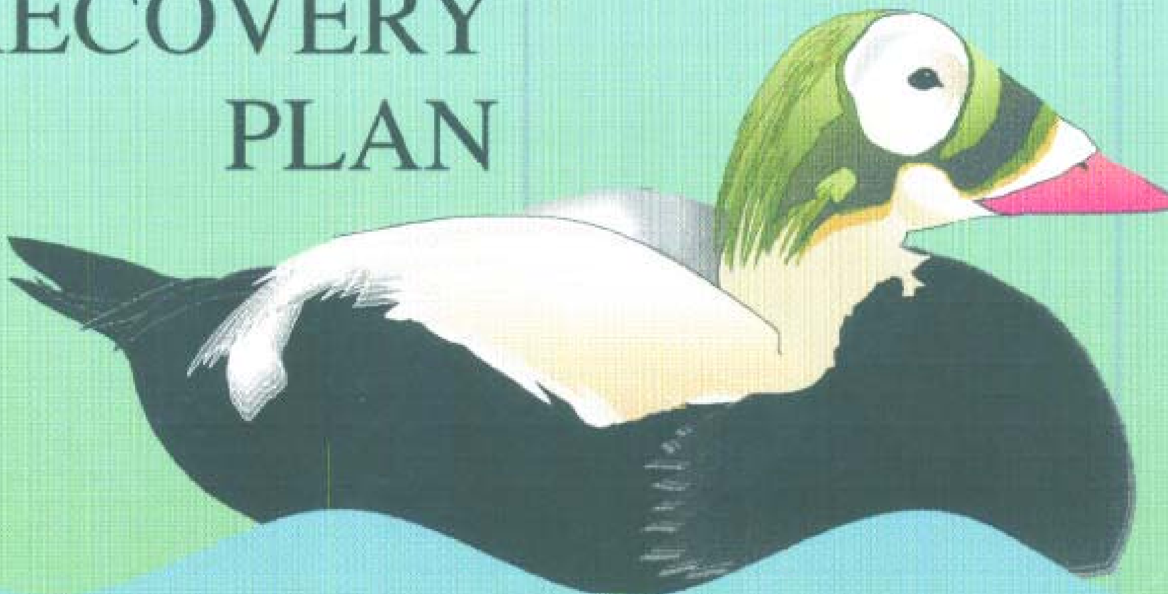
SPECTACLED EIDER

Somateria fischeri

RECOVERY PLAN



SPECTACLED EIDER RECOVERY PLAN

Prepared by the Spectacled Eider Recovery Team

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DISCLAIMER PAGE

Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect listed species. Plans are published by the U.S. Fish and Wildlife Service, sometimes prepared with the assistance of recovery teams, contractors, state agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service **only** after they have been signed by the Regional Director or Director as **approved**. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

LITERATURE CITATION

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EXECUTIVE SUMMARY
OF THE RECOVERY PLAN FOR THE SPECTACLED EIDER

Current Status: This species is listed as threatened. Three breeding populations have been identified: Yukon-Kuskokwim Delta (YKD), North Slope of Alaska (NS), and Arctic Russia (AR). The breeding range of the YKD population is reduced and the population appears to have declined by more than 96% since the mid-1970s. The NS breeding population apparently has experienced localized declines but data are insufficient to determine an overall trend. The AR population is quite large; but the trend is unknown and the historic range appears to be reduced.

Habitat Requirements and Limiting Factors: The Spectacled Eider breeds in low-lying arctic and sub-arctic wetlands dominated by graminoids and characterized by numerous shallow ponds and lakes. On the YKD, these wetlands are near the coast and partially drained by complex slough and river systems. The NS and AR breeding habitats are low-lying, poorly-drained, coastal plains. Molting occurs at sea in nearshore waters. Principal known Spectacled Eider wintering areas are in the central Bering Sea. Preliminary analyses using Common Eider demographic data suggest that adult survival may be the most important variable affecting population growth rate. Lead poisoning from ingested lead shotgun pellets may have contributed to the rapid decline observed on the Yukon-Kuskokwim Delta. Numerous factors known or suspected of affecting adult survival have been identified, but their relative importance is unknown.

Recovery Objective: Delisting

Recovery Criteria: Spectacled Eiders will be considered recovered when each of the three recognized populations: 1) is stable or increasing over 10 or more years and the minimum estimated population size is at least 6,000 breeding pairs, or 2) numbers at least 10,000 breeding pairs over 3 or more years, or 3) numbers at least 25,000 breeding pairs in one year.

Actions Needed:
1. Coordinate recovery and management efforts between and among government agencies and Native and other non-governmental organizations.
2. Increase efforts to reduce mortality.
3. Quantify and monitor existing breeding populations.
4. Determine molting, migration, and wintering areas and habitats.
5. Conduct research on the demography and biology of the species and develop demographic models.
6. Attempt to determine the obstacles to recovery and causes for decline.

Costs: ($000's):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Total
1	95	253	183	290	1,349	555	2,725
2	95	218	183	110	1,122	155	1,883
3	95	218	173	60	1,082	90	1,718
4	80	218	85	60	322	70	835
5	80	218	85	60	322	70	835
Total	445	1,125	709	580	4,197	940	7,996

Date of Recovery: The estimated date for recovery of the world population of the Spectacled Eider is unknown due to: 1) uncertainty of causes for decline and obstacles to recovery, and 2) potential inability to eliminate effects of causes and obstacles once they are identified.

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I. INTRODUCTION

The Endangered Species Act of 1973, as amended, calls for preparation of recovery plans for listed species that are likely to benefit from the effort, and authorizes the Secretary of the Interior to appoint recovery teams to prepare them. A recovery plan must establish recovery goals and objectives, describe site-specific management actions recommended to achieve those goals, and estimate the time and cost required for recovery. A recovery plan does not commit resources, but instead presents a comprehensive framework and list of tasks that are thought to be necessary to achieve recovery. This plan has been approved by the U.S. Fish and Wildlife Service (Service), but may not reflect the views of other parties involved in recovery.

The Spectacled Eider Recovery Team currently consists of 7 members with a variety of expertise in Spectacled Eider (*Somateria fischeri*) biology, conservation biology, population biology, marine ecology, Native Alaskan culture, and wildlife management. In addition to the core Recovery Team members, 4 consultants were appointed to assist the Team. The consultants brought to the Recovery Team expertise in Spectacled Eider field research, Alaska's habitats and natural history, and extensive practical knowledge of Alaska field research techniques. The Recovery Team and its consultants met 8 times from May 1993 to December 1995, to develop recovery strategies and recommendations. During the development of the Recovery Plan, the Team solicited input from others with experience in Alaska waterfowl biology and management, and subsistence harvest practices and management.

The Recovery Plan is comprised of four major sections:

(1) Introduction: this section acquaints the reader with the Spectacled Eider, its status, and the threats it faces. It also serves as a review of the biological literature for the species.

(2) Recovery: this section describes recovery objectives, criteria for delisting or for changing the status of Spectacled Eiders between threatened and endangered, the recovery strategy and its underlying principles, and actions or tasks needed to achieve recovery. These recovery tasks are presented in a narrative outline, organized by major topics, and laid out in an abbreviated, step-down outline for quick reference.

(3) Implementation Schedule: this section presents the recovery tasks from the narrative outline in table format, assigns responsibilities for task funding and or implementation, and estimates the cost of the recovery program.

(4) Appendices: Appendix I presents a Population Viability Assessment for the Spectacled Eider; Appendix II describes how the Recovery Team selected quantitative criteria for reclassifying Spectacled Eiders; Appendix III discusses Spectacled Eider demography and presents a demographic population model; Appendix IV outlines recommended protection measures for Spectacled Eiders; and Appendix V contains responses to reviewer comments.

A. Status of the Spectacled Eider

Reasons for Listing

The Service responded to a December 1990 petition to list the Spectacled Eider as endangered by conducting a review of the species' status. After evaluation of available scientific and commercial information and public comments, the species was designated as threatened on May 10, 1993 (Federal Register 58(88):27474-27480). The primary reasons for listing Spectacled Eiders were their rapid and continuing decline on the Yukon-Kuskokwim Delta (YKD) breeding grounds (a major nesting area) (Dau and Stehn 1991; Stehn et al. 1993) and indications that they may have declined on Alaska's North Slope (NS) as well .

Status and Trends

Spectacled Eiders are known to breed in three primary locations: the YKD, the NS, and Arctic Russia (AR) (Figure 1). Limited nesting may also occur on St. Lawrence Island and the Seward Peninsula in Alaska (Fay and Cade 1959). The Spectacled Eider was listed as threatened primarily on the basis of Service estimates that the number of nesting pairs on the YKD had declined from approximately 47,740 pairs in the early 1970s to 1,721 by 1992--a rapid and continuing decline of over 96% overall (Stehn et al. 1993) (Figure 2). Numbers of nesting Spectacled Eiders on the Kashunuk River (YKD) declined by more than 75% from 1969-1992 (Ely et al. 1994). Corroborating evidence for the decline came from aerial and ground surveys conducted since 1985 that indicated that the YKD breeding population was continuing to decline by 9-14%/year through 1992 (ibid; Figure 3). From 1992-1995, these surveys suggested that the YKD breeding population may have at least temporarily stabilized.

In the early 1970s, biologists estimated that approximately 60% of the species' population nested on the YKD (Dau and Kistchinski 1977); historical population estimates for the NS and AR were highly tentative, however, so this estimate was likely inaccurate. Information from researchers in the Prudhoe Bay oilfields (Warnock and Troy 1992) and Native elders at Wainwright (R. Suydam, pers. comm.) suggest local population declines on the NS. Although no data are available for examining overall trends on the NS or in AR, surveys were recently completed in both areas. Aerial surveys of the NS provided population estimates (uncorrected for visibility) of >9000, 7000, and 7500 for 1993-1995, respectively (W. Larned, pers. comm.). The breeding distribution of the AR population is extensive and efforts over three breeding seasons were required to complete a comprehensive survey. The minimum estimate (uncorrected for visibility) exceeded 140,000 birds (Hodges and Eldridge 1995).

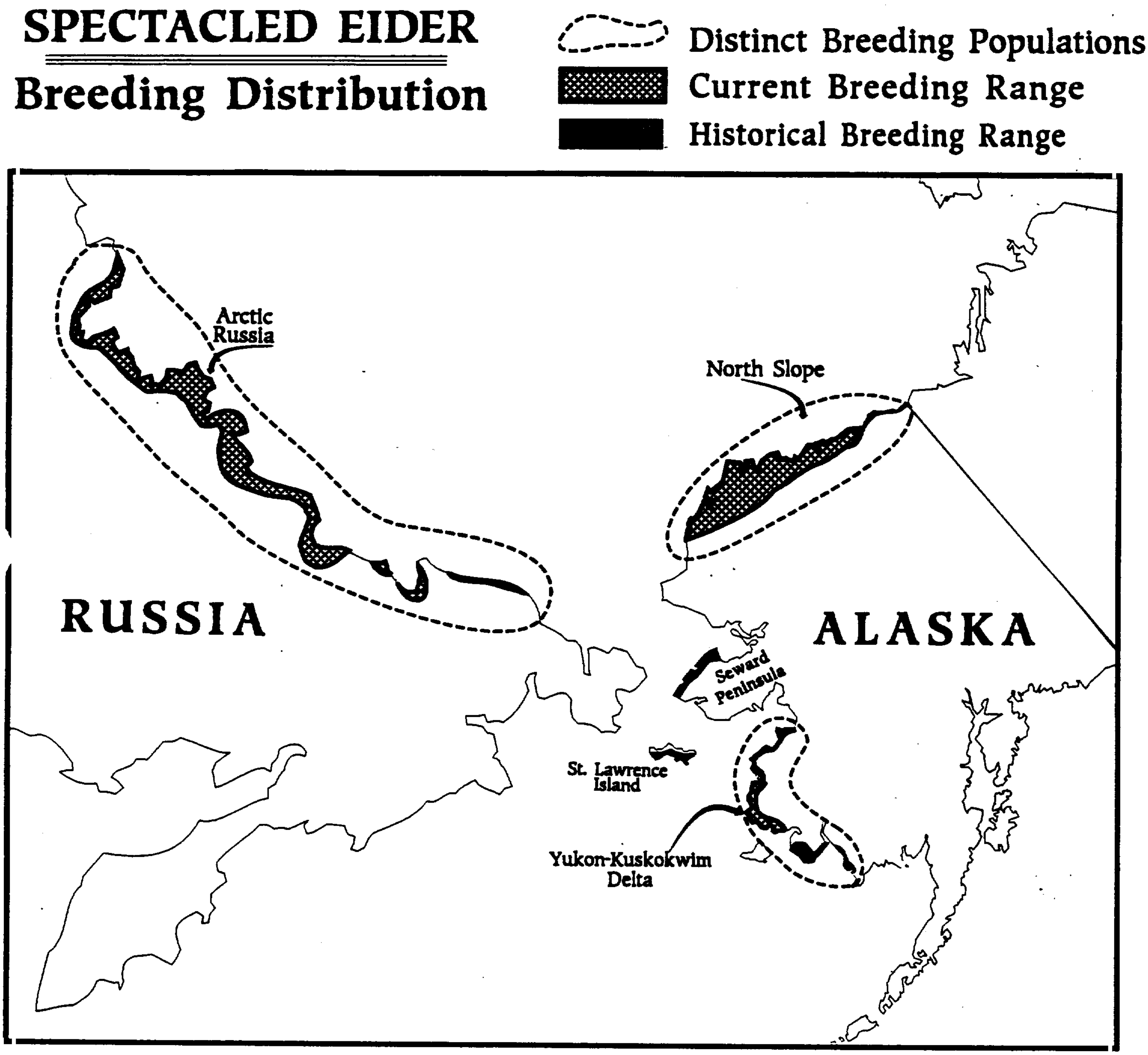

Figure 1. Breeding distribution of Spectacled Eiders. Historical breeding range (cross-hatching) is based on anecdotal information from various sources. Current breeding range (heavy outlines) indicates areas where recent surveys have confirmed current breeding pair occurrence. Low-density breeding may still occur outside these areas. All historical range except St. Lawrence Island has been surveyed at least once since 1992. Breeding range appears to be less extensive than it was historically in all three populations. Dashed lines encircle the three distinct breeding populations. For purposes of this recovery plan, any nesting birds on St. Lawrence Island and the Seward Peninsula will be classified with the North Slope population. (Figure by P. Gallagher).

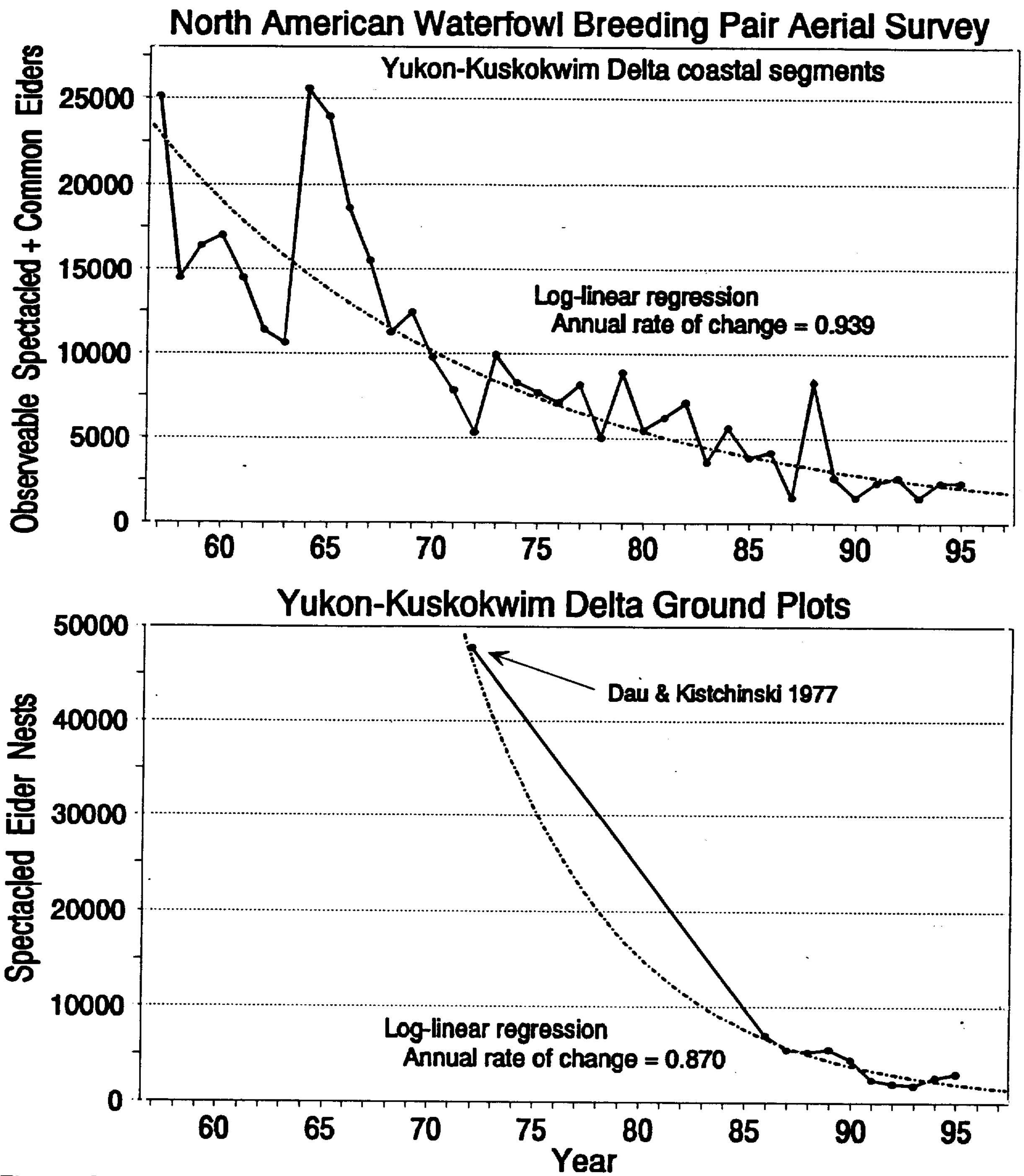

Figure 2. Long-term population trends for Spectacled Eiders on the Yukon-Kuskokwim Delta based on the North American Waterfowl Breeding Pair Survey and nest plots. The breeding pair survey is an aerial strip transect survey that combines observations of Spectacled, Common, and Steller's eiders. The estimate of total indicated birds, twice the singles plus pairs observed, was not corrected for incomplete visibility. The 1986-1995 estimates for nests were derived by searching randomly located plots in the central coast strata and expanding by the inverse proportion of the aerial observations within the sampled area (see Stehn et al. 1993). The 1972 nest population estimate (Dau and Kistchinski 1977) was extrapolated from densities in pre-1973 study plots. (Figure by R. Stehn)

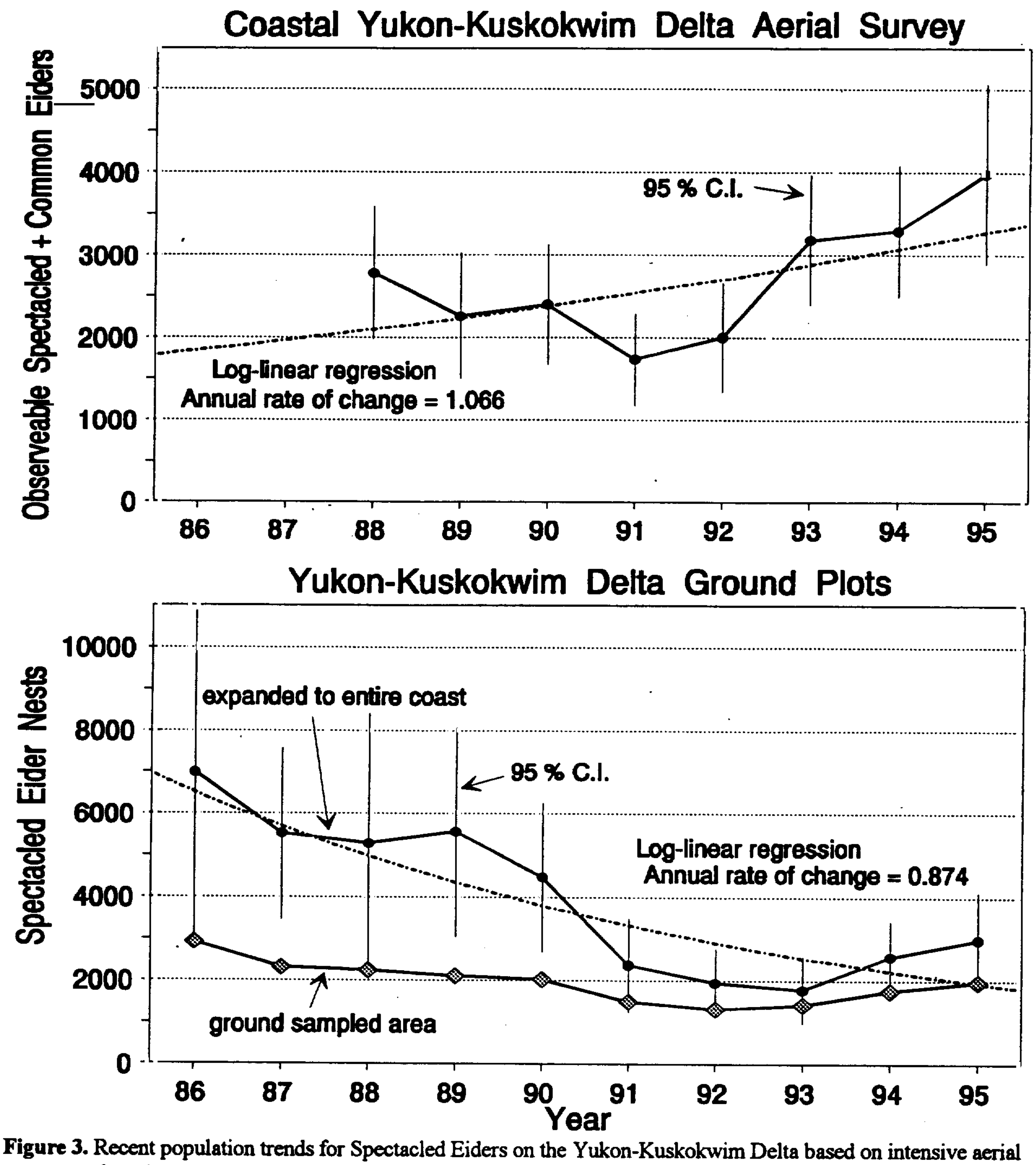

Figure 3. Recent population trends for Spectacled Eiders on the Yukon-Kuskokwim Delta based on intensive aerial surveys and random ground plot sampling. Since 1988, an intensive aerial survey flown on the coastal fringe has monitored eider populations. The index combined singles or pairs observed for Spectacled and unidentified eiders and was not corrected for incomplete visibility; most unidentified eiders were probably Spectacled Eiders. The 1986-1995 estimates for nests were derived by searching randomly located plots in central coast strata and expanding by the inverse proportion of total aerial observations within the sampled area. Expansion in 1986 and 1987 was based on the average of 1988-1991 aerial observations. (Figure by R. Stehn)

B. Causes for Decline and Obstacles to Recovery

Factors known to affect or suspected of affecting Spectacled Eider survival, both on the breeding grounds and at sea, have been identified; however, the relative importance of these factors to the species' decline and to recovery are not known. A brief discussion of these factors follows; for a description of how they are addressed in the plan, see the Strategies for Recovery section. The cause(s) of the decline are factors that affect the dynamics of the population in such a way that they contribute substantially to a lowering of the population size. Obstacle(s) to recovery are factors that affect the dynamics of the population in such a way that they prevent or substantially retard recovery of the present population to a higher, desired level.

Factors Affecting Survival on the Breeding Grounds

The extent and causes of population declines or extirpations directly related to breeding grounds are difficult to assess because historical data are lacking for many breeding locations. Even on the YKD, which is a major, historical nesting area for the species that has received the most attention from biologists, long-term variation in the intensity of various sources of mortality is not well-documented. Several of the factors discussed here are known to affect survival during the nesting season, but it is not yet clear whether they played a prominent role in the Spectacled Eider's population decline.

The deposit of lead shot in habitats used for foraging is a threat to Spectacled Eiders. An eider was found with ingested lead shot on the YKD in 1978 (C.P. Dau in Franson et al. 1995), and confirmed mortalities due to lead ingestion were recorded in 1992-1994 (Franson et al. 1995). Lead has been detected in blood samples and ingested lead was found on x-rays of Spectacled Eiders on the YKD (P.L. Flint, pers. comm.; J.B. Grand, pers. comm.; M.R. Petersen, pers. comm.). Birds dying of lead poisoning have been confirmed from two locations on the YKD (Franson et al. 1995), but it is not known how common or widespread this problem is on the YKD or elsewhere.

On the breeding grounds, predators of Spectacled Eider eggs, young, and (to a lesser degree) adults, include Arctic Foxes (*Alopex lagopus*), Red Foxes (*Vulpes fulva*), large gulls (*Larus* spp.), jaegers (*Stercorarius* spp.), and Snowy Owls (*Nyctea scandiaca*). Stehn et al. (1993) suggested that predation on the YKD population may have been more pronounced since the early 1980s and contributed to the long-term population decline. Foxes may have increased because of reduced trapping efforts by local people. In addition, an estimated 85% long-term decline in 4 goose species on the YKD (O'Neill 1979; Raveling 1984; King and Derksen 1986) could have shifted predation pressure to other species such as Spectacled Eiders. On the NS, Native elders believe that fox numbers have increased in recent decades as a result of reduced trapping (R. Suydam, pers. comm.). In the NS oilfields, foxes obtain supplemental food from human-generated food supplies (D. Troy, pers. comm.). Similarly, populations of large gulls may have grown as a result of increased food supplies from anthropogenic wastes. Commercial fisheries in the Bering Sea and North Pacific have expanded, and the amount of garbage generated by coastal communities has increased; both fishery and village wastes increase the year-round food supply for gulls (R. Suydam, pers. comm.). Grand (pers. comm.) observed a four-fold increase in Spectacled Eider nest success when Mew Gulls (*Larus canus*) were controlled. However, a recent study of Glaucous Gull (*Larus hyperboreus*) predation in the Hazen Bay area of the YKD suggested that these gulls were not consuming Spectacled Eider ducklings (T. Bowman, pers. comm.)

Although demographic analyses indicate that eider population growth rates are most affected by changes in adult survival (Appendix III), chronically high levels of predation on eggs and ducklings may have exacerbated the Spectacled Eiders' decline on the YKD. Even if predation was not the principal cause of the population decline, it remains an obstacle to recovery. Local control of predators provides a tool to maintain eider production at specific sites, at least in the short term.

Direct take of Spectacled Eiders by humans is another potential cause of the decline. Waterfowl, including Spectacled Eiders, were traditionally harvested by Alaska Natives from coastal villages in Alaska, particularly in the spring (Klein 1966; Johnson 1971). In recent years, fall harvest and egg collecting have been minimal for Spectacled Eiders (Dau 1974; C. Wentworth, pers. comm.; Braund et al. 1989a, 1989b). Although the human population on the YKD has grown substantially, changes in the numbers of active hunters are unknown. Similarly, available harvest technologies have become increasingly efficient, but the actual effects of new technologies on harvest levels are unknown.

Although Klein (1966) estimated eider harvest on the YKD in 1964, the harvest was not identified to the species level. In addition, his methodologies for both data collection and analyses differed substantially from those used in the current survey (C. Wentworth, pers. comm.). As a result, no conclusions can be drawn concerning trends in the harvest of Spectacled Eiders on the YKD over the last 3 decades. The estimated harvest from 1985-1995 averaged about 272 birds/year (C. Wentworth, pers. comm.). As the population declined over this interval, however, this relatively small harvest comprised an increasing percentage of the YKD nesting population (up to almost 10% of the total YKD population in 1992). Due to the sensitivity of eider populations to adult mortality rates (Appendix III), especially if survival or recruitment are depressed by other causes, continuing harvest is an obstacle to recovery. Overharvest of Common Eiders (*Somateria mollissima*) has resulted in the extirpation of local populations in Canada (Cooch 1986).

Probably few Spectacled Eiders are taken during the nesting season on the NS (R. Suydam, pers. comm.). There are no quantitative estimates of the harvest in AR, but A. Degtyarev (pers. comm.) suspects that 10% of the population is shot annually. Without more information on Spectacled Eider population biology, researchers will be unable to determine whether this level of harvest is sustainable.

Increasing interest in avicultural egg collecting was reflected in the increasing numbers of permit applications in the five years before avicultural collecting of Spectacled Eider eggs was banned in 1991 (J. Sheridan, pers. comm.). The reported take of eider eggs for avicultural purposes in those five years--all from the North Slope--did not exceed 150 eggs/year; however, the actual take may have been twice this number (ibid).

Many residents of rural communities within the breeding range of Spectacled Eiders suspect that the activities of researchers negatively affect breeding waterfowl. Although the impact of research is probably minimal at the population level, investigations can be disruptive, and a few cases of researcher-induced mortality have occurred. Despite the development of protocols to minimize impacts, the cumulative effects of research activity on Spectacled Eiders have not been adequately documented.

Investigations of eider ecology in Alaska NS oilfields are ongoing (Warnock and Troy 1992; Ritchie and Stickney 1991; Anderson et al. 1991, 1992a, 1992b; Burgess and Stickney 1992; Murphy and Anderson 1992b; TERA 1993, 1995; Smith et al. 1994; Anderson and Cooper 1994; Anderson et al. 1995; Johnson 1995; Anderson and Johnson in press). In the oilfields, the distribution of Spectacled Eiders during the nesting season was altered in response to noise from a compressor plant (Anderson et al. 1992b). In preliminary sampling at Prudhoe Bay, Warnock and Troy (1992) found that Spectacled Eiders and their nests were neither closer to nor farther from oilfield facilities than expected from random sampling, with the exception that water impoundments adjacent to facilities supported above-average densities of birds. Mining and petroleum-related activity also occur in Spectacled Eider breeding habitat in AR (Tichotsky 1991), but the extent of these developments and their overall impacts are unknown.

Factors Affecting Survival At Sea

Threats at sea, both known and potential, represent the greatest source of uncertainty in understanding the Spectacled Eider's decline. This uncertainty reflects the lack of information about at-sea distribution and ecology. For example, competition for food with other species of seaducks, marine mammals, and possibly fishes could decrease the carrying capacity of winter habitats for Spectacled Eiders. Pacific Walrus (*Odobenus rosmarus*) and Gray Whale (*Eschrichtius robustus*) populations may have tripled in size from 1960 to 1980 (Fay et al. 1989), and may have adversely affected food resources used by Spectacled Eiders. Fay et al. (1989) hypothesized that fluctuations occurring in marine bird populations in the Bering Sea may be the result of a complex of changes in fish and invertebrate populations.

Eiders may be accumulating environmental contaminants from sources within the marine environment that cause mortality, reduce propensity for nesting, reduce productivity, or reduce juvenile survival. For example, preliminary analysis of tissues from a small sample of birds suggests that some Spectacled Eiders may carry elevated levels of cadmium, selenium, and strontium (K. Trust, pers. comm.). However, baseline levels of these elements have never been determined for ecologically or physiologically similar species. At present, data are lacking to quantify the magnitude and impacts of contaminants on Spectacled Eiders and their habitats.

There are also few data on human harvest levels away from the breeding grounds. Spectacled Eiders are taken by subsistence hunters during migration along the coast of northwestern Alaska (Johnson 1971; Braund et al. 1989a, 1989b) as well as in Bering Strait and near St. Lawrence Island (J. Cochrane, pers. comm.). Sport hunters also harvested Spectacled Eiders before 1991, primarily near St. Lawrence Island. On the only sport hunt during which quantitative data were gathered (fall 1990), 137 Spectacled Eiders were taken by two hunters [or "one hunting party"] (C. Dau, pers. comm.). Neither the number of hunters participating in this type of hunt nor the numbers of years during which this sport harvest occurred is known.

Diseases and parasites may act synergistically with other stress factors to increase mortality rates at sea, where eiders may experience prolonged environmental stress during winter and spring storms. Little is known about diseases and parasites in Spectacled Eider populations. Dau (1974) believed juvenile birds suffered substantial mortality during their post-fledging transition to salt-water habitats, due in part to stress from parasite loads.

Commercial fishing may impact Spectacled Eiders by disturbing benthic feeding areas. In addition, accidental strikes affecting "hundreds" of unidentified eiders have been reported from the winter crab fishery in the northern Bering Sea (S. Tuttle, pers. comm.). Trawlers operating in Russian waters may be accidentally catching eiders in fishing nets or removing foods important to Spectacled Eiders. In summary, many potential threats to Spectacled Eiders in the marine environment have been suggested, but due to a lack of research, few have been confirmed.

C. Current Management

U.S. Fish and Wildlife Service

The Service has implemented numerous conservation measures for Spectacled Eiders. These include protecting birds nesting near activities that are federally funded, authorized, or conducted (through Section 7 consultations) and overseeing Spectacled Eider research and management activities (through intra-Service Section 7 consultations and Section 10 endangered species permitting). For example, standard provisions to locate and avoid impacts to nesting and brood-rearing birds have been implemented successfully in the NS oilfields (Appendix IV).

Other conservation measures include implementing and enforcing Migratory Bird Treaty Act regulations to reduce opportunities for take of Spectacled Eiders. Avicultural egg collecting and sport hunting of Spectacled Eiders were prohibited in 1991, in response to the listing petition. In response to illegal take of Spectacled Eider eggs by aviculturalists holding permits to collect other eider and duck species in 1992 and 1993, the Service banned all avicultural egg collecting in Alaska in 1994. Violations of the closed hunting season in 1991 (for sport and taxidermy) were also successfully prosecuted under the Migratory Bird Treaty Act before Spectacled Eiders were listed as threatened.

Lead poisoning resulting from ingestion of spent lead shot was determined in 1995 to be a significant problem for breeding Spectacled Eiders and their ducklings on the Yukon Delta. Since that time, the Service and ADF&G have initiated efforts to eliminate the use of lead shot in Spectacled Eider breeding habitat. Non-toxic shot education in villages and meetings with Native organizations to inform them of the lead problem have been increased, and negotiations have begun to establish a date beyond which lead shot use will be eliminated in Spectacled Eider nesting habitat. Significant progress towards the ultimate elimination of lead shot was made at the March 1996, meeting of the Waterfowl Conservation Committee of the Association of Village Council Presidents. The Committee drafted a resolution recognizing the problem of spent lead shot ingestion by Spectacled Eiders and encouraging the use of shotgun shells containing non-toxic shot. After consideration by residents of Yukon Delta villages, this resolution will be considered for passage at the next Committee meeting. Once the resolution is passed, language encouraging the use of non-toxic shot will be incorporated into the Yukon-Kuskokwim Delta Goose Management Plan.

Section 10(e) of the Endangered Species Act exempts Alaska Natives and permanent residents of Alaska Native villages from prohibitions against taking listed species. Special regulations can be promulgated to restrict subsistence harvest under the Endangered Species Act if such take is determined to threaten the species, but only after affected communities are provided public hearings. Such regulations may become appropriate for Spectacled Eiders if harvest is not effectively eliminated by voluntary means.

To date, measures to reduce subsistence harvest of Spectacled Eiders have concentrated on providing information and education (I&E) about the species' plight and the closed season policy under the Migratory Bird Treaty Act. In 1993, Spectacled Eiders were added to the "no take" provisions of the closed season discretionary law enforcement policy for the subsistence take of migratory birds. The Service has relied on both formal and informal communications to elicit voluntary restraint on harvest. I&E activities have included extensive village visits by Service employees, mailings, poster and leaflet distribution, public service announcements, video productions, and television and radio appearances. In the future, the I&E program will benefit from increased involvement and ownership of the recovery effort by Alaska Natives, as described in this plan.

Following the listing petition (December 1990) and a workshop on eiders held in Anchorage (February 1991), the need for a concerted survey and research effort for Spectacled Eiders became apparent. In 1992, the Service established an Eider Working Group made up of Service and Alaska Department of Fish and Game (ADF&G) biologists. This group provided recommendations for new survey and research projects, including the NS aerial survey, YKD satellite telemetry, nesting, and survivorship studies, and cooperative studies with Russian biologists on the Indigirka Delta. The Eider Working Group evolved into a Sea Duck Working Group in early 1993 but has been largely inactive following establishment of the Spectacled Eider Recovery Team in May 1993.

Other Federal Agencies, State Agencies, and Native Organizations

In addition to the Service, two other federal agencies in Alaska manage lands where Spectacled Eiders nest: the Bureau of Land Management (BLM--National Petroleum Reserve-Alaska (NPRA)) and the National Park Service (NPS--Bering Land Bridge National Preserve). The BLM initiated a land cover classification project on the NPRA that included examination of Spectacled Eider nesting habitat in 1994 (D. Yokel, pers. comm.).

While the State of Alaska has not conducted any projects specific to Spectacled Eiders, ADF&G biologists have been directly involved in the Service's eider program through their participation on the Eider Working Group and Spectacled Eider Recovery Team. In addition, Spectacled Eider concerns have been incorporated in State plans, permits, and actions related to land uses, development impact assessments, and special area management programs. The State's steel shot education program and non-toxic shot regulations (1991) have direct conservation benefits for Spectacled Eiders.

The North Slope Borough, which encompasses the entire NS breeding range of Spectacled Eiders, also has been involved in the working group and recovery team. The North Slope Borough Department of Wildlife Management has initiated two eider studies in cooperation with Service biologists and conducts other studies near Barrow from which Spectacled Eider data are obtained. The two eider studies are: (1) migration counts at Barrow; and (2) nesting research focused on Steller's Eiders (*Polysticta stelleri*) that provides information on Spectacled Eiders as well. The North Slope Borough is considered a key partner in eider conservation on the NS.

The YKD region does not have a regional government equivalent to the North Slope Borough. However, the Association of Village Council Presidents has supported the recovery effort by providing a representative to the recovery team. The Traditional Village Councils in Gambell and Savoonga on St. Lawrence Island have cooperated with I&E programs in their communities and have offered their cooperation on future at-sea surveys and contaminants collection projects. Finally, the contribution of individual Alaskans to the eider recovery program is worth noting, particularly Native hunters (from Barrow, Savoonga, Unalakeet, and Wales) who on separate occasions rescued and cared for injured Spectacled Eiders until they could be released or transported for rehabilitation.

D. Natural History of the Spectacled Eider

Nomenclature and Description

Sea ducks, waterfowl that spend at least part of their lives at sea, are a subgroup of the Subfamily Anatinae, Family Anatidae. Within the subfamily, taxonomists group the waterfowl species into tribes, but while Delacour and Mayr (1945) originally placed the eiders (Tribe Somaterini) in a separate tribe from other sea ducks (Tribe Mergini), Johnsgard (1960) and others have grouped them together under Tribe Mergini.

Many species of Mergini spend part or all of their lives in northern (arctic and subarctic) regions; these include King Eiders (*Somateria spectabilis*), Common Eiders (*Somateria mollissima*), Spectacled Eiders (*Somateria fischeri*), and Steller's Eiders (*Polysticta stelleri*). In Alaska, all four eider species breed along the arctic coastal plain or along the coast of western Alaska and migrate south to wintering areas in the Bering Sea, Aleutian Islands and Gulf of Alaska.

The Spectacled Eider, a large-bodied sea duck, is one of three species in the genus *Somateria*. Originally, Common, King, and Spectacled Eiders were placed in three monotypic genera (Brandt 1847) before their close affinities resulted in their current placement in *Somateria* (Humphrey 1958; Johnsgard 1964b; AOU 1983).

The male Spectacled Eider has a green crown and nape with a long, sloping forehead, large and distinctive white eye patches, a charcoal-colored chest, and a white back (Palmer 1976). Body plumage of the male Spectacled Eider most closely resembles that of the larger Common Eider. Females of all three *Somateria* species have similar body plumage, with only slight differences in head coloration and shape. Juvenile and adult female Spectacled Eiders are barred and mottled brown with indistinct eye patches. The iris of both sexes is blue, and the bills of adult males and females are orange and bluish-grey, respectively.

Distribution and Abundance

Historically, Spectacled Eiders nested discontinuously from the Nushagak Peninsula of southwestern Alaska north to Barrow and east nearly to the Yukon Territory of Canada (Phillips 1922-1926; Bent 1925; Bailey 1948; Dau and Kistchinski 1977; Derksen et al. 1981; Garner and Reynolds 1986; Johnson and Herter 1989) (Figure 1). They also have nested on St. Lawrence Island (Fay 1961). Along the arctic coast of Russia, Spectacled Eiders nested from the northern side of the Chukotsk Peninsula west to the Lena River Delta and the Novosibirski Islands (Buturlin 1910; Dementev and Gladkov 1952; Portenko 1972; Kistchinski 1973).

Today, primary nesting grounds of the Spectacled Eider are the YKD (Figure 4) and the NS

(Cape Simpson to the Sagavanirktok River) of Alaska (Figure 5), and in the Chaun Gulf and on the Kolyma, Indigirka, and Yana river deltas of AR (Figure 6). Breeding Spectacled Eiders were formerly common in small patches of suitable habitat in northwestern Alaska from Norton Sound to Kotzebue Sound (Nelson 1887; Bent 1925; Bailey 1948), where they now are rare or absent (Kessel 1989). Local residents report they can still be found nesting on St. Lawrence Island (J. Cochrane, pers. comm.) (Figure 1).

The distribution of Spectacled Eiders during the 8-to-10-month non-breeding season was poorly understood until recent studies combining satellite telemetry (Petersen et al. 1995) and aerial survey techniques, documented locations used by Spectacled Eiders during this period (Figure 7). Post-breeding flocks of staging and molting Spectacled Eiders were surveyed in Mechigmenan Bay, on the eastern coast of Russia's Chukotsk Peninsula (W. Larned, pers. comm.); Alaska's Ledyard Bay, southwest of Point Lay (W. Larned, pers. comm.); Peard Bay (Laing and Platte 1994; W. Larned, pers. comm.); Norton Sound (Larned and McCaffery 1993; W. Larned, pers. comm.), and 80 km south of St. Lawrence Island (W. Larned, pers. comm.). Larned (pers. comm.) has found eiders isolated in relatively small areas in both Ledyard Bay and Norton Sound. Preliminary information suggests males from the YKD and AR use all major molting/staging areas (M.R. Petersen, pers. comm.). Females from the YKD were found in Norton Sound (Petersen et al. 1995); females from the NS were found in the other major molting/staging areas (M.R. Petersen, pers. comm.).

In March and April 1995, the combination of satellite telemetry (Petersen et al. 1995) and aerial survey techniques (W. Larned, pers. comm.) helped biologists discover Spectacled Eiders in late winter. Information from a single satellite transmitter signal from a female Spectacled Eider directed biologists to an area 110 km NNE of St. Matthew Island in the north central Bering Sea. In March, they found large, dense flocks of Spectacled Eiders in small holes in the nearly-continuous sea ice. Spectacled Eiders were seen in the same vicinity in April, but observers had the impression that open water was more abundant and Spectacled Eiders were more sparsely distributed.

Dau and Kistchinski (1977) estimated the world's breeding population of Spectacled Eiders at about 100,000 pairs in the early 1970s. Because of a lack of data from most of the species' breeding range, this preliminary estimate was derived by determining local densities at a few sites, and then extrapolating range-wide. In recent years, however, more quantitative estimates have been obtained in all 3 major breeding areas.

Population estimates for the YKD, NS and AR have been calculated based on data from aerial surveys. On the YKD, the dramatic population decline over the last 2 decades (Stehn et al. 1993) has resulted in an uncorrected population estimate (i.e., not expanded by a visibility correction factor) of fewer than 3,000 breeding pairs in each of the last 4 years (Stehn et al. 1993; R. Platte, pers. comm.). In 1993, 1994, and 1995, a broad-scale fixed-wing survey yielded uncorrected estimates for the arctic coastal plain of greater than 9000, 7000, and 7000 total birds, respectively (Larned and Balogh 1994; G. Balogh, pers.comm.). Data from

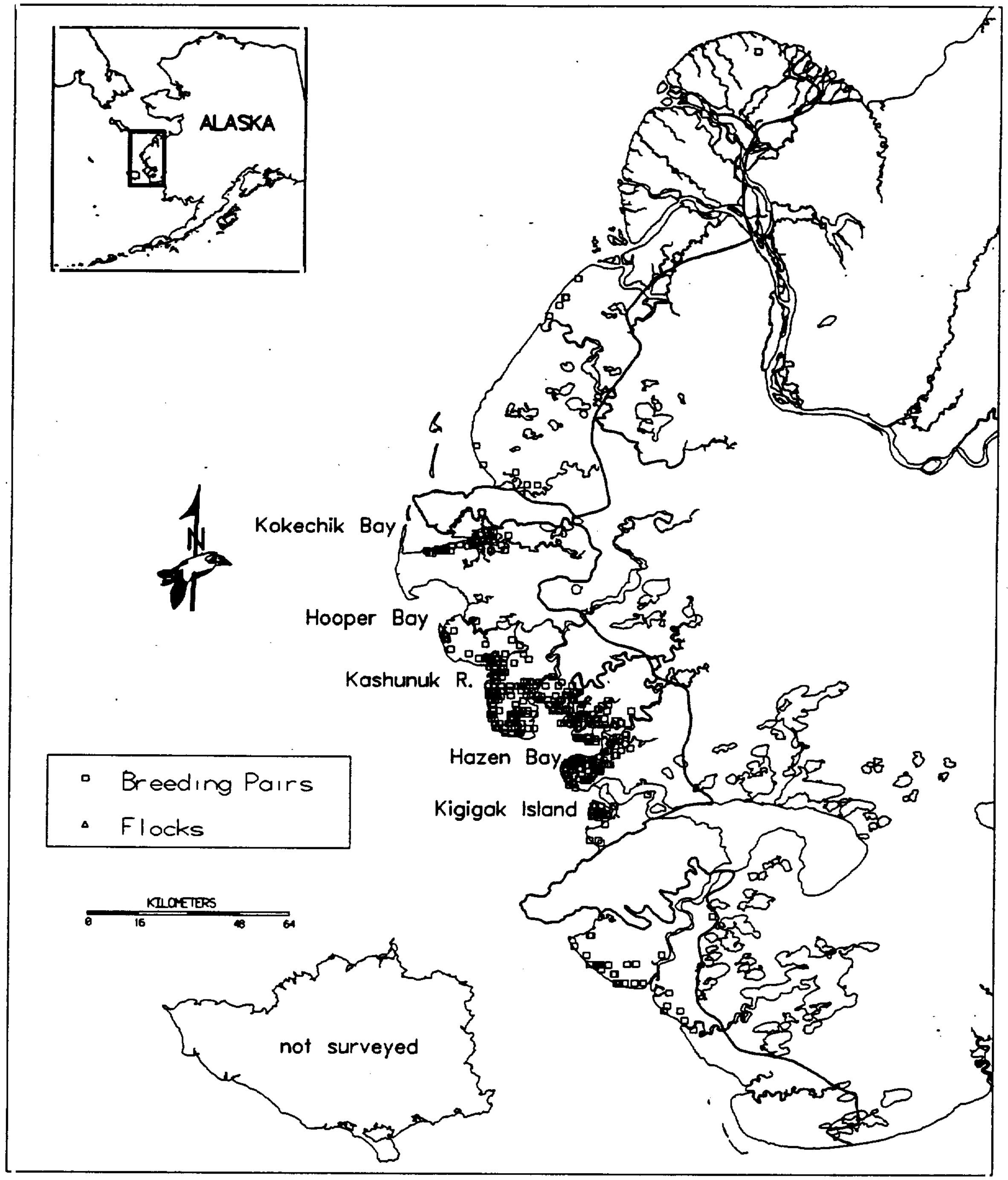

Figure 4. Yukon-Kuskokwim Delta locations of Spectacled Eiders based on aerial surveys 1988-1995 (see Stehn et al. 1993 for methods). Sample transects on the central coast, where most Spectacled Eiders nest, are spaced 1 mile apart. On more inland, northern and southern strata, survey effort is less intensive with transects 2-8 miles apart. The dark boundary line represents the eastern boundary of the aerial survey area. Spectacled Eiders may also nest farther south on the coast toward Kuskokwim Bay, outside the survey area. (Figure by R. Platte).

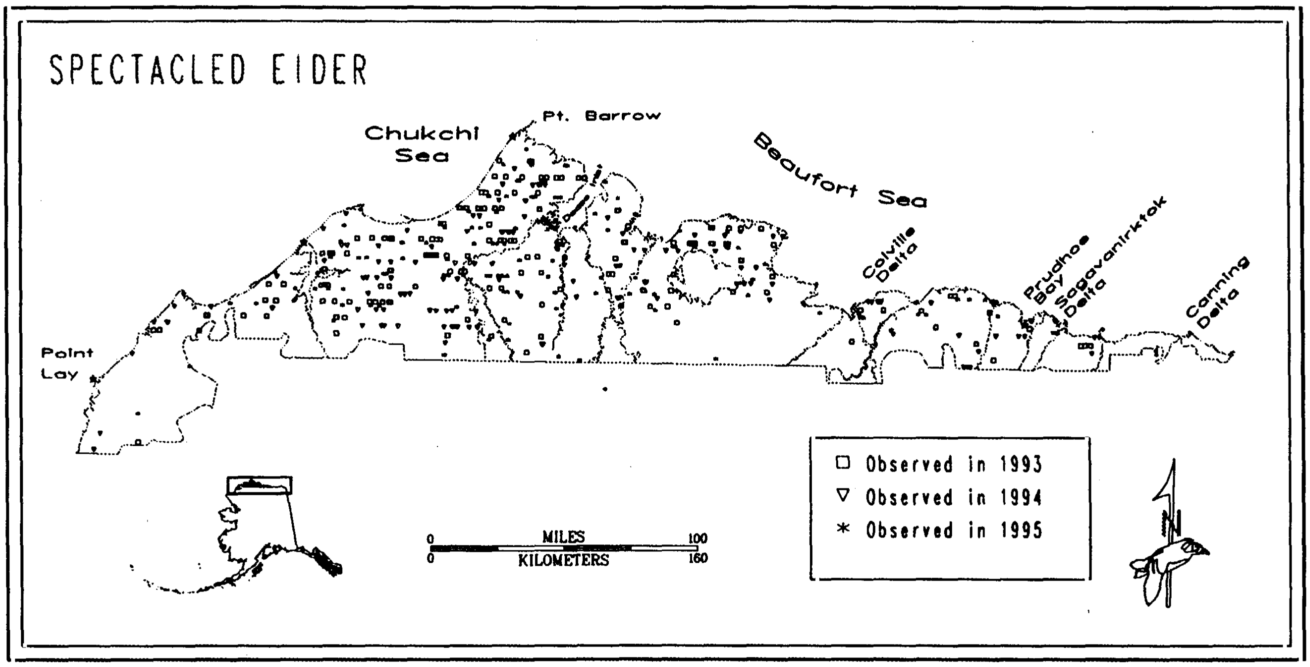

Figure 5. North Slope breeding range and point locations of Spectacled Eiders based on mid-June aerial surveys in 1993-1995. Methods are similar to those used on YKD aerial survey, with 2.5 nautical mile spacing between transects and coverage alternating between adjacent transects annually (e.g., only half of the transects flown each year) (W. Larned, pers. comm.). The southern boundary of the survey area is shown. (Figure by G. Balogh).

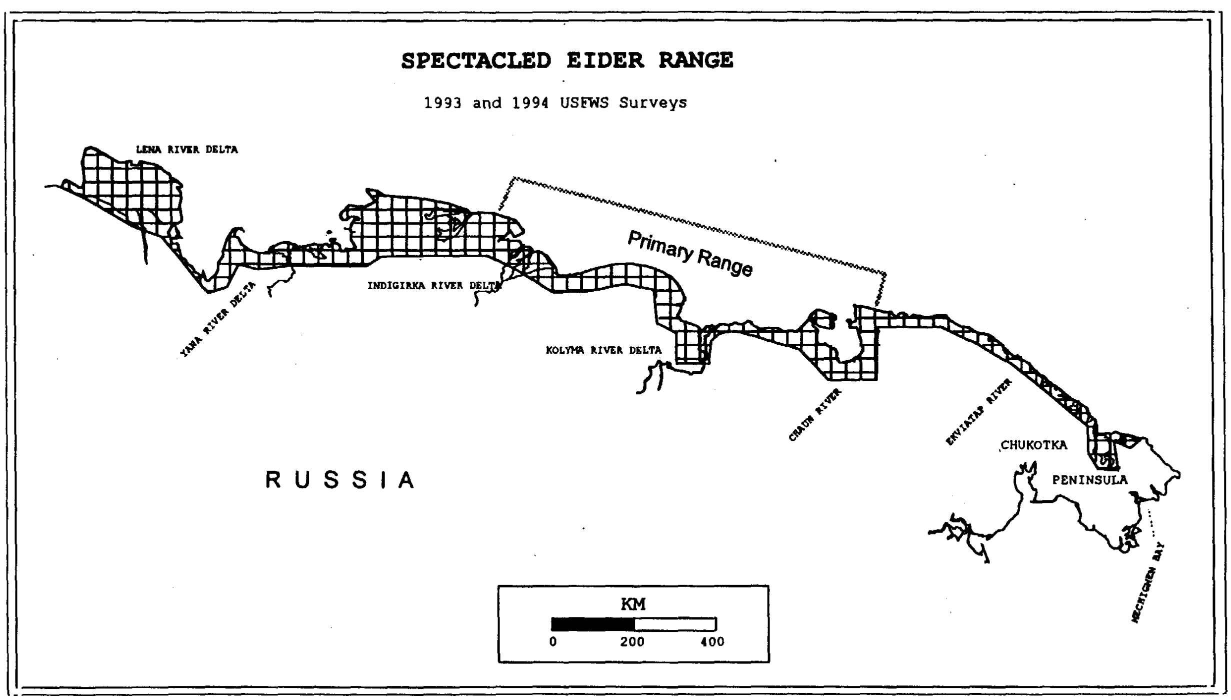

Figure 6. Arctic Russia breeding range of Spectacled Eiders based on aerial surveys 1993-1994. Spectacled Eiders were observed within the survey area indicated in this figure. Each area has been surveyed only once, so data are insufficient to map eider density. (Figure by J. Hodges)

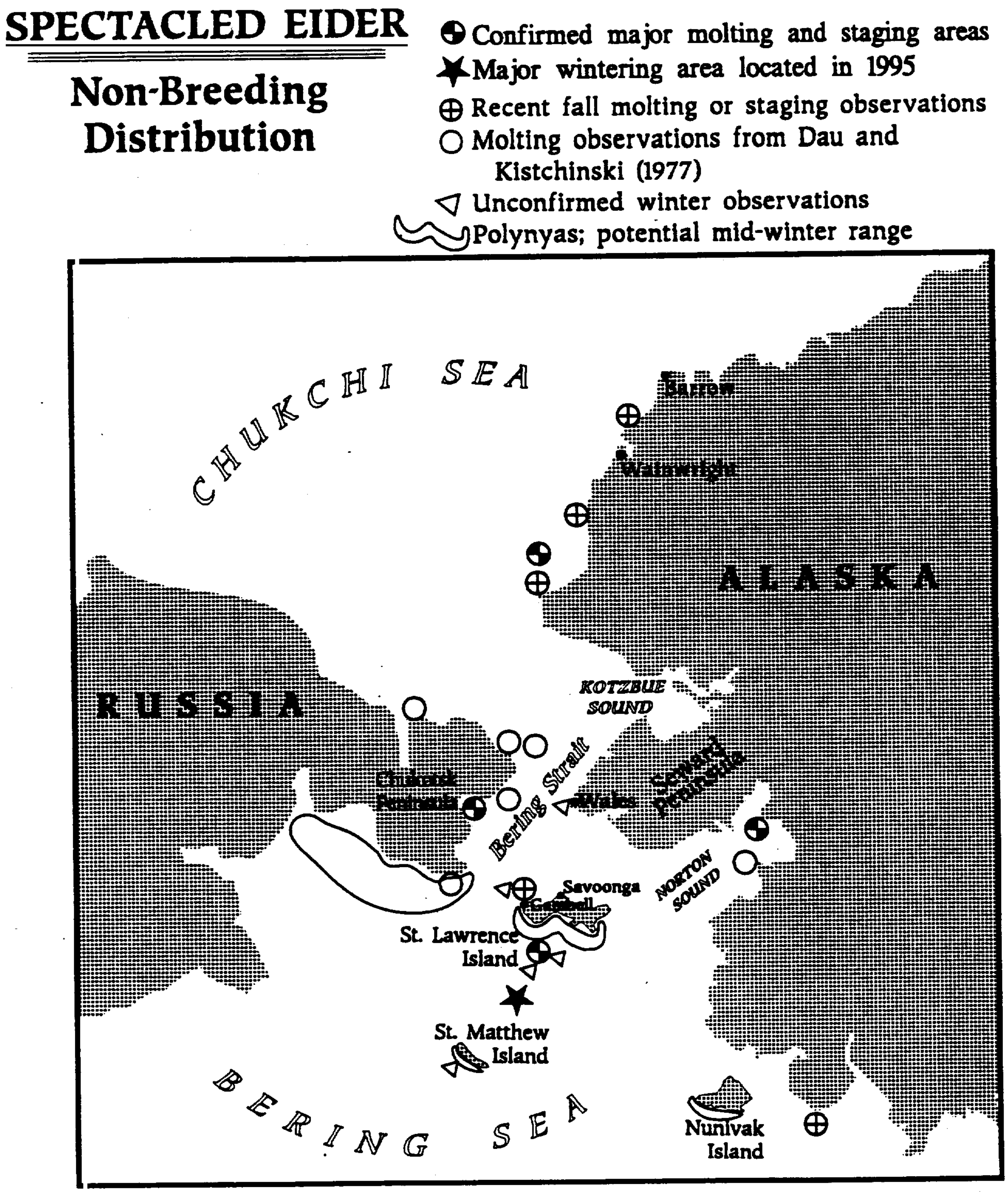

Figure 7. Non-breeding distribution of Spectacled Eiders. Significant numbers of the Arctic Russia breeding population molt offshore and eastward of the Indigirka Delta. A few extra-limital winter records exist for the Alaska Peninsula, Kodiak Island, and Katchemak Bay in lower Cook Inlet. Polynyas are mapped generally; ice-free areas vary annually. The southern limit of the pack ice at mid-winter may extend south of the Pribilof Islands, off this map. (Figure by P. Gallagher)

helicopter surveys in the Prudhoe Bay region, expanded to the entire arctic coastal plain yielded an uncorrected estimate of 16,000 total birds in 1993; this is an underestimate of total birds because the density of Spectacled Eiders is lower in Prudhoe Bay than in other areas of the arctic coastal plain (TERA 1993).

Aerial surveys of the eider's entire current breeding range along the arctic coast of eastern Russia were conducted in late June 1993 and 1994. Combining data from these surveys between the Kolyma River and Kolychin Bay (1993) and Kolyma and Lena River deltas (1994) suggests that there may be > 140,000 birds in AR (Hodges and Eldridge 1994, 1995).

Life History and Ecology

Life history characteristics include survivorship, fecundity, age at first reproduction, frequency of reproduction, and lifespan. These traits vary with changes in populations and their environments. A suite of life history characteristics can be referred to as a life history strategy.

Important influences on life history strategies of northern sea ducks are the extreme environmental conditions in both breeding and non-breeding environments and the high degree of variability both within and between these environments. The timing, length and climate of the breeding season varies from year to year in northern regions. Life cycles of northern marine birds (timing of arrival on breeding grounds, reproductive cycle, and migration) are directly affected by seasonal changes in the hydrological and hydrobiological conditions (Uspenskii 1984). The timing of snow melt, and the break up of seasonal ice in marine waters along migration routes and in freshwater ponds on breeding grounds can vary by several weeks from year to year. This increases the potential for delayed availability of nesting habitat, reduced clutch sizes, and non-breeding (Barry 1960, 1967; Cooch 1965; Ryder 1967; Kistchinski and Flint 1974).

Sea ducks must be adapted to life at sea and on land, and to both marine and freshwater environments. Different strategies for foraging, locomotion, water balance, and thermoregulation are required in each of these environments. Furthermore, life in northern regions requires specialized adaptations to extreme temperatures and to large variations in weather and temperature. For example, a northern sea duck must be able to maintain its body temperature in temperatures from <-50°C (<-58°F) during severe weather in wintering areas, to >15°C (>60°F) during the summer.

Basic life history information is lacking for many of the sea duck species. The available information indicates that sea ducks are long-lived, annual adult survival is high (in a healthy population), annual recruitment to breeding age is low, annual breeding rates and success is variable, clutch size is small, and sexual maturity is deferred (Goudie et al. 1994). Ecologists refer to species with this suite of characteristics as "K-selected" (Wilson 1980). This type of strategy minimizes the importance of annual investment in reproduction and maximizes the importance of annual survival; population stability is dependent on high adult survival and a few successful years of reproduction (ibid.).

Summer in northern regions can be highly productive because of long hours of sunlight. Although the length of the arctic summer can vary from year to year, it is relatively short. Ducklings must be ready to leave the breeding grounds, transition to the marine environment, and undertake migrations by the end of this short season. If nest initiation is late in a given year because of climatic conditions, the likelihood of reproductive success is low. Therefore, there is a greater likelihood of failed breeding occurring in any given year, as a result of delayed onset of breeding, than there would be at more southerly latitudes. A life history strategy that favors adult survival and a longer lifespan ("K-selected") rather than high productivity and a short lifespan ("r-selected strategy") may result in greater total lifetime productivity (Goudie et al. 1994).

Management for recovery of declining eider populations is difficult because K-selected life history traits may limit the rate of recovery. Small clutch size, low rates of annual reproduction and low annual recruitment to breeding population may result in slow population growth even in the absence of threats. Information about life history characteristics can guide researchers in testing hypotheses about causes of population declines.

Our knowledge of the life history and ecology of the Spectacled Eider comes from anecdotal accounts in early years (Turner 1886; Nelson 1887; Dufresne 1924; Murie 1924; Conover 1926; Gillham 1941, 1942; Brandt 1943; Bailey 1948; Johnsgard 1964a; Portenko 1972) and formal studies in recent years (Dau 1974; Kistchinski and Flint 1974; Mickelson 1975; Harwood and Moran 1991; Kondratev and Zadorina 1992; Warnock and Troy 1992; Harwood and Moran 1993; TERA 1993; Anderson and Cooper 1994; Moran and Harwood 1994; Smith et al. 1994; Anderson et al. 1995; Johnson 1995; Moran 1995; TERA 1995; J. B. Grand, pers. comm.).

On the YKD, Spectacled Eiders are primarily dispersed nesters, often associated with other waterbird species (Dau 1974; Strang 1976). Johnsgard (1964a), however, found Spectacled Eider nests clumped at some sites on the YKD, suggesting a degree of "incipient colonialism." Nests are susceptible to both avian and mammalian predation, which varies both annually and geographically on the basis of predator and prey densities (Kistchinski and Flint 1974; C. Harwood, pers. comm.; T. Moran, pers. comm.; J.B. Grand, pers. comm.).

On the Indigirka and Chaun River deltas in AR, most Spectacled Eiders nest semi-colonially in association with gull or tern colonies; they nest less often as dispersed single birds (Kistchinski and Flint 1974; Kondratev and Zadorina 1992). As on the YKD, they nest near water and are vulnerable to predation (Kistchinski and Flint 1974). On the NS, Spectacled Eiders are dispersed, low-density nesters (Derksen et al. 1981; Warnock and Troy 1992) and are not associated with gull or tern colonies.

At least some female Spectacled Eiders exhibit strong fidelity for nesting areas (Dau 1974). On the YKD, females nested within 1.5 km from their previous nest sites (Dau 1974; Harwood and Moran 1993; Moran and Harwood 1994; Moran 1995; Moran 1996). If characteristic, this tendency has important implications for protecting and recovering specific geographic populations, because immigration of breeding females from other populations may occur at a very low frequency. This potential problem would be exacerbated if Spectacled Eiders exhibit strong natal philopatry when recruiting into the breeding population. Virtually nothing is known, however, about this aspect of eider ecology.

Age at first breeding has not been determined but probably occurs most often in the third year for females, and the third or fourth year for males, coinciding with the acquisition of definitive plumage (Portenko 1952; Palmer 1976; Skakuj 1990). Breeding as early as 2 years of age has been documented among wild (J.B. Grand, pers. comm.; T. Moran, pers. comm.) and captive (G. Howe, pers. comm.) Spectacled Eiders, but the extent of such early breeding is not known. Few data are available on reproductive senescence and overall longevity for males or females. On the YKD, of 2 adult females banded in 1972, 1 returned to breed when ≥7 years old, and 1 when ≥8 years old (C. P. Dau, pers. comm.). A hen banded as a duckling on the Colville Delta in 1984 returned to nest in every year from 1987 through 1994, but did not return in 1995 (J. Helmericks, pers. comm.).

Spectacled Eiders arrive on the breeding grounds paired, often in small flocks, at breeding areas in mid-May in subarctic (YKD) (Dau 1974) and in late May to early June in arctic portions of their range (Kistchinski and Flint 1974; Anderson and Cooper 1994; Smith et al. 1994; TERA 1993, 1995). Equal proportions of adult males and females are observed during spring migration, whereas subadults are rarely seen (Dau and Kistchinski 1977; P.L. Flint, pers. obs.; J.B. Grand, pers. obs.). Male Spectacled Eiders begin leaving breeding areas during incubation, and a substantial proportion have departed breeding areas by mid-June in the subarctic (Dau 1974; J.B. Grand, pers. comm.), and late June in the arctic (Kistchinski and Flint 1974; Warnock and Troy 1992; Anderson and Cooper 1994). Males take no role in incubating or brood rearing.

On the YKD, nest initiation by Spectacled Eiders occurs approximately 7 days, and peaks approximately 12 days, after first arrival (Dau 1974). On the Indigirka Delta, and probably elsewhere in the arctic, peak nesting may occur as much as 2 weeks after first arrival (Kistchinski and Flint 1974; D. Esler, pers. comm.). On the North Slope of Alaska, peak observation of pairs occurs in mid-June (Smith et al. 1994) and numbers observed decline 4-5 days later (Anderson and Cooper 1994; Anderson et al. 1995).

Female Spectacled Eiders lay one egg per day and begin incubation with the laying of the last or penultimate egg (Dau 1974). Incubation lasts 20-25 days (Dau 1974; Kondratev and Zadorina 1992; Harwood and Moran 1993; Moran and Harwood 1994; Moran 1995) and typically is synchronized between nests within a region and in a given year (Dau 1974; J.B. Grand, pers. comm.). Most eggs on the YKD hatch between 25 June and 5 July, but hatching may begin in mid-June or extend to mid-July, depending on the timing of snow melt and the synchrony of nest initiation (C. Dau, pers. comm.; C. Harwood, pers. comm.). Hatching in the arctic occurs up to 2 weeks later than on the YKD, from mid- to late July (Kistchinski and Flint 1974; Warnock and Troy 1992). Nests that are initiated early are more likely to be successful than nests initiated later (Dau 1974; C. Harwood, pers. comm.).

Spectacled Eiders generally lay 3 to 6 eggs, although average clutch size may vary among years and locations. On the YKD, 4 studies report average clutch sizes between 4.7 and 5.5 eggs (Dau 1974; Harwood and Moran 1991; Harwood and Moran 1993; Stehn et al. 1993; Moran and Harwood 1994; Moran 1995; Moran 1996; J. B. Grand, pers. comm.). On the NS, 4 studies report average clutch sizes between 3.8 and 4.5 eggs (Bergman et al. 1977; Warnock and Troy 1992; Anderson and Cooper 1994; Smith et al. 1994). In AR, 4 studies report average clutch sizes between 4.5 and 5.6 eggs (Kistchinski and Flint 1974; Krechmar et al. 1991; Kondratev and Zadorina 1992; D. Esler, pers. comm.). Phenological variation in weather and habitat availability on the YKD results in fewer eggs being laid in years of delayed nesting (Dau 1976). An exception was noted in 1993, when the earliest nesting dates but smallest clutch sizes were noted (R.A. Stehn, pers. comm.).

Nesting success (the percentage of nests that successfully hatched at least one egg) on the YKD averaged 71.4% (apparent nesting success, which may substantially overestimate success) from 1969 to 1973 at the Onumtuk study area (Figure 8; Dau 1974). In 1991-1995, nesting success at Kigigak Island (see Figure 8 for location) on the YKD was between approximately 20% and 95% (Harwood and Moran 1991, 1993; Moran and Harwood 1994; Moran 1995; Moran 1996; based on Mayfield [1961; 1975] methods). The apparently high nesting success on Kigigak in 1992 may have occurred because foxes had been eliminated from the island by trapping before the nesting season. Nesting success at Hock Slough was between approximately 30% and 80% in 1991-1995 (J. B. Grand, pers. comm.; Mayfield method), with substantial fox predation on eggs recorded. Apparent nesting success during 1991 and 1993-1995 was between 25% and 40% for birds nesting on the NS, in the Kuparuk and Prudhoe Bay oil fields (Warnock and Troy 1992; Anderson and Johnson in press).

Kistchinski and Flint (1974) suggest that apparent success on the Indigirka River Delta in 1971 was 10-15%, and that eiders nesting in close proximity to gull nests had higher nesting success. Nesting success on the Indigirka River Delta was <2% in 1994 and approximately 27% in 1995; nest predators such as Arctic Foxes, Glaucous Gulls, Herring Gulls (*Larus argentatus*), Parasitic Jaegers (*Stercorarius parasiticus*) and Pomarine Jaegers (*Stercorarius pomarinus*) are suspected to have depredated most of the nests (D. Esler, pers. comm.). Kondratev and Zadorina (1992) also recorded nearly complete predation of Spectacled Eider nests by jaegers and foxes on the Chaun River Delta after a June snow storm.

Predation by gulls, jaegers, Arctic Foxes, and (in the sub-arctic) Red Foxes probably affects the survival of Spectacled Eider eggs and ducklings throughout the species' range. Nest success at Hock Slough more than doubled when Mew Gulls were controlled (J.B. Grand, pers.comm.). However, no remains of Spectacled Eider ducklings were found in the stomachs of 434 Glaucous Gulls sampled on the YKD in 1995, suggesting that Glaucous Gull predation on Spectacled Eiders on the YKD is insignificant (T. Bowman, pers. comm.). No other data are available to indicate the significance of predation on the overall population of Spectacled Eiders.

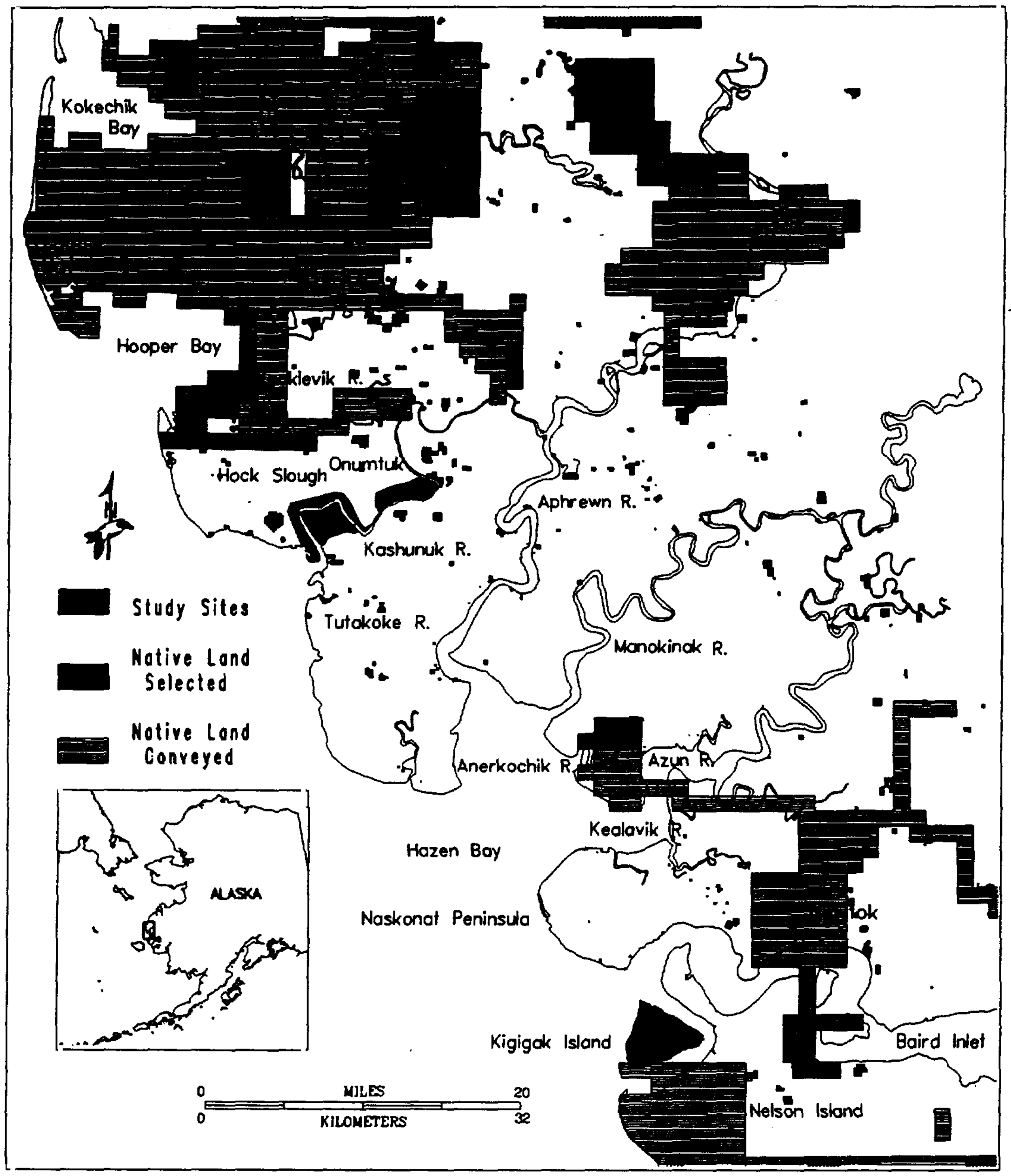

Figure 8. Study sites and land status on the central coast of the YKD. Lightly shaded areas represent lands that have been conveyed, or selected of possible conveyance, to Native corporations or individuals within the Yukon Delta National Wildlife Refuge. (Figure by R. Platte)

Hens may move the brood up to 14 km from the nest site by the time young fledge (J.B. Grand, pers. comm.). However, most broods are raised within 5 km of where they were hatched (Dau 1974; Harwood and Moran 1993; Moran and Harwood 1994; TERA 1995; J.B. Grand, pers. comm.). Studies tracking hens with broods on a regular basis through the brood-rearing period on the YKD (J.B. Grand, pers. comm.) and on the North Slope (TERA 1995) suggest that broods rarely move more than 1.5 km during any 24 hour period. Initial movements away from the nesting areas may be a response to potential duckling predation (TERA 1995) or movements toward better brood rearing habitat.

The only quantitative measure of adult female and duckling survival is from a study at Hock Slough on the YKD; over the first 30 days of the brood rearing period in 1993-1995, adult female survival averaged 93%, and duckling survival averaged 34% (Flint and Grand in press).

Fledging occurs approximately 50 days post-hatching, after which females and their broods move directly from freshwater to marine habitats (Dau 1974; Kistchinski and Flint 1974). Dau (1974) believed that physiological stresses occurring partially as a result of this abrupt shift from freshwater to marine habitats may cause significant juvenile mortality.

On their nesting grounds, Spectacled Eiders feed primarily by dabbling in shallow fresh or brackish ponds, or on flooded tundra (Dau 1974; Kistchinski and Flint 1974). Cottam (1939) analyzed 16 adults collected in May-July (possibly including migrant birds) and found that animal foods, primarily molluscs, comprised 75% of stomach contents. Cranefly larvae (Tipulidae, *Prionocera* spp.) dominated in pre-break-up (YKD) (Dau 1974) and June (AR) (Kistchinski and Flint 1974) adult diets, and insects in general dominated all age-class diets after break-up (Dau 1974; Kistchinski and Flint 1974). Kondratev and Zadorina (1992) found that trichopterans and chironimid larvae dominated the diet of adult hens on the Chaun River Delta, especially in spring, followed by crustaceans later in the season. Chicks feed predominantly on small, freshwater crustaceans (ibid). Plants were taken by all age classes, particularly *Potamogeton* seeds (Dau 1974) and *Ranunculus* seeds (Kistchinski and Flint 1974), which may act as stomach gastrolites in the absence of available gravel (ibid). Upland feeding on *Empetrum nigrum* (crowberry) also has been recorded (Cottam 1939; Dau 1974).

Few data are available on the diets of Spectacled Eiders at sea. Cottam (1939) found primarily amphipods, as well as molluscs, in 2 birds collected at St. Lawrence Island in January. The most common foods taken by Spectacled Eiders shot by subsistence hunters in May and June near St. Lawrence Island were molluscs and crabs (M. R. Petersen, pers. comm.).

The little information available on diseases in Spectacled Eiders comes from birds in captivity: captive eiders are known to be susceptible to aspergillosis (Hillgarth and Kear 1979; Allen and Allen undated). More research has been conducted on parasites of Spectacled Eiders than on their diseases (e.g., Schiller 1954, 1955; Deblock and Rausch 1972; Bondarenko 1975; Bondarenko and Kontrimavichus 1976, 1979; Dau 1978; Atrashkevich 1982; Regel and Bondarenko 1982; Regel 1986; Nikishin and Krasnoshchekov 1986; Nikishin 1988). Most of this literature is on the taxonomy and morphology of the parasites themselves rather than on the effects of the parasites on the birds.

Habitat

Breeding habitats of Spectacled Eiders have been described in both subarctic (Dau 1974; Harwood and Moran 1991, 1993; Moran and Harwood 1994; Moran 1995; J. B. Grand, pers. comm.) and arctic areas (Kistchinski and Flint 1974; Derksen et al. 1981; Kondratev and Zadorina 1992; Warnock and Troy 1992; TERA 1995). Although subarctic and arctic nesting areas differ in vegetative composition and some aspects of physiography, most Spectacled Eiders in both regions occur in coastal habitats.

The coastal fringe of the YKD is the only high-density Spectacled Eider (3.0-6.8 birds/km^2) subarctic breeding habitat (Dau and Kistchinski 1977; C. Harwood, pers. comm.; T. Moran, pers. comm.; W. Eldridge, pers. comm.). In this area, nesting is restricted to low, wet sedge and grass marshes with numerous small, shallow waterbodies. Most nesting sites are within 2m of waterbodies, primarily along shorelines, peninsulas, or on islands (Dau 1974; Moran and Harwood 1994). Nests rarely occur more than 190 m from water. These habitats can be inundated by extreme high tides or during storm surges; because of this irregular flooding, they are referred to collectively as the "vegetated intertidal zone" (King and Dau 1981). Spectacled Eiders share this zone with several species of geese and numerous other waterbird species, including Common Eiders (King and Lensink 1971; King and Dau 1981).

Nesting habitats for Spectacled Eiders on the YKD are within the Yukon Delta National Wildlife Refuge (YDNWR) or on lands owned by various Native village corporations (Figure 8). The historically dispersed human population in this area has expanded and converged into large, permanent villages. Hunting and other forms of disturbance in habitats used frequently by humans may have altered the distribution and habitat use by Spectacled Eiders and other species on the YKD (Nelson 1887; Brandt 1943; Kertell 1991; Stehn et al. 1993).

Important habitats for arctic-breeding Spectacled Eiders include large river deltas, tundra rich in lakes, and wet, polygonized coastal plains with numerous waterbodies. Densities of 0.1 to 12 birds/km^2 have been recorded in these areas (Dementev and Gladkov 1952; Kistchinski and Flint 1974; Derksen et al. 1981; Stishov 1992; Warnock and Troy 1992). Along the arctic coast of Alaska, Spectacled Eiders are seen most commonly during the breeding season near shallow-*Arctophila* and shallow-*Carex* ponds (Derksen et. al. 1981; Warnock and Troy 1992; Anderson and Cooper 1994), which are flooded but vegetated, with low islands or ridges suitable as nest sites (Anderson et al. 1995). Warnock and Troy (1992) recorded substantial use of artificial impoundments near oil development facilities in Prudhoe Bay for feeding.

In this region, Spectacled Eider nests are generally within several meters of waterbodies (TERA 1993; Anderson and Cooper 1994; Smith et al. 1994; Anderson et al. 1995; Johnson 1995; B. Anderson, pers. comm.), and are found on lake edges in basin wetland complexes (Smith et al. 1994), on ridges on polygons containing permanent water and emergent sedge or grass (Rothe et al. 1983; North 1990), and along the edge of deep open lakes (Bergman et al. 1977; Derksen et al. 1981).

Nesting habitats of Spectacled Eiders in coastal Russia have been described near the Indigirka (Kistchinski and Flint 1974; D. Esler, pers. comm.), Ekviatap (Stishov 1992), and Chaun rivers (Kondratev and Zadorina 1992). Nests were generally within several meters of waterbodies, except on coastal islands of the Indigirka River Delta where some nests were found >50m from the nearest waterbody (D. Esler, per. comm.). Preferred habitats on the Indigirka River and Chaun River deltas were islands in lakes or small, elevated areas in flooded sedge and grass marshes called "laydas" (Kistchinski and Flint 1974; Kondratev and Zadorina 1992). In these habitats, Spectacled Eider nests were found commonly near colonies of gulls or terns. In contrast, solitary pairs nested in low densities in uniform tundra areas that were rich in lakes.

Female Spectacled Eiders rear their broods in shallow ponds and lakes with emergent vegetation, in basin wetland complexes and on deep open lakes (Dau 1974; Kistchinski and Flint 1974; Derksen et al. 1981; Warnock and Troy 1992; Anderson and Cooper 1994; Anderson et al. 1995; C. Harwood, pers. comm.; T. Moran, pers. comm.; J. B. Grand, pers. comm.). J. B. Grand and associates (pers. comm.) found that females selected areas of low to moderate salinity for brood-rearing. Ducklings of other species are known to exhibit adverse physiological effects when freshwater is not available (Schmidt-Nielsen and Kim 1964; Baudinette et al. 1982; Moorman 1990). In the arctic, Derksen et al. (1981) found Spectacled Eider broods associated with shallow-*Carex* and deep-open *Arctophila* lakes. Ponds with emergents are important brood-rearing habitats (Warnock and Troy 1992; Anderson and Cooper 1994; Anderson et al. 1995; TERA 1995).

Spectacled Eiders spend 8-10 months/year in the Bering and Chukchi seas (Dau and Kistchinski 1977). Although considerable data exist on the climate (Brower et al. 1977), oceanography, and biological resources of these areas (Hood and Kelley 1974; Sayles et al. 1979; Hood and Calder 1981), an evaluation of the relationship between environmental parameters and the seasonal distribution of molting, staging, and wintering Spectacled Eiders is lacking. Satellite monitoring of climatic and sea ice conditions was used to identify polynyas in the Bering Sea which may be potential Spectacled Eider habitat (Dau and Kistchinski 1977), but these areas have not been adequately surveyed (McRoy et al. 1971; Everett et al. 1989). Dau and Kistchinski (1977) thought Spectacled Eiders would be found in waters ≤30 m deep. Recent data from fall staging and wintering areas suggest that Spectacled Eiders may be found in waters twice that depth (M. R. Petersen, pers. comm.).

E. Distinct Population Segments

The Endangered Species Act (as amended in 1978) provides protection to "...any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." Congress (Senate Report 151, 96th Congress, 1st Session) instructed the Secretary of the Interior to exercise this authority "...sparingly and only when the biological evidence indicates that such action is warranted."

In the "Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species Act" (USFWS 1996), the Service defined "distinct population segment" for the purposes of listing, delisting and reclassifying vertebrates. Under the policy, three elements are to be considered *sequentially* in determining the status of a potentially distinct population segment: 1) the discreteness of the population relative to the rest of the species; 2) the significance of the population segment to the species; and 3) the population segment's conservation status in relation to the Act's standards for listing (i.e., is the population segment endangered or threatened when treated as if it were a species?).

The three breeding populations of Spectacled Eiders (i.e., YKD, NS, and AR) meet the criteria for designation as distinct population segments under the policy. The criteria for evaluating each element are presented below, along with the corresponding analyses of the Spectacled Eider breeding populations.

<u>Element I - Discreteness</u>

Criteria

A population segment of a vertebrate species may be considered discrete if it satisfies one of the following criteria:

1. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors.

2. It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act.

Analysis

The three main breeding populations are physically separated from one another by several hundred kilometers, and, on that basis alone, they fulfill the first criterion of being "markedly separated." Although perhaps only reflecting facultative responses to the environment, these populations also exhibit marked ecological and behavioral differences such as different migration routes and breeding chronologies. No data exist to evaluate the possibility of physiological differences.

Under this policy, Spectacled Eiders breeding in Russia and Alaska can be defined as separate populations as well, because of the international boundary separating their nesting grounds. Although this criterion is not based in biology, it clearly reflects Congress' intent to recognize populations which might be negatively affected by international inconsistencies in conservation policy.

Element II - Significance

Criteria

If a population segment satisfies at least one of the above criteria for discreteness, its biological and ecological significance will then be considered. This consideration may include, but is not limited to, the following:

1. Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon.

2. Evidence that the loss of the discrete population segment would result in a significant gap in the range of the taxon.

3. Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant as an introduced population outside its historic range.

4. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

Because precise circumstances are likely to vary considerably from case-to-case, it is not possible to describe prospectively all the classes of information that might bear on the biological and ecological importance of a discrete population segment.

Analysis

The first two significance criteria are germane to the Spectacled Eider populations in question. Under the first criterion, the YKD population is unique in two ways: it is the only major subarctic population and the only population limited almost exclusively to vegetated intertidal habitats. On both counts, the YKD population warrants designation as a significant population segment. All three populations warrant distinct population status under the second criterion, for the loss of any one of the three would result in a significant gap in the range of the taxon.

The third criterion does not apply to the Spectacled Eider. The possibility of genetic differentiation among the three populations (criterion 4) is currently being explored, but the analysis has not yet been completed.

A final consideration involves information related to, but not specifically addressed in, the criteria listed above. One of the purposes of the Endangered Species Act is to "provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." The Service has recently instituted an ecosystem approach to fish and wildlife management. As part of this effort, the Service has defined 52 ecosystems nationwide. The YKD is one of 7 terrestrial ecosystems in Alaska, and the NS comprises a major portion of the Arctic Alaska ecosystem. Thus, from an ecosystem perspective, the two Alaskan populations of Spectacled Eiders inhabit different ecological settings.

Element III - Status

If a population segment is discrete and significant (i.e., it is a distinct population segment), its evaluation for endangered or threatened status will be based on the Act's definition of those terms and a review of the factors enumerated in section 4(a). It may be appropriate to assign different classifications to different distinct population segments of the same vertebrate taxon.

Analysis

The three Spectacled Eider populations warrant designation as distinct population segments. All three fulfill at least one criterion under both the discreteness and significance elements of the vertebrate population policy. This recovery plan calls for analysis of the status of each Spectacled Eider population in respect to the recovery criteria outlined in the next section (Part II - Recovery).

The status and trend of the YKD population are well known; only recently have minimum population estimates been obtained for AR and NS populations. The YKD population is quite low relative to historical levels and has sustained a steep, long-term population decline.

The AR population is quite large, but no reliable trend information is likely to be available in the near future. Survey data over 3 years suggest that the NS population is larger than originally suspected (Dau and Kistchinski 1977), and continued annual surveys should provide trend data within a few years. Status reviews of AR and YKD populations appear warranted at this time. Additional years of survey data are required for the NS population before a status review is appropriate.

II. RECOVERY

A. Objective and Criteria

Overview

The objective of this plan is to provide strategies that recover the world population of Spectacled Eiders so that the species can be delisted. Criteria and threshold levels for reclassifying (i.e., from threatened to endangered or from endangered to threatened) and for complete delisting are presented in the following discussion. Justification for the use of specific thresholds appears in Appendices I and II. The Service will obtain recommendations for reclassification and delisting from the Spectacled Eider Recovery Team, or, if the Recovery Team no longer exists, by independent review of the evidence by qualified scientists.

For reclassifying the status of Spectacled Eiders, the status of each of the 3 major populations will be considered independently. Unless otherwise indicated, the term "population" means the pool of birds that breeds in one of three primary geographic areas (YKD, NS, and AR; see Section E, Introduction). A few tens of Spectacled Eiders also may nest on St. Lawrence Island and the Seward Peninsula of Alaska. For the purposes of this plan, they will be classified with the NS population until data are obtained that support an alternative approach.

The goal of classifying populations as threatened or endangered is to establish priorities for research and management according to the relative risk the populations face. One widely used measure of risk is the probability of becoming extinct in a specified amount of time. The probability of going extinct cannot be measured directly; it can, however, be estimated as the consequence of the population growth rate and the variability in that rate. For Spectacled Eiders, we must convert abundance estimates through time (i.e., trends) into measures of risk (e.g., probabilities of extinction).

Uncertainty in Decision-making

Translating trend data into measures of risk is not a straightforward task. Because we cannot count all the birds in a population, measures of abundance are uncertain. In addition, population growth rates may be relatively constant through time or they may fluctuate widely. This uncertainty makes our decisions about classifying a population according to risk uncertain as well. Appendices I and II address this complexity and describe in detail how population growth rate, estimated by regressing abundance against time, is translated into risk of extinction. The implications of uncertainty are provided here in a less technical format.

Trend data are analyzed to inform wildlife managers about the risks faced by populations. As noted above, however, the uncertainty in abundance and trend data can lead to errors of interpretation and, therefore, decision-making. In terms of threatened and endangered species classifications, two possible errors might occur: 1) failing to classify a threatened or endangered population that should be classified (the under-protective error); and 2) classifying a population as threatened or endangered when it should not be classified (the over-protective error). The decision about when to classify a species to a specific risk category depends on the costs of making the over- or under-protective errors. We analyze the eider trend data using Bayesian statistics, which allows us to directly incorporate the costs of errors into the decision-making framework. For the purposes of this analysis, the team considered the costs of committing under- or over-protective errors to be equal.

Bayesian analysis results in a probability distribution for population growth rate (r) given all the available data and uncertainty about the variability in population growth rate (Taylor et al. in press). We can therefore answer such questions as "What is the probability that this population was experiencing a decline of ≥5%/year when these data were gathered?" Before using such a probability distribution (called a posterior distribution in Bayesian statistics) in decision making, we must specify the costs of committing errors. If we erroneously fail to classify a population declining at 5%/year, it is a more serious mistake than failing to classify a population declining at 1%/year. Indeed, we have just noted that species should be classified by the level of risk and the level of risk increases with increasing rate of decline. Bayesians call the costs at different values of r (population growth rate) "loss functions" (Figure 9, details in Appendix II). References to "loss" and "loss functions" in the following discussion refer to the costs of making incorrect management decisions and should not be confused with loss of birds (i.e. a population decline).

The cost of making decision errors (loss functions) is measured in terms of the probability of decreasing to under 250 adults in 50 years. Thus, the loss functions are in units that reflect the consequences of the management decision. The time required to determine the cause of decline and attempt to reverse was estimated by the recovery team to be about 50 years. A population of 250 adults was chosen as the point when prudent management action is reduced to the single alternative of captive breeding. A decision with high risk is one which has a greater likelihood of resulting in the population decreasing to under 250 adults in 50 years. A decision with low risk is one which has less likelihood of resulting in the population decreasing to under 250 adults in 50 years. In Figure 9, the loss function with filled square symbols gives the loss of not classifying the population for different population growth rates (the under-protection error). Clearly, there is no loss when the population is stable or growing ($r \geq 0$) because the correct decision was made. Similarly, if the decision threshold to classify as endangered is $r = -0.05$, then the loss if the decision is to classify is zero when $r \leq -0.05$ because the correct decision was made. The decision to equalize over and under-protection errors makes these functions symmetrical around $r = -0.025$.

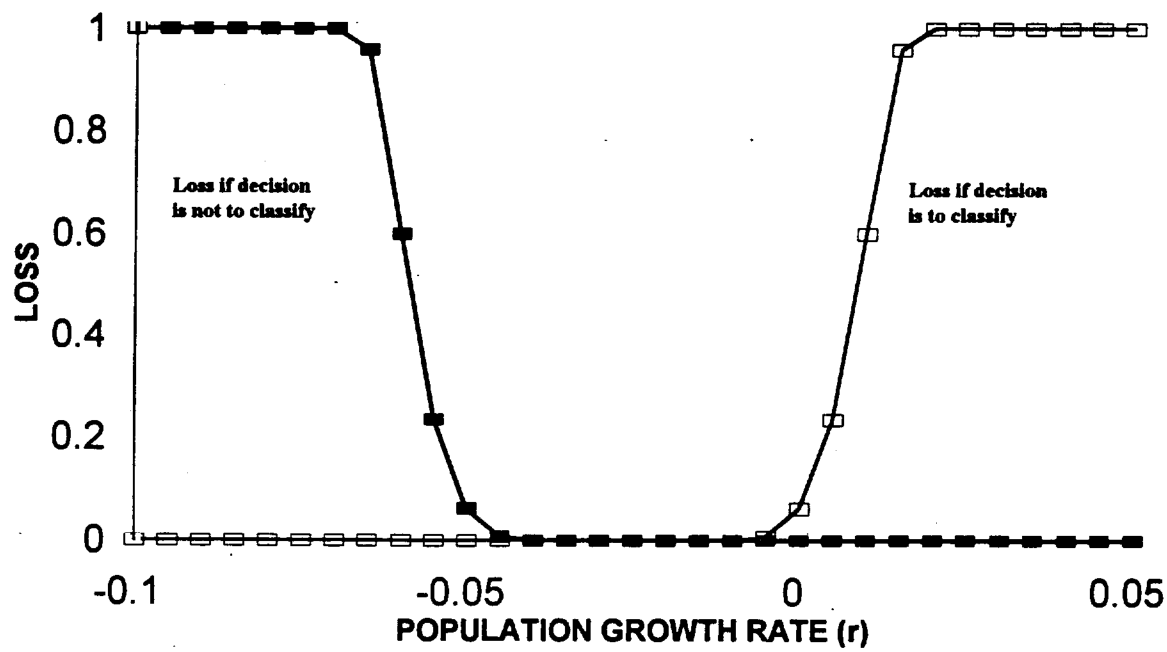

Figure 9. Loss functions for the under-protection error (failure to classify) in filled squares and the over-protection error (falsely classifying) in open squares. Risk is measured as the probability of becoming critical (<250 adults) within 50 years. The decision to equalize risk makes the functions symmetrical around r = -0.025.

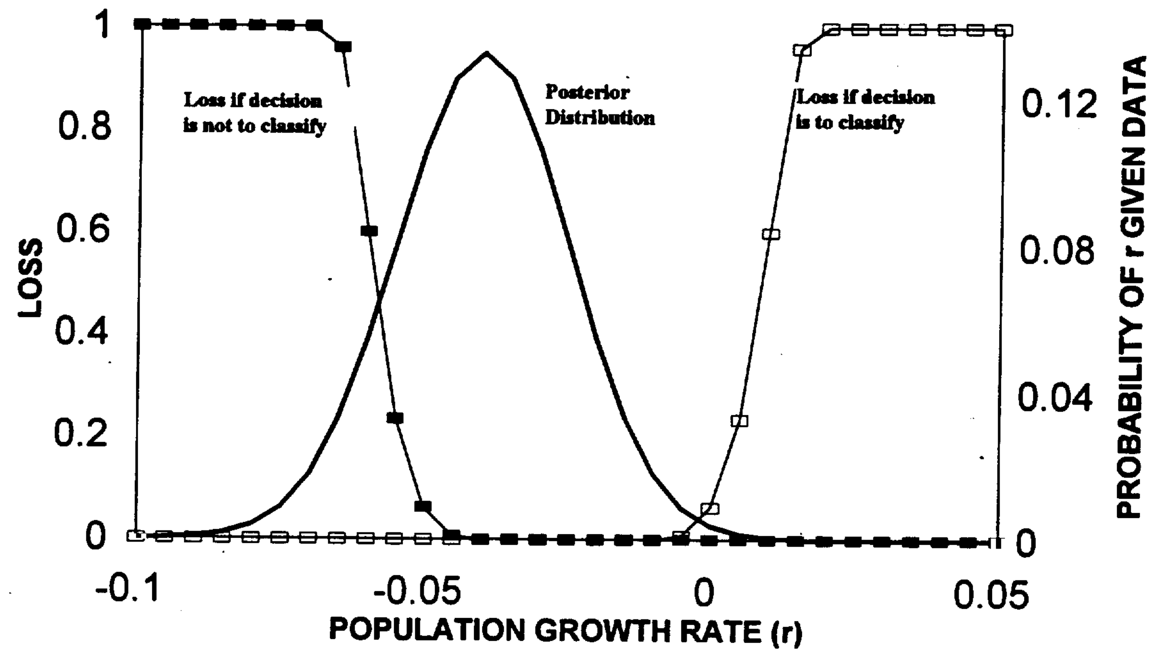

Figure 10. A hypothetical posterior distribution for r superimposed on the loss functions. Calculating the under-protection error loss is done by multiplying the loss function for the decision not to classify times the posterior distribution for each value of r and summing the results. The over-protection loss is calculated in a similar fashion. Table 1 in Appendix II gives the calculation for this sample figure.

If we knew the exact population growth rate we could simply make the decision that resulted in the smallest loss. For example, if r = -0.05, the decision to not classify would result in a loss of 0.06, while the decision to classify would result in a loss of zero. We are therefore likely to incur a greater loss (make a more costly decision) if we decide not to classify than if we chose to classify the populations. We would therefore choose to classify the populations as endangered so as to minimize loss. Although the estimate of r will contain large degrees of uncertainty, the Bayesian analysis produces a distribution giving the probability of having obtained the existing trend data (from annual surveys) for each population growth rate. We can then estimate the losses from over and under-protection errors by multiplying the loss function times the probability of r given the trend data for each possible value of r and summing these products to get the total loss.

Figure 10 shows a hypothetical example with a probability distribution for r superimposed on the loss functions. Table 1 in Appendix II shows a simplified calculation of the total losses to illustrate the multiplication process. For this example the under-protection loss (0.124) is over 100 times the over-protection loss (0.001) so the decision that minimizes loss is to classify the population.

Thresholds

A recovery plan must establish quantitative criteria for reclassifying a species or population from threatened to endangered (and vice-versa), as well as for delisting entirely. These criteria can be thought of as action thresholds. For each possible reclassification (including delisting), this plan provides two alternative criteria which independently trigger a reevaluation of the population's status. The first alternative in each case couples trend and abundance data; when trend data are lacking, the second alternative allows for decision-making using only an estimate of abundance. For declining populations, the abundance thresholds coupled with trend data are greater than the thresholds when trend data are lacking. Conversely, when populations are increasing, the abundance thresholds coupled with trend data are lower than the thresholds when trend data are lacking. In both cases, a change in status is warranted sooner if the direction and magnitude of population change are known.

Appendix I develops the rationale for selecting specific quantitative thresholds. For declining populations, thresholds should provide time to identify the cause(s) of decline and implement recovery actions before the population shrinks to dangerously low levels. For growing populations, the thresholds should guarantee that progress to recovery cannot be reversed easily, while simultaneously ensuring that the rigorous protection of the Endangered Species Act is not unnecessarily extended. The reader should note, however, that the uncertainty in trend and abundance estimates is exacerbated by an even greater uncertainty in the efficacy of recovery efforts. We are unable to predict exactly how quickly a population will decline or how quickly it will respond to recovery efforts. As a result, the selection of thresholds involves a blend of both science and intuition, and is, therefore, somewhat arbitrary. Like medical guidelines for conditions such as high blood pressure and high cholesterol, population thresholds are not "magic numbers" that guarantee extinction or recovery. Instead, these thresholds serve as mileposts that identify populations at high risk and measure progress at reducing that risk.

For example, the World Conservation Union (International Union for the Conservation of Nature [IUCN]) has suggested risk levels (i.e., thresholds) for classifying species (see Appendix I). The Service considered the IUCN criteria as guidelines in developing the reclassification criteria for Spectacled Eiders. Specifically, the IUCN has identified a population level of 125 pairs as critically endangered, and the population models in Appendix I of this plan use 125 pairs as a benchmark for assessing the risk of extinction.

There is no particular biological significance to the exact number chosen for the "critical" population size. The value could just have easily been 150 or 100. Despite the somewhat arbitrary nature of the number, however, such a figure has both heuristic and practical applications. Consider a population of 2,000 pairs (roughly the size of the Spectacled Eider population on the YKD in 1994). If the population declines at a rate of 5%/year, extinction is over a century away, but the population will spend nearly half of the next 100 years at numbers less than 125 pairs (Figure 11). Thus, the extinction time gives an overly optimistic picture of how much time remains for conservation action to be implemented effectively. In other words, in most cases, once a population falls below about 125 pairs, only the most radical conservation efforts will result in its full recovery. The critical population size, therefore, is used as a practical baseline to estimate the time remaining for constructive research and recovery actions.

The reclassification criteria presented below should be viewed in the same light. Passing a specific population threshold defined in this plan neither seals the fate of declining populations nor secures the future for increasing populations. Rather than defining biological failsafe points, the criteria identify thresholds at which the Service's level of concern about a population changes. The calculations in the appendices provide a quantitative framework of objectivity for what are, ultimately, subjective decisions. By indicating when different levels of protection are required, the criteria represent the Service's most prudent assessment of a population's risk.

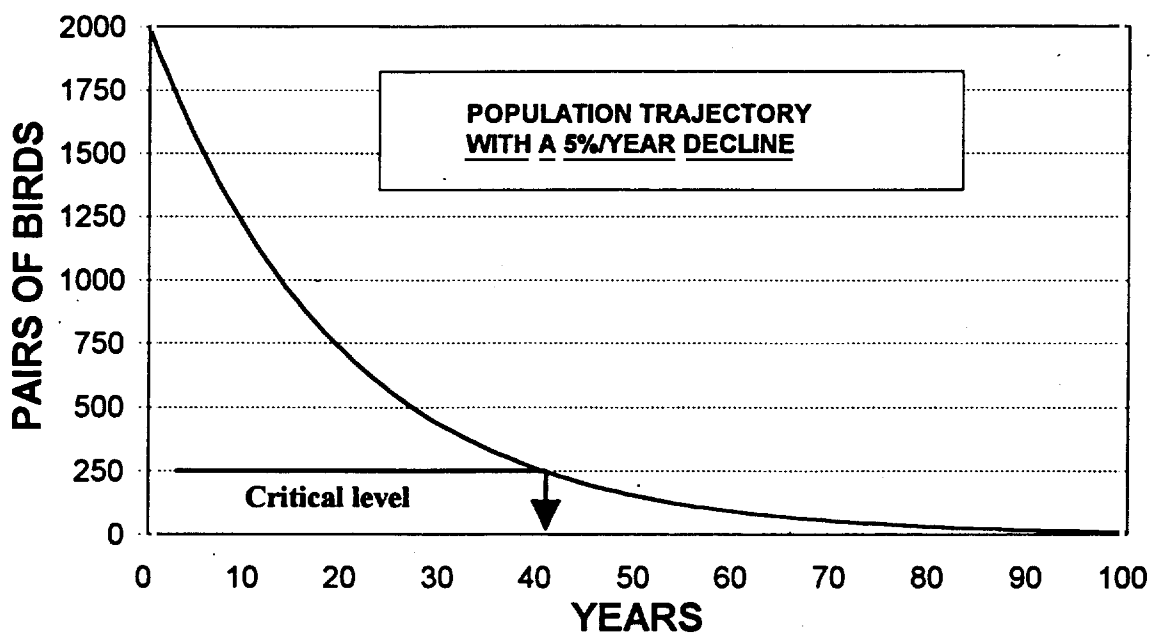

Figure 11. A population of 2,000 pairs, declining at 5%/year, will reach the IUCN critical level of 125 pairs in just 55 years. Although extinction does not occur within the first 100 years, 94% of the population has been lost by the time it reaches the critical level. (Figure by D. Burn)

Criteria for Reclassifying from Threatened to Endangered

Section 4 (a) (1) of the Endangered Species Act lists five factors which must be considered when evaluating the status of a declining species: 1) present or threatened destruction, modification, or curtailment of its habitat or range; 2) overutilization for commercial, recreational, scientific, or educational purposes; 3) disease or predation; 4) the inadequacy of existing regulatory mechanisms; and 5) other natural or manmade factors affecting its continued existence. For the purposes of this plan, a population of Spectacled Eiders will be considered for reclassification from threatened to endangered when these five factors are reviewed for evidence of threats to the population and when:

(1) The population is declining by ≥5%/year, as judged by the following statistical measures:

- the under-protection loss exceeds the over-protection loss, which is calculated using trend data [based on at least 5 years (1 survey/year) of data but not exceeding a 15 year period] and loss functions where the loss when classifying is zero when $r \leq -0.05$ and the loss when not classifying is zero when $r \geq 0$ (figure 9); AND

- the minimum estimated population size is <3,000 breeding pairs for ≥1 year;

OR

(2) the minimum estimated population size is <2,000 breeding pairs in any 1 year, unless ≥1 survey during the following 2 years produces an estimate of >2,000 breeding pairs.

In these criteria, "r" is the population growth rate. "Minimum estimated breeding population size" is intended to mean that the population has a very high probability of exceeding this value. It therefore can be the greater of two estimates, as determined from the "best" available data: (1) the lower limit of the 95% confidence interval (CI) of the population estimate (derived from using any subset of the data that yields the highest lower limit), including a visibility correction factor; or (2) the actual number of birds counted during population surveys. Use of the lower 95% CI of the population estimate accounts conservatively for lack of precision in abundance estimates. Using the lower 95% CI means there will be **at least** that many, and probably more, pairs of birds still breeding in that population. Breeding population size may be estimated by aerial (breeding pair) surveys or ground (nesting) surveys, whichever provides more precise estimates.

Note that the criteria for reclassifying from threatened to endangered status are independent, in that either criterion may be met for reclassification. Either strong evidence for a "significant" decline over a several-year period, in conjunction with a specific minimum population size, or a low minimum size of the breeding population signifies the possibility of imminent extinction of that population. The ≥5 samples (surveys) should be taken over ≥5 consecutive years, although the use of consecutive years is not a formal requirement. Use of trend data is also limited to the 15 most recent years to omit historical data from current estimates of risk. Further, the specified rate of decline does not have to be met every year of the sampling period--it only must average this rate over the entire sampling period.

Criteria for Reclassifying from Endangered to Threatened

A population will be considered for reclassification from endangered to threatened status when the five factors for listing under the Endangered Species Act are reviewed for evidence of threats to the population and when:

(1) The population is increasing as judged by the following statistical measures:

- the over-protection loss exceeds the under-protection loss, which is calculated using trend data [based on at least 10 years (1 survey/year) of data but not exceeding a 15 year period] and where loss functions are symmetrical around $r = 0$ with a zero loss for both functions when $r = 0$ (see Appendix II, Figure II-1); AND

- the minimum estimated population size is ≥3,000 breeding pairs for ≥1 year;

OR

(2) The minimum estimated population size is ≥5,000 breeding pairs over ≥3 surveys (1 survey/year, with surveys preferably being consecutive).

Note that the criteria for reclassifying from endangered to threatened status are independent, in that either criterion may be met for reclassification to occur. Before reclassifying a population from endangered to threatened, however, there should be high confidence that the population is increasing and that it has increased in overall size to the point at which it is no longer in imminent danger of extinction. Knowing the exact rate of increase of the population is not a formal requirement in this case--there simply should be strong evidence that an increase is occurring. If, however, the population meets criterion (1) above within 10 years, it will have increased dramatically from endangered levels. It is more likely that the population will increase at a slower rate, requiring more than 10 years for the minimum estimated population size of 3,000 breeding pairs to be achieved. This increased time, in turn, will increase the statistical power of the test and, thus, confidence that the population actually is increasing.

Criteria for Delisting from Threatened Status

A population will be considered for delisting from threatened status when the five factors for listing under the Endangered Species Act are reviewed for evidence of threats to the population and when

(1) The population is increasing as judged by the following statistical measures:

- the over-protection loss exceeds the under-protection loss, which is calculated using trend data [based on at least 10 years (1 survey/year) of data but not exceeding a 15 year period] and where loss functions symmetrical around $r = 0$ with a zero loss for both functions when $r = 0$ (see Appendix II, Figure II-1); AND

- the minimum estimated population size is ≥6,000 breeding pairs;

OR

(2) the minimum estimated population size is ≥10,000 breeding pairs over ≥3 surveys (1 survey/year, with surveys preferably being consecutive) or the minimum estimate of abundance exceeds 25,000 breeding pairs in any survey.

Note that the criteria for delisting a population from threatened status are independent, in that either criterion may be met for delisting to occur. Once recovery has begun, the evidence should be strong that a population is either large, or increasing, self-sustaining, and no longer in foreseeable danger of extinction.

Toward achieving the recovery objectives outlined above, this plan establishes intermediate objectives to: (1) identify and, if possible, eliminate the cause(s) of the decline; and (2) identify and, if possible, eliminate any obstacle(s) to recovery (see Narrative Outline). Achieving these intermediate objectives will almost certainly be required to halt the current population decline(s) and to allow recovery. Substantially increasing our understanding of causes and obstacles as they relate to recovery is not, in and of itself, the primary objective of this recovery plan. For example, the species may recover without the Service ever determining the actual cause for the original decline. Under such circumstances, delisting should proceed if the population has increased to desired levels and appears to be in no danger of extinction.

Estimated date for completion of recovery

The estimated date for recovery of the world population of Spectacled Eiders is unknown, for several reasons. First, the cause(s) of the decline are unknown. Second, some obstacle(s) to recovery are unknown or poorly understood. Third, even if all cause(s) and obstacle(s) are identified, it is possible that they are caused by factors that cannot be eliminated or altered sufficiently to allow recovery. As more information becomes available, the recovery date will be estimated in subsequent revisions of this plan.

B. Strategies for Recovery

In "Policy Guidelines for Planning and Coordinating Recovery of Endangered and Threatened Species" (USFWS 1990), recovery teams are directed to enumerate actions that address threats to the species of concern. In the Narrative Outline, all tasks necessary to achieve full recovery of the species are to be specified. Such an approach is premature for Spectacled Eiders, however. Causes of the dramatic decline of this species, as well as current obstacles to recovery, have yet to be determined. Basic information about the distribution and abundance of Spectacled Eiders throughout the year is fragmentary, as is our understanding of the demography and population dynamics of this species. Whether the nesting populations of Spectacled Eiders in the three primary geographic areas are genetically or demographically distinct is unknown, yet specific recovery actions and priorities may hinge on such a determination. In light of these significant data gaps, an exhaustive list of tasks required to achieve recovery cannot yet be presented. Instead, interim recovery efforts are recommended that proceed simultaneously along three fronts: (1) preliminary management actions targeting known sources of mortality; (2) exploratory data collection and analysis; and (3) hypothesis-testing.

The first aspect of this plan's approach to Spectacled Eider recovery includes management actions: those tasks that typically are identified in the Narrative Outline of a recovery plan to effect a species' recovery. Management actions to eliminate the threats to a species (be they causes of the decline or obstacles to recovery) can proceed most constructively when those threats have been identified and their effects quantified. Management actions, however, should not be set aside until exploratory data collection has been completed. When possible, managers should strive to eliminate sources of mortality, even if such sources are unlikely to be responsible for the initial decline of the species. Early, effective efforts to reduce mortality and increase productivity will provide additional time for the eiders until researchers have confirmed or identified the actual causes of decline and the most serious threats to the birds' future.

The second aspect of recovery activity--exploratory data collection and analysis--should be a continuation and refinement of the research and survey efforts that were initiated in 1991 after the petition to list this species. To address the many topics in need of elucidation, these efforts will have to be expanded significantly in the immediate future. Truly exploratory data collection probably will continue for at least four more years.

The final aspect of Spectacled Eider recovery will involve the formulation and testing of specific hypotheses about the cause(s) of the eiders' decline and the importance of specific obstacles to recovery. To date, several hypotheses have been suggested to account for the decline of this species, and the Service's prioritization of these preliminary hypotheses has guided much of the ongoing exploratory data collection. At present, however, data are inadequate for rigorously developing and quantitatively testing most of them. In addition, the relatively few data pertaining to these hypotheses have yet to be comprehensively summarized and evaluated.

To make substantial progress toward recovery, it is imperative that all research be designed and implemented within a hypothesis-testing framework. The current lack of data, however, should not be construed as an excuse for unfocused data collection during the exploratory phase, nor should all hypothesis refinement be postponed until the end of exploratory investigation. As data become available incrementally, the hypotheses should be increasingly fine-tuned. Whenever possible, the Service should evaluate hypotheses on the basis of existing data and summarize these evaluations in the form of official position papers. These summaries will be essential for prioritizing work plans to ensure that scarce dollars and human resources are consistently applied to the most viable and/or most easily-tested hypotheses. Exploratory data collection and hypothesis-testing are concurrent processes, with improvements, refinements, and evaluations of the latter task ultimately being contingent upon successful completion of the former one.

Over the next several years, recovery efforts should focus on the following topics:

a. Management Actions--Although limited in scope, a suite of management actions is available that could reduce the rate of the Spectacled Eider's population decline and pave the way for recovery once the obstacles have been identified. Most specific tasks fall into four broad categories: (1) reduction of eider mortality; (2) development of ownership in recovery through increased dialogue and Memoranda of Agreement; (3) Section 7 consultations and permitting; and (4) development of captive flocks.

Confirmed sources of eider mortality include lead poisoning, predation, human harvest, injury, and researcher impact. Since these sources of Spectacled Eider mortality operate on the breeding grounds, the people who share the land with the eiders must be intimately involved in the recovery process. Current dialogue must be expanded to develop a common understanding and cooperation essential to effect recovery. Through Memoranda of Agreement, the Service involves in the decision making process local governments, Native organizations and villages, the ADF&G, and the National Biological Service in developing the most effective strategies to achieve reductions in eider mortality. If appropriate, the Memoranda of Agreement for managing marine mammals and the Yukon-Kuskokwim Delta Goose Management Plan could serve as models for eider agreements.

At the same time, the Service should continue to limit collecting eiders or their eggs for scientific, educational, and avicultural use. In addition, recommendations for avoiding adverse impacts (Appendix IV) from development activities have been drafted and used in Section 7 consultations since 1993. These measures should be refined and continued, with cumulative impacts from all biological and industrial activities tracked.

The Service also should continue to cooperate in the development of captive flocks of Spectacled Eiders. Although the Spectacled Eider has not yet declined to the point where captive-breeding for reintroduction is necessary, prudence dictates that preliminary efforts in this direction be initiated. The value of captive flocks transcends the need to be prepared for last-ditch reintroductions. For example, studies of captive birds can provide important data about the species' basic biology. Such information may illuminate avenues of research, increase our ability to evaluate hypotheses, and directly aid in practical recovery efforts.

Traditional law enforcement activities (e.g., hunter contacts, citations) can be important tools for maintaining or restoring wildlife populations. in the absence of an understanding among the resource users of the eider population problems and the benefits of reduced harvest, however, such actions are unlikely to contribute significantly to a reduction in Spectacled Eider mortality. In fact, an enforcement policy which specifically targets the harvest of Spectacled Eiders would almost certainly reduce the reporting rate of surveyed hunters and engender resentment among potential partners in recovery. Therefore, an increase in traditional law enforcement activity is not recommended until law enforcement and other harvest reduction tools are addressed through increased communication, perhaps including Memoranda of Understanding. Existing law enforcement levels under the Migratory Bird Treaty Act will continue.

b. Abundance and Distribution--Much remains to be learned about the distribution of Spectacled Eiders in space and time. The broad outlines of distribution are best known for the breeding season. Even then, geographic variation in abundance is poorly understood for the NS and AR. Such spatial heterogeneity can seriously compromise monitoring efforts, and surveys that are being developed to monitor these populations should be improved and continued. Away from the breeding grounds, there are few data on distribution and abundance. Recent satellite telemetry and fall aerial surveys have suggested spatial and temporal patterns for migration routes, staging areas, and wintering sites of the three breeding populations, but additional aerial surveys and studies using longer-lasting transmitters will be required to confirm these patterns. These sites should be visited to determine seasonal patterns of abundance and habitat use by different age and sex classes. Either aerial or ship-based surveys may be appropriate.

For evaluating the status of a population, trend data may be as important as are estimates of abundance. Long-term trend data exist only for the YKD breeding population of Spectacled Eiders. Several independent data sets from that area demonstrate striking concordance in their descriptions of the eiders' decline. Neither of the two most precise surveys (one aerial, one ground-based), however, were designed specifically to monitor numbers of Spectacled Eiders. Manipulation of these databases to include inter-survey comparisons and restratification may lead to survey modifications that will yield a more precise estimate of the breeding population and its trend.

With the exception of a small data set from the Prudhoe Bay oil fields and traditional ecological knowledge from Wainwright, no trend data exist for Spectacled Eider populations on the NS or in AR. Further, with the exception of a crude estimate from the Indigirka Delta, there are no estimates of historical population sizes in either of these two regions. Accurate and precise estimates of sizes and trends of populations will be needed for evaluating whether or not these populations meet the criteria for reclassification. Therefore, it is important that recently-initiated survey efforts on the NS and in AR be continued and enhanced with consideration of the effort needed to obtain the precision achieved on the YKD. For all surveys, a power analysis should be conducted. In other words, the probability of detecting a true change in population size must be determined, and surveys should be refined accordingly to improve precision.

c. Population Dynamics--Although trend data can indicate the overall response of a population to its environment, such data alone can neither illuminate the causes for such responses nor predict the probabilities of specific responses in the future. Questions concerning population dynamics fall within the scope of population modeling and demographics.

Among various types of population models, population viability analysis (PVA) has become almost de rigeur in recovery planning for endangered species. PVA can generate estimates for minimum viable population sizes at varying levels of risk (i.e., probabilities of long-term persistence). PVA has limitations, however, and such an approach is not necessarily appropriate in all circumstances. Specifically, it is inappropriate to use demographic data from a declining population (such as the Spectacled Eider population on the YKD) to conduct a PVA.

As an exercise, however, PVA can help to guide decisions about research priorities and recovery criteria. Population modeling, including PVA, will be a central aspect of Spectacled Eider recovery planning, both during and beyond the exploratory phase of data collection. Initially, this modeling will highlight critical data gaps. Then, as life history data accumulate, the models should become increasingly robust and predictive and, thus, should allow evaluation of hypotheses addressing the cause(s) of the eiders' decline and assessing obstacles to recovery. In addition, some models may help us assess the urgency of required actions if populations slip toward extinction. For stable or growing populations, minimum viable population models should allow us to estimate the time needed for recovery, and, for planning purposes, the cost of that recovery.

Quantitative criteria for reclassifying and delisting Spectacled Eiders are proposed in this document. These criteria, however, were developed in the general absence of basic demographic data for this species. Similarly, the population model presented in Appendix III represents, at best, a crude estimate, since many of the data used in generating this model were derived from similar species for which data are available. To be able to develop models with greater predictive power and delisting criteria with stronger foundations, we must obtain accurate and precise estimates for critical demographic variables such as adult survival, juvenile survival, fecundity, and age at first breeding.

Data-rich population models also will be important for evaluating hypotheses used in addressing the cause(s) of the Spectacled Eider's decline. For example, estimates of adult female survivorship can be used to test the null hypothesis that the decline was caused by excessive adult female mortality. Strong evidence refuting this hypothesis would allow investigators to move on to a consideration of other hypotheses. If, however, the survivorship data indicate that a certain age or sex class is exhibiting a disproportionately high mortality rate, research efforts can be reoriented to target that portion of the population. Such focused research increases the likelihood of both discovering the primary causes of decline and identifying current obstacles to recovery.

A final benefit of robust demographic data pertains to population monitoring. Two methods are available for monitoring populations of free-ranging vertebrates: field surveys and demographic analyses. As population size and density increase, field surveys are more powerful than demographic analyses. At very low population sizes and densities, however, a demographic analysis of population trends becomes increasingly powerful (Taylor and Gerrodette 1993). If Spectacled Eider populations continue to decline, this alternative method for evaluating population trends may become necessary.

d. Contaminants--In recent years, several species of marine vertebrates have exhibited population declines or reproductive failures in the Bering Sea and North Pacific. One hypothesis to account for these declines and failures suggests that animals high in the food chain are accumulating dangerous levels of environmental contaminants. Although the links between specific contaminant levels and reductions in survival and reproduction remain to be demonstrated in many cases, apparently high concentrations of certain contaminants have been discovered in several species of northern marine birds and mammals.

Preliminary assessments of contaminants in Spectacled Eiders have not been encouraging: at several sites on the YKD, some nesting eiders are accumulating lead on the breeding grounds, and subsequent death by lead poisoning has been confirmed (Franson et al., 1995). Analyses of a limited sample of Spectacled Eider carcasses and feathers suggest that cadmium, selenium, and strontium occur at levels considered elevated in other species. Because of the insidious nature of environmental contamination and the current paucity of data on both levels and effects of this contamination, efforts to assess contamination should be strongly encouraged.

e. Food Habits--The habitats used and prey items selected by foraging Spectacled Eiders away from the breeding grounds remain largely unknown. This absence of data prevents an evaluation of hypotheses attributing the decline in eiders to either natural or anthropogenic changes in the trophic structure of Bering Sea food webs. Similarly, without knowing where and what eiders eat, researchers will be unable to determine the pathways by which birds might accumulate contaminants.

f. Harvest Levels--Even if available data do not indicate that human harvest triggered or contributed markedly to the decline of Spectacled Eiders, harvest is still an obstacle to recovery. Despite the small absolute numbers reported in recent harvest surveys, a low but constant harvest level will have an increasing impact as population size declines. Of all known sources of mortality, however, the human harvest of Spectacled Eiders is potentially the most manageable. Increasing adult survival is probably the most effective means to improve population growth (see Appendix III). To assess both the contribution of harvest to population trends and the efficacy of specific management actions, a statistically robust estimate of harvest is necessary.

In theory, the magnitude of mortality by intentional and incidental harvest can be estimated more rigorously and can be reduced more rapidly than can any other source of mortality. It will be necessary to evaluate, refine, and expand current harvest monitoring efforts to include all geographic areas and seasons in which harvest occurs. As with population monitoring, the power of both ongoing and developing harvest surveys needs to be determined. Current survey design was not intended and is inadequate for documenting either annual variation or trends in harvest levels. For example, although the current harvest survey on the YKD is statistically valid, it is not powerful: the annual 95% CI for 1985-1992 averages ±80% of the harvest estimate. In other words, the survey is insensitive to all but extreme changes in harvest levels. Greater precision could be achieved by restratifying and restricting the analysis to those communities known to harvest Spectacled Eiders or by increasing the sample size. All avenues of survey improvement should be explored promptly, for both managers and modelers will require estimates of harvest that are as accurate and precise as possible.

g. Predation--On the breeding grounds, eggs, ducklings, and (to a lesser extent) adults are susceptible to predation. Foxes, jaegers, and large gulls are probably the most serious threats during nesting and brood-rearing. Because detailed studies of the Spectacled Eider were not initiated until the population decline was already underway, it is not known if predation rates in the last few decades have been higher than historical levels. Several lines of evidence suggest that predation rates have increased, perhaps as a result of declines in the abundance of alternative prey resources or of putative increases in predator numbers.

Whether such changes in predator-prey relationships can account for the eiders' decline has not been determined.

Like human harvest, predation is a known source of Spectacled Eider mortality and may prove amenable to active management efforts at a local level. The effectiveness of fox control as a management tool for enhancing eider production needs to be evaluated more thoroughly. Similarly, the efficacy and limitations of gull control for improving eider production need to be assessed.

h. Genetics--In Section II.A, several reasons are provided for managing and assessing the status of Spectacled Eiders at the population level. Although studies of nuclear DNA indicate a single panmictic population of spectacled eiders (K. Scribner, pers. comm.), it has not yet been determined whether these populations can be identified by distinctive mitochondrial DNA markers or if they differ in behavioral or ecological characteristics that reflect heritable differences. If there are consistent genetic differences among breeding areas, the need to maintain genetic diversity in the species will provide additional impetus for management at the population level. The degree of population-level distinctiveness also may affect efforts to define viable population sizes for future recovery planning. Finally, using genetic markers to link eiders sampled during the non-breeding season to specific breeding populations with differing growth rates may provide a context for evaluating hypotheses concerning the cause(s) of the decline and obstacles to recovery. Therefore, it is important to determine the genetic profile and identify potentially heritable traits of birds breeding in each of the three major populations.

i. Diseases and Parasites--Few data have been collected on the impacts of diseases and parasites on Spectacled Eiders. Both factors, however, are known to contribute to mortality in the more-thoroughly-studied Common Eider. Although these phenomena are a natural aspect of waterfowl ecology, other debilitating factors (e.g., food limitation, contaminant loads) may be acting synergistically to increase the susceptibility of Spectacled Eiders to disease and parasites.

Physiological Condition--Waterfowl frequently exhibit significant intrapopulational variation in body condition (e.g., fat level, body mass). Recent investigations support the hypotheses that mortality is high or productivity is low among individuals with poor body condition (Esler and Grand 1994). An analysis of the body condition of Spectacled Eiders might indicate which group of mortality factors is contributing significantly to the decline and/or preventing recovery. Specific physiological or histopathological markers also can serve as indicators of specific disease or stress conditions, including environmental contaminants. Poor body condition could be a symptom of heavy metal contamination, food scarcity, parasites, or disease. If the distribution of Spectacled Eider body conditions differs from related species that are sharing similar habitats, these mortality factors might be implicated. If the distribution of body conditions is comparable to that for other similar species, however, other mortality factors (e.g., predation, subsistence harvest) would be implicated. In the absence of historical data on Spectacled Eider body conditions during periods of population growth or stability, however, interpretations of the body condition data will be seriously compromised if valid interspecific comparisons cannot be made.

C. Narrative Outline of Recovery Tasks

The purpose of this Narrative Outline is to identify and describe all tasks presently thought to be necessary to meet the recovery objective. This list of tasks is based on the best available information at the time the plan was prepared and the current state of knowledge in conservation biology. Biological studies recommended in this plan, including some ongoing projects, will be providing substantial new information about Spectacled Eider ecology, population dynamics and recovery obstacles. These new data may alter our understanding of recovery obstacles and influence management recommendations. Hence, this recovery plan should be reassessed 1 year after initial implementation and at least every 3 years thereafter or at any time if it becomes apparent that the plan is not fulfilling its function to guide Spectacled Eider recovery. Reassessment should be based on population trends, on recent and ongoing research, and on the results of any restoration efforts.

The Narrative Outline is structurally different from previous sections and provides greater detail to the level of specific tasks. The outline follows the sequence of topics in the Strategies for Recovery. Within each section, general headings describe common topics under which similar tasks are grouped. The tasks represent action items. The task numbers in the Narrative Outline are cross referenced in the Implementation Schedule. Tasks under topics that are fairly well understood at this time are outlined in more detail (e.g., identify and monitor breeding populations). For topics that have not been explored to date (e.g., evaluate physiological condition throughout the year), the tasks in this plan are quite general. The broadly defined tasks should become more specific, and possibly subdivided, in the future as our understanding of Spectacled Eider ecology and threats increases.

A. Management Actions

A1. Designate and support a Regional Eider Coordinator to oversee recovery plan implementation. The Spectacled Eider recovery plan proposes a complex, multi-agency, multi-disciplinary recovery effort with major efforts directed towards public outreach, population inventory and monitoring, research on population dynamics and the causes for historical and current population problems, and management efforts to reduce mortality. A Regional Eider Coordinator is needed to oversee plan implementation and coordinate activities both among organizations and within Fish and Wildlife Service Divisions. The Coordinator would ensure that all funded tasks are assigned, implemented, accomplished, reported, and evaluated. The Coordinator would maintain open communication between all parties, including providing frequent updates to the Recovery Team, government agencies, Native organizations, and private interests. (Eider Coordinator appointed in 1995)

A2. Verify the recovery objectives and periodically update the recovery plan. The recovery objectives should be reviewed periodically (at least every 3 years). The recovery objectives may be revised based on investigations of hypotheses about the obstacles to recovery (task C5), development of population monitoring techniques (task B1), refinement of the demographic population model (task C2), and/or computer simulations of population viability. The need for updating or revising recovery plan tasks and task priorities should be evaluated annually by the Spectacled Eider Recovery Team. The team may also provide recommendations for annual implementation of the recovery plan.

A2.1. Prepare a technical report on population modeling and viability simulations, and their applications in recovery objectives. The modeling and analysis presented in Appendices I-III should be compiled in a more detailed, technical report to provide documentation for future refinements.

A3. Conduct a status review for each population. A status review of each distinct population (YKD, NS, AR) that addresses the Recovery Criteria in this plan should be conducted. Available data suggest that the YKD and AR populations may warrant reclassification.

A4. Provide Native organizations with opportunities for participation in the decision-making process in implementing the Spectacled Eider Recovery Plan. The Service should encourage involvement by Native Organizations in the implementation of recovery tasks, particularly but not only tasks related to Information and Education (I&E) and Spectacled Eider harvest management. Government agencies would retain legal authorities and jurisdiction over their trust resources, but the Service and ADF&G should work cooperatively with Native representatives to formulate and implement mutually beneficial conservation actions. Ultimate decision making authority is retained by the Service for all migratory birds.

A4.1. Develop Memoranda of Agreement between the Service, Native Organizations, and ADF&G to implement the Spectacled Eider Recovery Plan. These agreements could be similar in concept to the Yukon-Kuskokwim Delta Goose Management Plan or the Sea Otter Memorandum of Understanding with ADF&G and the Sea Otter Commission. Three separate agreements are recommended: YKD, NS, and the Bering Strait area. The three regions have different Native organizations and governments and represent distinct Native cultures (including three languages).

As part of the Memoranda of Agreement, programs should be developed to eliminate intentional subsistence harvest and minimize incidental subsistence take of Spectacled Eiders. Available data indicate that subsistence harvest of Spectacled Eiders is limited, but this mortality is still significant at least for the YKD population considering: (1) the currently small size of the YKD eider population; (2) the inherent vulnerability of sea ducks to excessive adult mortality; and (3) the fact that most of the harvest is presumed to occur during spring migration and therefore probably is concentrated on adult breeding birds. It is important that the Spectacled Eider harvest be eliminated until it can be managed in such a way that viable populations can be maintained.

This plan recommends that the most effective method for eliminating intentional and incidental subsistence harvest is through information programs aimed at obtaining voluntary hunting restraints. Such restraints should be sought through increased dialogue and development of Memoranda of Agreement with Native organizations. The harvest reduction programs may include, but would not be limited to, public information activities, local initiatives, and enforcing Federal and State laws through appropriate methods. It is essential that all stakeholders have a voice in how the program is designed and implemented.

In addition to information and law enforcement programs designed to eliminate subsistence harvest, the Memoranda of Agreement should benefit the recovery program by facilitating: (1) the exchange of local and traditional knowledge; and (2) the participation of Alaskan Natives in research and management functions, where appropriate. Memoranda of Agreement should also cover other aspects of the Recovery Plan, where appropriate.

A4.1.1. Develop and implement a Memorandum of Agreement on the YKD.

A4.1.2. Develop and implement a Memorandum of Agreement on the NS.

A4.1.3. Develop and implement a Memorandum of Agreement for the Bering Strait area. An agreement is needed for this region because it is a major migration and staging area for at least one and possibly all three of the major breeding populations. Levels of eider mortality from natural and anthropogenic causes are unknown for this region.

A5. Designate a Native Liaison who would facilitate communication between Native organizations, the Recovery Team, government agencies and researchers, and affected villages. Effective local contacts are necessary for transmitting accurate information on recovery projects, soliciting suggestions, and gaining informed consent for the Memoranda of Agreement. It is essential that local communities become fully informed about recovery projects that affect Spectacled Eiders or other important local resources. The Service and Native organizations should designate a liaison who possesses expertise in inter-cultural communication, appropriate Native cultures, regional subsistence practices and management, and biology. Success of the Memoranda of Agreement will depend on facilitation by the Native Liaison.

A6. Develop and coordinate information and education activities. The Spectacled Eider I&E program should be directed at three audiences: Native Alaskans in rural Alaska, the general public in Alaska, and the general public outside Alaska. The I&E activities directed toward Alaska Natives should be focused primarily in those villages within the range of the Spectacled Eider that currently harvest or have harvested Spectacled Eiders. Current emphasis on steel shot education and negotiations culminating in a "date certain" for cessation of lead shot use in Yukon Delta eider habitat should be continued. The I&E program should be developed from an Alaska Native perspective, as part of the Memoranda of Agreement. The Native Liaison would coordinate implementation of I&E directed toward Alaska Natives, in consultation with the Service and Native organizations on the YKD, NS, and Bering Strait Regions.

Outreach activities are also needed for the general public, regionally and nationally. These audiences should be informed about the roles of the Endangered Species Act and Migratory Bird Treaty Act; the need for eliminating intentional harvest and avoiding incidental take; items of general biological and ecological interest; and the recovery program. I&E activities targeting limited audiences should also be developed where appropriate, such as soliciting eider observation records from Bering Sea vessel operators. The Regional Eider Coordinator would oversee the general I&E program, with substantial contributions by the Native Liaison and agency staffs (I&E program initiated in 1991).

A7. Evaluate the Memoranda of Agreement annually.

A7.1 Evaluate and recommend revision of Memoranda of Agreement activities where appropriate With assistance from the Spectacled Eider Recovery Team and Memoranda of Agreement partners, the Service should annually review whether: (1) the Memoranda of Agreement are effective in reducing subsistence harvest of Spectacled Eiders; and (2) Alaska Natives are participating in the decision-making process for the recovery program. The effectiveness of the I&E programs, regulatory protection under the Endangered Species Act and Migratory Bird Treaty Act, and other strategies for addressing subsistence harvest should be included in these annual reviews. These evaluations should consider adequate time allowances for implementation of the Memoranda of Agreement. Based on these reviews, implementation of the Memoranda of Agreement may be revised by joint agreement. The annual review should continue until viable populations capable of sustaining harvest have been achieved. Refer to related tasks F1 and C5.3.

A7.2. Promulgate regulations pursuant to section 10(e)(4) of the Endangered Species Act to prohibit take of Spectacled Eiders by Alaska Natives for subsistence purposes. Contingent upon results of the annual review of the Memoranda of Agreement (task A7.1), including the effects of harvest on Spectacled Eider populations, the Service may find that it is necessary to initiate action to prohibit subsistence take of Spectacled Eiders under the Endangered Species Act. Specific efforts directed at subsistence take of Spectacled Eiders should be addressed initially through the Memoranda of Agreement (task A4). If full implementation of the Memoranda of Agreement cannot be accomplished and tasks A7.1 and C5.3 demonstrate that subsistence harvest is adversely affecting Spectacled Eider populations, then the Service should consider increased law enforcement actions. Section 10(e)(1) of the Endangered Species Act exempts Alaska Natives and permanent residents of Alaska Native villages from the prohibitions on taking listed species. This exemption is inconsistent with regulations implementing the Migratory Bird Treaty Act. The discrepancy between the Endangered Species Act and Migratory Bird Treaty Act may cause difficulties with law enforcement, should additional law enforcement activities be initiated specifically for Spectacled Eiders based on tasks A7.1 and C5.3. In this case, regulations prohibiting take of Spectacled Eiders under section 10(e)(4) of the Endangered Species Act should be published. Special consideration, beyond the minimum legal requirements, should be given to notification and public involvement processes in the Native communities most likely to be affected by the promulgation of new Federal regulations.

A8. Continue routine law enforcement under the closed season policy for administration of the Migratory Bird Treaty Act. Under the Migratory Bird Treaty Act, it is illegal to take eiders or their parts, eggs, nests, and young except as permitted by the Service. The fall hunting season has been closed since 1991. All spring and summer (March 10-September 1) hunting of eiders in Alaska is in violation of the Migratory Bird Treaty Act, and since 1993 Spectacled Eiders have been included in the Service's discretionary policy to enforce spring subsistence hunting violations. Violations under the Migratory Bird Treaty Act that are encountered during routine law enforcement activities are cited. If additional recommendations for law enforcement activity result from the Memoranda of Agreement or the annual review of the Memoranda of Agreement (tasks A4.1 and A7.1), they should be implemented in coordination with these ongoing Migratory Bird Treaty Act enforcement activities.

A9. Eliminate the use of lead shot for hunting within Spectacled Eider habitats. Currently, lead shot is prohibited nationally for hunting waterfowl; however, it is still legal for hunting upland game birds. Eider deaths due to lead poisoning and evidence of significant levels of lead exposure in Spectacled Eiders on the central Yukon-Kuskokwim Delta coast, indicate that lead shot may be a significant mortality factor. Lead shot may accumulate in the abundant shallow ponds, tidal flats and sloughs along the coast where Spectacled Eiders feed during the nesting season. Thus, any use of lead shot for hunting within Spectacled Eider nesting range, even if it is not being used to shoot waterfowl, may pose a substantial threat to eiders and should be eliminated. The following tasks may be necessary to effectively eliminate lead shot as a threat to Spectacled Eiders on the YKD, where it is a demonstrated problem. Additional tasks regarding lead poisoning research are D4, D5, and D6.

A9.1. Explore and implement mechanisms for reducing availability of lead shot and increasing availability and reducing the cost of non-toxic shot in rural Alaska. Options for reducing lead availability in rural Alaska should be examined and implemented to the fullest extent where appropriate. This would include working with ammunition marketers to provide non-toxic shot at reasonable cost.

A9.2. Continue hunter information on non-toxic shot throughout rural areas where Spectacled Eiders occur. Non-toxic shot information programs teach hunters about the negative impacts to wildlife from exposure to lead shot in the environment and how to adjust to using non-toxic shot. This existing State and Federal-run program should be expanded to ensure that it is available to all hunters within the range of Spectacled Eiders, so that the threat to Spectacled Eiders from lead shot is eliminated.

A9.3. Promulgate regulations prohibiting use of lead shot for all hunting within Spectacled Eider range, beginning with the Yukon Delta National Wildlife Refuge. The use of lead shot for hunting waterfowl was banned in 1991 in Alaska. The Service, with involvement from Native organizations, should propose new regulations to prohibit the use of lead shot for any purposes within Spectacled Eider nesting range, beginning with Federal refuge lands. Negotiations for a "date certain" should be completed and an enforcement program should be implemented after that date.

A10. Ensure compliance with the Endangered Species Act and Migratory Bird Treaty Act. Sections 7 (consultation) and 10 (permitting) of the Endangered Species Act provide essential tools for avoiding jeopardy to listed species, avoiding or minimizing incidental take, and promoting full species recovery. These processes also provide valuable opportunities to inform agencies and scientists of their responsibility to contribute to the recovery program. The Migratory Bird Treaty Act provides a vehicle for management of Spectacled Eiders through the annual promulgation of sport hunting regulations and case-by-case permitting for take.

A10.1 Implement sections 7, 9, and 10 of the Endangered Species Act. Sections 7, 9, and 10 should be implemented so as to maximize the effectiveness of these tools for Spectacled Eider recovery. The protection guidelines in Appendix D should be reviewed annually and revised as appropriate. Cumulative records of permitted take (section 10) and incidental take (section 7) estimates should be maintained, with evaluation and documentation that this level of take is not adversely affecting the species (see task A11). Spectacled Eider location data should be added to the Service's endangered species database and Geographic Information System (GIS).

A10.2. Monitor scientific collecting of eggs and birds, and sea duck sport hunting within Spectacled Eider range. Permits may be issued under the Migratory Bird Treaty Act for scientific collecting of waterfowl eggs or birds within Spectacled Eider nesting range (permits for scientific collecting of Spectacled Eiders or their eggs may also be issued under the Endangered Species Act). Because of the potential for misidentifying similar species, all permit applications should be screened carefully to assure that the investigators are credible and safeguards are in place to minimize the risk of unintentional take of Spectacled Eiders. In addition, recreational hunting for Common and King eiders may occur within Spectacled Eider range during the open season. Law enforcement agents in the Bering Strait region should routinely monitor sea duck hunting activity to determine whether either incidental or deliberate take of Spectacled Eiders is occurring.

A10.3. Ban collecting eider eggs for avicultural purposes within Spectacled Eider nesting range. The Service stopped issuing permits for any avicultural egg collecting within Spectacled Eider nesting range in 1994, following cases where aviculturalists illegally collected Spectacled Eider eggs. This ban should be continued until Spectacled Eiders recover.

A10.4. Investigate incidental take by commercial fisheries. Information is needed to determine whether incidental take in gill nets or from striking lighted fishing vessels is occurring, as indicated by anecdotal reports. If so, it will be important to document where and how often it occurs, how many birds are involved, and what can be done to reduce or eliminate this take. Take may be documented with observer or voluntary reporting programs. For federally-regulated fisheries this should be part of the section 7 consultation process. Potential overlap in range between Spectacled Eiders and fishing operations should also be mapped. If incidental take is documented, discussions should be held with participants in the involved fisheries to identify means for reducing or eliminating the take.

A11. Investigate the extent of international trade. Russian scientists have expressed concern about Spectacled Eider egg collection and subsequent trade to European markets. The extent of this trade and its impact on the AR population should be investigated, and Spectacled Eiders should be nominated for inclusion in the CITES appendices, if appropriate. (Task may be accomplished with task A3).

A12. Reduce predation on Spectacled Eiders and their eggs at selected sites.

A12.1. Initiate control of foxes in selected Spectacled Eider nesting habitats. Predation by foxes varies substantially from year to year and may at times have a substantial effect on eider productivity. Reducing fox densities on restricted nesting areas where fox immigration is naturally limited (e.g., islands and "island-like" habitats surrounded by rivers) is practical. Given Spectacled Eider population declines, creating fox-free nesting locations may provide a reservoir of high eider productivity to sustain local populations. These sites are not expected to be sufficient to reverse widespread population declines. Yet, establishing at least a few pockets of high reproductive success could maintain a core eider population while research on other recovery obstacles is completed and before other, more extensive, management actions can be implemented. Suitable sites should be identified on the YKD and possibly the NS, and fox control initiated and its effects evaluated annually. Local residents should participate in decisions about fox control and its implementation (e.g., with trapping), where possible, as specified under the Memoranda of Agreement (task A4.1; also see related tasks G1 and G2).

A12.2. Initiate control of Glaucous Gulls in selected Spectacled Eider nesting habitats. Predation by Glaucous Gulls may at certain times and in some areas be an important factor in the high post-hatch mortality of eider ducklings on the Yukon Delta. A recent study on the YKD suggested that gulls nesting in the Hazen Bay area did not feed on eider ducklings. It may be possible to temporarily reduce local gull populations by destruction of nests or similar means. Suitable sites should be identified on the YKD and possibly NS. Control should not be initiated without more evidence that predation is a problem. Local residents should participate in decisions about gull control and its implementation, where possible, as specified under the Memoranda of Agreement (task A4.1; also see related tasks All.3, G4 and G5).

A12.3. Investigate and, if feasible, implement mechanisms to reduce artificial food sources to reduce predator numbers on Spectacled Eider nesting grounds. Artificial food sources such as garbage handouts, open landfills and fish processing wastes may be sustaining populations of eider predators above historical levels. The direct effects of waste food availability on predator populations have not been documented; however, reducing artificial food sources may benefit Spectacled Eiders by lowering the local carrying capacity for predator populations (primarily large gulls and foxes). The Service, other agencies, and local communities should work together (see task A4.1) to investigate and, if feasible, implement mechanisms for reducing waste availability to wildlife in Spectacled Eider range. This concern should be addressed in section 7 consultations, where appropriate.

A13. Conduct experimental translocation of both wild and captive-reared eiders to assess the feasibility of this method for recolonizing vacated areas. If current population trends continue, Spectacled Eiders will reach critically low numbers on at least the YKD within the next few decades. Translocation experiments should be completed before translocation or captive rearing and release become necessary, so that translocation could be implemented efficiently should the need arise in the future. Experiments with similar species such as King Eiders may be appropriate. Translocation between populations should not be initiated until distinctiveness of the populations is evaluated (task H2.).

A14. Maintain a captive flocks program to support the recovery effort for Spectacled Eiders. Captive flocks would be used for studies of physiology, body condition, and contaminants effects, and for documentation of plumage sequences, development of non-lethal diet sampling techniques, development of captive propagation techniques, and other studies. The Service should work cooperatively with the International Species Information System and Captive Breeding Survival Group to maintain an up-to-date data base of all captive Spectacled Eiders worldwide. The Service also should develop a protocol for handling sick or injured birds found in the wild. Criteria are needed for determining whether or not birds found incapacitated in the wild should be transported to a rehabilitation center or treated in the field, and whether they subsequently should be released, sent to a captive rearing facility, or sacrificed for necropsy and analysis. (Initiated 1994)

A15. Produce a handbook summarizing all information on identifying, ageing and sexing Spectacled Eiders. This information, including plumage sequences and morphology, is needed to assist with ageing and sexing birds in the hand and during aerial, boat and ground surveys.

B. **Abundance and Distribution**

B1. Delineate and monitor breeding populations. Changes in listing status (Threatened to Endangered, Endangered to Threatened, Threatened to delisted) will be based on total numbers of breeding birds and changes in the numbers of breeding birds in the three breeding populations (YKD, NS, AR).. Breeding populations cannot be adequately monitored until the major breeding areas are delineated. Presently only the YKD breeding area is thoroughly described and mapped; the geographic distribution and relative densities of breeding pairs on the NS and AR are currently being determined. Management actions to prevent extinction depend upon knowing whether a population is declining rapidly or has already declined to critically low numbers. Thus, population monitoring is critical for species recovery.

Surveys for monitoring eider populations must be efficient and affordable to be maintained over extended periods. Aerial surveys appear to offer the greatest potential for cost-efficient, long-term surveys over the breeding range of the species.

If surveys indicated that all three populations were declining, a common causative problem or problems would be indicated. In contrast, different trends among populations would suggest that the primary causes of observed declines occurred on the breeding grounds or on distinct at-sea ranges. Trend and abundance information will assist in setting priorities for tasks to identify obstacles to recovery and causes of decline. Trends and abundance estimates should be of sufficient accuracy and precision to satisfy the Recovery Criteria.

B1.1. Determine the breeding range and relative abundance of Spectacled Eiders on the NS. Experimental surveys initiated in 1992 defined the geographic limits and relative abundance of this breeding population. (See task B1.4.2.4 for long-term monitoring on NS). Completed.

B1.2. Determine the breeding range and relative abundance of Spectacled Eiders in AR. The distribution and relative abundance of the AR population is poorly defined.

B1.2.1. Complete geographically extensive surveys across AR. The Service has attempted waterfowl breeding pair surveys in AR for a few years; survey results from 1993 and 1994 permitted gross delineation of Spectacled Eider breeding areas and relative numbers in AR. Analysis and mapping of general range were completed in 1995.

B1.2.2. Quantify breeding population size on the Indigirka River Delta, AR. An intensive survey for breeding pairs on the Indigirka in 1994 was completed.

B1.3. Determine the breeding range and relative abundance of Spectacled Eiders on St. Lawrence Island. Residents of St. Lawrence Island report that Spectacled Eiders are still nesting on the island and they believe nesting numbers may be substantial. The possibility that a viable nesting population is extant on St. Lawrence Island should be investigated, either with aerial or ground-based surveys.

B1.4. Monitor trends and generate breeding pair abundance estimates for the three breeding populations. At present, aerial surveys are the only technique known to be feasible for monitoring very wide ranging populations such as on the NS and AR. The effectiveness of current surveys (NS and YKD coastal breeding pair aerial survey) should be evaluated in light of the Recovery Criteria. If precision requirements in the Recovery Criteria can not be met with current methods then survey design should be re-evaluated and modified. Power analyses to determine the magnitude of population change detectable on current surveys should guide decisions on survey effort and frequency. Results of B1.1. and B1.2. will define the geographic range and relative abundance of NS and AR populations in order to design appropriate surveys for these regions.

B1.4.1. Develop methods for determining visibility correction factors. Visibility correction factors with associated inter-annual variances are necessary to provide population size estimates from surveys. Biologists generally agree that habitats differ significantly between the arctic (NS, AR) and subarctic (YKD), and that waterfowl visibility differs between the regions even when aerial survey methods are the same. Hence, methods for determining visibility correction factors may need to be specific for each region. The relative merits of various methods for developing correction factors should be assessed, including ground and aerial methods at different frequencies (e.g., annual or less frequently). Once developed, these methods will be incorporated into the surveys in task B1.4.2. Following two years of experimental assessments on the YKD (tasks B1.4.1.1 and B1.4.1.4), the relative utility of aerial and ground surveys for monitoring Spectacled Eider breeding populations should be re-evaluated.

B1.4.1.1. Develop visibility correction factor methods for the YKD aerial survey. This task may be possible using existing data from air and ground surveys, although these data sets are not directly comparable. Experimental use of helicopters or expanded fixed-wing surveys may require prior coordination with local communities (following task A4.1.1).

B1.4.1.2. Develop visibility correction factor methods for the NS aerial survey. Recent helicopter:fixed-wing survey comparisons completed by industry contract biologists should be evaluated to determine whether they provide valid methods for calculating visibility correction factors on the NS. If not, then alternative methods should be designed and implemented.

B1.4.1.3. Develop visibility correction factor methods for the AR aerial survey. Since aircraft used in Russian aerial surveys typically differ from those used in Alaska, eider visibility is likely to differ as well. Hence, visibility correction factors are needed specific to this region and the aircraft or observation platform used.

B1.4.1.4. Develop nest detection correction factor methods for the YKD ground plot nest survey. With an unbiased correction factor for nest detection rates the ground plot data may provide the best annual estimate of absolute breeding pair abundance. Present survey design assumes that some nests are missed during these mid-incubation surveys, but the proportion missed is relatively constant between years. Further, it is assumed that Spectacled Eiders nest synchronously and never or rarely re-nest if nests are destroyed after incubation is initiated. Yet these assumptions may not be valid and need to be tested. Detection rates may vary due to differences in habitat, observer training or survey timing; hence, detection or visibility correction factors are needed to provide more accurate abundance and trend estimates.

B1.4.2. Monitor trends in the three populations. Either existing or newly developed surveys should be implemented as soon as acceptable methods incorporating visibility correction factor methods are developed (task B1.4.1). To meet the recovery criteria, both absolute abundance and population trend data must be monitored in each population.

B1.4.2.1. Analyze existing YKD aerial and ground survey data to refine survey methods. Both aerial and ground survey population estimates may be improved by re-stratifying the sample design or re-allocating ground survey effort. Data sets are presently being analyzed to determine whether precision can be improved with changes in the survey design. If re-allocation of effort is warranted, survey methods should be revised accordingly. Additional analyses should: 1) evaluate the effects of breeding phenology on results obtained from eider breeding pairs surveys as they are currently conducted on the Yukon Delta, and 2) examine bias associated with extrapolating eider estimates outside of sampled areas as is currently done for the Yukon Delta surveys. Potentially, a separate survey for Spectacled Eiders may be needed since the existing surveys were designed primarily for geese and optimization for Spectacled Eiders may be incompatible with objectives for other species. This effort is ongoing.

B1.4.2.2. Continue the YKD coastal breeding pair survey or implement alternative Spectacled Eider survey as determined in B1.4.2.1. The current aerial survey method incorporates fixed-wing, systematic strip plots over extensive geographic areas. Single birds, breeding pairs, and flocks are enumerated separately to generate estimates of total breeding birds. If task B1.4.1.1 results in recommendations for expanded surveys, particularly using helicopters, then local villages and the Waterfowl Conservation Committee of the Association of Village Council Presidents should be informed and consulted (see task A4.1.1).

B1.4.2.3. Continue YKD ground plot survey. The ground plot survey provides the only estimate of actual nest numbers. Trends in nest abundance provide critical information about population dynamics. If non-breeding birds return to nesting grounds and are counted on aerial surveys, those surveys may not detect population changes while actual nest numbers or total productivity are declining. In addition, ground plot surveys may assist in evaluating visibility bias on aerial surveys.

B1.4.2.4. Design and implement a NS survey. Results of exploratory surveys (tasks B1.1 and B1.4.1.2) should be used to design a survey program for the NS; either continuing or revising the current survey protocol.

B1.4.2.5. Design and implement an AR survey. The option of dividing the AR range into two or more survey areas to be surveyed in successive years, with an index area to be surveyed annually, should be investigated. The logistical and economic feasibility of alternate approaches, either an American-led cooperative survey or training Russian pilots and biologists to assume survey responsibilities for AR population, should be investigated. The results of joint venture surveys with U.S. and Russian biologists, and both Service and Russian aircraft (tasks B1.2.1 and B1.4.1.3), should be helpful in determining the feasibility and quantitative comparability of a Russian-led survey.

B2. Delineate at-sea range and relative abundance of Spectacled Eiders by breeding population. Spectacled Eider distribution away from the breeding grounds is poorly known. Since eiders spend most of their lives at sea, understanding at-sea distribution will be critical to determining and addressing threats to the populations. Identifying the location(s) and timing where annual mortality is greatest would be especially useful for directing research and recovery actions. Other factors that may be influencing population trends, such as marine food abundance and contamination, can only be investigated if at-sea feeding areas are known. Further, it is important to determine whether, where, and when the three breeding populations share habitats away from nesting grounds. Such information may reveal differences between the populations and their trends. Hence, Spectacled Eider movements and habitats during non-breeding should be determined for each of the three populations.

B2.1. Delineate non-breeding distributions of Spectacled Eiders with satellite telemetry. Preferably, satellite telemetry would be implemented simultaneously in the three populations to clarify intra-annual range overlap. Due to logistical and cost constraints, however, the three populations were proposed in sequence. In 1995, however, transmitters were implanted in birds from all three populations.

B2.1.1. Implement YKD satellite transmitter project. Transmitter implants into birds at Hock Slough, YKD, was initiated in 1993 and should continue until sample size requirements are met. Preferably, the YKD telemetry work should be expanded to include an additional study site to test whether YKD breeders use common post-breeding habitats. (Completed in 1995.)

B2.1.2. Implement NS satellite transmitter project. This project would follow the YKD project. (Initiated in 1995.)

B2.1.3. Implement AR satellite transmitter project. This project would follow the NS project. (Initiated in 1995.)

B2.2. Identify, describe and monitor use of at-sea habitats. Initial survey efforts should be based on: (1) locations derived from satellite telemetry studies, (2) other direct observations, and (3) an assessment of probable habitats such as polynyas. Surveys may be aerial or ship-board, depending on location and logistical constraints. Other opportunities to obtain at-sea distribution and habitat data opportunistically, such as marine mammal surveys, should also be pursued. These surveys will confirm and describe the extent to which Spectacled Eiders use the areas where transmittered birds are recorded or non-transmittered birds are observed, preferably in the year when satellite or observation data are obtained. Initial efforts should also be used to assess the feasibility of a geographically extensive, multi-year effort designed to identify the major at-sea areas and provide data on distribution, numbers, sex and age ratios, and annual geographical variability of use.

If feasible, identifying summering sites for non-breeding birds would be valuable to determine the magnitude and sex and age composition of the non-breeding components of each population. If the number of non-breeding birds could be determined annually by population, then population trends on the breeding grounds could be interpreted more accurately.

The geographic range of juveniles away from the breeding grounds should also be determined, especially by tracking transmittered females after breeding (assuming juveniles stay with females) or juveniles after fledging (see tasks C2.1 and C2.2). In particular, it is important to determine locations where juveniles congregate after fledging and during the pre-breeding years. Since juvenile mortality is thought to be substantial immediately after they move from nesting grounds to salt water, valuable demographic data might be obtained if fall staging areas were identified and surveyed. Information on reproductive success of the YKD population could be obtained by conducting 2 photo flights of Norton Sound in early August and late September to determine changes in sex and age ratios. In addition, surveys of eiders using Kuskokwim shoals (and areas south) during August should be conducted.

Once identified and generally described, at-sea habitats should be mapped in a GIS by source population, season, age and sex. Long-term monitoring plans should then be developed. Initial at-sea surveys will be somewhat opportunistic, for example, as new satellite transmitter data accumulate. In general, however, the following list should guide survey priorities, where feasible: (1) mid-winter (February to early March); (2) molting females (late August to early September); (3) post-fledging juveniles (if different from #2); (4) spring staging (April); (5) other staging, e.g., post-breeding/early wintering; (6) molting males (late July to August); and (7) summer non-breeding (June to July or later).

B3. Quantitatively describe at-sea habitats. Marine habitats and habitat-use are poorly understood. Quantitative habitat information would be used in identifying obstacles to recovery, determining sites for any necessary studies of eider biology and ecology, and ensuring the long-term security of these habitats. This task will depend upon the results of task B2.2., although cataloging information related to known use areas should be initiated immediately and continually updated.

B4. Quantitatively describe breeding habitats. Quantitative habitat description may be useful in understanding potential threats to Spectacled Eiders, such as accumulation of lead shot. Information on nesting and brood-rearing habitats will be used to ensure long-term security of these habitats. While this task is not presently a high priority compared to other recovery tasks, data on breeding habitats can and should be obtained incidental to other tasks. Site-specific habitat information may be important for meeting section 7 consultation requirements (task A11.1).

B4.1. Describe nesting and brood-rearing habitats on the YKD. Substantial data are currently available, particularly from the Hock Slough study site. These data should be analyzed and summarized.

B4.2. Describe nesting and brood-rearing habitats on the NS. Habitat information may be needed to fulfill section 7 consultation requirements for federally-permitted projects in the NS oil fields. These data may contribute to assessing hypotheses about industrial development impacts (task C5.6) and should be useful for comparisons with other populations.

B4.3. Describe nesting and brood-rearing habitats in AR. This task should be accomplished as opportunities arise.

C. Population Dynamics

C1. Determine age structure of Spectacled Eider populations. Epidermal aging techniques may provide an accurate and efficient method for instantaneous measures of the age structure in any eider population. Age structure, in turn, indicates whether adult or juvenile mortality is affecting the population disproportionately and could guide recovery investigations (see

Appendix III). Since epidermal aging of a population could be accomplished in a single season, this approach could substantially reduce the need for time-intensive and more disruptive survivorship and productivity studies. Epidermal aging has been successfully developed for mammals. This approach needs to be evaluated further on Spectacled Eiders (preliminary efforts in 1994 were encouraging). If implementation tests are successful, all breeding populations should be sampled.

C2. Describe Spectacled Eider reproduction and survival rates. Obtaining valid demographic data for Spectacled Eiders is necessary to refine the demographic population model and evaluate changes in the values used for model parameters. Population modeling will require survivorship data from all life stages. Detailed demographic modeling is needed to illuminate probable causes for the population decline and obstacles to recovery. It is also critical for calculating extinction and recovery times for various population sizes. Further, demographic comparisons between the three populations will shed light on possible distinctions between them and their distinct recovery needs.

C2.1. Quantify annual survival and fecundity of adult females. Annual survival and fecundity estimates are needed for adult female eiders. The ongoing survivorship study relies on marking with color markers and re-sighting marked birds. Annual survival should be estimated for a 3- to 5-year period in at least two study areas within each population. Initial marking began in 1993 at two study areas on the YKD. Required sample sizes will need to be refined based on preliminary return observations, so that hypothesis tests about survival have sufficient statistical power (0.8).

In addition to survival rates, observations of marked birds will provide data on the breeding frequency among breeding-age females. If non-breeding females return to the nesting ground, it may also be possible to measure the ratio of breeding to non-breeding females directly and determine if annual changes in the ratio can be detected. Depending on sample sizes, survivorship may be compared between successful, unsuccessful, and non-breeding females, or between females exposed and not exposed to lead. Combined with data from radio and satellite transmitters attached to breeding females (task B2.1), marking will also help to determine the distance females move from previous years' nest sites and augment our understanding of nest site philopatry.

Alternative marking methods that are more efficient may be developed in the future, such as remote marker detection. These methods should be assessed and implemented in place of color marking where appropriate and feasible. The alternative approach of measuring instantaneous population age structure (see task C1) may also supplant the need for multi-year survivorship studies in the future.

C2.1.1. Implement adult female and brood survivorship studies on the YKD.

C2.1.1.1. Conduct adult female and brood survivorship studies at Hock Slough and Kigigak Island on the YKD. A color marking project was initiated in 1993 at two study sites and is on-going. This study should be expanded to monitor survival of broods and hens after hatch and examine differences in survival of hens exposed and not exposed to lead.

C2.1.1.2. Identify a study site on the YKD free of accumulated lead shot for a study of adult female and brood survivorship.

C2.1.1.3. Conduct adult female and brood survivorship study at lead free study site on the YKD.

C2.1.2. Implement adult female and brood survivorship study on the NS.

C2.1.3. Implement adult female and brood survivorship study in AR.

C2.2. Quantify juvenile survival from fledging to recruitment, and determine age at first breeding and natal philopatry. If recruiting birds return to their natal area or other breeding areas that are being intensively studied, attaching color markings to juveniles just before fledging may provide important data on recruitment rates, age of first breeding and natal philopatry. Success will depend in part on attaining sufficient sample sizes to overcome presumed high mortality rates between fledging and recruitment. A supplemental or alternate approach to estimate juvenile survival with telemetry is included in task C2.3. and a potential alternative for determining population age structure estimates is included in task C1.

Preliminary marking is ongoing and should provide data for determining sample sizes necessary to estimate survival with power = 0.8. If the project is feasible and sample sizes can be obtained, color marking should be implemented on a wider scale. In cases where funds are not available to complete banding projects for both adult females and juveniles, the adult birds should receive priority.

C2.2.1. Implement juvenile survivorship study on the YKD.

C2.2.2. Implement juvenile survivorship study on the NS.

C2.2.3. Implement juvenile survivorship study in AR.

C2.3. Determine location and timing of juvenile mortality from fledging to one year. Survivorship data obtained through leg color-banding or other methods (task C2.2) may be inadequate because of low return rates due either to high mortality or emigration. Data on post-fledging and first winter mortality might be attainable by attaching satellite or conventional transmitters to juveniles and tracking them. Radio transmitters would be feasible if post-fledging staging areas have been identified (task B2.2.3) and may also provide new information about post-fledging areas if juveniles are detected coincidentally with other surveys. Presumed high mortality rates for juveniles make this approach less favorable. The best methods should be determined through preliminary studies. These studies should evaluate juvenile mortality beginning after day 45, when the ducklings are fully feathered with full wings, but before they migrate to the coast. Follow-up surveys of post-fledging habitats should be incorporated in project plans (see task B2.2).

C2.3.1. Implement juvenile post-fledging mortality study on the YKD.

C2.3.2. Implement juvenile post-fledging mortality study on the NS.

C2.3.3. Implement juvenile post-fledging mortality study in AR.

C2.4. Quantify duckling mortality. High nesting success may not correlate with high fledging success if ducklings suffer high mortality rates. Further, since predation and lead poisoning are suspected obstacles to recovery, data are needed on duckling survival and fledging rates. Sampling design should account for local and annual variation in duckling survival, which may be substantial. Hence, studies should be conducted at more than one site per breeding population; optimally at the same sites as those used to determine egg production, recruitment, and adult mortality.

C2.4.1. Assess and modify methods for radio-tracking hens on the YKD to monitor brood mortality. Studies on duckling mortality should be continued at Hock Slough until sufficient data are available to evaluate variability in duckling survival. Study protocols, which presently are unable to adequately monitor mortality during the first two weeks post-hatch, should be assessed and modified if feasible. Mortality immediately post-hatch and while broods are moving from nesting to initial brood-rearing habitats--a presumed period of high mortality--might be detected with more intensive monitoring. Project was initiated in 1993.

C2.4.2. Implement radio-tracking of hens on the NS to monitor brood mortality. Comparable data on brood mortality are needed from both developed and undeveloped sites on the NS to address the hypothesis that industrial development has adversely affected local populations. Further, this information is needed to interpret comparisons between NS and other populations. Current studies within the NS oil fields could be duplicated in ecologically similar, undeveloped sites.

C2.4.3. Implement radio-tracking of hens in AR to monitor brood mortality.

C2.5. Monitor brood production. Brood surveys would provide the most direct evidence of annual breeding success prior to fledging. Production data collected thus far primarily have been very local in nature (associated with research projects) and may not be representative of the breeding populations as a whole. Surveys should be designed to be representative of the breeding populations.

C2.5.1. Monitor brood production on the YKD.

C2.5.2. Monitor brood production on the NS.

C2.5.3. Monitor brood production in AR.

C2.6. Quantify clutch sizes and nest and egg survival rates. Based on current data and preliminary modeling (Appendix III), low production is not suspected to have caused the observed population declines. Yet for detailed demographic modeling to be accurate, annual production data should be gathered in conjunction with duckling and adult survivorship data. At least two study sites should be sampled for each of the three populations. Sampling should include clutch size and hatching success. Studies within each population should be conducted concurrently so that data are statistically comparable. Identifying the proximate causes of egg mortality (e.g., infertility, dead embryos, predation) may illuminate potential obstacles to population recovery. Changes in clutch size and hatching success should be compared among years as well as locations. Some previous studies may provide data for comparison with on-going studies and these data sets should be evaluated.

C2.6.1. Monitor nesting success on the YKD. Reproductive success data have been gathered at the Hock Slough and Kigigak Island study sites since 1992, providing preliminary input for modeling. Although a low priority by itself, annual reproductive success data should continue to be gathered at these sites coincidentally with the ongoing survivorship studies (task C2.1.1), if feasible, so that site-specific population dynamics can be assessed. Further, indications of high frequency of egg addling rates on the YKD need to be investigated to determine if addling has increased and what effect it may have on total production.

C2.6.2. Monitor nesting success on the NS. Comparable data on nesting from both developed and undeveloped sites on the NS may be useful for addressing the hypothesis that industrial development has adversely affected local populations. Further, this information is needed to interpret comparisons between NS and other populations. Current studies within the NS oil fields could be duplicated in ecologically similar, undeveloped sites. Reproductive success data could be obtained coincident with survivorship studies (task C2.1.2) or section 7-related evaluations.

C2.6.3. Monitor nesting success in AR.

C3. Evaluate the impact of biological studies on eider hatching success and brood survival. Based on studies of other species on the YKD and incidental observations, researchers have presumed that their activities have minimal effects on bird populations. Yet data are lacking to demonstrate that biological studies do not affect Spectacled Eider nesting propensity, clutch size, nesting success, or bird survival. The effects of ground studies, aerial surveys, and cumulative research-related activities on Spectacled Eiders should be investigated and quantified. Quantifying the potential effects will also resolve issues of potential bias in sampling design, guide mitigation measures to minimize investigator effects and permit an assessment of whether further, intensive studies are appropriate. This information is also important for addressing the hypothesis that human disturbance contributed to the Spectacled Eider decline or is an obstacle to recovery (task C5.7).

C3.1. Evaluate the effects of nasal markers. On-going marking studies include both nasal markers and leg bands. Since birds are merely observed and not re-captured for marker identification, nasal markers provide substantially more reliable re-sighting rates than do less visible leg bands. Although nasal markers are widely used on waterfowl and are presumed to have minimal adverse effects, data are lacking to demonstrate that marker attachment does not affect survival, nesting propensity, clutch size, and nesting success. A study should be conducted on the effects of nasal markers on birds that winter in sub-arctic, marine environments, preferably using a similar species rather than Spectacled Eiders. Quantifying the potential effects will resolve issues of bias in the sample design and permit an assessment of whether marking studies are appropriate.

C3.2. Evaluate the impacts of nesting studies. The study should determine an accurate, unbiased estimate of change in predation or abandonment rates as a result of biologists visiting nests and gathering information on eggs and hens during incubation. (Three year study initiated on YKD in 1994).

C3.3. Convene a workshop to develop methods for evaluating other research-related effects. Presently, methods have not been developed that would provide an accurate and unbiased estimate of the effects of aerial survey over-flights. In addition, the overall impact of research activities needs to be investigated, including but not limited to camp establishment and occupation, aircraft support, and, particularly, travel around a study area not directed to specific nests. Methods for determining specific research effects, such as increased predation or nest abandonment, need to be determined. Workshop participants should include biologists with expertise in studying disturbance effects, statisticians, and Native representatives who are concerned about this issue. Implementation of additional impacts studies should be based on the results of this workshop.

C4. Refine the demographic model for Spectacled Eiders. Understanding the population dynamics of this species will result in a more realistic assessment of various, potential causes of decline and obstacles to recovery. An improved model could improve our ability to determine the costs and benefits of reducing certain obstacles to recovery. The model in Appendix III should be refined based on data obtained from tasks under tasks C1 and C2. A sensitivity analysis should be conducted to assess the effects of uncertainty and environmental stochasticity on parameter estimation. The accuracy of parameter values required for various levels of confidence in the model must be determined, in addition to identifying how big an error in the estimates causes significant changes in the population parameters. Errors in current estimates may need to be reduced to improve the predictive capacity of the population model.

The model should incorporate recruitment and survival rates of similar species until Spectacled Eider data become available. If the AR population is not declining, data on reproduction and survival from the AR population would be particularly valuable to further the understanding of "normal" Spectacled Eider dynamics. The effects of changes in reproductive and survival parameters on Spectacled Eider populations and recovery should be investigated through simulations. This would include determining the magnitude of change in each parameter necessary to have a significant impact on recovery as well as determining likely causes for the decline. Parameters should include: adult survival, age of first reproduction, nesting propensity, clutch size, hatching success, brood survival, duckling survival, and fledgling survival.

C5. Summarize and evaluate available information on potential causes of decline and obstacles to recovery. Understanding the relative, cumulative, or synergistic impacts of various influences on eider populations will assist in establishing priorities for recovery efforts. Preliminary investigations outlined in this plan will help to determine the potential magnitude of the effects on eider populations of contaminants, competition, subsistence harvest, predation, fisheries, NS oil development activities, disturbance, and changes in long-term weather patterns. Data pertaining to these potential cause(s) of the eiders' decline and obstacles to recovery have yet to be comprehensively summarized and evaluated. Each of these topics should be investigated and the hypotheses refined so that data collection during the exploratory research phase is focused on hypothesis-testing.

The following 8 tasks call for preparing summary documents addressing 2 hypotheses about potentially major influences on Spectacled Eider populations: (1) this factor was an important cause of the Spectacled Eider population decline; and (2) this factor is an important obstacle to population recovery. These documents should summarize and evaluate all existing information, including evaluation through modeling, where appropriate. These summaries will be critical in developing work plans and formulating more precise, testable hypotheses as research continues. Because our present understanding of Spectacled Eider population dynamics is so limited, these topics should be addressed individually at first. In time, the goal should be to develop complex population models that permit assessment of multiple factors simultaneously. Tasks C5.1-C5.10 should be repeated regularly as data accumulate on each topic.

C5.1. Prepare summary report about environmental contaminants. The potential relationships between contamination and the observed historical declines and recovery should be evaluated and summarized in a report. Existing information on environmental contaminants within Spectacled Eider marine and breeding ranges needs to be compiled and evaluated to identify which contaminants may be adversely affecting Spectacled Eider populations (see task D1). The summary should: (1) describe contaminant concentrations recorded in eiders, other marine birds and marine mammals; (2) interpret inter-population variability in contaminant levels; and (3) compare contaminant levels to concentrations found in other species and to levels known to cause physiological or behavioral effects in waterfowl and marine birds (toxic and chronic effects) (initiated 1994).

C5.2. Prepare summary report about competition for food and loss of food supplies due to benthic disturbance. The potential relationships between competition and the observed historical declines and recovery should be evaluated and summarized in a report. Population trends, long-term distribution, and food habits of potential competitors including other marine birds, walrus, and Gray Whales should be examined and compared with these traits for Spectacled Eiders (see task E1). The spatial and temporal overlap of Spectacled Eiders with potential competitors should be compiled in a GIS data base. All available data on benthic fauna for at-sea Spectacled Eider habitat should be compiled. In addition to direct competition, food supplies may be inadequate due to benthic damage caused by Gray Whales displacing benthic substrates while they feed. Thus indirect competition through benthic disturbance should be included as part of this hypothesis testing. The levels of resource use overlap, niche breadths, competitor abundance, and benthic disturbance should be evaluated (this task may overlap with tasks C5.5 and C5.9).

C5.3. Prepare summary report about harvest. The potential relationships between harvest and the observed historical declines and recovery should be evaluated and summarized in a report. Historical subsistence harvest survey data, where available, and anecdotal data should be collected and examined for comparatibility and potentially for use in examining historical changes in magnitude and distribution of harvest. Historical sport harvest data should be derived from ADF&G and Service harvest surveys and anecdotal data. Factors that may have contributed to historical changes in the subsistence and sport harvests should be identified.

C5.4. Prepare summary report about predation. The potential relationships between predation on eggs, ducklings, and adults and the observed historical declines and recovery should be evaluated and summarized. The evaluation should consider: (1) gull population trends, and foraging behavior and diets (task G3); (2) correlations between gull and eider densities and changes in those densities on the YKD; (3) changes in fox populations on both the YKD and the NS, and effects of fox control on waterfowl predation (task G1); and (4) population-level trends for other fox and gull prey species compared with Spectacled Eider population trends.

C5.5. Prepare summary report about Bering Sea Fisheries. The potential relationships between fisheries activities and the observed historical declines and recovery should be evaluated and summarized. If preliminary assessment points to potential interaction between Spectacled Eiders and fishery activities, the spatio-temporal patterns of Bering Sea fishery activities, both seasonally and across years, should be summarized in a GIS data base. Any available fishery data should be assessed to determine whether these fisheries: (1) impact eider foraging ecology through competition; (2) result in substantial mortality from colliding with lighted boats during periods of darkness or drowning in nets (task A11.4.); (3) disturb benthic substrates where eiders feed; and (4) coincide with the time frame of the eiders' decline (this task may overlap with tasks C5.2 and C5.9).

C5.6. Prepare summary report about industrial development on the NS. The potential relationships between industrial development and the possible declines and recovery should be evaluated and summarized. This summary should incorporate data on the impacts on nesting success, brood success, duckling survival, hen survival, and nesting distribution. The potential effects of any planned expansions or changes of facilities, roads, and other structures or changes in activity levels on recovery should also be evaluated (this task may overlap with task C5.7).

C5.7. Prepare summary report about human disturbance. The potential relationships between human disturbance and the observed historical declines and recovery should be evaluated and summarized. Variables such as increases in the local human population, changes in human presence on the breeding grounds (including local residents and biologists), and changes in amount of vehicular disturbance (snow machines, outboard boats, off-road vehicles, aircraft) on the breeding grounds should be considered.

C5.8. Prepare summary report about changes in long-term weather patterns and current weather patterns. The potential relationships between weather changes and the observed historical declines and recovery should be evaluated and summarized. Long-term changes as well as brief, potentially catastrophic events should be considered. Changes in local (breeding ground) and large scale (Bering Sea) weather conditions should be compared to declines in Spectacled Eiders. Critical periods in the eiders' annual cycle such as hatch, fledging, transition of young to marine environment, and winter conditions should be examined to identify plausible links between potential or identified weather changes and the eider decline. Information on weather-related changes in primary production, carbon flux to the benthos, standing stocks of benthic biomass, and abundance or species composition of eider prey stock may be beneficial.

C5.9 Prepare summary report about chronic oiling from bilge pumping in Spectacled Eider wintering habitat. The potential relationships between bilge discharges and the observed historical declines and recovery should be evaluated and summarized. Vessels traveling in the Bering and Chukchi seas may be incidentally contaminating the marine environment by pumping bilge water containing petroleum products. In cold waters, oil degrades very slowly and may pose a persistent hazard to marine animals. Exposure to even small quantities of oil may be harmful or fatal to sea ducks including eiders, especially during severe winter weather. Sea ducks that winter in cold waters likely have limited ability to withstand additional physiological stresses such as reduced waterproofing of feathers. Data on vessel traffic, bilge pumping, oil spills and chronic oiling should be compiled in a GIS data base. Once rates of potential chronic oiling in at-sea Spectacled Eiders are determined, effects on eider populations should be evaluated (this task may overlap with tasks C5.2 and C5.5).

C5.10. Prepare summary report on diseases and parasites. A thorough literature review should be completed to identify common diseases and parasites that may affect eiders and to determine their potential prevalence in the population. Based on known effects in other species and any sampling of Spectacled Eiders (task I1), the possible impact of diseases and parasites on eider survival and fecundity should be determined to assess the potential contribution to observed declines.

D. Contaminants

D1. Determine contaminants levels in the three Spectacled Eider populations. Except for lead poisoning due to lead shot ingestion, nothing is known about the effects of environmental contaminants on Spectacled Eiders. Preliminary tissue analyses from a few Spectacled Eiders suggest that some birds have elevated concentrations of several elements, including selenium and cadmium. Implications of these elevated concentrations are poorly understood in sea ducks. In addition to metals, eiders may be exposed to organochlorine compounds, such as DDT and PCBs, and radioactive compounds from ocean dumping of nuclear wastes. Only limited toxicological information, mainly restricted to mammalian species, is available for other northern species inhabiting the same geographical region as eiders.

A small baseline sample of Spectacled Eiders should be collected from their wintering areas and screened for presence, concentrations and variability of contaminants. To maximize the information gained from these birds, physiological and toxicological endpoints should also be measured. If other critical gaps have been identified (task C5.1), and if baseline analysis indicates a potential problem, protocols for obtaining additional data on contaminant levels and associated physiological and histological status for individual populations should be implemented using the least-impact methods available. Potential population-level effects of collecting wild spectacled eiders should be identified before collection is authorized. Potential sources for the implicated contaminants in high-latitude marine environments should also be described. Incidentally collected carcasses should be necropsied and screened for contaminants. Collection of a sample of healthy birds was completed in 1995.

D2. Initiate contaminant exposure studies in captive birds. Depending on the results of task C5.1 and D1, it may become important to determine the effects of high contaminant levels on eider physiology, survival, and reproduction. If necessary, specific physiological markers that could be tied to contaminant levels and effects should be evaluated in controlled trials with captive birds to develop methods for field sampling wild birds. Either captive Spectacled Eiders or similar species such as Common Eiders may be suitable for this study.

D3. Determine contaminant levels in primary prey species and substrates. Once the Spectacled Eider's primary prey are known (task E1), prey and substrate contaminant levels can be determined. Assessing prey and substrate contamination will indicate the contaminant transport modes and exposure rates for Spectacled Eiders.

D3.1. Determine contaminant levels in primary marine prey species and substrates.

D3.2. Determine contaminant levels in primary breeding season prey species and substrates. On the YKD, this task can be accomplished simultaneously with lead shot investigations (task D5.1).

D4. Investigate the frequency of exposure to ingested lead shot of Spectacled Eiders and other species that use Spectacled Eider feeding habitats. Lead poisoning by ingestion of lead shot has been documented in Spectacled Eiders on the YKD. Studies are needed to determine: (1) what proportion of the Spectacled Eider population(s) is ingesting lead (e.g., whether or not lead poisoning is a limited, local event); and (2) how extensively lead shot is distributed in tundra ponds.

D4.1. Screen for exposure to lead within the YKD breeding population. Spectacled Eiders and sympatric species should be sampled for blood lead concentration and lead shot exposure frequency. Sites should be selected to represent a range of habitats used by each population (task initiated in 1993).

D4.2. Screen for exposure to lead within NS breeding population. This task could be accomplished when birds are captured for telemetry (task B2.1.2). Samples were collected in the Prudhoe Bay area in 1995.

D4.3. Screen for exposure to lead within AR breeding population. Sampling should be conducted opportunistically in the course of other projects in which eiders are captured. (Initiated in 1995)

D5. Investigate extent of lead shot occurrence in Spectacled Eider foraging habitats within nesting range. If feasible, Spectacled Eider foraging habitats within current breeding range should be systematically sampled to determine lead shot distribution and accumulation levels. The priority of this task will depend on results of eider screening (task D4).

D5.1. Investigate lead shot distribution and density on the YKD.

D5.2. Investigate lead shot distribution and density on the NS.

D5.3. Investigate lead shot distribution and density in AR.

D6. Investigate lead shot persistence and availability to foraging eiders in coastal wetland habitats. In temperate climate wetlands, waste lead shot typically sinks below the substrate surface after a year and is no longer available to foraging ducks. Because soil dynamics are different in sub-arctic and arctic wetlands, the long-term behavior of lead shot at higher latitudes is not known. Controlled, site-specific studies of multi-year lead shot behavior should be conducted in principal substrates found in arctic and sub-arctic wetlands used by foraging Spectacled Eiders.

D6.1. Investigate lead shot persistence and availability on the YKD. This task was initiated in 1994.

D6.2. Investigate lead shot persistence and availability on the NS. This task will only be needed if eider screening (task D4.2) indicates a problem with lead exposure on the NS. A study of lead shot persistence on the NS potentially would illuminate concerns for both NS and AR nesting populations, since wetland soils at similar latitudes might be similar.

D7. Determine contaminant sources, transport modes, and uptake mechanisms. If contaminants are determined to be a factor affecting Spectacled Eiders (tasks C5.1 and D1), studies should be initiated to trace contaminants to their source(s) (also see task D3).

D8. Design and implement a monitoring program to assess contaminant levels in each population over time. If contaminants are determined to be adversely affecting Spectacled Eiders (tasks D1 and C5.1), a long-term monitoring program should be implemented.

E. Food Habits

E1. Assess eider diets in marine habitats used during summer, molting, fall staging, winter, and spring staging. Knowledge of eider diets is necessary to understand potential obstacles to recovery such as contaminants and competition.

E1.1. Assess food habits from incidentally obtained data. Collecting adequate sample sizes for a traditional food habits study (i.e., shooting tens of birds or more), may not be an acceptable approach for a threatened species. Thus, food habits information should first be gathered incidentally from dead birds and birds collected for other purposes (ongoing).

E1.2. Develop means of capturing live Spectacled Eiders for marine diet sampling. Task E1.1 may not result in adequate information about food habits. If food habits could be determined without killing birds, then more accurate information about diet would be possible without adverse effects on the population. Techniques for capturing live eiders at-sea should be developed.

E1.3. Determine food habits in marine environments. Stomach samples should be obtained by methods developed in task E1.2, if feasible. If methods for capturing live eiders at-sea cannot be developed, then the population effects of collecting a valid sample of wild birds should be determined (see task C5.7). If these population effects would not threaten any of the populations, then collections should be implemented to assess eider diets in marine habitats. Whenever wild birds are collected, data required for all pertinent tasks (e.g., contaminants, physiological conditions, diet, plumage) should be obtained.

F. **Harvest Levels**

F1. Assess annual subsistence harvest of Spectacled Eiders. Subsistence harvest of Spectacled Eiders and their eggs should be monitored. The magnitude, distribution, and sex and age composition of the harvest should be determined, preferably annually for all important locations. Subsistence harvest surveyors should be trained and prepared to both provide and solicit information concerning eiders. Anecdotal information on harvest traditions should be collected to help direct and design scientific sampling and also to illuminate the possible range of historical harvest levels. Harvest survey tasks may be especially suitable for cooperative or contract work as developed under the Memoranda of Agreement (task A4).

F1.1. Re-analyze subsistence harvest data of Spectacled Eiders on the YKD and redesign harvest surveys. The precision of subsistence harvest estimates from the YKD might be improved substantially with alternative analysis techniques. The data should be re-analyzed to calculate harvest levels in only the strata in which Spectacled Eiders were harvested. Adjusted estimates for harvest and annual variation will be used for hypothesis evaluation (task C5.3). This analysis should also direct re-design of the harvest surveys to improve precision.

F1.2. Continue Yukon-Kuskokwim Delta and St. Lawrence Island subsistence harvest surveys. Annual subsistence harvest surveys have been conducted on the YKD since 1985 and on St. Lawrence Island since 1993. If re-analysis and re-stratification (task F1.1) do not improve precision sufficiently to permit hypothesis testing about harvest impacts, then options for revising methodology should be explored. Future surveys should be designed to assess and improve accuracy, provide precise harvest estimates, and evaluate the effectiveness of harvest reduction programs.

F1.3. Determine harvest levels on the NS and in the Bering Strait region (other than St. Lawrence Island). Spectacled Eiders are harvested in several villages where harvest surveys are not currently conducted, but the distribution and quantity of harvest in the Bering Strait and on the NS are not known. Surveys that provide precise, accurate harvest information are needed for all Alaskan villages where Spectacled Eiders are likely to be taken.

F1.4. Assess the feasibility of initiating a harvest survey in Russia. The harvest level in Russia is unknown. Anecdotal data should guide establishment of a subsistence harvest survey in AR. This task may also include gathering information on non-subsistence harvest and scientific collecting (see task A12).

G. **Predation**

G1. Assess fox predation levels on Spectacled Eider productivity. Current fox predation rates should be determined at a number of sites to assess predation rates throughout the populations.

The reproductive stages (eggs, young, adults) where fox predation is most serious should be determined, to guide possible control activities (task A13.1). Inter-annual variation in fox predation and the role of buffer species should be evaluated.

G2. Evaluate Spectacled Eider population-wide control of foxes as a means to improve reproductive success of Spectacled Eiders. On islands where foxes can be completely eliminated, fox control has been implemented to increase local waterfowl production (also see task A13.1). Previous experiments with fox control on the YKD, however, indicate that attempts to control fox predation rates by reducing fox numbers with the experimental methods will not be successful on a wide scale. Yet, since predator control is one of the few tools currently available with any hope of affecting Spectacled Eider survival, further assessment of the feasibility and effectiveness of widespread fox control for boosting Spectacled Eider survival is warranted. The impacts of fox removal on eider productivity, and adult survival, if feasible, should be studied at two or more ecologically similar, non-island sites (i.e., control and removal areas). The feasibility of wide-spread control of foxes should then be evaluated.

G3. Determine gull foraging patterns and population trends on the YKD. These ongoing studies are designed to assess: (1) gull population size and historical trends in gull numbers on the YKD; (2) correlations between gull densities and eider densities and correlations between gull densities and changes in eider densities; and (3) gull food habits and foraging behavior. Summary results from this study will contribute to task C5.4 by assessing the importance of avian predation within the YKD eider population. Based on this assessment, expanded studies of regional gull populations and overwinter survival rates may be warranted. The gull food habits study was concluded in 1995. Spectacled Eider ducklings were not consumed by any of the Glaucous Gulls sampled in the Hazen Bay area in 1994.

G4. Evaluate population-wide control of gulls as a means to improve reproductive success of Spectacled Eiders. Gull populations are thought to have increased in coastal habitats in recent decades due to increased availability of waste food supplies. If gull predation on young eiders is determined to be an obstacle to recovery (tasks G3 and C5.4), the potential means for reducing predation by controlling gulls should be identified, then the feasibility and effectiveness of gull control should be investigated. A study to assess the impacts of gull removal on Spectacled Eider productivity should then be implemented. The study should be conducted on at least two ecologically similar, control and removal areas. The feasibility of wide-spread control of gulls should be considered. Control measures may include eliminating gull colonies through reducing gull food supplies (e.g., improving landfill management and changing fishery waste disposal methods) or repetitive nest destruction (see also tasks A11.1, A13.2 and A13.3).

H. Genetics

H1. Determine population structure and gene flow between the major breeding populations. The magnitude of variation in gene frequency among nesting populations is a function of the rate of inter-population gene flow and effective breeding population size. Nuclear and mitochondrial DNA gene frequencies can be used to assess the degree of reproductive isolation among nesting populations. The presence of "unique" alleles within specific populations is also important, as certain populations may harbor a greater proportion of the total species genetic diversity than might otherwise be expected based on total population size alone. Genetic samples should be taken from more than one area within each geographically defined nesting population and from peripheral areas including St. Lawrence Island and the Seward Peninsula. Sampling was initiated in 1993.

H2. Assess evidence for ecological and genetic distinctness of the YKD, NS, and AR populations. If population segments are reproductively isolated, they may exhibit heritable distinguishing characteristics that warrant special management consideration. Hence, it is important to evaluate evidence for ecological and genetic distinctness between populations. To the extent possible, this assessment must carefully sort out differences that are likely heritable from those that are largely influenced by environmental factors. Direct genetic studies (e.g. electrophoresis, DNA analysis) may be inconclusive, but adaptive, heritable differences may be indicated indirectly from examination of other characteristics. Phenotypic and life history traits and habitat characteristics should be evaluated for each population. Once protocols for incidental data collection are set up, data for this task can be obtained as part of other tasks (e.g., birds handled for banding or at museums).

Nuclear DNA studies completed in 1995 suggested the presence of one panmictic Spectacled Eider population. However, heritable differences in suspected female-philopatric species such as Spectacled Eiders would likely be more evident in mitochondrial DNA. Studies will be initiated in 1996.

H3. Determine genetic variability within each of three nesting populations. Genotype frequencies and measures of genetic variability obtained from nuclear and mitochondrial DNA markers can be used to assess within-population breeding structure (i.e., potential inbreeding) and to compare population measures of genetic diversity with known aspects of each populations' ecology (e.g., recruitment and breeding population size). Comparisons should be made between present population levels of genetic diversity and estimates based on samples obtained from museum specimens collected from the same areas prior to population declines (see data obtained for task H1). The magnitude of change in genetic diversity and population gene frequency should be used to evaluate the potential effects of declines in effective breeding population size and degree of isolation from other nesting populations.

I. Diseases, Parasites, and Physiological Condition

I1. Screen eiders for diseases and parasites. Disease and parasite screening should be completed on all eiders salvaged or collected for other purposes; collecting birds specifically for disease or parasite screening is not warranted at this time.

I2. Investigate physiological condition of Spectacled Eiders. Whether caused by poor food supplies, chronic oiling, metal contamination, or other factors, poor physiological condition could result in unsustainable mortality levels. Determining whether body condition in Spectacled Eiders is inadequate to sustain "normal" survival rates would guide research and management activities toward potential causes for reduced body condition.

I2.1. Collect standard blood panels. Blood analysis provides an indication of overall body condition and stress in live birds. Opportunistic collection of blood samples from eiders trapped for other studies and from captive flocks was initiated in 1994. Samples should be collected from each population to allow comparisons between the body condition indicators and relative "health" of the three populations, captive birds, and related species.

I2.2. Determine and evaluate body condition indices for Spectacled Eiders. Body condition (such as body fat level of dead birds or the ratio of body mass to some measures of body size of live birds) should be evaluated in Spectacled Eiders collected incidentally or handled for other studies. These data should be compared to survival and reproductive success data for the represented population. Preliminary data would also establish sample sizes needed for a comprehensive study.

I2.3. Evaluate the physiological condition of Spectacled Eiders throughout the year. Based on the results of I2.2, a study should be designed and implemented to evaluate the physiological condition of Spectacled Eiders at different locations throughout the year. Non-lethal methods should be used if they provide statistically reliable information; collecting should be implemented only if it is determined that it will not adversely affect any population.

I2.4 Compare distributions of Spectacled Eider body condition with those of related species. If the distribution of Spectacled Eider body conditions differs from related species that are sharing similar habitats, mortality factors such as heavy metal contamination, food scarcity, parasites, or disease might be implicated. However, if the distribution of body conditions is comparable to that for other similar species, other mortality factors (e.g., predation, subsistence harvest) would be implicated.

LITERATURE CITED

Allen, H. III, and L. Allen. n.d. Spectacled Eider "Duck of Mystery:" Its natural history and captive management. Game Bird Gazette 31: 13-19.

Anderson, B.A., and B.A. Cooper. 1994. Distribution and abundance of Spectacled Eiders in the Kuparuk and Milne Point Oilfields, Alaska, 1993. Final Report prepared for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK by Alaska Biological Research, Inc., Fairbanks, AK.

____________, and C.B. Johnson. In Press. Spectacled eider studies in the Kuparuk Oilfield, Alaska, 1995. Unpubl. Rep. prepared for ARCO Alaska, Inc. and the Kuparuk River Unit, Anchorage, AK by Alaska Biological Research, Inc.

____________, S.M. Murphy, and M.T. Jorgenson. 1992a. Seasonal patterns of habitat use by geese in the Prudhoe Bay oilfields, Alaska, 1985-1989. Proc. 7th N. Am. Arctic Goose Conference and Workshop, 7-12 Jan. 1992, Vallejo, CA. (Abstract)

____________, S.M. Murphy, and M.T. Jorgenson, D.S. Barber, and B.A. Kugler. 1992b. GHX-1 Waterbird and Noise Monitoring Program. Final Report prepared for ARCO Alaska, Inc., Anchorage, AK by Alaska Biological Research, Inc., Fairbanks, AK and BBN Systems and Technologies Corp., Canoga Park, CA.

____________, R.J. Ritchie, and A.A. Stickney. 1991. Abundance, distribution and movements of brood-rearing brant in Prudhoe Bay, Alaska. Alaska Bird Conference and Workshop, 19-22 Nov. 1991, Anchorage, AK. (Abstract)

____________, A.A. Stickney, R.J. Ritchie, and B.A. Cooper. 1995. Avian studies in the Kuparuk Oilfield, Alaska, 1994. Unpubl. Rept. for ARCO Alaska, Inc. and The Kuparuk River Unit, Anchorage, AK.

AOU (American Ornithologists Union). 1983. Checklist of North American birds. 6th edition. Am. Ornithol. Union, New York, NY.

Atrashkevich, G.I. 1982. *Filicollis trophimenkoi n.*sp. (Acanthocephala: Polymorphidae) from Anatidae in north-western Chukotka. Parazitologiya 16:102-106.

Bailey, A.M. 1948. Birds of Arctic Alaska. Colorado Mus. Nat. Hist., Pop. Ser. No. 8. 113p.

Barry, T.W. 1960. Breeding biology of the Atlantic Brant (*Branta bernicla hrota*). M.S. Thesis, Cornell Univ., Ithaca, NY. 81 p.

____________. 1967. The geese of the Anderson River Delta, NWT. Completion Report, Can. Wildl. Serv.

Baudinette, R.V., F.I. Norman, and J. Roberts. 1982. Salt gland secretion in saline-acclimated chestnut teal, and its relevance to release programs. Aust. J. Zool. 30:407-15.

Bent, A.C. 1925. Life histories of North American wild fowl. U.S. Nat. Mus. Bull. 130, Washington, DC.

Bergman, R.D., R.L. Howard, K.A. Abraham, and M.W. Weller. 1977. Waterbirds and their wetland resources in relation to oil development at Storkersen Point, Alaska. U.S. Fish and Wildl. Serv., Res. Pub. 129.

Bondarenko, S.K. 1975. Cestodes from the genus *Aploparaksis* Clerc, 1903 (Hymenolepididae) from Anatidae and their life-cycles. Akademiya Nauk SSSR, Dal'nevostochnyi Nauchnyi Tsentr. 78-96.

____________, and V.L. Kontrimavichus. 1976. The life-cycles of the hymenolepidids, *Aploparaksis birulai* (Linstow, 1905) and *A. brachyphallos* (Krabbe, 1869). Parazitologiya. 10:163-169.

____________, and V.L. Kontrimavichus. 1979. The life-cycle and post-embryonic development of *Aploparaksis (Tanureria) diagonalis* Spasskii et Bobova, 1961, a parasite of Charadriiformes. Nauka: 38-45.

Brandt, J.F. 1847. Fuligulam (Lampronettam) Fischeri. Nov. Avium Rossicarum Spec. 18 p.

Brandt, H. 1943. Alaska Bird Trails. Bird Research Foundation, Cleveland, OH. 464 p.

Braund, S.R., D.C. Burnham, E. Loring, L. Morehead, T.P. Holmes, E. Witten, and J.A. Kruse. 1989a. North Slope subsistence study, Wainwright, 1988. U.S. Minerals Management Service Technical Report No. 136, MMS 89-0078, Anchorage, AK.

____________, T.P. Holmes, J.A. Kruse, L. Morehead, E. Witten, D.C. Burnham, and A. Stoker. 1989b. North Slope subsistence study, Barrow, 1988. U.S. Minerals Management Service Technical Report No. 135, MMS 89-0077, Anchorage, AK.

Brower, W.A., Jr., H.W. Searby, J.L. Wise, H.F. Diaz, and A.S. Prechtel. 1977. Climatic atlas of the outer continental shelf waters and coastal regions of Alaska. AEIDC Pub. B-77, Vol. 3., NOAA, Asheville, NC.

Burgess, R.M., and A.A. Stickney. 1992. Reaction of brood-rearing snow geese to oil development related and natural disturbances in the Endicott development area, Alaska, 1985-1990. Proc. North American Arctic Goose Conference and Workshop, 7-12 Jan. 1992, Vallejo CA. (Abstract)

Buturlin, S.A. 1910. The true home of the spectacled eider. Condor 12:46.

Conover, H.B. 1926. Game birds of the Hooper Bay Region, Alaska. Auk 43:162-180, 303-318.

Cooch, F.G. 1965. The breeding biology and management of the northern eider (*Somateria mollissima borealis*) in the Cape Dorset area, NWT. Can. Wildl. Serv., Wildl. Manage. Bull., Ser. 2, No. 10.

____________. 1986. The numbers of nesting Northern Eiders on the West Foxe Islands, NWT, in 1956 and 1976 *in* A. Reed (ed.), Eider ducks in Canada. Can. Wildl. Serv., 1141 route de l'Église, Ste-Foy, Que, G1V 4H5. Pages 114-118.

Cottam, C. 1939. Food habits of North American diving ducks. U.S. Dept. Agric. Tech. Bull. No. 643, Washington, D.C.

Dau, C.P. 1974. Nesting biology of the spectacled eider, *Somateria fischeri* (Brandt), on the Yukon-Kuskokwim Delta, Alaska. M.S. Thesis, Univ. Alaska, Fairbanks, AK. 72 p.

____________. 1976. Clutch sizes of the spectacled eider on the Yukon-Kuskokwim delta, Alaska. Wildfowl 27:111-113.

____________. 1978. Observations on helminth parasites of the spectacled eider, *Somateria fischeri* (Brandt), in Alaska. Can. J. Zool. 56:1882-1885.

____________, and A.A. Kistchinski. 1977. Seasonal movements and distribution of the spectacled eider. Wildfowl 28:65-75.

____________,, and R.A. Stehn. 1991. Population size and distribution of Spectacled Eiders on the Yukon-Kuskokwim Delta. Alaska Bird Conf. and Workshop: Shared avian resources of Beringia. Nov. 19-22, 1991. Abstract Only.

Deblock, S., and R.L. Rausch. 1972. Contribution to the study of Microphallidae Travassos, 1920 (Trematoda). XXVI. On some species from Alaska. Ann. Parast. Hum. Comp. 47:701-715.

Delacour, J., and E. Mayr. 1945. The family Anatidae. Wilson Bull. 57:3-55.

Dementev, G.P., and N.A. Gladkov (eds.). 1952. Birds of the Soviet Union, Vol. 4. Translated by the Israel Program for Scientific Translations in 1967. National Tech. Info. Serv., U.S. Dept. Comm., Springfield, VA.

Derksen, D.V., T.C. Rothe, and W.D. Eldridge. 1981. Use of wetland habitats in the National Petroleum Reserve-Alaska. U.S. Fish and Wildl. Serv., Res. Pub. 141.

Dufresne, F. 1924. Report on investigations of birds and mammals of the Hooper Bay section of Alaska during the spring and summer of 1924. Unpubl. Rept., U.S. Dept. Agric., Bur. Biol. Surv., Washington, DC.

Ely, C.R., C.P. Dau, and C.A. Babcock. 1994. Decline in a population of spectacled eiders nesting on the Yukon-Kuskokwim Delta, Alaska. Northwest. Nat. 75:81-87.

Esler, D., and J.B. Grand. 1994. The role of nutrient reserves for clutch formation by northern pintails in Alaska. Condor 96:422-432.

Everett, W.T., M. L. Ward, and J.J. Brueggeman. 1989. Birds observed in the central Bering Sea pack ice in February and March 1983. Le Gerfaut 79:159-166.

Fay, F.H., and T.J. Cade. 1959. An ecological analysis of the avifauna of St. Lawrence Island Alaska. Univ. of California Press, Berkeley, CA. 149 p.

____________. 1961. The distribution of waterfowl on St. Lawrence Island, Alaska. Wildfowl 12:70-80.

____________, B.P. Kelly, and J.L. Sease. 1989. Managing the exploitation of Pacific walruses: a tragedy of delayed response and poor communication. Marine Mammal Sci. 5:1-16.

Flint, P.L., and J.B. Grand. In Press. Survival of spectacled eider adult females and ducklings during brood rearing. J. Wildl. Manage. 0(0)000-000.

Franson, J.C., M.R. Petersen, C.U. Meteyer, and M.R. Smith. 1995. Lead poisoning of spectacled eiders (*Somateria fischeri*) and of a common eider (*Somateria mollissima*) in Alaska. J. Wild. Diseases 31:268-271.

Garner, G.W., and P.E. Reynolds (eds). 1986. Arctic National Wildlife Refuge Coastal Plain Resource Assessment. Final Rept., Baseline Study of the Fish, Wildlife, and their Habitats. Vol. I.

Gillham, C.E. 1941. Report on waterfowl investigations, summer 1941, lower Yukon River, Chevak, Hooper Bay. Unpubl. Rept., U.S. Fish and Wildl. Serv., Washington, DC.

___________. 1942. Report on waterfowl, Hooper Bay, Alaska, 1942. Unpubl. Rept., U.S. Fish and Wildl. Serv., Washington, DC.

Goudie, R.I., A.V. Kondratyev, S. Brault, M.R. Petersen, B. Conant, and K. Vermeer. 1994. The status of sea ducks in the North Pacific Rim: Toward their conservation and management. Pages 27-49 *in* Martell, A.M., and A.W. Palmisano, eds., Conserving international resources of the North Pacific Rim. Trans. 59th N. Am. Wildl. and Nat. Res. Conf. (1994). Wildl. Manage. Inst. Publ.

Harwood, C.M. and T. Moran. 1991. Nesting chronology, reproductive success, and brood rearing for Spectacled and Common Eiders on Kigigak Island, 1991. Unpubl. Rept. U.S. Fish and Wildl. Serv., Bethel, AK.

___________, and T. Moran. 1993. Productivity, brood survival, and mortality factors for spectacled eiders on Kigigak Island, Yukon Delta NWR, Alaska, 1992. Unpubl. Rept. U.S. Fish and Wildl. Serv. Bethel, AK.

Hillgarth, N., and J. Kear. 1979. Diseases of seaducks in captivity. Wildfowl 30:135-141.

Hodges, J.I., and W.D. Eldridge. 1994. Aerial waterfowl surveys on the arctic coast of Eastern Russia, 1993. Unpubl. Rept., U.S. Fish and Wildl. Serv. Anchorage, AK.

___________, and W.D. Eldridge. 1995. Aerial waterfowl surveys on the arctic coast of Eastern Russia, 1994. Unpubl. Rept., U.S. Fish and Wildl. Serv., Washington, DC.

Hood, D.W., and E.J. Kelly (eds). 1974. Oceanography of the Bering Sea, with emphasis on renewable resources. Occas. Pap. No. 2, Inst. Marine Sci., Univ. Alaska., Fairbanks, AK.

___________, and J.A. Calder (eds). 1981. The Eastern Bering Sea Shelf: Oceanography and Resources. Vol. 2, Univ. Wash. Press., Seattle, WA. 1339 p.

Humphrey, P.S. 1958. Classification and systematic position of the eiders. Condor 60:129-135.

Johnsgard, P.A. 1960. Classification and evolutionary relationships of the sea ducks. Condor 62:426-433.

__________. 1964a. Observations on the biology of the spectacled eider. Wildfowl 15:104-107.

__________. 1964b. Comparative behavior and relationships of the eiders. Condor 66:113-129.

Johnson, C.B. 1995. Abundance and distribution of eiders on the Colville River delta, Alaska, 1994. Unpubl. Rept. for ARCO Alaska, Inc. Anchorage, AK.

Johnson, L.L. 1971. The migration, harvest, and importance of waterfowl at Barrow, Alaska. M.S. thesis, Univ. Alaska, Fairbanks, AK. 87 p.

Johnson, S.R., and D.R. Herter. 1989. The birds of the Beaufort Sea. BP Exploration Alaska, Inc., Anchorage, AK. 372 p.

Kertell, K. 1991. Disappearance of the Steller's eider from the Yukon-Kuskokwim Delta, Alaska. Arctic 44:177-187.

Kessel, B. 1989. Birds of the Seward Peninsula, Alaska. Univ. Alaska Press., Fairbanks, AK.

King, J.G., and C.J.Lensink. 1971. An evaluation of Alaska habitat for migratory birds. Unpubl. Rept., U.S. Fish and Wild. Serv., Washington, DC.

__________, and C.P. Dau. 1981. Waterfowl and their habitats in the eastern Bering Sea. Pages 739-753 *in* Hood, D.W., and J.A. Calder (eds.), The eastern Bering Sea shelf: Oceanography and resources. Vol. 2, Univ. Wash. Press, Seattle, WA.

__________, and D.V. Derksen. 1986. Alaska goose populations: Past, present and future. Pages 464-479 *in* Trans. 51st N. Am. Wildl. and Nat. Res. Conf.

Kistchinski, A.A. 1973. Waterfowl in north-east Asia. Wildfowl 24:88-102.

__________, and V.E. Flint. 1974. On the biology of the spectacled eider. Wildfowl 25:5-15.

Klein, D.R. 1966. Waterfowl in the economy of the Eskimos on the Yukon-Kuskokwim Delta, Alaska. Arctic 19:319-336.

Kondratev, A.V., and L.V. Zadorina. 1992. Comparative ecology of the king eider *Somateria spectabilis* and spectacled eider *Somateria fischeri* on the Chaun tundra. Zool. Zhur. 71:99-108. (in Russian; translation by J. Pearce, National Biological Survey, Anchorage, AK).

Krechmar, A.V., A.V. Andreev, and A.Ya. Kondratev. 1991. Birds of the northern plains. Nauka, Leningrad, Russia. (In Russian; translation by C.P. Dau, U.S. Fish and Wildl. Serv., Cold Bay, AK).

Laing, K., and B. Platte. 1994. Ledyard and Peard Bays spectacled eider surveys, August 18-19, 1994. Unpubl. Trip Rept. U.S. Fish and Wildl. Serv. Anchorage, AK.

Larned, W., and G. Balogh. 1994. Eider breeding population survey, Alaska arctic coastal plain, 1993. Unpubl. Prog. Rept., U.S. Fish and Wildl. Serv., Anchorage, AK.

___________, and B. McCaffery. 1993. Norton Sound eider survey, August 30-31, 1993. Unpubl. Trip Rept., U.S. Fish and Wildl. Serv. Anchorage, AK.

Mayfield, H. 1961. Nesting success calculated from exposure. Wilson Bull. 73:255-261.

___________. 1975. Suggestions for calculating nest success. Wilson Bull. 87:456-466.

Mickelson, P.G. 1975. Breeding biology of cackling geese and associated species on the Yukon-Kuskokwim Delta, Alaska. Wildl. Monogr. 45.

Moorman, A. 1990. Effects of saline drinking water on the growth and development of mottled duck ducklings. M.S. Thesis. State Univ. of NY, Syracuse. 27 p.

Moran, T. 1995. Nesting ecology of spectacled eiders on Kigigak Island, Yukon Delta NWR, Alaska, 1994. Unpubl. Rept. U. S. Fish and Wildl. Serv., Bethel, AK.

Moran, T. 1996. Nesting ecology of Spectacled Eiders on Kigigak Island, Yukon Delta NWR, Alaska, 1995. Unpubl. Rept. U.S. Fish and Wildl. Serv., Bethel, AK.

___________, and C.M. Harwood. 1994. Nesting ecology, brood survival, and movements of spectacled eiders on Kigigak Island, Yukon Delta NWR, Alaska, 1993. Unpubl. Rept. U.S. Fish and Wildl. Serv. Bethel, AK.

Murie, O.J. 1924. Report on investigations of birds and mammals of the Hooper Bay section of Alaska during the spring and summer of 1924. Unpubl. Rept., U.S. Dept. Agric., Bur. Biol. Surv., Washington, DC.

Murphy, S.M., and B.A. Anderson. 1992. Effects of the Lisburne oil development project on geese nesting in Prudhoe Bay, Alaska, 1985-1989. Proc. 7th N. Am. Arctic Goose Conference and Workshop, 7-12 Jan 1992, Vallejo, CA. (Abstract)

McRoy, C.P., S.W. Stoker, G.E. Hall, and E. Muktoyuk. 1971. Winter observations of mammals and birds, St. Matthew Island. Arctic 24:63-64.

Nelson, E.W. 1887. Report upon natural history collections made in Alaska between the years 1877 and 1881. Arctic Ser. Publ. No. 3, U.S. Signal Service, Washington, DC.

Nikishin, V.P. 1988. Ultrastructure of embryonal membranes of *Polymorphus magnus*. Parazitologiya 22:100-103.

__________, and G.P. Krasnoshchekov. 1986. Micromorphology of the 'central mass' of Acanthors in the Acanthocephala *Polymorphis magnus*. Tsitologiya 28:1261-1263.

North, M.R. 1990. Distribution, abundance, and status of Spectacled Eiders in arctic Alaska. Unpubl. Rept. U.S. Fish and Wildl. Serv., Anchorage, AK.

O'Neill, E.J. 1979. Fourteen years of goose populations and trends at Klamath Basin Refuges. Pages 316-321 in R.L. Jarvis and J.C. Bartonek, eds., Management and Biology of Pacific Flyway Geese. OSU Bookstores, Inc., Corvallis, OR.

Palmer, R.S. 1976. Handbook of North American Birds. Vol. 3. Yale Univ. Press, New Haven, CT.

Petersen, M.R., D.C. Douglas, and D.M. Mulcahy. 1995. Use of implanted satellite transmitters to locate spectacled eiders at-sea. Condor 97:276-278.

Phillips, J.C. 1922-1926. A natural history of the ducks. Vol. 4, Houghton Mifflin, Boston, MA. 489 p.

Portenko, L.A. 1952. Age and seasonal changes in eider plumages. Trudy Zool. Inst. AN.,USSR, Vol. IX, No.4, 1100-1132. (Can. Wildl. Serv. translation).

__________. 1972. Birds of the Chukchi Peninsula and Wrangel Island. Vol. 2, Nauka, Leningrad, USSR (in Russian).

Raveling, D.G. 1984. Geese and hunters of Alaska's Yukon Delta: Management problems and political dilemmas. Trans. N. Am. Wildl. Nat. Res. Conf. 49:555-575.

Regel, K.V. 1986. Development of larvocysts of the cyclocerus type. Parazitologiya 20:188-194.

__________, and S.K. Bondarenko. 1982. The systematic status and life-cycles of *Wardium retracta* (Linstow, 1905) *n. comb.* and *W. pararetracta n.*sp. (Cyclophyllidae, Hymenolepididae). Zool. Zhurnal 61:325-335.

Ritchie, R.J., and A.A. Stickney. 1991. Brant distribution and productivity in the North Slope oilfields. Alaska Bird Conference and Workshop, 19-22 Nov. 1991, Anchorage, AK. (Abstract)

Rothe, T.C., C.J. Markon, L.L. Hawkins, and P.S. Koehl. 1983. Waterbird populations and habitat analysis of the Colville River Delta, Alaska: 1981 summary report. Unpubl. Prog. Rept. prepared by Office of Special Studies, U.S. Fish Wildl. Serv., Anchorage, AK.

Ryder, J.P. 1967. The breeding biology of Ross' goose in the Perry River region, NWT. Can. Wildl. Serv., Rept. Ser. No. 3.

Sayles, M.A., K. Aagaard, and L.K. Coachman. 1979. Oceanographic atlas of the Bering Sea basin. Univ. Wash. Press, Seattle, WA. 158 p.

Schiller, E.L. 1954. Studies on the helminth fauna of Alaska XVIII. Cestode parasites of young Anseriformes on the Yukon Delta nesting grounds. Trans. Am. Microsc. Soc. 73:194-201.

____________. 1955. Studies on the helminth fauna of Alaska XXIII. Some cestode parasites of the eider ducks. J. Parasitol. 41:79-88.

Schmidt-Nielsen, K., and Y.T. Kim. 1964. The effect of salt intake on the size and function of the salt gland of ducks. Auk 81:160-172.

Skakuj, M. 1990. Identification of the eiders *Somateria mollissima, spectablis, fischeri* and *Polysticta*. Limicola 4:285-306. (In German, English summary).

Smith, L.N., L.C. Byrne, C.B. Johnson, and A.A. Stickney. 1994. Wildlife studies on the Colville River Delta, Alaska, 1993. Unpubl. Rept. for Arco Alaska, Inc. Anchorage, AK.

Stehn, R.A., C.P. Dau, B. Conant, and W.I. Butler, Jr. 1993. Decline of spectacled eiders nesting in western Alaska. Arctic 46:264-277.

Stishov, M.S. 1992. Bird community of the lower Ekvivatap River (Vancarem Lowland, Chukotka). Russ. J. Ornithol. 1:245-251. (In Russian, English summary).

Strang, C.A. 1976. Feeding behavior and ecology of glaucous gulls in western Alaska. Ph.D. Thesis, Purdue Univ., Lafayette, IN. 145 p.

Taylor, B.L., and T. Gerrodette. 1993. The uses of statistical power in conservation biology: the baquita and northern spotted owl. Conserv. Biol. 7:489-500.

__________, P.R. Wade, R.A. Stehn, and J.F. Cochrane. In press. A Bayesian approach to classification criteria for Spectacled eiders. Ecological Applications.

Tichotsky, J. 1991. Use and allocation of natural resources in the Chukotka Autonomous District. ISER, Univ. Alaska, Fairbanks, AK.

Troy Ecological Research Associates. 1993. Distribution and abundance of Spectacled Eiders in the vicinity of Prudhoe Bay, Alaska: 1992 status. Unpubl. Rept. for BP Exploration Alaska, Inc., Environmental and Regulatory Affairs Department, Anchorage, AK.

__________. 1995. Distribution and abundance of Spectacled Eiders in the vicinity of Prudhoe Bay, Alaska, 1991-1993. Unpubl. Rept. for BP Exploration Alaska, Inc., Environmental and Regulatory Affairs Department, Anchorage, AK.

Turner, L.M. 1886. Contributions to the natural history of Alaska: Results of investigations made chiefly in the Yukon District and the Aleutian Islands. Arctic Ser. Publ. No. 2, U.S. Signal Service, Washington, DC.

U.S. Fish and Wildlife Service. 1990. Policy and guidelines for planning and coordinating recovery of endangered and threatened species. Division of Endangered Species, Washington, DC.

__________. 1996. Policy regarding the recognition of distinct vertebrate population segments under the Endangered Species Act. FR Vol. 61, No. 26, February 7, 1996, p. 4721-4725.

Uspenskii, S.M. 1984. Life in high latitudes: A study of bird life. Amerind Publishing Co., Pvt. Ltd., New Delhi. 385 p.

Warnock, N.D., and D.M. Troy. 1992. Distribution and abundance of spectacled eiders at Prudhoe Bay, Alaska: 1991. Unpubl. Rept. for BP Exploration Alaska, Inc., Environmental and Regulatory Affairs Department, Anchorage, AK.

Wilson, E.O. 1980. Sociobiology. The abridged edition. The Belknap Press of Harvard Univ. Press., Cambridge, MA. 366 pp.

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III. IMPLEMENTATION SCHEDULE

The following table outlines actions and estimated costs for the Spectacled Eider recovery program. It is a guide to meet the recovery objectives discussed in Part II of this plan. This table indicates the task priorities, task numbers, brief task descriptions, duration of tasks, the responsible agencies, and lastly, the estimated costs. These actions, when accomplished, should move the Spectacled Eider toward recovery. The estimated costs for all parties involved in recovery actions are identified, and therefore, Part III reflects the total estimated cost for the recovery of this species.

Priorities in column two of the implementation schedule are assigned as follows:

1. Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

2. Priority 2: An action that must be taken to prevent a significant decline in population or habitat quality, or some other significant negative impact short of extinction.

3. Priority 3: All other actions necessary to meet recovery objectives.

Because of the continuing decline of Spectacled Eiders on the YKD, actions that may lead to identifying and understanding the relative importance of obstacles to recovery, and therefore, solutions to overcoming those obstacles, are considered priority 1. Similar actions for the NS and AR are considered priority 2. All other actions are considered priority 3.

The lack of knowledge on the obstacles to the recovery of Spectacled Eiders precludes the estimation of a recovery date at this time. In order to provide some continuity in recovery planning, however, costs have been estimated for a five year period beginning with the first year in which a task is implemented (year 1). Cost estimates are based on the best possible information about study plans, materials, and logistics. Estimates will be adjusted when necessary as a result of new information, or revised task methods. Estimates do not include salaries for permanent employees of responsible parties.

KEY

Task Duration and Costs

TBD - To Be Determined

Responsible Parties

AAZP - American Association of Zoological Parks
ADFG - Alaska Department of Fish and Game
ADPS - Alaska Department of Public Safety
BLM - Bureau of Land Management
FWS - Fish and Wildlife Service
NAO - Native Alaskan Representatives and Organizations
NBS - National Biological Survey
NMFS - National Marine Fisheries Service
NOAA - National Oceanic and Atmospheric Administration
PO - Private Organization
RT - Recovery Team
* - Lead Agency/Party

SPECTACLED EIDER RECOVERY PLAN
IMPLEMENTATION SCHEDULE

TASK #	PRIOR-ITY #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONS-IBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000)					
						YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	COMMENTS
PRIORITY 1 TASKS											
A3	1	Conduct a status review for each population.	3	FWS	45.00	15	15	15	0	0	
A4.1.1	1	Develop and implement a Memorandum of Agreement on the YKD.	5	FWS NAO	50.00	10	10	10	10	10	
A4.1.2	1	Develop and implement a Memorandum of Agreement on the NS.	5	BLM *FWS *NAO	50.00	10	10	10	10	10	
A4.1.3	1	Develop and implement a Memorandum of Agreement in the Bering Straits area.	5	FWS NAO	50.00	10	10	10	10	10	
A5	1	Designate a Native Liaison who would facilitate communication between the Native organizations, the Recovery Team, government agencies, researchers, and affected villages.	5+	BLM *FWS *NAO	150.00	30	30	30	30	30	
A6	1	Develop and coordinate information and education activities with emphasis on steel shot.	ongoing	BLM *FWS *NAO ADFG	75.00	15	15	15	15	15	
A9.1	1	Explore and implement mechanisms for reducing availability of lead shot and increasing availability and reducing the cost of non-toxic shot in rural Alaska.	ongoing	ADFG FWS	0.00	0	0	0	0	0	Cost included under task # A9.2
A9.2	1	Continue hunter education on non-toxic shot throughout rural areas where Spectacled Eiders occur.	ongoing	*ADFG FWS NAO	325.00	35 30	35 30	35 30	35 30	35 30	
B1.1	1	Determine the breeding range and relative abundance of Spectacled Eiders on the NS.	completed	*FWS NAO	0.00	0	0	0	0	0	see task #B1.4.2.4 for long-term monitoring.

TASK #	PRIOR-ITY #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONS-IBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000)					
						YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	COMMENTS
B1.4.1 .1	1	Develop visibility correction factor methods for the YKD aerial survey.	5+	FWS	25.00	5	5	5	5	5	
B1.4.1 .2	1	Develop visibility correction factor methods for the NS aerial survey.	5+	FWS	25.00	5	5	5	5	5	
B1.4.1 .4	1	Develop nest detection correction factor methods for the YKD ground plot nest survey.	5+	FWS	65.00	13	13	13	13	13	
B1.4.2 .1	1	Analyze existing YKD aerial and ground survey data to refine survey methods.	3	*FWS NBS	30.00	10	10	10	0	0	
B1.4.2 .2	1	Continue the YKD coastal breeding pair survey or implement alternative Spectacled Eider survey as determined in B1.4.2.1.	ongoing	FWS	100.00	20	20	20	20	20	
B1.4.2 .3	1	Continue YKD ground plot survey.	ongoing	FWS	125.00	25	25	25	25	25	
B1.4.2 .4	1	Design and implement a NS survey.	ongoing	*FWS NBS	100.00	20	20	20	20	20	Design completed
B2.1.1	1	Implement YKD satellite transmitter project.	completed	FWS NBS	0.00	0	0	0	0	0	
B2.1.2	1	Implement NS satellite transmitter project.	2	FWS NBS	125.00	100	25	0	0	0	
B2.2	1	Identify, describe, and monitor use of at-sea habitats.	ongoing	FWS	250.00	50	50	50	50	50	
B3	1	Quantitatively describe at-sea habitats.	5+	*FWS NBS NOAA NMFS	50.00	10	10	10	10	10	
C1	1	Determine age structure of Spectacled Eider populations.	onging	FWS NBS	40.00	20	20	0	0	0	

TASK #	PRIORITY #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000) YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	COMMENTS
C2.1.1 .1	1	Conduct adult female and brood survivorship studies at Hock Slough and Kigigak Is. on the YKD.	ongoing	FWS NBS	130.00	130	0	0	0	0	
C2.2.1	1	Implement juvenile survivorship study on the YKD.	3	FWS NBS	300.00	20	140	140	0	0	In year 1, camp costs covered under task #C2.1.1
C2.3.1	1	Implement juvenile post fledging mortality study on the YKD.	3	FWS NBS	150.00	50	50	50	0	0	
C4	1	Refine the demographic model for Spectacled Eiders.	5+	FWS NBS RT	14.00	10	1	1	1	1	
C5.1	1	Prepare summary report about environmental contaminants.	1	FWS NBS	10.00	10	0	0	0	0	
C5.2	1	Prepare summary report about competition for food and loss of food supplies due to benthic disturbance.	1	FWS NBS PO NAO	10.00	10	0	0	0	0	
C5.3	1	Prepare summary report about harvest.	1	FWS NBS RT	10.00	10	0	0	0	0	
C5.4	1	Prepare summary report about predation.	1	FWS NBS RT	10.00	10	0	0	0	0	
C5.9	1	Prepare summary report about chronic oiling from bilge pumping in Spectacled Eider wintering habitat.	1	FWS	10.00	10	0	0	0	0	
D1	1	Determine contaminants levels of the three Spectacled Eider populations.	2	FWS	100.00	50	50	0	0	0	
D4.1	1	Screen for exposure to lead within YKD breeding population.	ongoing	FWS NBS	50.00	10	10	10	10	10	
D6.1	1	Investigate lead shot persistence and availability on the YKD.	ongoing	FWS NBS	50.00	10	10	10	10	10	

TASK #	PRIORITY #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000)					
						YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	COMMENTS
D7	1	Determine contaminant sources, transport modes, and uptake mechanisms.	2	FWS	30.00	15	15	0	0	0	
E1.2	1	Develop means of capturing live Spectacled Eiders for marine diet sampling.	1	FWS NBS	50.00	50	0	0	0	0	
E1.3	1	Determine food habits in marine environments.	3	ADFG *FWS NBS NAO	150.00	50	50	50	0	0	
F1.1	1	Re-analyze subsistence harvest data of Spectacled Eiders on the YKD and redesign harvest surveys.	1	FWS	5.00	5	0	0	0	0	
F1.2	1	Continue Yukon-Kuskokwim Delta and St. Lawrence Island subsistence harvest surveys.	ongoing	FWS	225.00	45	45	45	45	45	
H1	1	Determine population structure and gene flow between the major breeding populations.	1	FWS NBS	10.00	10	0	0	0	0	
PRIORITY 1 TASKS - SUB TOTAL					2994.00	938.00	729.00	619.00	354.00	354.00	

TASK #	PRIOR-ITY #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONS-IBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000)					
						YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	COMMENTS
PRIORITY 2 TASKS											
A1	2	Designate and support a Regional Elder Coordinator to oversee recovery plan implementation.	5+	FWS	0.00	0	0	0	0	0	Elder Coordinator appointed October 1995. Salary costs reflected in individual tasks.
A2	2	Verify the recovery objectives and periodically update the recovery plan.	5+	FWS *RT	75.00	15	15	15	15	15	
A2.1	2	Prepare a technical report on population modeling and viability simulations, and their applications in recovery actions.	1	FWS *NMFS RT	15.00	15	0	0	0	0	
A7.1	2	Evaluate and recommend revisions of MOA activities where appropriate.	5+	FWS RT	25.00	5	5	5	5	5	
A7.2	2	Promulgate regulations pursuant to section 10(e)(4) of the Endangered Species Act to prohibit take of Spectacled Eiders by Alaska Natives for subsistence purposes	1	FWS	10.00	10	0	0	0	0	
A9.3	2	Promulgate regulations prohibiting use of lead shot for all hunting within Spectacled Eider range, beginning with the Yukon Delta National Wildlife Refuge.	2	FWS ADFG	10.00	5	5	0	0	0	
A10.1	2	Implement sections 7, 9, and 10 of the Endangered Species Act.	ongoing	FWS	100.00	20	20	20	20	20	
A10.2	2	Monitor scientific collecting of eggs and birds, and sea duck sport hunting within Spectacled Eider range.	ongoing	ADPS FWS ADFG	50.00	10	10	10	10	10	
A12.1	2	Initiate control of foxes in selected Spectacled Eider nesting habitats.	5+	ADFG *FWS	450.00	90	90	90	90	90	

TASK #	PRIOR-ITY #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONS-IBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000)					
						YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	COMMENTS
A12.3	2	Investigate, and if feasible, implement mechanisms to reduce artificial food sources to reduce predator numbers on Spectacled Eider nesting grounds.	5+	*FWS NAO	50.00	10	10	10	10	10	
A14	2	Maintain a captive flocks program to support the recovery effort for Spectacled Eiders.	ongoing	FWS AAZP	250.00	50	50	50	50	50	
B1.2.1	2	Complete geographically extensive surveys across AR.	completed	FWS	0.00	0	0	0	0	0	Monitoring is under B.1.4.2.5
B1.2.2	2	Quantify breeding population size on the Indigirka River Delta, AR.	completed	FWS NBS	0.00	0	0	0	0	0	
B1.4.2 .5	2	Design and implement an AR survey.	3	FWS	180.00	60	60	60	0	0	
B2.1.3	2	Implement AR satellite transmitter project.	2	FWS NBS	155.00	130	25	0	0	0	
C2.1.2	2	Implement adult female and brood survivorship study on the NS.	3	FWS NBS	480.00	160	160	160	0	0	
C2.2.2	2	Implement juvenile survivorship study on the NS.	3	FWS NBS	60.00	20	20	20	0	0	
C2.3.2	2	Implement juvenile post-fledging mortality study on the NS.	1	FWS NBS	20.00	20	0	0	0	0	Preliminary study only.
C2.4.1	2	Assess and modify methods for radio-tracking hens on the YKD to monitor brood mortality.	3	FWS NBS	60.00	20	20	20	0	0	
C2.4.2	2	Implement radio-tracking of hens on the NS to monitor brood mortality.	3	FWS NBS	60.00	20	20	20	0	0	
C2.5.1	2	Monitor brood production on the YKD.	5+	FWS	200.00	40	40	40	40	40	

TASK #	PRIOR-ITY #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONS-IBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000)					
						YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	COMMENTS
C2.5.2	2	Monitor brood production on the NS.	5+	FWS	300.00	60	60	60	60	60	
C2.6.1	2	Monitor nesting success on the YKD.	5+	FWS NBS	100.00	20	20	20	20	20	
C2.6.2	2	Monitor nesting success on the NS.	5+	BLM *FWS NAO NBS PO	250.00	50	50	50	50	50	
C3.1	2	Evaluate the effects of nasal markers.	4	FWS NBS	TBD	-	-	-	-	-	
C3.2	2	Evaluate the impacts of nesting studies.	ongoing	FWS NBS	8.00	8	0	0	0	0	
C3.3	2	Convene a workshop to develop methods for evaluating other research-related effects.	1	FWS	20.00	20	0	0	0	0	
C5.5	2	Prepare summary report about Bering Sea Fisheries.	1	FWS NBS RT	10.00	10	0	0	0	0	
C5.7	2	Prepare summary report about human disturbance.	1	FWS NBS RT	10.00	10	0	0	0	0	
C5.8	2	Prepare summary report about changes in long-term weather patterns and current weather patterns.	1	FWS NBS RT	10.00	10	0	0	0	0	
D2	2	Initiate contaminant exposure studies in captive birds.	3	FWS	60.00	20	20	20	0	0	
D3.1	2	Determine contaminant levels in primary marine prey species and substrates.	1	FWS NBS	150.00	150	0	0	0	0	
D3.2	2	Determine contaminant levels in primary terrestrial prey species and substrates.	1	FWS	100.00	100	0	0	0	0	
D4.2	2	Screen for exposure to lead within NS breeding population.	1	FWS NBS	50.00	50	0	0	0	0	

TASK #	PRIOR-ITY #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONS-IBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000) YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	COMMENTS
D5.1	2	Investigate lead shot distribution and density on the YKD.	see comments	FWS NBS	-	-	-	-	-	-	study discontinued - sampling of lead in substrates was not feasible
D8	2	Design and implement a monitoring program to assess contaminant levels in each population over time.	5+	FWS	225.00	45	45	45	45	45	
E1.1	2	Assess food habits from incidentally obtained data.	5+	FWS *NBS	25.00	5	5	5	5	5	
F1.3	2	Determine harvest levels on the NS and in the Bering Strait region (other than St. Lawrence Island).	5+	*FWS NAO ADFG	250.00	50	50	50	50	50	
G1	2	Assess fox predation levels on Spectacled Eider productivity.	TBD	FWS NBS	-	-	-	-	-	-	TBD based on summary report on predation.
G2	2	Evaluate Spectacled eider population-wide control of foxes as a means to improve reproductive success of Spectacled Eiders.	TBD	FWS NBS	-	-	-	-	-	-	TBD based on summary of report on predation.
G3	2	Determine gull foraging patterns and population trends on the YKD.	1	FWS NBS	20	20	0	0	0	0	
G4	2	Evaluate Spectacled Eider population-wide control of gulls as a means to improve reproductive success of Spectacled Eiders.	TBD	FWS NBS	TBD	-	-	-	-	-	Cost TBD as a result of task C.5.4
H2	2	Assess evidence for ecological and genetic distinctness of the YKD, NS, and AR populations.	2	FWS NBS	20.00	10	10	0	0	0	
I1	2	Screen eiders for diseases and parasites.	ongoing	FWS NBS	25.00	5	5	5	5	5	
I2.1	2	Collect standard blood panels.	ongoing	*FWS NBS	5.00	1	1	1	1	1	0.00
I2.2	2	Determine body condition indices for Spectacled Eiders.	2	FWS NBS	20.00	10	10	0	0	0	

TASK #	PRIOR-ITY #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONS-IBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000)					
						YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	COMMENTS
12.3	2	Evaluate the physiological condition of Spectacled Eiders throughout the year.	TBD	FWS NBS	TBD	-	-	-	-	-	Methods of study to be determined.
PRIORITY 2 TASKS - SUB TOTAL					3908.00	1354.00	826.00	776.00	476.00	476.00	

TASK #	PRIOR-ITY #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONS-IBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000)					
						YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	COMMENTS
						PRIORITY 3 TASKS					
A8	3	Continue routine law enforcement under the closed season policy for administration of the Migratory Bird Treaty Act.	ongoing	FWS ADFG ADPS	0.00	0	0	0	0	0	
A10.3	3	Ban collecting eider eggs for avicultural purposes within Spectacled Eider range.	ongoing	FWS ADFG	0.00	0	0	0	0	0	
A10.4	3	Investigate incidental take by commercial fisheries.	ongoing	FWS NMFS	15.00	1 2	1 2	1 2	1 2	1 2	
A11	3	Investigate the extent of international trade.	1	FWS	5.00	5	0	0	0	0	
A12.2	3	Initiate control of Glaucous Gulls in selected Spectacled Eider nesting habitats.	TBD	FWS	TBD	-	-	-	-	-	Cost and methods TBD after summary report on predation is completed.
A13	3	Conduct experimental translocations of both wild and captive-reared eiders to assess the feasibility of this method for recolonizing vacated areas.	TBD	FWS	TBD	-	-	-	-	-	
A15	3	Produce a handbook summarizing all information on identifying, ageing, and sexing Spectacled Eiders.	1	FWS NBS	20.00	20	0	0	0	0	
B1.3	3	Determine the breeding range and relative abundance of Spectacled Eiders on St. Lawrence Island.	3	FWS	30.00	10	10	10	0	0	
B1.4.1.3	3	Develop visibility correction factor methods for the AR aerial survey.	3	FWS	15.00	5	5	5	0	0	
B4.1	3	Describe nesting and brood-rearing habitats on the YKD.	2	FWS NBS	10.00	5	5	0	0	0	
B4.2	3	Describe nesting and brood-rearing habitats on the NS.	2	FWS NBS	10.00	5	5	0	0	0	

TASK #	PRIOR-ITY #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONS-IBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000)					
						YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	COMMENTS
B4.3	3	Describe nesting and brood-rearing habitats in AR.	TBD	FWS NBS	TBD	-	-	-	-	-	TBD based on feasibility of working in AR, and plans for other studies.
C2.1.1 .2	3	Identify a study site on the YKD free of accumulated lead shot for a study of adult female and brood survivorship.	1	FWS NBS	50.00	50	0	0	0	0	
C2.1.1 .3	3	Conduct adult female and brood survivorship study at lead-free study site on the YKD..	3	FWS NBS	420.00	140	140	140	0	0	
C2.1.3	3	Implement adult female and brood survivorship study in AR.	3	FWS NBS	30.00	10	10	10	0	0	
C2.2.3	3	Implement juvenile survivorship study in AR.	3	FWS NBS	390.00	130	130	130	0	0	
C2.3.3	3	Implement juvenile post-fledging mortality study in AR.	TBD	FWS NBS	TBD	-	-	-	-	-	TBD based on methods developed on NS (task C.2.3.2)
C2.4.3	3	Implement radio-tracking of hens in AR to monitor brood mortality.	3	FWS NBS	60.00	20	20	20	0	0	Most costs covered under realted studies.
C2.5.3	3	Monitor brood production in AR.	TBD	FWS	TBD	-	-	-	-	-	TBD based on feasibility of working in AR, and plans for other studies
C2.6.3	3	Monitor nesting success in AR.	TBD	FWS NBS	TBD	-	-	-	-	-	TBD based on feasibility of working in AR, and plans for other studies.
C5.6	3	Prepare summary report about industrial development on the NS.	1	FWS NBS RT	10.00	10	0	0	0	0	
C5.10	3	Prepare summary report on diseases and parasites.	1	FWS NBS	10.00	10	0	0	0	0	
D4.3	3	Screen for exposure to lead within AR breeding population.	TBD	FWS NBS	TBD	-	-	-	-	-	TBD based on feasibility of working in AR, and plans for other studies.
D5.2	3	Investigate lead shot distribution and density on the NS.	TBD	FWS NBS	TBD	-	-	-	-	-	TBD based on summary report on contaminants.

TASK #	PRIORITY #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000)					
						YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	COMMENTS
D5.3	3	Investigate lead shot distribution and density in AR.	TBD	FWS NBS	TBD	-	-	-	-	-	TBD based on feasibility of working in AR, and plans for other studies.
D6.2	3	Investigate lead shot persistence and availability on the NS.	TBD	FWS NBS	TBD	-	-	-	-	-	TBD based on summary report on contaminants.
F1.4	3	Assess the feasibility of initiating a harvest survey in Russia.	TBD	FWS	TBD	-	-	-	-	-	TBD based on feasibility of working in AR, and plans for other studies.
H3	3	Determine genetic variability within each of the three nesting populations.	1	FWS NBS	10.00	10	0	0	0	0	
I2.4	3	Compare distributions of Spectacled Eider body condition with those of related species.	TBD	FWS NBS	TBD	-	-	-	-	-	TBD based on summary reports.
PRIORITY 3 TASKS - SUBTOTAL					1085.00	433.00	328.00	318.00	3.00	3.00	
PRIORITY 2 TASKS - SUBTOTAL					3908.00	1354.00	826.00	776.00	476.00	476.00	
PRIORITY 1 TASKS - SUBTOTAL					2994.00	938.00	729.00	619.00	354.00	354.00	
GRAND TOTAL					7987.00	2725.00	1883.00	1713.00	833.00	833.00	

APPENDIX I

POPULATION VIABILITY ANALYSIS FOR SPECTACLED EIDERS

Introduction

PVA Background

Population Viability Analysis (PVA) is an analytical technique that is used to estimate a Minimum Viable Population (MVP) (Gilpin & Soulé 1986). "Viable" is defined as a chosen probability of persisting for a given time (Shaffer 1981; Frankel & Soulé 1981). For example, Shaffer (1987) proposed that Minimum Viable Population be defined as that population size that will have a 99% chance of surviving for 1,000 years. The future is unpredictable, so it is impossible to predict the exact extinction time of any population. An understanding of how population growth rates vary temporally allows the calculation of a distribution of possible extinction times. Numerous factors that influence the growth rate of populations, such as susceptibility to changing weather and food resources, genetics, and behavior, must be integrated into these calculations. These risk factors fall into four categories (Shaffer 1987).

The first risk factor is demographic stochasticity, which is caused by chance changes in birth and survival rates (Goodman 1987). A stochastic event implies an event that occurs by chance, such as a 50% chance of rain. Birth and survival events are chance events that, when taken over many individuals, have average probabilities of occurrence depending on age. When the number of individuals (sample size) becomes small, observed demographic rates vary simply because of sampling error. For example, with a population of 10 animals and a survival rate of 0.95, in any given year it is not possible to observe a survival rate of 0.95. Instead, the observed rate would be 1.0, 0.9 or rarely ≤0.8. Thus, demographic stochasticity is a sampling phenomenon in which average demographic parameters remain constant. Demographic stochasticity is only important for populations of small sizes (<1,000).

Environmental stochasticity, the second risk factor, is important for all population sizes. Because individuals in populations experience an abiotic and biotic environment in common, there are interannual variations in birth and survival rates for the entire population. Catastrophic die-offs can be considered an extreme result of environmental variation.

The third risk factor concerns the spatial configuration of a species' distribution. A species composed of fragmented populations that experience local extinction and recolonization should be modeled as a metapopulation. Metapopulation dynamics can decrease persistence time if the extinction rate exceeds the colonization rate or if the reduced effective population size leads to loss of genetic variability (Gilpin 1990). On the other hand, persistence time may increase in fragmented populations because of risk spreading if environmental heterogeneity is present.

The final risk factor is the effect of genetic changes, such as loss of heterozygosity and inbreeding depression, upon population fitness (translated as population growth rates). Mating among closely related individuals can expose lethal recessive alleles, which can compromise either survival or fecundity of the individual. Loss of heterozygosity has been linked to reduced fitness and can lead to a reduced ability of the species to adapt to new circumstances. As with demographic stochasticity, inbreeding depression is important only for small population sizes.

Not only must these factors be integrated into a single model, but the model must be stochastic in nature. Deterministic models, such as the Leslie model for demographic projections, are inadequate for two reasons. First, deterministic models usually cannot incorporate changes in demographic parameters that are caused by low population size, such as demographic stochasticity and density decompensatory mechanisms (mechanisms that reduce birth and survival rates at low density such as reduced ability to defend against predators, difficulty in finding a mate, etc.). Second, deterministic models have difficulty incorporating variations in birth and survival rates and synergistic effects between risk factors. Synergistic effects are expected in small populations and are referred to as extinction vortices (Gilpin & Soulé 1986). An example would be a decreased population size that is initially caused by environmental variation that then leads to loss of genetic variability, which further leads to a reduction in population growth rate and a further population decline.

Although there are benefits to using more detailed models to model extinction, these stochastic models require the estimation of many parameters and, hence, require many data. For this reason, analytical models that allow the calculation of extinction statistics from data on the population's mean growth rate and the variance in that rate have been developed. One group of models allows the calculation of expected (mean) extinction time (Leigh 1981; Richter-Dyn and Goel 1972; Goodman 1987). These models solve for the mean extinction time and are analytical models. Unfortunately, because population growth is a multiplicative process, extinction distributions tend to be log-normally distributed. A log-normal distribution of extinction probabilities peaks on the left side and has a long tail on the right. This results in the median probabilities of extinction (the time with a 50% chance of going extinct) that is much less than the mean extinction time. The probability of extinction which corresponds to the mean extinction time (the statistic given by the aforementioned analytical models) is unknown. The mean actually corresponds to the balance point in the lop-sided log-normal distribution: a point of questionable relevance to managers. Managers are usually interested in low probabilities of extinction, such as a 5% or 20% chance of going extinct.

Another analytical model that avoids the need for detailed demographic data and yet gives an analytical means of calculating an entire extinction distribution from a time series of abundances was developed by Dennis et al. (1991). The accuracy of this technique depends on two critical assumptions: (1) abundance estimates are for the entire population; and (2) abundance estimates are very accurate, so that interannual variance reflects actual population fluctuations and not imprecision of abundance estimates. Unfortunately, as populations decrease, so does the precision of estimating abundance (Taylor and Gerrodette 1993). The result is that for most endangered or threatened populations (including the Spectacled Eider) this analytical technique cannot be used.

The common solution for uncertainty in parameter estimation in PVA models is to model a series of possible scenarios that use a different set of parameters. Each scenario yields a distribution of extinction times. Each distribution will give a different MVP, each of which could be possible. It then becomes a management problem to decide which is the most prudent value for MVP.

The strategy followed in this PVA is to incorporate the uncertainty in parameter estimation into a single extinction probability distribution. Instead of modeling extreme values for each unknown parameter, parameters are given a probability distribution between minimum and maximum values, and these distributions of possible values determine the distribution of population responses. Thus, the distribution reflects two types of uncertainty: (1) uncertainty because of the stochastic nature of population dynamics; and (2) uncertainty because of our ignorance about the population dynamics as reflected in the uncertainty in estimating parameters used in the model.

Background on Spectacled Eiders

Details on the biology of Spectacled Eiders are presented in the introduction to this recovery plan. The object of this section is to highlight points relevant to the PVA. Because population sizes are still much larger than those in which inbreeding becomes a problem, genetic factors are unlikely to contribute to a diminished growth rate. Further, the effect of inbreeding or loss of heterozygosity on sea ducks is unknown. Therefore, a genetic component will be omitted from the PVA with the knowledge that extinction times will possibly be biased positively (i.e., toward longer times) because of this omission.

This plan divides the species into three geographically defined populations. Even if these populations do not prove to be genetically distinct, this division is wise as a tactic for reducing extinction risk. It is a general tenet of conservation biology that more than one population should be maintained; single populations are susceptible to local catastrophes such as severe weather and oil or chemical spills. Spectacled Eiders are perhaps more susceptible to loss of populations than many species because: (1) they are an arctic species and may have naturally variable population sizes because of large interannual variations in weather and resources; (2) the distribution of this species is highly concentrated at times; and (3) this species probably has a low recolonization rate. Female eiders are known for having high site fidelity (Cooch 1965; Wakely 1973; Milne 1974; Dau 1974; Reed 1975; Swennen 1976; Wakely and Mendall 1976). Scientists have argued that areas that have been locally depleted may take many years to be recolonized, if indeed recolonization occurs at all (Cooch 1986). In addition, the distribution of Spectacled Eiders at sea can be very clumped (W. Larned, pers. comm.).

This PVA will treat two population types: (1) the Yukon-Kuskokwim Delta (YKD) population (for which good information on population trends is available); and (2) an "unknown" population, which describes the North Slope (NS) population and the Arctic Russian (AR) population. The YKD population type will provide specific estimates of extinction probabilities, whereas the "unknown" type will provide guidance for choosing criteria for classification decisions. Finally, estimates of MVP sizes and expected time to go from various population sizes to a critical size (i.e., 125 pairs) are made to provide additional quantitative guidance for selecting criteria used for classification decisions.

Methods

The preferred method for conducting an accurate PVA is to develop a demographic model that includes information on age-specific birth and survival rates, the way in which those rates vary through time, and the way in which those rates change with population density. Not only are these data unavailable for Spectacled Eiders, but crucial elements are missing from detailed studies of Common Eiders (Milne 1974, Swennen 1983, Coulson 1984) which might otherwise serve as an adequate surrogate for modelling purposes. Perhaps the most important missing data are estimates of first-year survival rates and the variability in those rates. It is theoretically possible to calculate those rates given information on adult survival rates, birth rates, and rates of survival to fledging. Unfortunately, using the estimates provided in published accounts of the Common Eider, studies to derive juvenile survival rate often resulted in nonsensical values, such as survival with a probability >1. For this reason, a detailed demographic model for the PVA was not possible (although a separate Appendix (III) on eider demography is included). Instead, a simple model of exponential growth was used.

This model uses a mean growth rate and a variance in growth rate to project population sizes through time. Variance in growth rate for Spectacled Eiders is unknown. Figure I-1 shows the influence of variability in population growth rate on the distributions of extinction times. The example considers the case where the average growth rate is a 5%/year decline ($r = -0.05$) and the initial population size is 5,000 pairs. Three curves are shown for increasing variability in population growth rate (small--coefficient of variation (CV) = 0.05; medium--CV = 0.15; and large--CV = 0.25). Clearly, the more variable the growth rate of a population, the higher are its chances of experiencing a string of years of bad luck that could lead to extinction. Indeed, high variability in population growth rates has been correlated with increased probabilities of population extinction in wild populations of lagomorphs (Soulé 1987).

There are two studies on Common Eiders from which estimates of population growth variability can be made. In Scotland, wintering eiders can be counted with high accuracy (Milne 1974). A 10-year time series of population estimates (which included a year of high adult mortality from an oil spill) yielded a standard deviation (s) for r of 0.21. At about the same time, a nesting population in the Netherlands had an $s = 0.07$ (Swennen 1983). For the

PVA we chose randomly from a uniform distribution of variability in growth rates, between 0.07 and 0.21.

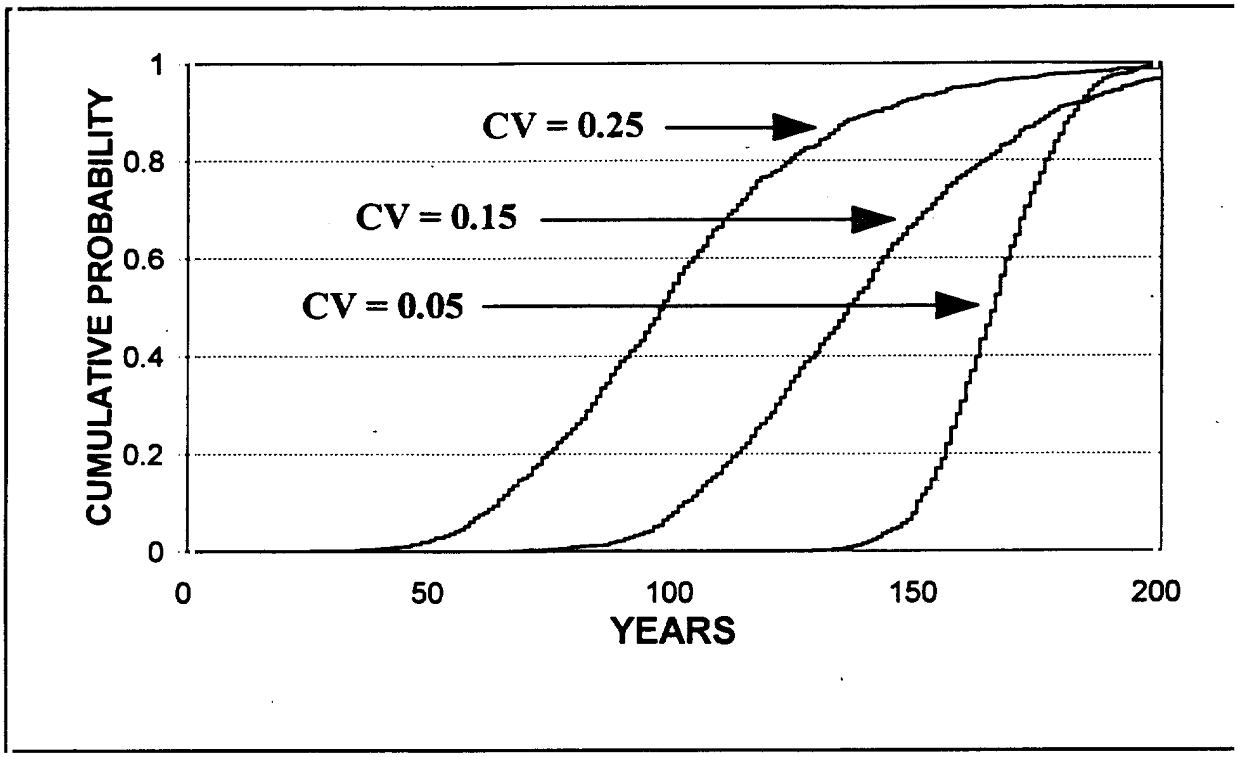

Figure I-1. Cumulative probability of extinction for populations initially numbering 5,000 pairs, with a mean (geometric) growth rate of -0.05. The figure shows that not only does the median time to extinction decrease as growth rate becomes more variable, but that the variance in extinction time increases.

Yukon-Kuskokwim Delta PVA

A dramatic decline has been documented for Spectacled Eiders on the YKD (Stehn et al. 1993) (see Figure 2 in the Introduction). Time series from three surveys were available: the North American Breeding Pair Survey (YKD segments), the random ground plot survey, and the aerial survey of coastal YKD. For clarity these will be referred to as the breeding pair survey (an aerial survey), the ground plot survey and the coastal aerial survey. These data on trends should provide the basis for estimating the population growth rate and the uncertainty in that rate. The population growth rate is the primary parameter determining the probability of extinction. Statistically-based abundance estimates can be used in classical Bayesian analyses to yield a probability distribution for population growth rates. The estimates of absolute abundance with associated estimates of precision are used to calculate the statistical likelihood of hypotheses of population growth rate.

Both aerial surveys are conducted as strip transect surveys, which assume that 100% of the animals within the strip are seen. This assumption is known to be false and a visibility correction factor is often applied. Estimates of the visibility correction factor were made for the 1995 season (R.A. Stehn, pers. comm.). Within a survey the visibility correction factor probably varies depending on proportion of male eiders present at the time of the survey, snow cover, habitat type, and density of other bird species also being counted. Between years the visibility correction factor may vary because of differences between observers, proportion of male eiders present at the time of the survey, and snow cover. The visibility correction factor can affect both bias and precision of the abundance estimates. Estimation of a more accurate visibility correction factor will require continuing research (Steinhorst and Samuel 1989). Until the variance for the visibility correction factor is included in the variance for the abundance estimate, it is likely that the variance for the abundance estimate will be negatively biased.

The random ground plot survey is also subject to bias. These surveys search randomly chosen ground plots for nests. A correction factor for number of nests missed was estimated for the 1995 season at about 0.74 (R.A. Stehn, pers. comm.). More research is encouraged, however, on the proportion of nests missed and variance in this proportion. There is also an intriguing problem with the estimated precision of the ground plot surveys. The mean abundance estimates are much closer to the expected values from a linear regression than could be expected for the calculated CVs. Thus, it appears that the abundance estimates may be more precise than indicated by the calculated CVs (R.A. Stehn, pers. comm.).

There appear to be discrepancies between the trends indicated from the coastal versus the ground plot survey. Trends in the early years of the Coastal and Ground Plot surveys run in opposite directions. There are several possible explanations, such as learning of the correct search image for the rear seat aerial observer or differing dates of male eider departure. We cannot at this time determine the cause of these discrepancies. Therefore, until we understand this discrepancy or the discrepancy disappears due to improved methods, the Spectacled Eider Recovery Team urges the continuation of the ground plot surveys.

A Bayesian analysis was developed for analysis of all three census data sets (Taylor et al. in press). The underlying model is assumed to be exponential growth (see equation 1 in Calculations of Post-Model Distributions section). As discussed above, abundance is not known but estimated. Population growth rate (r) can be estimated by regressing the log of population growth rate against time. The probability of observing a series of abundance estimates can be calculated for a set of hypotheses about r and the precision of the abundance estimate. Details of the analysis are given below and in Taylor et al. (in press). Basically the likelihood of observing the survey data is evaluated for every plausible population growth rate (r). The full model has eight parameters, given below. The analysis chooses randomly from the prior distributions for each parameter, projects the population and evaluates the likelihood of observing the data. A prior distribution reflects prior knowledge of a distribution. Because we have no prior knowledge the distributions were uniform and set to just encompass the range of the posterior distribution (in an iterative process). This random selection process is repeated eight million times saving the chosen parameters and their resultant likelihood. A bootstrap process is used to get the posterior distribution. 10,000 sets of parameters are randomly selected from the set of eight million weighted by their likelihood.

The analysis in this Recovery Plan differs from Taylor et al. (in press) in that the recovery team wanted the best estimate of the current risk the YKD population faces. To limit the impact of the historical decline in the breeding pair survey on the analysis we decided to use only the most recent 15 years of data. This period of time was a compromise between a shorter period that may reveal short-term growth rates caused by environmental fluctuations (a series of good or bad years), and a longer-term trend that may contain a history not pertinent to the current situation. Specifically, the team was concerned that, because of the strong (and influential) decline in the early years (1957-1980), more recent changes in population growth rate might be masked for several years when using our simple exponential model.

Posterior distributions (Figure I-2) differ for the different surveys. Unfortunately, there are difficulties with each of the surveys. The breeding pair survey has the most precise post-model distribution because of its duration (36 years). But this survey is for all eider species combined. It is believed that the Common Eider population (which originally was a small component of the total eider population on the YKD) has remained fairly constant though there are no actual data on Common Eider numbers. If Common Eiders were remaining at a constant abundance, then the abundance estimate would contribute a positive bias to the estimated population growth rate, which would be accentuated in recent years. There is a second source of potential positive bias. In the early years of the survey, the populations of several species of geese were much larger than they are now. It is possible that the sheer number of birds, along with an emphasis on gathering data on geese rather than eiders, may have lead to proportionately more eiders being missed in the early years. Thus, the population growth rate in Figure I-2a, which gives a high probability that r was between -0.08 and -0.05, is probably optimistic (positively biased).

The posterior distribution for the coastal YKD aerial survey indicates that a larger range of hypotheses concerning growth rates are compatible with the data (Figure I-2c). This could indicate either a negative bias in the estimated CV for abundance or that the population actually was fluctuating and thus there is some lack of fit to the exponential model. Further, this apparent fluctuation could either be the result of fluctuations in the total population, fluctuations in the proportion of birds coming to the breeding grounds, or both.

The posterior distribution for the ground plot survey overlaps rather little with either of the other surveys, indicating an even greater rate of decline than the breeding pair survey but still having some small overlap with the coastal survey because the posterior distributions for both the recent surveys are so broad.

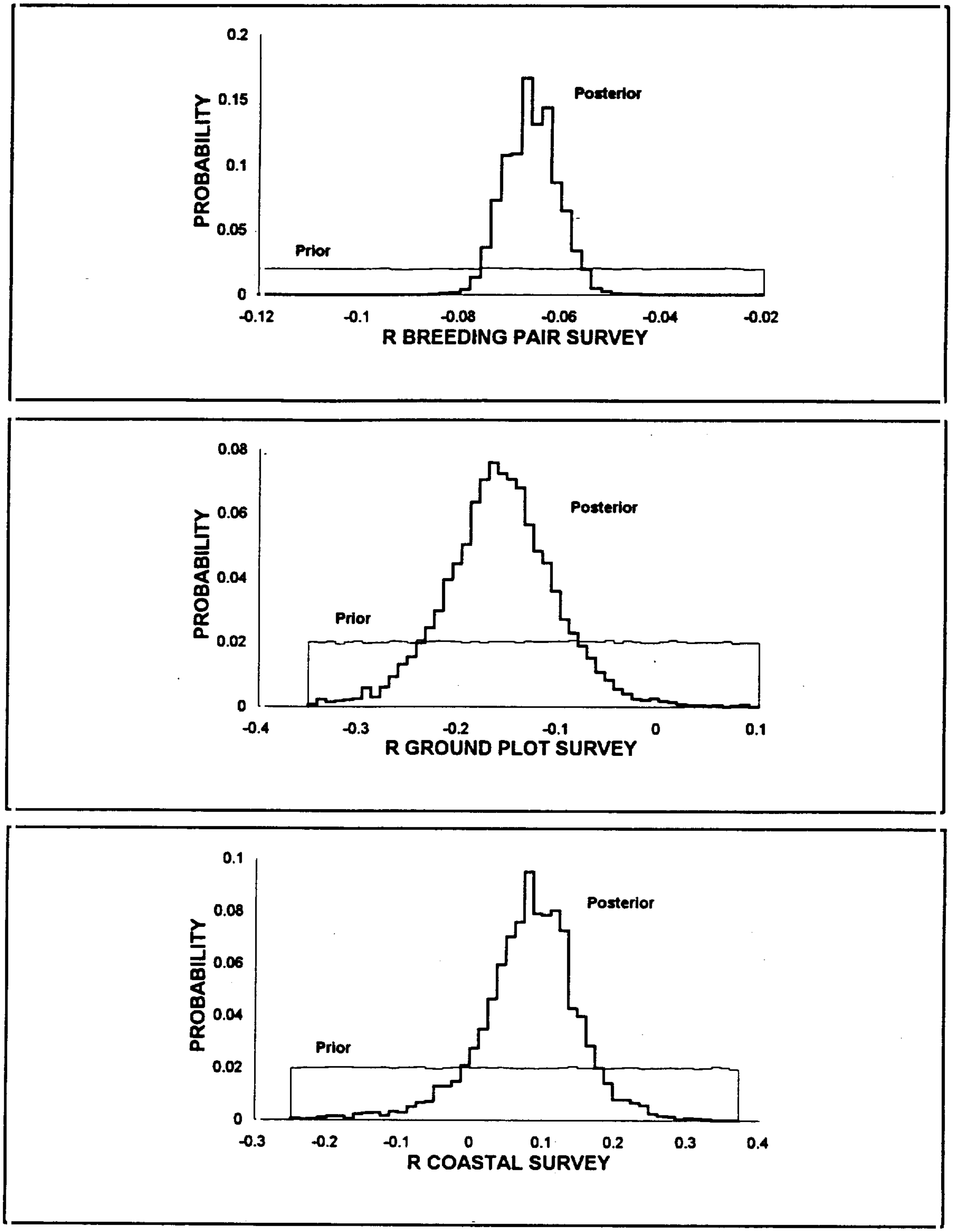

Figure I-2. Prior and posterior distributions for the three surveys conducted on the YKD: a--breeding pair survey, b--ground plot survey, c--coastal survey.

As can be seen in Figure I-2, the posterior distributions from the three surveys differ quite dramatically. We used data from the last 15 years for all three surveys to estimate a joint posterior distribution (Figure I-3). Because the surveys were rather disparate, the analysis required eight million random selections of parameters to obtain the posterior distribution. Although the posterior distribution is very broad it is still highly likely that the YKD population has declined over the past 15 years.

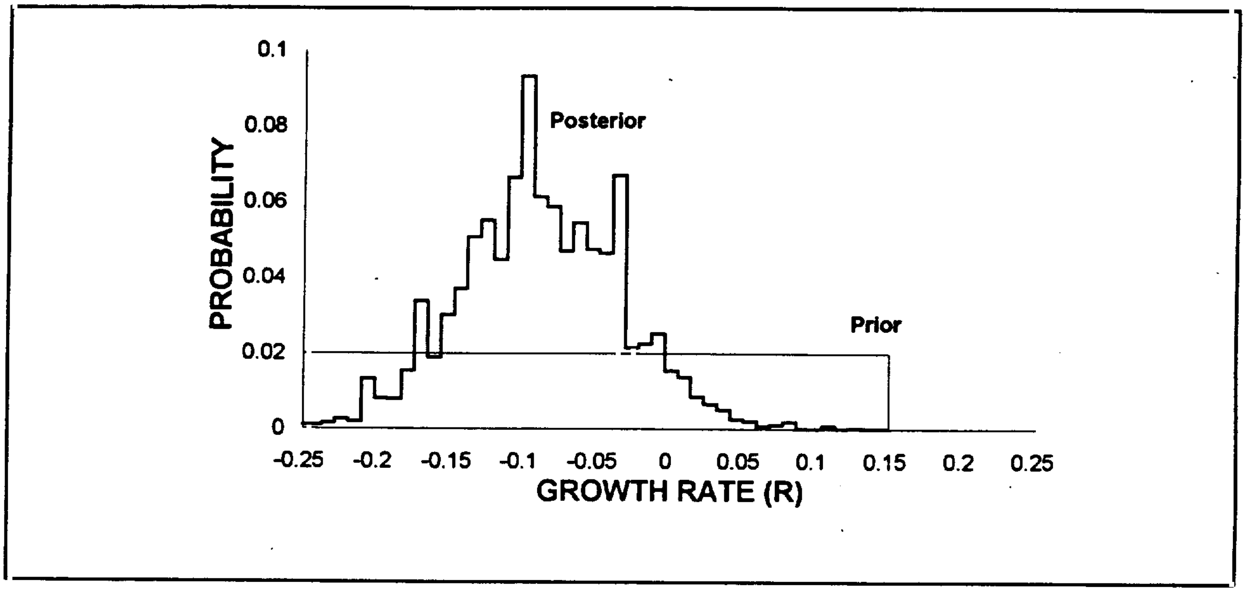

Figure I-3. Prior and posterior distributions for only the last 15 years of all three surveys.

The re-sampled 10,000 sets of values for the eight parameters represents the joint posterior distribution. We utilize this joint posterior distribution to perform a PVA that includes the uncertainty in our data (the abundance index surveys) and the model (prior information on variability in r). We sequentially used each set of parameter values as input parameters for a stochastic population projection. Required input parameters are: N_0, r, and s_r. Each simulation began with N_0 individuals. The initial number, N_0, was drawn from either the 1995 estimated abundance distribution for the Coastal or the Ground survey with equal probability. The simulation proceeded according to equation 1 (below), where r' was drawn from a Normal distribution (mean = r, variance = s_r^2). Both the time to extinction (<2 adults), and the time to critical status (<250 adults) were stored.

The latter time, which has been called a pseudo-extinction level (Ginzburg et al. 1990), is useful for several reasons. First, exponential population declines result in hypothetical populations that remain at very low levels for a substantial proportion of the total time to extinction. Therefore, extinction time may be misleading in terms of the amount of time remaining before the population reaches critically low levels. The choice of 125 pairs stems from the classification criteria proposed for use by the World Conservation Union (IUCN) for the category "critical" (Mace and Stuart 1994).

Biologists are aware that, when populations reach very low levels, population parameters are likely to change. For example, birth rates may change because of difficulty in finding mates or for colonial species survival rates may decline because of difficulties in defending territories against predators. If the cause of the population decline is unknown (the case for Spectacled Eiders), time will be required to find the cause(s) of the decline. The most productive research will occur with population sizes higher than this critical level. Similarly, the range of useful management actions is greatly reduced at very small population sizes. By the time a population reaches 125 pairs the most serious management option is taking the remaining birds into a captive breeding program. This is a particularly undesirable outcome if the cause of the decline is still unknown. It is therefore useful to know how much time is available before critical levels are reached.

The results of the simulations are shown in Figure I-4. Criteria for classification as endangered are usually defined in terms of either probabilities of extinction or population growth rates. Various criteria have been proposed for classification as endangered (Shaffer 1981; Mace and Lande 1991; Mace et al. 1992). The Mace and Lande (1991) criteria IUCN

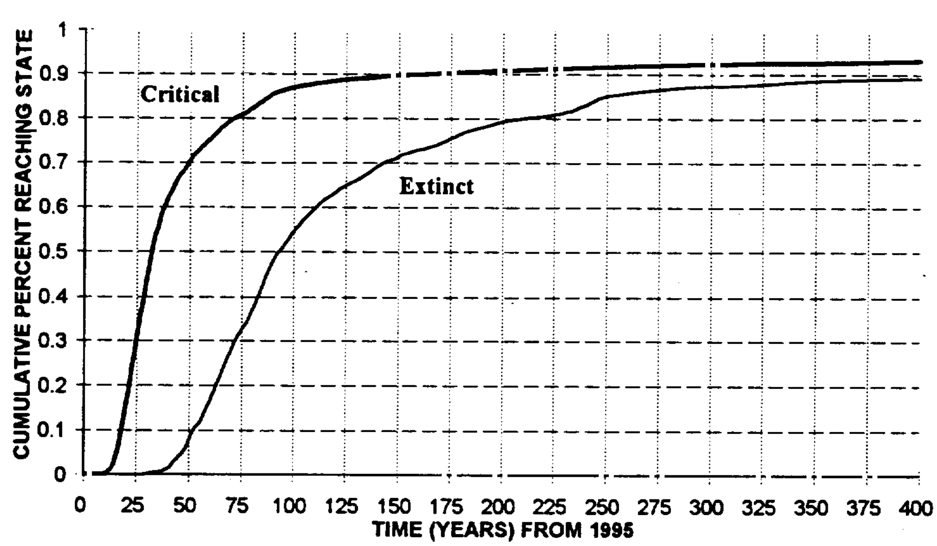

Figure I-4. Cumulative probability curves for the time to reach critical (125 pairs) and the time to extinction.

scheme (Mace and Stuart 1994) allow use of either growth rates or extinction probabilities but they are not necessarily consistent. We know that for the same mean rate of decline, probabilities of extinction will increase as variance in population growth rate increases. Because the criteria use only one estimate for population growth rate, it will only match to the probability of extinction for a single variance. According to the rate of decline criteria (the IUCN criteria are also at $r \leq -0.05$ for the Endangered category), Spectacled Eiders on the YKD would qualify as Endangered under any of the aforementioned criteria. In contrast, the YKD population does not qualify as Endangered since it does not reach a 20% chance of extinction in 38 years or 5.2 generations, given the mean generation time (Fig. I-3). Under the current IUCN criteria, Spectacled Eiders would qualify for the less risky Vulnerable category using the extinction probability criteria. Note that an earlier draft of the IUCN criteria used a 20% chance of extinction in 10 generations and that the YKD population would qualify under these less stringent criteria. Endangered classification would be warranted under the recovery objective for endangered in this plan and we further discuss why in Appendix II, which covers decision analysis.

The Unknown Population

This section strives to give guidance on setting appropriate criteria for classifying populations into the different risk categories (i.e., endangered, threatened, delisted). The category of endangered is examined first. As shown in Figure I-1, probability of extinction is a function of both population growth rate and the variance in that rate. For population growth rates ranging from -0.01 to -0.16 and population sizes ranging from 1,000 to 5,000 pairs, simulations were conducted as follows: (1) choose variation in growth rate from a uniform distribution ranging from standard deviation (s) = 0.07 to 0.21; (2) project population for 1,000 years. [Note that s is used rather than CV because as the mean growth rate (r) goes to zero, the CV goes to infinity.] The median probability of reaching critical population size was recorded for each of 10,000 simulations (Figure I-5).

At high rates of decline, increasing population size has little effect on the time to reach critical. For example, assuming $r = -0.15$ (the estimated rate from the ground plot surveys) it would take <25 years for a population of 5,000 pairs to reach the critical level of 125 pairs; and this length of time differs little over the range of 1,000 to 5,000 pairs in initial population size. Population size does not have the desired effect of dramatically increasing the amount of time to critical population sizes until the rate of decrease is <5%/year. It is at about -5%/year that the time period to critical levels increases to 50 years, which is perhaps sufficient time to find the cause of the decline and reverse it.

It is clear that rapid rates of decline leave little time for management actions regardless of initial population size. We desire, therefore, to classify populations as endangered when rates of decline allow a reasonable amount of time to correct the situation. Consider a population of 10,000 pairs. How long would it take for such a population declining at a given rate with a standard deviation of 0.21 (environmental stochasticity from Milne 1974) to: (1) reach the critical population size; and (2) become extinct? A simulation similar to the one just described was run for different rates of decline. Results (Figure I-6) are summarized in Table I-1.

For a margin of safety, we desire to have small probabilities of reaching critical levels within 50 years. We see from Figure I-6 that probability of reaching critical size within 50 years increases dramatically when r < -0.05. Criteria for classification as endangered are usually expressed as probabilities of extinction. Values that have been proposed for classification as endangered are: (1) a 20% chance of extinction in 10 generations or a growth rate < -0.05 (Mace and Lande 1991); and (2) a 20% chance of extinction in 5 generations or 50% decline in two generations (an annual decline of r = -0.046 for Spectacled Eiders) (Mace and Stuart 1994). These suggested probabilities of extinction to qualify as endangered seem to be set too high because the corresponding probability of becoming critical within 50 years is almost

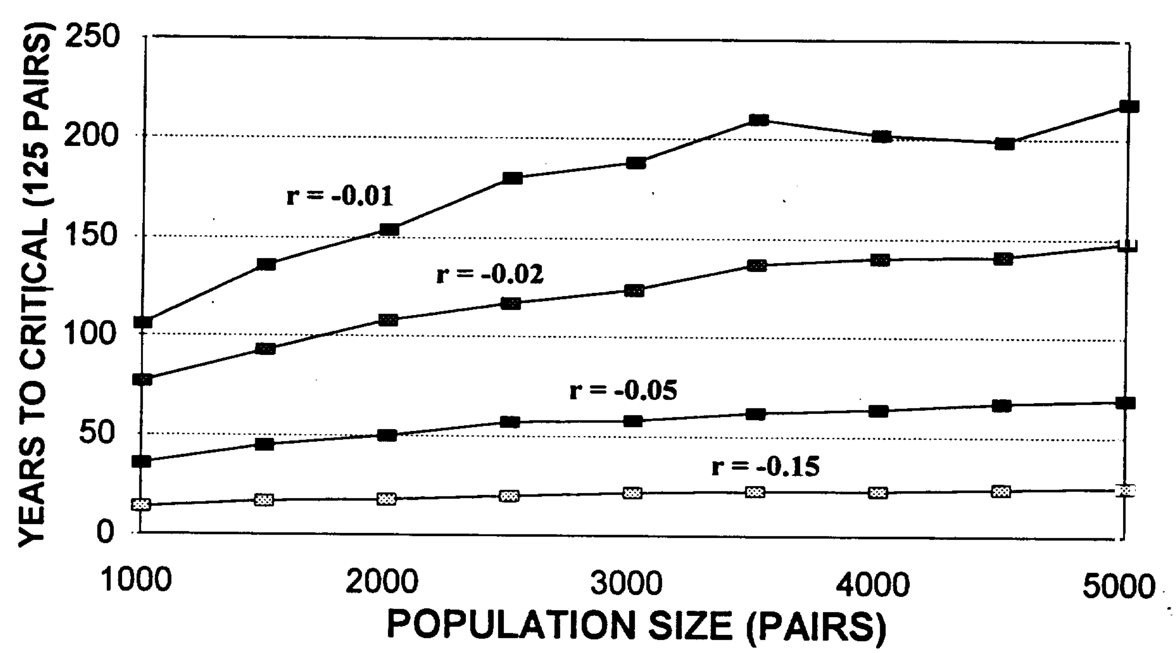

Figure I-5. The median number of years to reach critical levels from different population sizes at different growth rates. For all simulations the highest rate of growth rate variability (s = 0.21) was used.

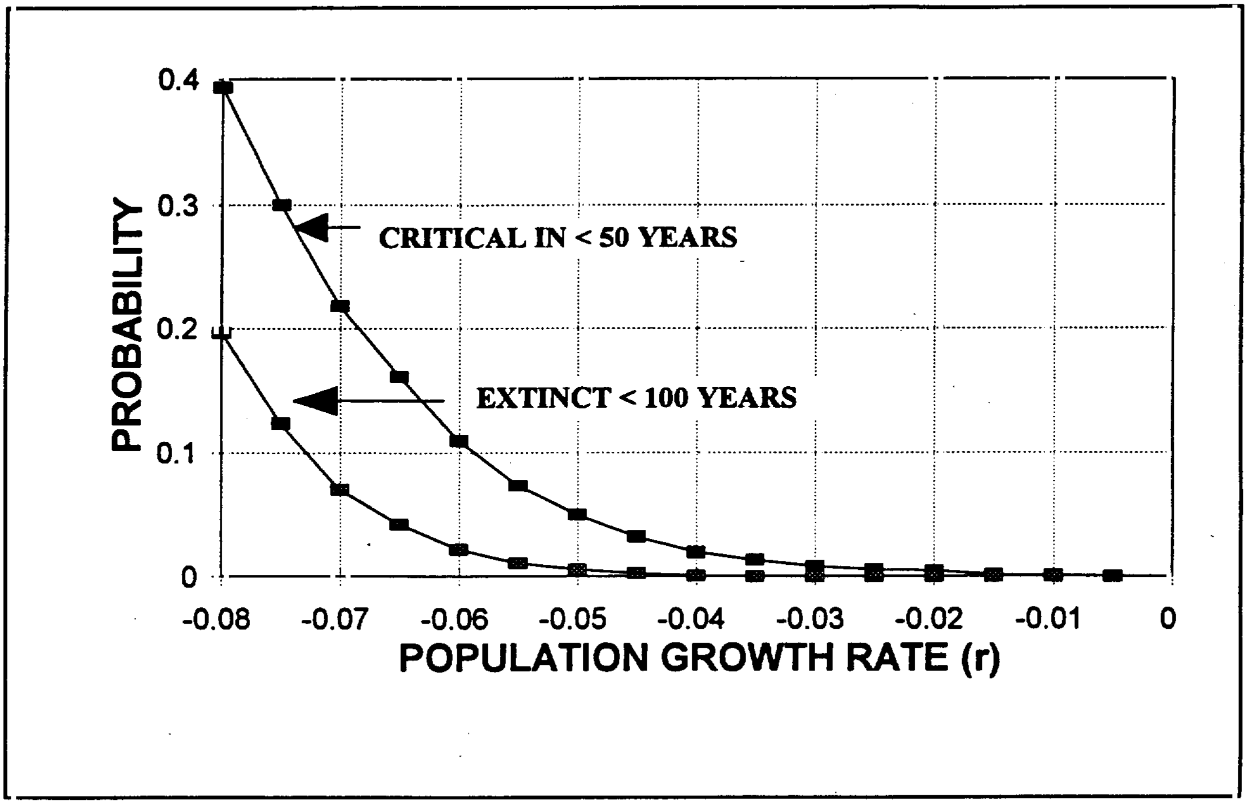

Figure I-6. The probabilities of becoming extinct in 100 years or becoming critical in 50 years for different growth rates from an initial population size of 10,000 pairs. The population size of 10,000 pairs was chosen because this abundance is the criterion for delisting. For all simulations the highest rate of growth rate variability (s = 0.21) was used.

Table I-1. Results from stochastic simulations with an initial population size of 10,000 pairs.

PROBABILITY OF EXTINCTION IN 100 YEARS	PROBABILITY OF BECOMING CRITICAL WITHIN 50 YEARS	GROWTH RATE (r)
0.006	0.050	-0.050
0.010	0.069	-0.054
0.050	0.177	-0.066
0.100	0.264	-0.073
0.200	0.397	-0.080

40%. The population growth rate criteria (<-0.05) is much less stringent, corresponding for spectacled Eiders to a 0.6% probability of extinction in 100 years and a 5% probability of becoming critical in 50 years. Given the uncertainty in the Spectacled Eider data, it does seems reasonable to adopt a critical value of $r \leq -0.05$ as a criterion for listing a population as endangered. Although this criteria gives a low probability of extinction within 100 years (0.6%), and a low probability of becoming critical within 50 years (5%), it is clear from Figure I-5 that both of these probabilities increase dramatically at rates of decline greater than this value.

Estimating the Minimum Viable Population

Because of the paucity of data on the Spectacled Eider's life history, only a crude estimate can be made of the MVP. Using the same bounds on variability in population growth rate (from 0.07 to 0.21), simulations can be run to characterize population risk by population size. Results are very sensitive to model choice: if a density dependent model is chosen then populations are drawn towards the carrying capacity and away from extinction. Some density dependence should be normal for most populations. There are no data on the responses of Spectacled Eiders to changes in population density, although increased clutch sizes in recent years (Stehn et al. 1993) suggest such a response and were noted in one decreasing population of Common Eiders (Hario and Selin 1988). It has been hypothesized, however, that increased clutch sizes are a result of a change in age structure such that the population is composed of a higher proportion of older females that have larger clutches (Stehn et al. 1993). Inclusion of even a small degree of density dependence greatly decreases the probability of extinction (Ginzburg et al. 1990; Stacey and Taper 1991).

The following exercise makes the pessimistic assumption that populations are not density dependent. On average, the population growth rate is zero (stable) but the population growth rate fluctuates randomly as defined by the standard deviation of the growth rate. The following results are, therefore, worse than would be expected for a "normal" population and would lead to conservative decisions concerning the MVP. This approach is very similar to the approach used to estimate MVP for desert tortoise in the draft recovery plan for that species. MVPs are supposed to be self-sustaining populations and probabilities of extinction are typically set at long time scales. For example, Shaffer (1987) recommended the MVP critical probability be set at a 1% chance of extinction in 1,000 years. Given the conservative nature of the Spectacled Eider model (i.e., with no density dependence), this probability seems overly restrictive. We recommend, therefore that 500 years (representing more than 65 eider generations) is a more suitable time frame.

To estimate the probability of extinction, 10,000 simulations of stochastic population growth for initial population sizes which doubled between 50 and 25,600 pairs were run as follows: (1) start at initial population size; (2) each year, choose population growth rate from a distribution with mean $r = 0$, $s = 0.21$; (3) project forward until < 1 pair remains. Figure I-6 shows the probability of extinction in 500 and 1,000 years if $s = 0.21$. Results of Figure I-

7 are summarized in Table I-2. A 5% chance of extinction in 500 years corresponds to a population size of 8,500. Thus, the delisting population size of 10,000 pairs corresponds to <5% chance of extinction in 500 years.

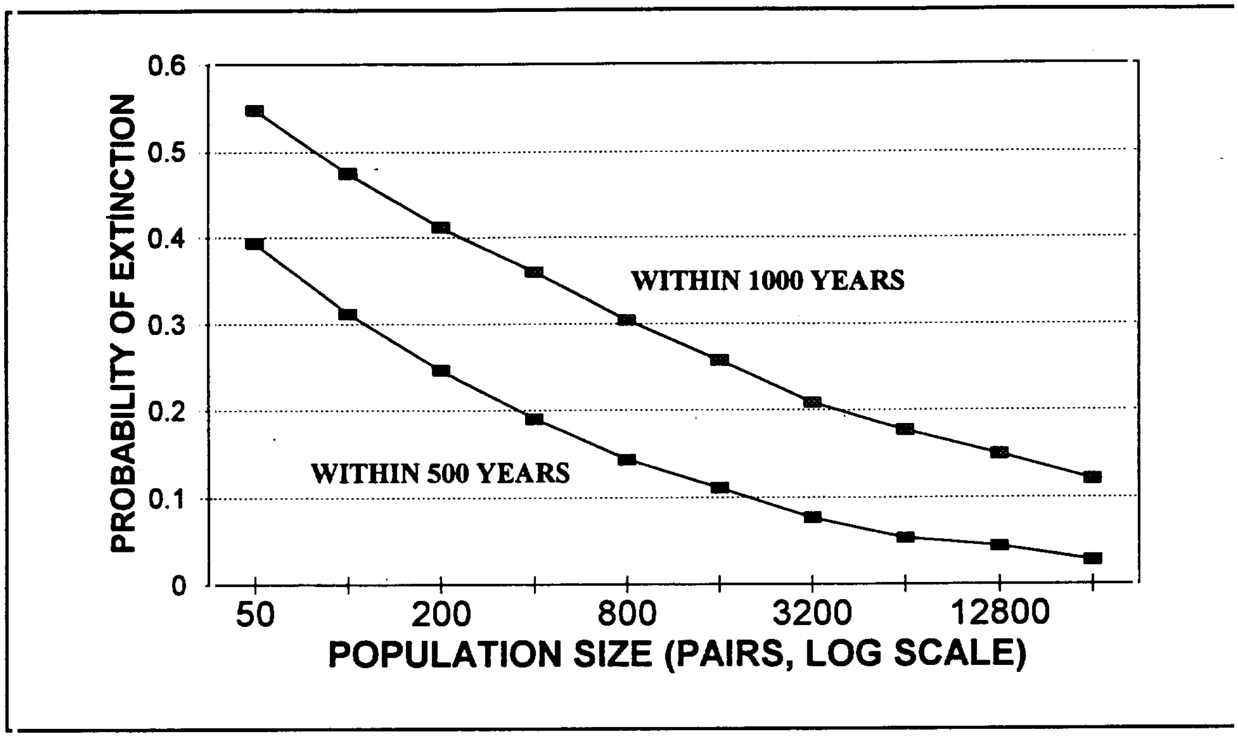

Figure I-7. Probability of extinction in 500 and 1,000 years for different population sizes. Population growth is chosen from distribution with mean r = 0, s = 0.21. No density dependence is assumed. Population dynamics are a random walk.

Table I-2. Results of simulation which assumes mean r = 0, s = 0.21 for population sizes corresponding to classification criteria in this plan. The last column is given for comparison so that managers can easily see the amount of time for research and management actions from the abundance threshold levels if a population was to start declining at a rate that would warrant endangered status (i.e., $r \leq -0.05$).

POPULATION SIZE (PAIRS)	PROBABILITY OF EXTINCTION IN 500 YEARS	YEARS TO REACH CRITICAL WITH r = -0.05
2,000	0.102	36
3,000	0.081	45
5,000	0.063	57
6,000	0.056	58
8,500	0.050	65
10,000	0.048	65
25,000	0.025	106

LITERATURE CITED
APPENDIX I

Cooch, F. G. 1965. Breeding biology and management of the Northern Eider (*Somateria mollissima borealis*) in the Cape Dorset area, Northwest Territories. Can. Wildl. Serv. Wildl. Manage. Bull. Ser. 2 No. 10.

__________. 1986. The numbers of nesting Northern Eiders on the West Foxe Islands, NWT, in 1956 and 1976. In A. Reed (ed.) Eider ducks in Canada. Canadian Wildlife Service, 1141 route de l'Église, Ste-Foy, Que, G1V 4H5. Pages 114-118.

Coulson, J. C. 1984. The population dynamics of the Eider Duck *Somateria mollissima* and evidence of extensive non-breeding by adult ducks. Ibis 126:525-543.

Dau, C. P. 1974. Nesting biology of the Spectacled Eider on the Yukon-Kuskokwim Delta, Alaska. M.S. Thesis, University of Alaska, Fairbanks. 72pp.

__________, and A.A. Kistchinski. 1977. Seasonal movements and distribution of the spectacled eider. Wildfowl 28:65-75.

Dennis, B., Munholland, P. L., and J. M. Scott. 1991. Estimation of growth and extinction parameters for endangered species. Ecol. Monog. 61:115-143.

Frankel, O.H. and M.E. Soulé. 1981. Conservation and Evolution. Cambridge University Press, New York.

Gilpin, M.E. 1990. The genetic effective size of a metapopulation. Biological J. Linn. Soc. 42: 165-175.

__________. and M.E. Soulé. 1986. Minimum viable populations: the processes of species extinctions. Pp. 13-34 In M.E. Soulé (ed.) Conservation Biology: the Science of Scarcity and Diversity. Sinauer Associates, Sunderland, Mass.

Ginzburg, L. R., S. Ferson, and H. R. Akçakaya. 1990. Reconstructibility of density dependence and the conservative assessment of extinction risks. Conservation Biology 4:63-70.

Goodman, D. 1987. The demography of chance extinction. In M.E. Soulé (ed.) Viable populations for conservation. Cambridge University Press. Cambridge England.

Hario, M. and K. Selin. 1988. Thirty-year trends in an eider population: timing of breeding, clutch size, and nest site preferences. Finnish Game Res. 45:3-10.

Hilborn, R. and C.J. Walters. 1992. Quantitative fisheries stock assessment: choice, dynamics, and uncertainty. Chapman and Hall, New York and London.

Leigh, E.G. 1981. The average lifetime of a population in a varying environment. J. Theor. Biol. 90:213-239.

Mace, G., N. Collar, J. Cooke, K. Gaston, J. Ginsberg, N. Leader Williams, M. Maunder, and E. J. Milner-Gulland. 1992. The development of new criteria for listing species on the IUCN red list. Species 16-22.

___________, and R. Lande. 1991. Assessing extinction threats: toward a reevaluation of IUCN threatened species categories. Conservation Biology 5:148-157.

___________. and S. Stuart. 1994. Draft IUCN red list categories, Version 2.2. Species 13-24.

Milne, H. 1974. Breeding numbers and reproductive rate of eiders at the sands of Forvie National Nature Reserve, Scotland. Ibis 116:135-154.

Reed, A. 1975. Migration, homing, and mortality of breeding female Eiders *Somateria mollissima dresseri* of the St. Lawrence estuary, Quebec. Ornis. Scan. 6:41-47.

Richter-Dyn, N. and N.S. Goel. 1972. On the extinction of a colonizing species. Theor. Pop. Biol. 3:406-433.

Shaffer, M.L. 1981. Minimum population sizes for species conservation. Bioscience 31: 131-134.

Shaffer, M. 1987. Minimum viable populations: coping with uncertainty. In M.E. Soulé (ed.) Viable Populations for Conservation. Cambridge University Press. Cambridge, England.

Smith, D. R. 1993. Accuracy of wintering waterfowl surveys: experimental evaluations of visibility bias and the efficiency of adaptive cluster sampling. Ph.D. thesis. University of Georgia, Athens, Georgia.

Soulé, M.E. 1987. Viable Populations for Conservation. Cambridge University Press. Cambridge, England.

Stacey P. B. and M. Taper. 1991. Environmental variation and the persistence of small populations. Ecological Applications 2: 18-29.

Stehn, R. A., C. P. Dau, B. Conant, and W. I. Butler, Jr. 1993. Decline of Spectacled Eiders nesting in western Alaska. Arctic 46:264-277.

Steinhorst, R. K., and M. D. Samuel. 1989. Sightability adjustment methods for aerial surveys of wildlife populations. Biometrics 45: 415-425.

Swennen C. 1976. Population structure and food of the eider *Somateria m. mollissima* in the Dutch Wadden Sea. Ardea 64:311-371.

____________. 1983. Reproductive output of Eiders *Somateria m. mollissima* on the southern border of its breeding range. Ardea 71:245-254.

Taylor, B.L. and T. Gerrodette. 1993. The uses of statistical power in conservation biology: the vaquita and northern spotted owl. Conservation Biology 7:489-500.

____________, P. R. Wade, R.A. Stehn and J.F. Cochrane. In press. A Bayesian approach to classification criteria for Spectacled Eiders. Ecological Applications.

Wakely J. S. 1973. An analysis of banding and recovery data for the American Eider (*Somateria mollissima dresseri*). unpublished Masters thesis, University of Maine at Orono.

____________. and H. L. Mendall. 1976. Migrational homing and survival of adult female Eiders in Maine. J. Wildl. Manage. 40(1):15-21.

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APPENDIX II

TECHNICAL DETAILS OF THE BAYSIAN ANALYSIS

CALCULATION OF POSTERIOR DISTRIBUTIONS

Estimation of the amount of risk to which Spectacled Eiders are exposed must be based primarily on an analysis of the rate of change of population abundance where abundance is estimated by various survey techniques. For the Spectacled Eider three time series of abundance estimates are analyzed: the North American breeding bird survey (number of estimates (n) = 39), aerial surveys of the YKD coast (n = 8), and ground plot surveys where random ground plots stratified by habitat type are exhaustively surveyed for nests (n = 10). For each survey we would like to know the probability of obtaining these data given various hypotheses concerning the unknowns: population growth rate (r--the slope estimate of a regression of population size against time) and variance in the estimate of population growth rate (the standard error of the estimate). Given a probability distribution for population growth rate for our particular set of data we can directly answer questions about the probability that the population is stable or growing. The range of hypotheses tested constitute the prior distribution and the resultant distribution, which is conditional on the data, is called the posterior distribution.

Our primary interest is in estimating the population growth rate from observed data, which are abundance index estimates with associated precision estimates. We assume an exponential model of population growth (equation 1).

$$N_t = N_0 \, e^{(r + e_t)\, t} \qquad (1) \qquad \textbf{(1)}$$

where N = number of breeding pairs, t = time (years), N_0 = initial number of breeding pairs, r = population growth rate and ϵ_t is Gaussian distribution symbolized as G ($\bar{x}$, s_r^2), where $\bar{x} = 0$ and s_r is the standard deviation of r. When $s_r = 0$ the model is deterministic. When $s_r > 0$ then the model is stochastic with annual growth rate drawn from a distribution. The parameter of interest for classification decisions is r. Parameters are estimated by fitting the model with the available time-series of abundance estimates using Bayesian methods. This is analogous to a weighted non-linear regression using classical statistical methods (essentially because the contribution of each abundance estimate to the estimation is weighted by the inverse of its estimated precision or CV).

Due to the nature of the available data set, several other parameters have to be defined and estimated. The abundance estimates and their associated coefficients of variation, CV (which were estimated from the sampling design for each survey), represent the observed data in this analysis. Because the number of eiders that breed and are thus available to be counted may vary through time (more than explained by trends in r), the estimated CV may not account for all of the variance in the abundance estimates. Therefore, we estimate a parameter (m) for the additional lack of fit to the model not accounted for by CV. This parameter multiplies the estimated CV to give a total estimated variance.

$$s^2 = \left(m \ \hat{CV}(N) \ \hat{N} \right)^2 \tag{2}$$

where s^2 = variance and the hat character indicates the estimated value from the survey data. A different parameter is specified for each of the three different abundance time-series (m_B, m_G, m_C where subscripts denote B for breeding, G for ground plot and C for coastal). The estimated CV's account for the precision of the surveys to estimate the number of eiders that are in the study area, whereas the purpose of the CV multipliers is to account for additional variance in the abundance estimates, such as the number of eiders that breed in each year and thus are available to be surveyed. These multipliers are assumed to be constant through time.

Two scaling parameters are required to scale the time series of abundance indices from different surveys to one another. This is because none of the survey estimates represent an estimate of absolute abundance, but instead serve as relative indices of abundance. Therefore we have arbitrarily chosen one of the surveys (the Breeding Pair survey) as the default unit of measure of relative abundance, and the other two surveys' data are scaled to these units. The two scaling parameters (a_G and a_C) are estimated as part of the overall analysis. So in summary, we estimate as many as eight parameters in the analysis.

We use Bayes' theorem to estimate the specified parameters from the abundance data. This theorem states that the probability of parameter θ given the data x, written $p(\theta|x)$, is proportional to the product of the probability of the data x given parameter θ, written $p(x|\theta)$, and the probability of the parameter, $p(\theta)$, not conditioned upon the data x. The probability $p(\theta|x)$ is called the posterior distribution for parameter θ, and is the end result of the analysis. The probability $p(x|\theta)$ is called the likelihood function, and is often written as $L(\theta|x)$. The probability $p(\theta)$ is called the prior distribution for θ, and represents the probability distribution for θ before the data x were known. Thus, the posterior distribution is equal to the product of the likelihood function and the prior distribution, normalized by the integral of the product of the likelihood and the prior:

$$p(\theta|x) = \frac{L(\theta|x)\,p(\theta)}{\int L(\theta|x)\,p(\theta)\,d\theta} \quad . \tag{3}$$

In our analysis of the Spectacled Eider, we have specified more than one parameter, so here θ represents up to 8 parameters. Thus, the integration in the denominator, which calculates the normalizing constant, is actually multidimensional with dimension equal to the number of parameters being estimated.

The likelihood function for the parameters in a population model, given a time series of abundance estimates, is relatively easy to write and calculate (e.g., De la Mare, 1986). In any single year, the likelihood of an observed abundance estimate in year t, N(t), given a specified model population size in year t, N_t, is straightfoward -- it is the likelihood function defined by the assumed sampling distribution of the abundance estimate. Here we assume the sampling distribution of the abundance estimates is distributed as a Gaussian distribution with estimated mean N(t) and standard deviation S(t), and thus the likelihood is:

$$L(N_t|N(t),S(t)) = \frac{1}{\sqrt{2\pi}\,S(t)}\, e^{-\frac{1}{2\,S(t)}(N(t)-N_t)^2} \cdot \qquad (4)$$

Although N_t is not an explicit parameter of the model, the model parameters N_0 and r uniquely determine a population trajectory N_1, N_2, ...N_c (where c is the last year projected to, the current year). Therefore, the total likelihood for N_0 and r given the data is the product series of all the individual likelihoods of the N_t 's (the model trajectory) given the N(t)'s (the time-series of abundance estimates).

More formally, the likelihood for the three surveys combined was:

$$L(\theta|\ \overline{N_B},\ \overline{N_G},\ \overline{N_C}) \equiv p\left(\overline{N_B},\ \overline{N_G},\ \overline{N_C}|\ \theta\right) \qquad (5)$$

$$= p\ (\overline{N_B}|\theta)\ \ p\ (\overline{N_G}|\theta)\ \ p\ (\overline{N_C}|\theta) \qquad (6)$$

$$= \prod_{t=1}^{n}\ p\ (N_B(t)|\theta)\ \ p\ (N_G(t)|\theta)\ \ p\ (N_C(t)|\theta) \qquad (7)$$

$$= \prod_{t=1}^{n}\ [\ L\left(N_0, r, m_B\ |\ N_B(t), CV(N_B(t))\right) \cdot\ L\left(N_0, r, m_G, a_G\ |\ N_G(t), CV(N_G(t))\right) \cdot\ L\left(N_0, r, m_C, a\right. \qquad (8)$$

$$= \prod_{t=1}^{n}\ \frac{1}{\sqrt{2\pi}\ s_B(t)}\, e^{-\frac{1}{2\,s_B(t)}(N_B(t)-N_t)^2} \cdot \frac{1}{\sqrt{2\pi}\ s_G(t)}\, e^{-\frac{1}{2\,s_G(t)}(N_G(t)\,a_G-N_t)^2} \cdot \qquad (9)$$

whwhere

N_t = model population size in year t, as projected from N_0 and r using equation 1,

N_I (t) = abundance index estimate for Survey I in year t,

a_I = scale parameter that scales an abundance estimate from survey I to the Breeding Pair survey,

I = index of the survey type, where B indicates the Breeding Pair surveys, G indicates the Ground Plot surveys, and C indicates the Coastal surveys,

S_I(t) = the total standard deviation of abundance estimate N_I(t), and is defined as:

$$S_I(t) = m_I \hat{CV}(\hat{N}_I(t)) \hat{N}_I(t) \quad (10)$$

where

m_I = the CV multiplier for survey I,

$CV(N_I(t))$ = the estimated survey precision (CV) of abundance estimate $N_I(t)$.

Note that parameter values that maximize equation 4 are the maximum likelihood estimates, a common point estimator in frequentist statistics. In Bayesian statistics, rather than maximizing equation 4 we need to integrate the product of it and the prior distribution of the parameters (defined below).

Until fairly recently, most Bayesian analyses were restricted to cases where the prior distribution could be chosen so that it was "conjugate" to the likelihood distribution, resulting in their product being a distribution of a known form, which was integratable by analytic methods. Advances in computing power and numerical and Monte Carlo integration methods have removed this restriction. We use the Sampling-Importance-Resampling routine of Rubin (1988), which Smith and Gelfand (1992) advocate as a particularly useful and simple integration technique for Bayesian statistics. In this method, values for the parameters are randomly selected from their joint prior distribution to form a sample set θ_i. The likelihood of the data given this particular θ_i is calculated and stored. This is repeated, generating n_1 θ_i's with associated likelihoods. These n_1 θ_i's are then re-sampled n_2 times with replacement, with probability equal to weight q_i, where

$$q_i = \frac{L(\theta_i|x)}{\sum_{j=1}^{n_1} L(\theta_j|x)} \quad (11)$$

Rubin (1988) showed that this generates a random sample from the joint posterior distribution of size n_2. The resampling with replacement from the n_1 θ_i's with weight q_i makes this process analogous to a weighted bootstrap procedure. We set values for n_1 and n_2 to yield smooth posterior distributions, which depended on the number of parameters estimated. For single survey analyses, n_1 = 300,000, n_2 = 5,000. For analyses of all three surveys, n_1 = 8,000,000, n_2 = 10,000. For analyses of all surveys with environmental stochasticity (equation 1), n_1 = 25,000,000, n_2 = 10,000. With the exception of initial population size, prior distributions were Uniform distributions that were iteratively set to encompass the values of the posterior distribution for each parameter.

For the full analysis using the deterministic population model (equation 1) and all three data sets, values were randomly drawn from their prior distributions for the seven parameters (r, N_0, m_B, m_G, m_C, a_G, and a_C) to form a θ_i. Those parameter values were then used to project a model population trajectory using equation 1, forming a series of model population sizes N_1, N_2, ..N_c. The likelihood of that population trajectory given the data was then calculated using equation 9, and the θ_i 's and associated likelihood value were stored. This was repeated n_1 times to form the initial sample. Then the θ_i were re-sampled n_2 times with replacement with weight q_i (equation 11) to form the second sample, which represents a random sample from the posterior distribution and is thus used to approximate the posterior distribution (Figure 2).

We analyze the three time series both together and separately to illustrate the effects of different quantities and qualities of data on the classification process. The seven parameters necessary for the analysis of all 3 data sets were given prior distributions as follows: (1) N_0 (initial population size in 1957, in units of Breeding Pair Survey) G (23,165, 19,111^2), (2) r [Uniform U (-0.095,-0.045), (3) m_B--multiplier for additional variance in Breeding Pair Survey U (0.3, 0.8), (4) m_G--multiplier for additional variance in Ground Plot Survey U (0.7, 3.5), (5) m_C--multiplier for additional variance in Coastal Survey U (0.8, 7.5), (6) a_G--scaler of abundance index for Ground Plot to Breeding Pair Survey U (0.35, 2.90), (7) a_C--scaler of Coastal to Breeding Pair Survey U (0.35, 2.50). The prior for N_0 is based on the first abundance estimate from the Breeding Pair survey in 1957. The other priors were chosen to be uniform distributions to represent no prior knowledge of their value. For practical purposes we bounded the prior distributions because extreme values had nearly zero likelihood. We set these bounds after a few trial runs to ensure that the priors included all possible values of the posterior distribution.

The classification criterion for endangered ($r \leq -0.05$) was based on simulations that included environmental stochasticity. Environmental stochasticity makes the long-term growth rate less than the expected growth rate (r). For example, a population with mean r = 0.00 and some amount of variance will not fluctuate around the initial abundance, but rather will decline. The difference between the expected growth rate and the long-term growth rate is because the long-term growth rate is actually the geometric mean of the distribution of growth rates, which is always less than the arithmetic mean. To check that our classification decisions are not influenced by the omission of environmental stochasticity, we re-analyzed the full data set using the stochastic population model (equation 1). The prior distribution for the additional parameter s_r, the standard deviation of the growth rate, was specified as follows. We used both a uniform distribution and a worst case scenario using only the highest value for variability in r. These values were based on the data available for Common Eiders. Therefore, the prior for s_r was either U (0.07, 0.21) or was fixed at 0.21.

This prior distribution for s_r points out another unique advantage of Bayesian methods -- an explicit framework for incorporating prior knowledge into an analysis. It is well known that when fitting a population model to abundance data it is impossible to distinguish between environmental variance and sampling error from the abundance data alone (Hilborn and Walters 1992). This has led researchers to ignore one or the other. Using a Bayesian framework has enabled us to incorporate both, as the sampling error is accounted for by the CV's and their multipliers, and uncertainty due to environmental variance is incorporated into the prior distribution for s_r, using data from Common Eiders. Admittedly the data on environmental variance are not ideal, but they are preferable to either ignoring stochastic population dynamics or assuming a non-informative prior which might over-emphasize the importance of variance in r.

BAYESIAN DECISION ANALYSIS FOR USE IN LISTING AND DELISTING DECISIONS ABOUT SPECTACLED EIDERS

Appendix I set thresholds for classification decisions and calculated the probability of different rates of population growth given the YKD survey data. Before deciding whether or not to classify a population in a certain risk category we must consider the consequences of either under- or over-protecting the species. Appendix I showed that populations declining at higher rates are at a higher risk of extinction. We expect, therefore, that the costs of not classifying a population declining at 10%/year will exceed those of a population declining at 5%/year. Bayesians call the function that relates cost to particular outcomes a "loss function". Our loss function quantifies the risk of extinction. We expect that the loss caused by incorrectly not classifying a species to a higher risk category will increase as the risk of extinction increases (although once the probability of extinction becomes nearly one, the cost should remain the same for all cases leading to that level of risk). We also expect this loss to become zero when the population is stable or growing because the decision not to classify to a higher risk category is correct. Because the recovery team chose to equalize over- and under-protection errors, the loss function for over-protecting the population is symmetrical to the under-protection loss function and becomes zero at the decision threshold. Figure 9 (Part II: Recovery) shows loss functions for the threatened to endangered classification decision. Figure II-1 shows the loss functions for the endangered to threatened and threatened to delisted classification decisions.

To obtain the loss functions we simulated population trajectories as follows, for rates of decline from r = 0.0 to r = -0.25: 1) choose N_0 with a 50% probability from the 1995 estimate for either the ground plot survey or the coastal survey, 2) choose s_r from U (0.07,0.21), 3) for each year choose r' from G (r,s_r^2), 4) project population for 50 years, 5) repeat steps 1-4 10,000 times recording each time the population ended with <250 adults. It may seem odd that a population declining at r = -0.07 incurs the same loss as one declining at r = -0.10. The consequences of failing to classify either of these populations, however, is the same. It is likely that either the population would go extinct or end up in a captive breeding program. One could compare it to the unpleasant event of being shot in the head where it matters little whether a .44 magnum or a shotgun were used because the result is the same.

Calculation of loss for each error type is done by multiplying the chosen posterior distribution for r by each loss function. Table 1 shows a simplified calculation for the hypothetical example given in II. Recovery. The tabulation for the actual posterior distribution for the YKD model is too long to show in a table, but is essentially the same calculation.

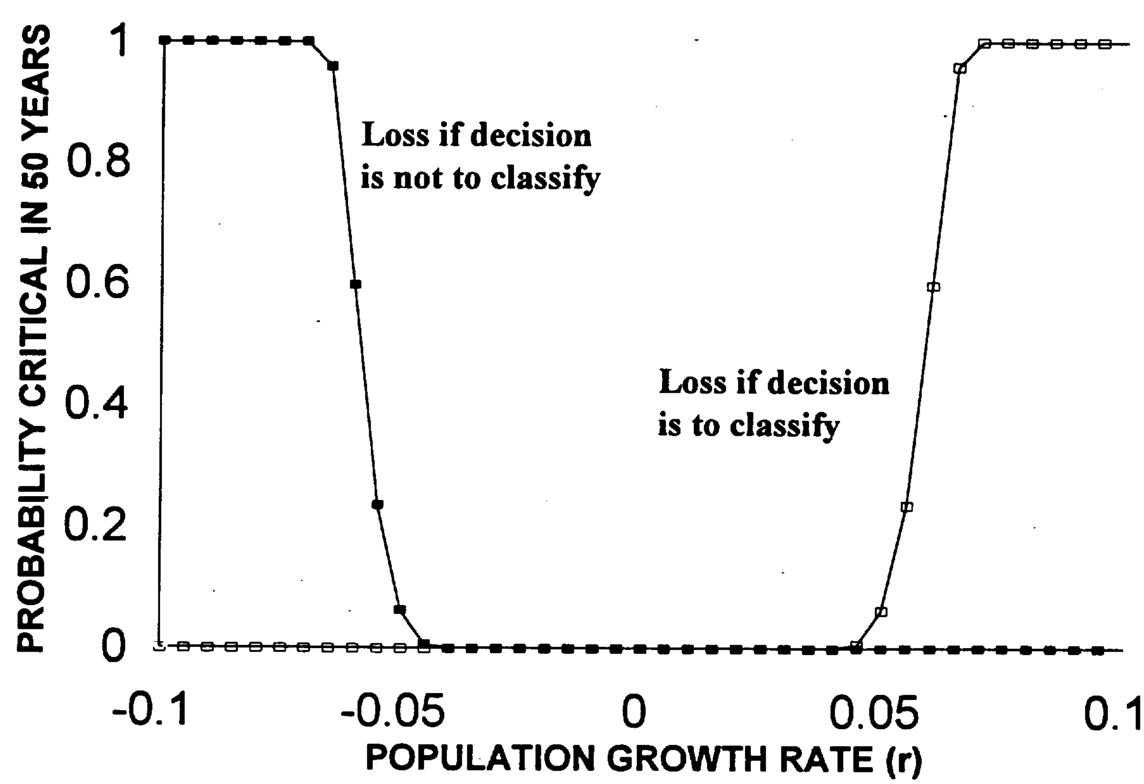

Figure II-1. Loss functions for the endangered to threatened and threatened to delisted classification decisions. Note that the functions are symmetrical around zero. The under-protection loss is symbolized with filled squares and the over-protection loss with open squares.

Table 1. Calculations for the over- and under-protective losses for the loss functions and trend probability distribution shown in Figure 10 in part II Recovery. The under-protection loss for a single value of r is the probability of r given the data times the value of the loss function. For example, if r = -0.05 then the loss calculation would be 0.10648 x 0.063 = 0.00671.

r	probability of r given data (hypothetical)	under-protection loss function	over-protection loss function	under- protection loss	over-protection loss
-0.105	0.00000	1.0000	0.0000	0.00000	0.00000
-0.100	0.00004	1.0000	0.0000	0.00005	0.00000
-0.095	0.00016	1.0000	0.0000	0.00016	0.00000
-0.090	0.00051	1.0000	0.0000	0.00051	0.00000
-0.085	0.00148	1.0000	0.0000	0.00148	0.00000
-0.080	0.00380	1.0000	0.0000	0.00380	0.00000
-0.075	0.00874	1.0000	0.0000	0.00874	0.00000
-0.070	0.01800	1.0000	0.0000	0.01800	0.00000
-0.065	0.03316	0.9600	0.0000	0.03183	0.00000
-0.060	0.05467	0.5990	0.0000	0.03275	0.00000
-0.055	0.08066	0.2360	0.0000	0.01904	0.00000
-0.050	0.10648	0.0630	0.0000	0.00671	0.00000
-0.045	0.12579	0.0070	0.0000	0.00088	0.00000
-0.040	0.13298	0.0000	0.0000	0.00000	0.00000
-0.035	0.12579	0.0000	0.0000	0.00000	0.00000
-0.030	0.10648	0.0000	0.0000	0.00000	0.00000
-0.025	0.08066	0.0000	0.0000	0.00000	0.00000
-0.020	0.05467	0.0000	0.0000	0.00000	0.00000
-0.015	0.03316	0.0000	0.0000	0.00000	0.00000
-0.010	0.01800	0.0000	0.0000	0.00000	0.00000
-0.005	0.00874	0.0000	0.0070	0.00000	0.00006
0.000	0.00380	0.0000	0.0630	0.00000	0.00024
0.005	0.00148	0.0000	0.2360	0.00000	0.00035
0.010	0.00051	0.0000	0.5990	0.00000	0.00031
0.015	0.00016	0.0000	0.9600	0.00000	0.00015
0.020	0.00004	0.0000	1.0000	0.00000	0.00005
0.025	0.00000	0.0000	1.0000	0.00000	0.00000
SUM	1.00000			0.12394	0.00116

LITERATURE CITED
APPENDIX II

De la Mare, W.K. 1986. Fitting population models to time series of abundance data. Rep. Int. Whal. Commn. 36:399-418.

Rubin, D. B. 1988. Using the SIR algorithm to simulate posterior distributions. In Bayesian Statistics 3, J. M. Bernardo et al. editors, Clarendon Press, Oxford.

Smith, A. F. M. and A. E. Gelfand. 1992. Bayesian statistics without tears: a sampling-resampling perspective. The American Statistician 46:84-88.

APPENDIX III

SPECTACLED EIDER DEMOGRAPHY

The single greatest difficulty in assisting the recovery of Spectacled Eiders is that the cause(s) of the decline is (are) unknown. Therefore, early efforts must concentrate on determining the cause(s) of the decline. Analysis of age-specific birth and survival rates and their effects on a population's dynamics can provide clues to the proximate cause of the decline and, thus, can help focus research. This section follows an analytical strategy similar to that in the other modeling appendices.

Although very little is known about the demography of Spectacled Eiders, many studies have been done on birth and survival rates of Common Eiders. At this time, the best that can be done to understand the life history strategy of Spectacled Eiders is to assume that birth and survival rates and age at first reproduction for Spectacled Eiders are within the range of those for Common Eiders. This exercise will attempt to include uncertainty in birth and survival rates into the demographic analysis to generate distributions of statistics, such as the changes required in various birth and survival rates to get the observed rate of decline. The technique used is Bayesian in flavor in that pre-model distributions for birth and survival rates are used (see Appendix II for a description of the Bayes-like approach). A pre-model distribution for a parameter gives the probability for different values of the parameter. For example, if we knew absolutely nothing about an organism, we might assume that adult survival could take on any value between 0 and 1 with equal likelihood (uniform distribution). If, however, we have some data on the species or data from a similar species, we could limit this range and perhaps make some values more likely than others.

clutch = mean number of eggs/clutch;
propnest = mean proportion of adult females that nest in a year;
AFR_{max} = the maximum age of first reproduction (i.e., all females have bred at least once);
p_a = adult survival rate (age > 1); and
p_j = juvenile survival rate (age 0 to 1).

In addition, the model assumes that the last year when no birds had bred was year 1. For birds younger than AFR_{max}, the proportion that was mature was calculated as a linear interpolation between a probability of 0 at age 1 and a probability of 1 at age AFR_{max}. We assumed the sex ratio was 1:1 and that the oldest age (ω) was when survivorship reached 1%. The crude birth rate was thus calculated as:

$$m_x = clutch * sex\ ratio * propnest \qquad (1)$$

where x = age. The fertility rate is therefore:

$$f_x = p_x \, m_{x+1} \qquad (2)$$

where p represents the survival rate. The proportion surviving (survivorship) to each age (l_x) is:

$$l_x = \prod_{x=0}^{x=\omega} p_x \qquad (3)$$

The intrinsic rate of growth of the population (r) is then calculated iteratively from Lotka's equation:

$$1 = \sum_{x=0}^{x=\omega} l_x f_x e^{-r(x+1)} \qquad (4)$$

Before introducing uncertainty in the estimation of birth and survival rates, it is instructive to use a simple example to examine the magnitude of differences expected in demographic statistics. The example is based on Coulson's (1984) Common Eider data. No estimate is given for juvenile survival rate. Juvenile survival rate is, therefore, initially solved for by assuming r = 0 and solving equation 4. If a population were to grow at the same rate for a long period of time, eventually the proportion of animals in each age would remain the same from year to year. This is called stable age distribution. The proportion of first-time nesters (recruits) to the total number of nesters can also be calculated. The proportion first-time nesters can be estimated from banding data (Coulson 1984). This proportion can potentially serve as a diagnostic to tell whether the nesting population is primarily old birds (a sign of low recruitment) or young birds (a sign of lowered adult survival). If we assume that a population decline can be attributed to change in a single parameter, we can calculate the stable age distribution and the proportion of recruits. The results of assuming a 15%/year decline (the estimate from the YKD ground plot data; Stehn et al. 1993), are presented in Figure III-1a. Most of the population is 0-year-olds (eggs) which makes detecting differences in older categories difficult to see.

A more informative depiction of age structure includes only ages older than two (Figure III-1b). If we assume that the current rate of decline is the point estimate from the ground plot survey (r = -0.15), we can ask what proportion of nesting females would be first-time nesters if the decline was solely because of decreases in various parameters. If the decline was due entirely to reduced juvenile (first-year) survival rate, the proportion of first-time nesters is much less (6.3%) than if the decline was due to a reduction in adult survival rates (21%). Two factors suggest that the age structure may have changed towards a higher proportion

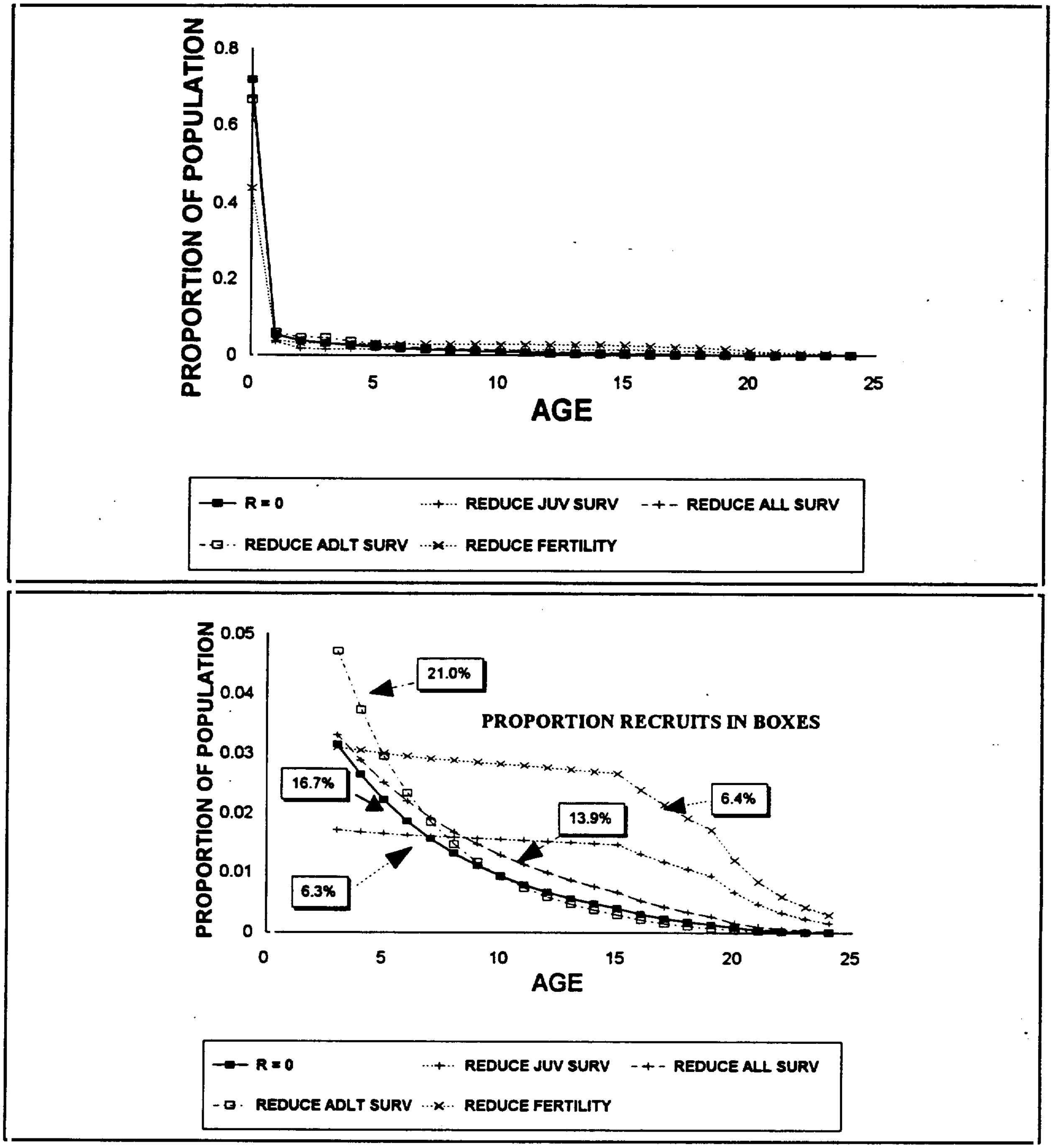

Figure III-1. Stable age distribution for Common Eiders based on Coulson's (1984) data. All ages are shown in "a". The key below the figure indicates the type of model. The initial model (r = 0) is shown for purposes of comparison. The models for reduced survival (r = -0.15) are: reduction in juvenile (first-year) survival rate, reduction in all survival rates, reduction in adult survival rate, and reduction in fertility. Only ages >2 are shown in "b". The proportion of the total nesting population that is first-time nesters is shown in boxes for the different models.

of older females: (1) older females in Common Eiders have larger mean clutch sizes (Baille and Milne 1982); and (2) mean clutch size has increased significantly on the YKD (Stehn et al. 1993). Although this increase in clutch size could be a density dependent response to reduced population size (Hario and Selin 1988), we would be encouraged to gather evidence on the proportion of new nesters *if* we had survival data of the quality of Coulson's.

Of course, we do not currently have sufficient data on Spectacled Eiders to estimate survival rates. It is therefore reasonable to ask whether, given the range of survival rates for Common Eiders, we expect to see differences in values (e.g., the proportion of first-time nesters), that would allow hypothesis testing with a high probability of correctly detecting a difference. The approach taken is similar to the exercise presented above. Parameter values for the first four parameters listed above are chosen from plausible distributions for those values based on Common Eider data where the population growth rate was thought to be near stable ($r = 0$). Because the null hypothesis is that the population is stable ($r = 0$), the final parameter, first-year survival rate, is solved to yield this growth rate. The alternate hypothesis is that one of the parameters decreased to give a plausible rate of decline for the YKD (chosen from the post-model distribution for the ground plot surveys in Appendix I). By decreasing adult survival, first-year survival and fertility separately, we can calculate distributions of what values these parameters would need to be to have been the sole cause of the decline. Comparison of these distributions then helps us assess whether demographic research will be likely to be able to eliminate hypotheses concerning the proximate cause of decline. For example, if we knew that juvenile survival was the primary cause of the decline, research priorities would be shifted to finding the cause for the reduction in juvenile survival.

To incorporate uncertainty in the four demographic parameters, each is drawn randomly from distributions intended to cover the possible range of values for that parameter when $r = 0$. For Common Eiders, demographic parameters each have quite large ranges. Because our understanding of how these parameters might represent Spectacled Eiders is rudimentary, we chose to represent most probability distributions with a triangular distribution. The triangular distributions are defined by the minimum and maximum values for the parameter found in the literature and have a maximum probability at the mean between the extreme values. Estimates of mean clutch size from Spectacled Eiders in Alaska are used for the pre-model distribution (minimum = 4.05, maximum = 5.92, maximum probability of triangular distribution = [minimum + maximum]/2 = 4.985). This minimum is the 1965-1976 mean (4.688) less 2 standard deviations (0.3176). The maximum is the 1986-1992 mean (5.104) plus 2 standard deviations (0.406) (Stehn et al. 1993). Data for the proportion of adult females nesting are: mean = 0.753 (Milne 1974), mean = 0.78 (Coulson 1984), 0.78-0.90 (Baillie and Milne 1982). Based on these values we used a triangular distribution: minimum = 0.5; maximum = 1.0; maximum probability = 0.75. Estimates of age-specific proportion mature are scarce but support a gradual onset of maturity between the ages of two and five (Reed 1983; Baille and Milne 1982). Estimates from Common Eider populations that do not show evidence of a decline (some were increasing at low rates usually <4%/year) were used for the pre-model distribution of adult survival (minimum = 0.75; maximum = 0.95 based on Table III-1; maximum probability = 0.85) (Table III-2). Juvenile survival was calculated as that value that given the other parameter values chosen would yield a population with no growth (r = 0, equation 4).

Table III-1. Adult survival rates for Common Eider populations not noted as declining.

ADULT SURVIVAL RATE	SOURCE	LOCATION
0.93-0.96	BAILLE AND MILNE 1982	SCOTLAND
> 0.9	SWENNEN 1972	NETHERLANDS
0.75-1.00, mean = 0.895	COULSON 1984	GREAT BRITAIN
0.85 (AVERAGE OF VARIOUS STUDIES)	REED AND ERSKINE 1986	CANADA
0.83	HARIO AND SELIN 1988	FINLAND
0.826 ± 0.099	REED 1983	CANADA
0.77 OR 0.81	WAKELY AND MENDALL 1976	MAINE
0.76, 0.78	WAKELY 1973	MAINE

Table III-2. Parameter ranges used in demographic analysis.

PARAMETER	MINIMUM	MAXIMUM
ADULT SURVIVAL	0.75	0.95
CLUTCH SIZE	4.05	5.92
PROPORTION NESTING	0.753	1.000
MAXIMUM AGE IMMATURE	3.5	5.0

RESULTS

Solutions for single cause decline (such as reduction in first-year survival) using randomly selected demographic parameters could not be attained for approximately 20% of the combinations. For example, if a high adult survival rate was chosen with a high rate of decline, it was not possible to obtain the rate of decline just by reducing first-year survival. If, for example adult survival rate = 0.90 and r = -0.15, if there was no recruitment, the population would decline at the adult survival rate (about r = -0.10). The following results are only for the cases for which a solution was possible. 100 simulations were run.

The resultant distribution of growth rates are shown in Figure III-2. The pre-model distribution used was the YKD post-model distribution for the ground plot surveys. The range for first-year survival rates when r = 0 is surprisingly large (Figure III-3). The high first-year survival rates are obtained when low values for both adult survival and clutch size are chosen. This case demonstrates what holds true for the rest of this analysis: wide ranges for pre-model distributions lead to wide ranges in parameters estimated from those distributions. The range of the pre-model distributions for mean adult survival rate reveals a life history strategy

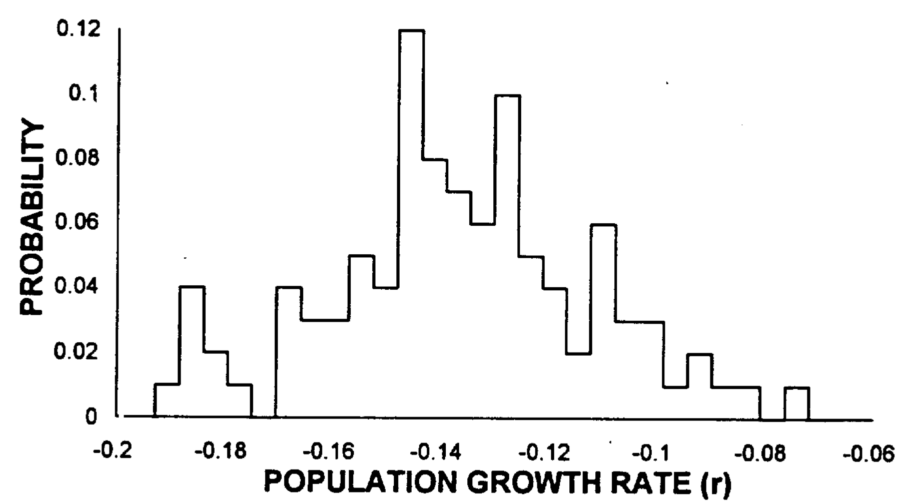

Figure III-2. Distribution of the growth rate (r) taken from the post-model distribution for r from the ground plot data (Appendix I). Only values which allowed single parameter changes to decrease growth rate from r = 0 were allowed. This distribution is slightly deficient in the expected number of values <-0.15 (compare to Figure I-2). This reflects the near impossibility of obtaining a high rate of decline simply by reducing recruitment.

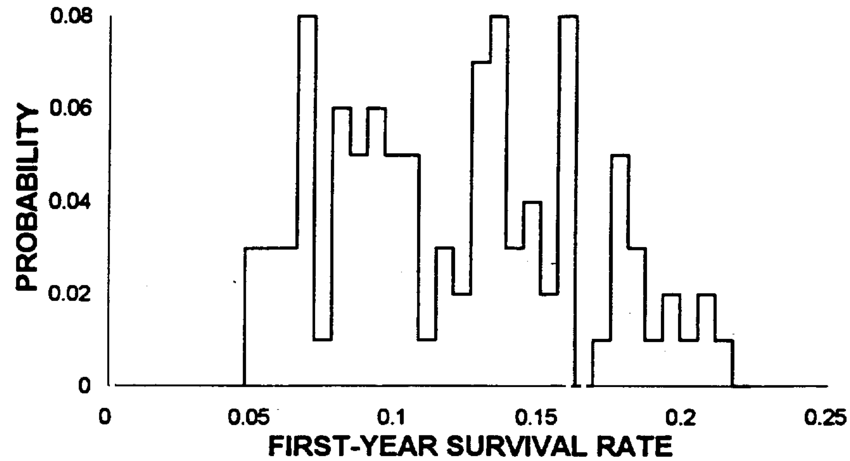

Figure III-3. The distribution of first-year survival rates which yield r = 0 given other randomly chosen demographic parameters. The rather large range of values is a result of rather wide pre-model distributions for adult survival rate and the distributions which yield fertility.

that appears to be quite flexible in Common Eiders. Scotland birds have the strategy of high adult survival coupled with low survival to fledging (Milne 1974). In a simultaneous study in the Netherlands (Swennen 1983), adults had lower adult survival coupled with higher survival to fledging.

If we assume first-year survival was the sole cause of decline, the post-model distribution (Figure III-4) reveals a moderate degree of overlap with the original distribution (Figure III-3). Only first-year survival rates less than 5%/year would identify this type of decline. A large proportion of the post-model distribution for adult survival (Figure III-5) is below the minimum survival rate of 0.75 of the pre-model distribution. It is interesting to note that preliminary estimates of adult survival on the YKD, 0.67-0.77 (J.B. Grand, pers. comm.), are well within the expected range if a reduction in adult survival was the sole cause of decline. Clutch size, on the other hand, shows almost no overlap with the pre-model distribution that had a minimum of 4.053 (Figure III-6). Even if addled eggs were subtracted from clutch size, reduced clutch size is not a viable hypothesis as the sole cause of the decline. Thus, even with very broad demographic pre-models, it is very unlikely that the decline could have been caused solely by a decrease in egg production. This is not a very startling conclusion since there has been a significant increase in clutch size during the decline (Stehn et al. 1993).

Generation time can be thought of as the average age of the parents of the offspring produced by a population at the stable age distribution (Caswell 1989). Recalling the different age structures in Figure III-1, we can guess that generation time is dependent on the population

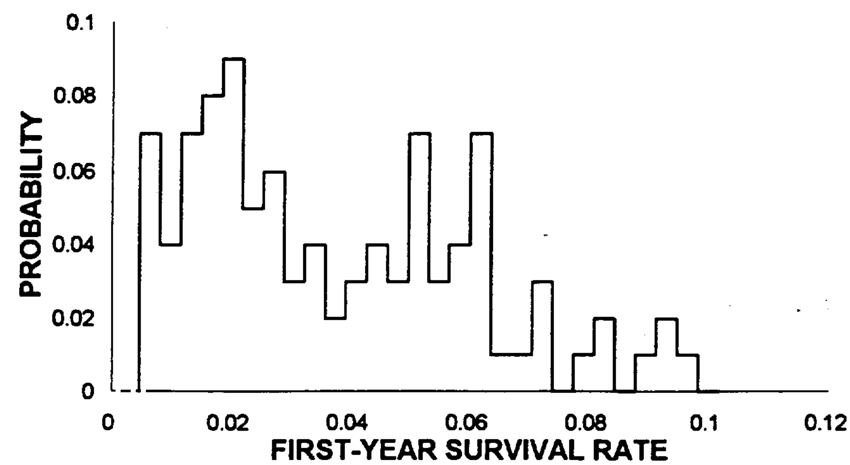

Figure III-4. The distribution of first-year survival rates assuming that the population decline was caused by a change in only first-year survival rates. Note that this distribution overlaps rather little with the distribution in Figure III-3.

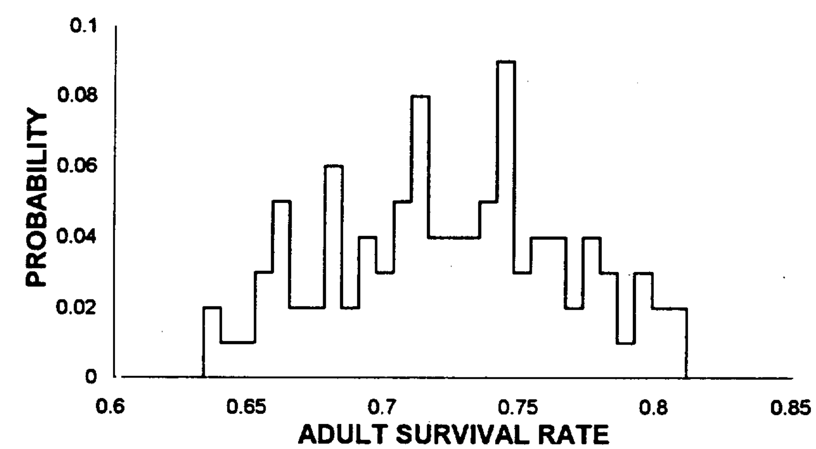

Figure III-5. The distribution of adult survival rates assuming that the population decline was caused by a change in only adult survival rates. Much of the distribution lies below 0.75 which was the minimum survival rate in the pre-model distribution.

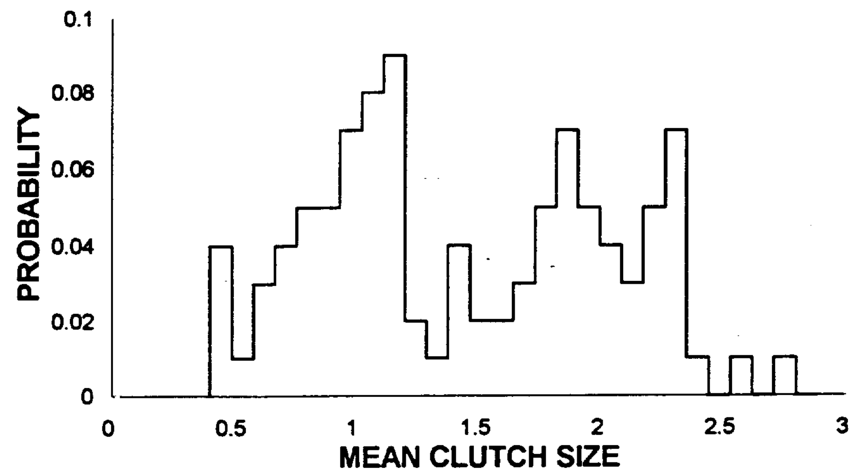

Figure III-6. The distribution of mean clutch size assuming that the population decline was caused by a change in only mean clutch size. Note that virtually all of this distribution lies below the minimum value in the pre-model distribution (2.5).

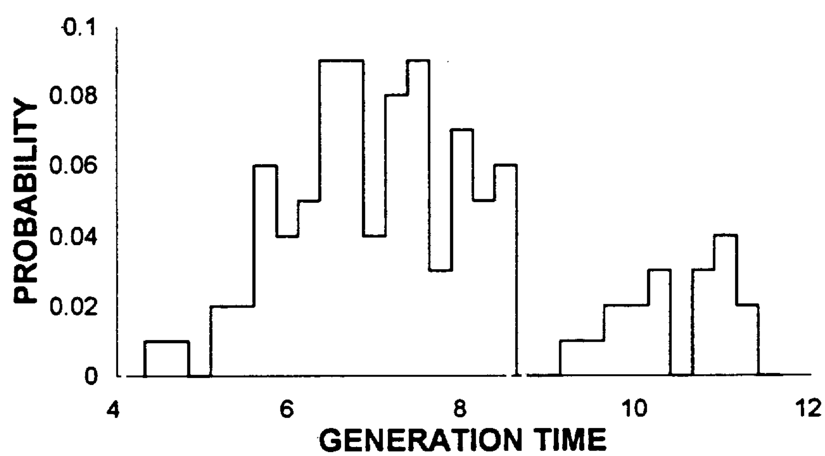

Figure III-7. The distribution of generation times for the 100 simulations of the declining population.

growth rate. Perhaps this can be more intuitively understood with a human example. The average age of parents in Sweden, a population which is declining slightly, is much older than the average age of parents in Mexico, a population growing at a rapid rate.

The distribution of generation times (using equation 5) for the declining YKD population (Figure III-7) averages 7.61 (s = 1.68). Generation time is often used as a unit of time in calculating probability of extinction (Appendix I).

$$T = \frac{\sum_{i=0}^{i=\omega-1} i \, e^{-ri} \, f_i \prod_{j=0}^{i-1} p_j}{\sum_{i=0}^{i=\omega-1} e^{-ri} \, f_i \prod_{j=0}^{i-1} p_j} \qquad (5)$$

Another way to view the broad combinations of demographic parameters possible given our current knowledge is by looking at a scatter plot of estimates of the parameters against growth rate (Figure III-8). We expect an increase in survival and/or birth rates with increasing growth rates. We observed that although expectations are met, there is a large scatter of possible values for any given growth rate. The large scatter in the range of clutch size as well as the greater amount of increase as growth rate increases is further evidence that this parameter has less of an effect on growth rates than do the other parameters.

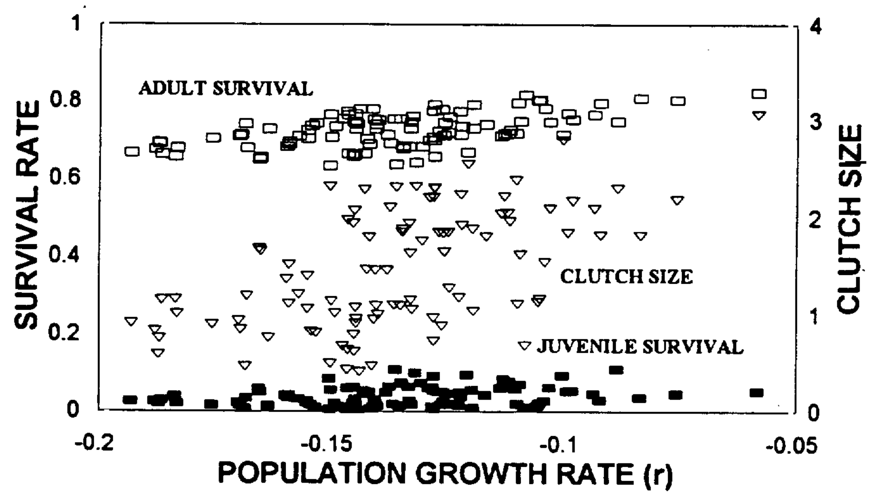

Figure III-8. Survival rates and mean clutch size plotted against the resulting growth rate (r). Symbols for the parameters are: adult survival--open square, clutch size--triangle, first-year survival--filled square.

How do the large number of demographic possibilities affect our ability to test hypotheses about the cause(s) of the decline? As mentioned, the proportion of new nesters could be used to determine whether adult survival or lack of recruitment was the primary cause of decline. Incorporating the uncertainty in parameters reduces our ability to detect differences between these alternatives (Figure III-9). Clearly, if the proportion new nesters/total nesters is greater than 0.22, then reduced adult survival is likely whereas if this proportion is less than 0.12, then reduced recruitment (either reduced fertility or reduced first-year survival) is the likely cause. Although there is some overlap between the distribution for reduction in adult survival and the distributions for reduced recruitment, it is anticipated that actual estimates from Spectacled Eiders will reduce the range for demographic parameters and tighten these distributions. Thus, it is still possible that the proportion of first-time nesters could be a useful diagnostic statistic.

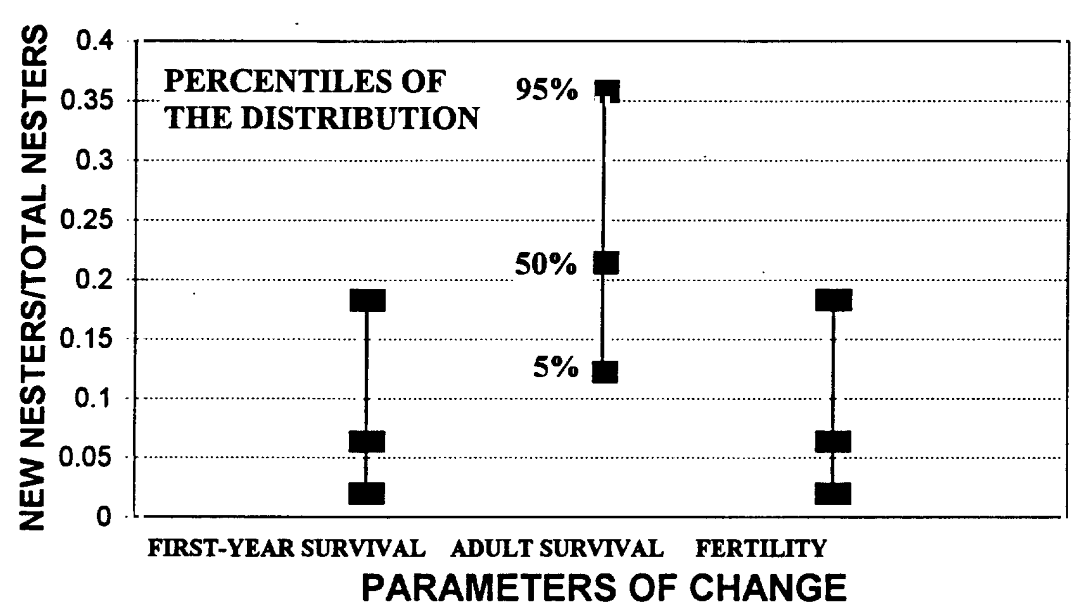

Figure III-9. The proportion of nesters which are first-time nesters, assuming the decline was caused by a reduction in: first-year survival only, adult survival only, and fertility only. The squares represent the following percentiles of the distributions: 5%, 50%, 95%. The percentiles are the same for first-year survival and fertility because both have the same effect on recruitment into the breeding population.

Despite large uncertainty in demographic parameters, the basic life history strategy of eiders is still quite clear (Figure III-10). Population growth is most sensitive to changes in adult survival, followed distantly by fertility and juvenile survival. Regardless of the cause of the decline, by far the fastest way to recovery is to increase adult survival. Therefore, efforts should be made to reduce predation (human or otherwise) on adults. To get equivalent results in increasing population growth by increasing juvenile survival will require enormous reductions in juvenile mortality.

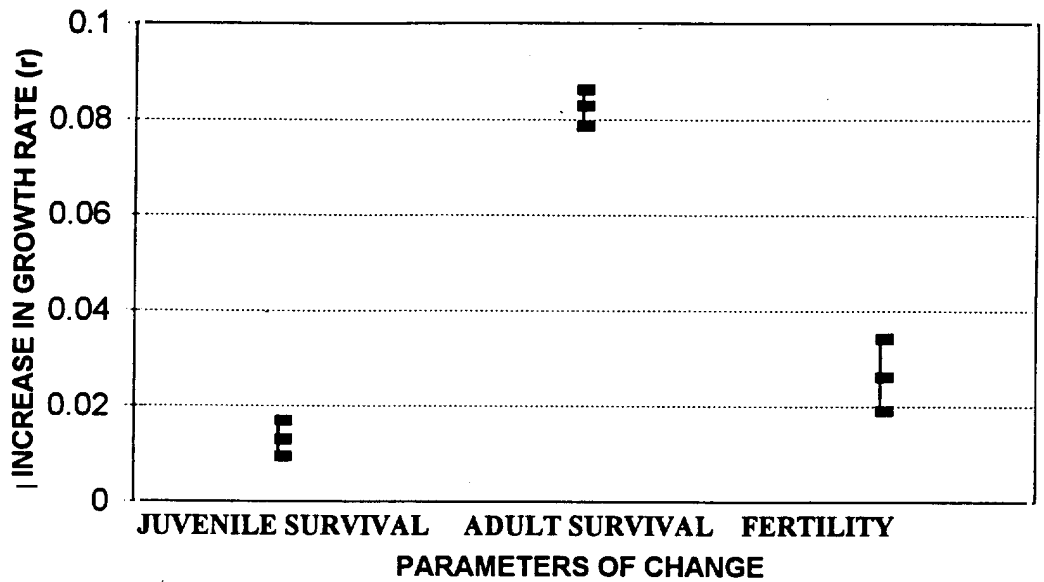

Figure III-10. Results of a demographic sensitivity analysis. Given a stable population (r = 0), the results give the population growth rate that would result from a 10% increase in: juvenile survival only, adult survival only, and fertility only. Growth rates are most sensitive to changes in adult survival rates: a 10% increase in adult survival results in about an 8% increase in population growth. An equivalent increase in juvenile survival rate results in <2% increase in r.

These results may appear discouraging but it must be remembered that they are entirely contingent upon very wide pre-model distributions based on another species. Data currently being gathered to estimate survival rates on the YKD cannot be used as data for pre-model distributions for r = 0. Once these data are available, the model presented here will have to be run in reverse: asking if increases in various survival or fertility factors lead to plausible values for survival or fertility when r = 0. Assessing what is plausible will either require use of selected data from other species or use of Spectacled Eider data from stable populations. Arctic Russia may offer an opportunity to study a stable population, but we are many years from being able to assess that possibility. At the current time, there are only a few lessons that can be learned from a demographic analysis. First, population growth rate is most sensitive to adult survival. If there is any possibility of increasing adult survival, it should be given high priority. Second, a low proportion of first time nesters (< 12%) indicates a lack of recruitment while a higher rate (> 22%) indicates reduced adult survival. Third, it is not likely that the decline was caused by decreased clutch size. Decreased fertility cannot be ruled out because of the lack of information on the proportion of adult females which nest in a given year.

LITERATURE CITED
APPENDIX III

Baillie S. R. and H. Milne. 1982. The influence of female age on breeding in the Eider *Somateria mollissima*. Bird Study 29:55-66.

Caswell, H. 1989. Matrix Population Models. Sinauer Associates, Inc. Sunderland, Massachusetts.

Cooch, F. G. 1986. The numbers of nesting Northern Eiders on the West Foxe Islands, NWT, in 1956 and 1976. in Eider ducks in Canada. ed. A. Reed. Canadian Wildlife Service, 1141 route de l'Église, Ste-Foy, Que, G1V 4H5. Pages 114-118.

Coulson, J. C. 1984. The population dynamics of the Eider Duck *Somateria mollissima* and evidence of extensive non-breeding by adult ducks. Ibis 126:525-543.

Franzmann, N. 1983. The migration and survival of an Eider *Somateria m. mollissima* population in the southern Baltic. Ornis Fennica, Suppl. 3:73-74.

Hario, M. and K. Selin. 1988. Thirty-year trends in an eider population: timing of breeding, clutch size, and nest site preferences. Finnish Game Res. 45:3-10.

Milne, H. 1974. Breeding numbers and reproductive rate of eiders at the sands of Forvie National Nature Reserve, Scotland. Ibis 116:135-154.

Reed, A. 1975. Migration, homing, and mortality of breeding female Eiders *Somateria mollissima dresseri* of the St. Lawrence estuary, Quebec. Ornis. Scan. 6:41-47.

____________. 1983. Eider ducks in Ungava Bay: Case history of a joint research project by the Inuit and government. First Western Hemisphere Waterfowl and Waterbird Symposium, Hugh Boyd, ed., pgs. 60-61.

____________. and A. J. Erskine. 1986. Populations of the Common Eider in eastern North America: their size and status. In A. Reed (ed.). Eider ducks in Canada. Canadian Wildlife Service, 1141 route de l'Église, Ste-Foy, Que, G1V 4H5. Pages 156-162.

Stehn, R. A., C. P. Dau, B. Conant, and W. I. Butler, Jr. 1993. Decline of Spectacled Eiders nesting in western Alaska. Arctic 46:264-277.

Swennen, C. 1972. Chlorinated hydrocarbons attacked the Eider population in the Netherlands. T.N.O.-nieuws. 27:556-560.

____________. 1983. Reproductive output of Eiders *Somateria m. mollissima* on the southern border of its breeding range. Ardea 71:245-254.

Wakely J. S. 1973. An analysis of banding and recovery data for the American Eider (*Somateria mollissima dresseri*). unpublished Masters thesis, University of Maine at Orono.

____________. and H. L. Mendall. 1976. Migrational homing and survival of adult female Eiders in Maine. J. Wildl. Manage. 40(1):15-21.

PERSONAL COMMUNICATION CITATIONS

J. Barry Grand, Alaska Science Center, National Biological Service, Anchorage, AK.

APPENDIX IV

SPECTACLED EIDER RECOVERY PLAN

GUIDANCE FOR PROJECT PLANNING AND SECTION 7 CONSULTATION FOR ACTIVITIES WITHIN THE BREEDING RANGE OF SPECTACLED EIDERS

U.S. Fish and Wildlife Service, Alaska
March 1996
Page 1 of 2

These guidelines are intended to assist federal agencies and project applicants (50 CFR 402.02) in planning projects that are within the breeding range of Spectacled Eiders (*Somateria fischeri*). Section 7(a)(2) of the Endangered Species Act of 1973, as amended, requires federal agencies to consult with the U.S. Fish and Wildlife Service (Service) on any project they authorize, fund, or carry out that may affect listed species, including Spectacled Eiders. All projects within the historical breeding range of Spectacled Eiders should be evaluated for their potential to affect Spectacled Eiders. In some cases, consultation with Service biologists regarding specific projects may result in less restrictive measures than those outlined in the guidelines if available information indicates that compliance with the guidelines is not necessary to avoid impacts to Spectacled Eiders, or more restrictive measures if guidelines do not provide adequate protection.

These guidelines apply to all activities within the historical breeding range of Spectacled Eiders which includes coastal areas of Alaska from the Yukon-Kuskokwim Delta to the Yukon Territory Border (see Figure 1 of the Recovery Plan). Eiders are present on the breeding grounds as early as mid-May through as late as mid-September, but activities during any time of the year have the potential to adversely affect Spectacled Eiders through habitat modification. Eiders are most vulnerable to disturbance during nesting; disturbance may cause a female to flush from the nest, leaving the eggs vulnerable to predation, or may cause nest abandonment. Female Spectacled Eiders may return to the same general area to breed each year, but they do not typically use the same nest site. Protecting previously used nest sites will not, therefore, adequately protect nesting Spectacled Eiders in the current year. If project activities take place during the breeding season, ground surveys for nest sites must be conducted in the year of construction, before the initiation of activities, to locate any nests in the project area. The consensus among biologists who have studied Spectacled Eiders during the breeding season is that a 200m buffer around nest sites is adequate to avoid impacts to nesting eiders.

Information on habitat preferences and use patterns, vulnerability to disturbance, and habitat availability is lacking for Spectacled Eiders. It is therefore difficult to develop specific guidelines which will apply to all project activities; projects should be reviewed on a case-by-case basis to evaluate the likelihood of adverse impacts to Spectacled Eiders.

These guidelines will be reviewed annually and updated when relevant new information becomes available.

A. Habitat in the project area must be assessed to determine if Spectacled Eiders are likely to use the area for nesting or brood rearing (see pages 24 and 25 of the Recovery Plan for habitat descriptions). If project activities are conducted during the breeding season, Service-approved surveys for Spectacled Eiders must be conducted in the year of construction, prior to initiation of such activities.

B. The following activities may adversely affect Spectacled Eiders, and therefore require formal consultation with the Service. If they are prohibited, however, within 200m of nest sites, it is unlikely that the project will adversely affect Spectacled Eiders.

1. Ground level activity (by vehicle or on foot) from 20 May through 1 August, except on existing thoroughfares.

2. Construction of permanent facilities, placement of fill, or alteration of habitat.

3. Introduction of high noise levels within 200m of nest sites (from activities at potentially greater distances), 20 May through 1 August. These may include but are not limited to: airports, blasting, and compressor stations.

For more information about spectacled eiders or the Endangered Species Act, or to initiate section 7 consultation with the Service regarding specific project plans, please contact:

Endangered Species, Ecological Services
U.S. Fish and Wildlife Service
Region 7 (Alaska)

Fairbanks Field Office
907-456-0239
For projects north of the Alaska Range, (except the Seward Peninsula).

Anchorage Field Office
907-271-2888 / 1-800-272-4174
For projects south of the Alaska Range, or on the Seward Peninsula, St. Lawrence Island, or Pribilof Islands.

Juneau Field Office
907-586-7240
For projects south of Icy Bay

APPENDIX V

COMMENTS RECEIVED ON DRAFT SPECTACLED EIDER RECOVERY PLAN

The U.S. Fish and Wildlife Service (Service) received comments on the Draft Spectacled Eider Recovery Plan from the following parties: BP Exploration (Alaska) Inc.; Phillips Petroleum Company; and ARCO, Alaska, Inc. Comments, attached as part of this appendix, were addressed in two ways: first, comments on format, style, or grammar were considered and incorporated if they improved the document without compromising content or clarity; second, comments on content were incorporated where appropriate and are addressed individually below. In general, commenters expressed approval of the document, and encouraged the Service to continue efforts to recover this species.

1. BP Exploration (Alaska) Inc:
This commenter encouraged the Service to "continue to base its assessments on the best scientific information available and to work closely with native communities, industry and other interested governmental authorities to ensure that data sets are integrated and that remedial or corrective action aimed at properly managing spectacled eider populations has the desired effect."

The Service concurs that these are essential considerations and is committed to working closely with all affected parties toward recovery of spectacled eiders. The Endangered Species Act of 1973, as amended, requires the Service to use the best available scientific and commercial information when making determinations for listing species as threatened or endangered. The best available information was used in developing the recovery plan for spectacled eiders, and will continue to be used in implementation of the plan.

2. Phillips Petroleum Company:
Phillips Petroleum urged the Service to "take extreme caution to assure that any actions resulting from...studies which might restrict or further restrict oil and gas development or exploration activities [are] carefully considered."

The Service carefully considers the likelihood of adverse effects to any listed species as a result of any federally funded, permitted, or conducted activities under the authority of section 7 of the Endangered Species Act of 1973 (Act). If the activity may adversely affect a listed species, formal consultation with the Service is required. Although there may be some changes to project plans as a result of section 7 consultation, in most cases, project changes are not likely to significantly restrict the action. The Service is committed to maintaining an excellent working relationship with industry representatives in Alaska while fulfilling obligations under the Act to protect spectacled eiders.

3. ARCO, Alaska, Inc:
This reviewer was disappointed that the recovery plan did not elaborate on management guidance for North Slope oil fields, and encouraged the Service to update the recommended protection measures for spectacled eiders during the breeding season (appendix IV).

The recommended protection measures are intended as general guidelines. Implementation of these guidelines varies with each project depending on timing of construction, habitat type, available survey information, and other factors. The Service strives to limit impacts to projects as much as possible while providing adequate protection to spectacled eiders. Changes were made in the draft guidelines to address some of the concerns raised by this commenter, and the Service will review the guidelines annually and update them as necessary. In addition, the recovery plan calls for preparation of summary reports on industrial development on the North Slope and on human disturbance. Further changes to the recommended protection measures will be considered when those reports are completed.