Species Status Summary and Information Needs

Sea Duck Joint Venture, June 2016

Spectacled Eider (*Somateria fischeri*)

Population Size and Trends: All Spectacled Eider breeding populations were listed as threatened on May 10, 1993 because of documented population declines. The Yukon-Kuskokwim Delta population declined by >90% between the 1970s and early 1990s. In 1971, the estimated number of breeding pairs was 50,000 with up to 70,000 pairs in high productivity years (Dau and Kistchinski 1977) but by 1992, there were only 1721 nesting pairs, a decline of 14% annually (Stehn et al. 1993). Anecdotal information indicated that populations in the other two primary breeding areas, the Russian and Alaskan Arctic Coastal Plains, also declined, along with the much smaller breeding population on St. Lawrence Island in the Bering Sea. Annual aerial surveys for breeding population trend have been developed for the two North American breeding subpopulations.

A ground-based nest survey is used in conjunction with aerial survey indices to provide an annual estimate of the Yukon-Kuskokwim Delta population. The total 2013 nest estimate for the Yukon-Kuskokwim Delta coastal zone was 5,435 and the average nest estimate during 2004-2013 was 5,617 (95% CI: 4,706-6,528; Fischer and Stehn 2015). The 2014 aerial survey estimate was 13,822 birds and the long-term (1988-2013) average population estimate was 12,358 (Platte and Stehn 2015). The ground nest survey indicates a stable population, with an average annual growth rate in number of nests of 1.000 (90% CI: 0.988-1.013) during 1985-2013 and 1.025 (90% CI: 0.977-1.975) during 2004-2013 (Fischer and Stehn 2015). The indicated total bird index from aerial surveys showed a population growth rate of 1.065 (90% CI: 1.056-1.075) during 1988-2014 and 1.040 (90% CI: 1.020-1.060) during 2005-2014 (Platte and Stehn 2015). The aerial and ground-based surveys, initiated in 1985, are considered to be much more useful in conjunction than either one would be singly (Platte and Stehn 2015).

A waterfowl breeding population survey was conducted on the Arctic Coastal Plain of Alaska (ACP Survey) from 1986-2006 in late June-early July, too late in the season to provide accurate estimates for eiders. The North Slope Eider Survey covered a much smaller area, but was used to assess and monitor distribution and abundance of Spectacled and Steller's eiders from 1992-2006. Beginning in 2007, both surveys were combined, with a study area similar to the 1986-2006 ACP survey but timing as in the 1992-2006 NSE Survey (Larned et al. 2012a). The average indicated total bird index during 1992-2012 was 7,158 (90% CI: 6,536-7,781) and during 2003-2012 was 6,933 (90% CI: 5,915-7,950) (Stehn et al. 2013). Using nest:pair ratios calculated from ground and aerial surveys on the Yukon-Kuskokwim Delta, the ACP average breeding estimate for 2003-2012 was 7,407 nests or 14,814 paired birds (SE = 798, 90% CI: 13,501-16,128;Stehn et al. 2013). The 1986-2012 average annual growth rate in the ACP indicated total bird index was 0.990 (90% CI: 0.997-1.003) and for 2003-2012 it was 0.976 (90% CI: 0.932-1.023) (Stehn et al. 2013). The North Slope was estimated to have over 33,000 birds present in the fall (Stehn et al. 2006 in BOEM 2010)

A single aerial survey, conducted over a 4-year period, provided a population index of 146,245 birds for the Arctic Russia breeding population (Hodges and Eldridge 2001). Winter surveys of the only known wintering area of this species (presumed to represent the world population) provided a total species estimate of 363,030 in 1996-1997 and 374,792 in 1998. Based on a combination of visual counts and photographs, the wintering population was estimated at 305,261 in 2009 and 369,122 in 2010 (Larned et al. 2012b). The 2009 count was likely biased low, as it was late in the season and some individuals had already begun to migrate northward (Larned et al. 2012b).

Based on nest survey data, the Yukon-Kuskokwim Delta subpopulation is close to benchmark criteria for consideration of delisting from threatened status; however, delisting requires that all three populations meet the benchmark criteria (Fischer and Stehn 2015).

Priority Information Needs:

1. Western Alaska breeding population size and trend estimates. Continue the *Yukon-Kuskokwim Delta Nest Plot Survey* and *Aerial Breeding Pair Survey* used together to provide a nest population estimate.
2. Global population size form wintering area. Repeat the survey of the wintering area (last conducted in 2010).
3. Northern Alaska breeding population size and trend. Continue the *Arctic Coastal Plain Survey*.
4. Arctic Russia breeding population size and trend. Conduct periodic breeding pair surveys of Russia breeding habitats.
5. Visibility correction factor for aerial survey indices (for Western and Northern Alaska breeding areas)
6. Re-analysis of the Bayesian model from the 1996 recovery plan using recent abundance and trend data for northern and western populations to determine current species status.

Population Delineation: From the single known wintering area in the northern Bering Sea, most Spectacled Eiders staged in nearshore areas of the western Bering Sea during spring migration, then dispersed to secondary staging locations closer to each of the three main breeding areas (Russia Arctic Coastal Plain, Alaska Arctic Coastal Plain, and Yukon-Kuskokwim Delta;Sexson et al. 2014). Adult females staged in the eastern Chukchi Sea and migrated to breeding areas in northern Alaska but males staged in the eastern Chukchi and migrated to northern Russia; females staged briefly in the Beaufort Sea en route to inland nesting areas in Alaska (Sexson et al. 2014).

During post-breeding migration, the eastern Chukchi Sea (including Ledyard Bay) was used exclusively by birds departing from northern Alaskan breeding areas while Norton Sound was used exclusively by birds departing from the Yukon-Kuskokwim Delta (Sexson et al. 2014). From western Alaska, 45 of 46 radio-tagged females molted in Norton Sound but most males migrated to western Bering Strait or East Siberian Sea. From the western Beaufort Sea, all females molted in eastern Chukchi Sea but males migrated to eastern Chukchi Sea, East Siberian Sea or western Bering Strait (Sexson et al. 2014).

Females showed high return rates to breeding areas in Alaska, and for females captured on nests, 98% of on-land locations in the following year were within 10 km of initial nest site (Sexson et al. 2014). Conversely, males that were marked on breeding areas in Alaska were likely to disperse to Russia in subsequent breeding seasons but males that used breeding areas in eastern Siberia were likely to return to that region in subsequent years (Sexson et al. 2014). Both sexes showed high return rates to molt sites and there appeared to be complete inter-annual fidelity to the north Bering Sea wintering area for all sex and age classes (Sexson et al. 2014). Migration data for adult males and females that breed in Russia and for juveniles that originate from western Alaska and Russia is lacking (Sexson et al. 2014)

Genetic analysis indicated the presence of three distinct breeding populations: Yukon-Kuskokwim Delta, Alaska Arctic Coastal Plain, and Russia (Indigirka River Delta; Scribner et al. 2001). This analysis also indicated that female philopatry is likely high, but with a greater rate of female gene flow between the Alaska Arctic Coastal Plain and Russia than either of those areas has with the Yukon-Kuskokwim Delta (Scribner et al. 2001).

Priority Information Needs:

1. Updated genetic analysis to better characterize the genetic population structure. Re-analysis of the 2001 study by Scribner et al. with larger sample sizes for each breeding area.

<u>Population Dynamics</u>: Survival data are mostly derived from site-specific studies of the Yukon-Kuskokwim Delta breeding population and may not be representative of the entire region. A breeding ecology study has been initiated near Barrow, in conjunction with a Steller's eider study. In 2012, Mayfield nest survival probability was estimated at 0.43 (95% CI: 0.17-0.67) with an average of 4.5 (± 0.3) ducklings hatched per successful nest and inviable eggs found in 0% of active nests (Safine 2013). Nesting females were marked with VHF transmitters and broods followed until mortality or fledging; daily brood survival rate was estimated to be 0.997 ± 0.003 and brood survival probability was 0.86 (95% CI: 0.34-0.98; Safine 2013). In the Colville River Delta, nest survival was 0.31 and brood size showed no detectable decline (i.e., low duckling mortality) from about July 10 (hatch) to mid-August (Bart and Earnst 2005). On the Yukon-Kuskokwim Delta, average duckling survival to 30 days was estimated to be 67% on Kigigak Island and 45% on the Kashunuk River with most mortality occurring in the first 10 days after hatch (Flint et al. 2006).

During winter surveys, the sex ratio (after-hatch-year females/after-hatch-year males) was 0.84 in 2009 and 0.74 in 2010 (Larned et al. 2012b). Productivity was measured using two indices; the hatch-year male/after-hatch-year male ratio was 0.052 in 2009 and 0.08 in 2010 while the (hatch-year male + hatch-year female)/after-hatch-year female ratio was 0.13 in 2009 and 0.24 in 2010 (Larned et al. 2012b).

Priority Information Needs:

1. Annual survival of western Alaska breeding birds. Capture and mark adult female Spectacled Eiders nesting on Kigigak Island, Yukon Delta NWR to estimate annual survival.

2. Productivity and recruitment estimates. Nest monitoring for Spectacled Eiders on Yukon Delta NWR (Kigigak Island and USFWS refuge-wide nest plots).
3. Estimate annual survival of Spectacled Eiders on the North Slope.
4. Conduct productivity and survival study of Spectacled Eiders in Arctic Russia comparable to the study conducted at Kigigak Island, Yukon- Kuskokwim Delta.

Population Ecology: Ecological characteristics of breeding areas in Alaska have been characterized, but ecological relationships of eiders to molting and wintering areas are less studied or unknown. Near Barrow, video monitoring of sea duck nests (Steller's, Spectacled and King eiders and Long-tailed Ducks) revealed predation primarily by jaegers (Parasitic and Pomarine), Glaucous Gulls, Snowy Owls and Arctic Fox (Safine 2013, 2015). On the Yukon-Kuskokwim Delta, higher apparent duckling growth rates corresponded with higher survival rates (Flint et al. 2006). Brood-rearing areas with higher salinity levels may have negatively affected early duckling growth and survival, perhaps due to decreased invertebrate availability and/or direct physiological effects on ducklings (Flint et al. 2006). Poorer foraging conditions may increase susceptibility to predation and recruitment may be limited by availability of high-quality brood-rearing habitat (Flint et al. 2006).

Based on analysis of various data sets, annual breeding population estimates for Spectacled Eiders in western Alaska appeared to be negatively affected by extended periods of dense sea-ice concentration and weather conditions during the previous winter, while changes in the benthic community on wintering grounds did not appear to have caused the observed population decline (Petersen and Douglas 2004). Breeding propensity and/or success likely depend on reserves accumulated prior to arrival at breeding areas, and in years when access to benthic feeding areas is limited by dense sea ice, it may be difficult for Spectacled Eiders to build sufficient reserves before leaving wintering areas (Cooper et al. 2013).

Use of wintering habitat appears to vary between adults and juveniles (first-winter). Juveniles from the northern Alaska breeding area migrated with adult females to offshore areas in the western Beaufort Sea, but then adult females left prior to offspring, and juveniles stayed in the Beaufort until late September-early October (Sexson et al. 2014). Most juveniles migrated to the eastern Chukchi Sea then the western Bering Sea with widespread movements, as far south as the Alaska Peninsula, before settling on the wintering area in the northern Bering Sea (Sexson et al. 2014). In early winter, juveniles were more widely distributed across the Bering Sea than were adults (Sexson et al. 2014) and within the main wintering location, they appeared to be concentrated within "brood flocks" (Larned et al. 2012b).

Priority Information Needs:

1. Explore hypothesis that sub-adults winter separately from adults.
2. Investigate competition with walrus in Ledyard Bay.
3. Evaluate factors affecting duckling growth and survival, including the effects of pond salinity.

4. Determine cause and population effects of egg inviability
5. Threats and population drivers in western and northern Alaska.

Habitat Requirements: Locations of major breeding, staging, molting and wintering areas in Alaska and Russia have been identified, and include the western Beaufort Sea, eastern Chukchi Sea, East Siberian Sea, western Bering Strait, Norton Sound, Yukon-Kuskokwim Delta and northern Bering Sea (Sexson et al. 2014). Physical characteristics of breeding areas in Alaska have been characterized, but characteristics of molting and wintering areas are less studied or unknown.

Near Barrow, ducklings mainly used deep open or *Arctophila* ponds or shallow *Carex* ponds which were, on average, ~700 m long and ~40 cm deep, with 20% coverage of emergent vegetation and salinity <0.5 ppt (Safine 2013). On the Colville River delta, they were found to prefer wetlands with islands and peninsulas and water depth >1 m (Bart and Earnst 2005).

Critical habitat for molting Spectacled Eiders was designated in Norton Sound and Ledyard Bay, Alaska in 2001, and nesting and wintering habitat in other areas. The Ledyard Bay Critical Habitat Unit (LBCHU) includes waters up to 40 nm from shore, excluding a 1 nm wide strip along the shoreline (BOEM 2010). Most Spectacled Eiders molting in this area were located ~10-20 nm offshore and many remain in the area until late October to mid-November when ice formation causes them to leave (Petersen et al. 1999). Spring lead systems in the pack ice are often used during migration from wintering areas, and the LBCHU often provides the only open water along the migration route (BOEM 2010). Mechigmenskiy Bay and the Indigirka/Kolyma deltas in Russia are molting areas that are also used by males that breed in Alaska (Petersen et al. 1999).

Virtually the entire global population winters in the Bering Sea near St. Lawrence Island, in a 2,900 km^2 area, with a core area of only 570 km^2 (Petersen and Douglas 2004). Based on satellite telemetry locations, mean water depth of the occupied wintering area was 42±13 m and the maximum amount of time spent there was 9 months (late September to late May) (Cooper et al. 2013). The core use area shifts during the winter, from an area about 45 km southwest of St. Lawrence Island in October-November to an area 70 west-southwest of the island for the remainder of the winter (Cooper et al. 2013). This pattern remained similar during 2008-2011, but did not appear to be caused by either sea ice formation or prey depletion (Cooper et al. 2013). However, distribution of eiders is strongly affected by the formation of movement of sea ice in winters with heavy ice cover (Cooper et al. 2013). The primary use area changed from 1993-1997 to 2008-2011, shifting ~50 km northeast (Cooper et al. 2013). This shift may have been related to changes in prey species, distribution and density, indicating the potential for designated protected areas to become ineffective (Lovvorn et al. 2009). Energy consumption models indicate that availability of sea ice for roosting is an important factor in their thermoregulatory strategy and that if sea ice were absent, Spectacled Eiders may not be able to survive in the current wintering area (Lovvorn et al. 2009). Conversely, if prevailing winds close leads in the pack ice, access to areas with high densities of bivalve prey may be restricted; in 2009, most of the wintering area was covered by pack ice, and body fat was 33-35% lower than in 2001 (Lovvorn et al. 2014).

Recent offshore oil and gas lease sales in the Chukchi Sea warrant further investigation of the potential impacts to eiders in that area. Oil and gas exploration and development could have negative impacts caused by disturbance, or mortality by collision and oil/toxic pollution (BOEM 2010). Activity in the LBCHU could result in physical modification of seafloor habitats, leading to decreased use by molting Spectacled Eiders (BOEM 2010). Potential breeding habitat availability in 2040 was modeled under differing climate projections and oil and gas development scenarios on the Arctic Coastal Plain and potential breeding distribution was predicted to increase under both climate scenarios used (Fuller et al. 2008). However, climate change is resulting in reduction in ice cover during winter and an increase in storm frequency and saltwater intrusion into coastal breeding habitats.

Priority Information Needs:

1. Characterize locations and use of marine habitats, especially in the Chukchi Sea.
2. Evaluate and reduce impacts from oil and gas activities on Spectacled Eiders in the Chukchi Sea, particularly in Critical Habitat in Ledyard Bay.
3. Evaluate and predict effects of environmental change in marine habitats and breeding areas on Spectacled Eiders.
4. Develop technique and identify information needs for evaluating cumulative effects of human development on Spectacled Eiders.

Harvest Assessment: Hunting of Spectacled Eiders is illegal, although a few are taken illegally or incidentally by subsistence hunters. The hunting season was closed in Alaska in 1991, after a petition was filed to list under the Endangered Species Act (Rothe et al. 2015). Although hunting of Spectacled Eiders is illegal, a few are taken illegally or incidentally by subsistence hunters. Spectacled Eider wings have never been recorded in the USFWS parts collection survey since it was initiated in Alaska in 1965, so estimates of harvest by sport hunters are non-existent (Rothe et al. 2015).

Subsistence harvest surveys are conducted annually for the western Alaska breeding population and harvest surveys of the North Slope breeding population have been initiated. Subsistence harvests on the Yukon-Kuskokwim Delta averaged 222/year during 1990-1994, 112/year during 1995-2000 and 37/year during 2001-2005 (Wentworth 2007a). In Bristol Bay, mean estimates were 91/year from 1995-2000 and 59/year from 2001-2005 (Wentworth 2007b). The Alaska Migratory Bird Subsistence Harvest Estimates for the annual harvest in 2009 were 225 birds on the Yukon-Kuskokwim Delta, 144 birds in Bering Strait-Norton Sound, and 392 birds on the North Slope, with no eggs taken in any areas (Naves 2011). During the fall-winter and spring hunts, much of the Alaskan harvest may be comprised of Spectacled Eiders that breed in Russia (Rothe et al. 2015).

Comprehensive harvest survey data are not available for Russia. Subsistence harvest surveys in Russia in 1999 and 2002-2005 (22 villages in Chukotka and Yakutia) reported harvest of 6,781Spectacled Eiders (Syroechkovski and Klokov 2009 in Baldassare 2014). These data were used to estimate an annual harvest of 10,000-14,000, with the largest harvests occurring on the Indigirka River delta and the Chukchi Peninsula (Syroechkovski and Klokov 2009 in Baldassare

2014). An estimated 700-1,500 were killed annually in the Yana River Delta by hunters from just four villages (Syroechkovski and Zockler 1997).

Priority Information Needs:

1. Reliably quantify the take of Spectacled Eiders throughout their range. Develop a subsistence harvest monitoring program with the appropriate evaluation instrument..
2. Evaluate and reduce impacts of commercial fishing on Spectacled Eiders in the Bering Sea, particularly in Critical Habitat south of St. Lawrence Island.

Parasites, Disease, Contaminants: In Alaska, the avian influenza virus seroprevalence rate was ~90% for Spectacled Eiders, but only 0.34 – 5% of the population tested positive for the actual virus (Wilson et al. 2013, Ip et al. 2008). Serologic evidence of reovirus and infectious bursal disease virus exposure have been detected as well as infection by *Plasmodium* sp. and *Leucocytozoon* sp, but population-level effects are unknown (Hollmen and Franson 2015). Spectacled Eiders have proven to be susceptible to aspergillosis in captivity.

Lethal and sublethal levels of lead poisoning from ingested lead shot have been documented for the Yukon-Kuskokwim Delta breeding population, and are sufficient to influence regional subpopulation dynamics (Flint et al. 2016). Negative effects on adult female survival may have contributed to population declines (Grand et al. 1998). Heavy metal concentrations (e.g., cadmium), have been found above background levels in Spectacled Eiders. In adults and ducklings captured in the Prudhoe Bay Oil Field, Alaska, selenium exceeded background levels in all adults and 75% of ducklings, mercury was detected in all adults and 42% of ducklings, barium was detected in 44% of adults and 25% of ducklings, 74% of adults had detectable levels of cadmium, and lead concentrations were above the clinical toxicity threshold in one duckling and two adult females (Wilson et al. 2004). In adult females, mercury concentrations increased during the breeding season while barium and selenium levels decreased (Wilson et al. 2004). Spectacled Eiders had exceptionally high concentrations of selenium (in livers) and cadmium (in kidneys) during late winter but there were no apparent negative effects on health and no indication that these high levels affected total body fat or protein (Lovvorn et al. 2013). High levels of these elements may be due to inherent physiological tendency to accumulate these elements, combined with high food intake and high concentrations in food web due to oceanic and atmospheric conditions (Lovvorn et al. 2013).

Priority Information Needs:

1. Continue monitoring Spectacled Eider blood lead levels in areas where information is lacking, such as the North Slope and Russia, and monitor lead levels periodically throughout the range of the eider.
2. Continue studies to increase understanding of the incidence and impact of diseases on eiders.
3. Monitor the use of lead shot by checking hunters and local stores for availability of lead shot.
4. Determine physiological effects of disease and contaminants (e.g., selenium, copper, and cadmium) on Spectacled Eiders.

5. Explore options for reducing the availability of, or contact with, lead already in the environment.

Literature Cited

Baldassare, G. A. 2014. Ducks, Geese, and Swans of North America. John Hopkins University Press, Baltimore, MD. 1027 pp.

Bart, J. and Earnst, S.L., 2013. Breeding ecology of Spectacled Eiders *Somateria fischeri* in Northern Alaska. Wildfowl 55: 83-98.

Bureau of Ocean Energy Management. 2010. Chukchi Sea Planning Area Oil and Gas Lease Sale 193: Draft Supplemental Environmental Impact Statement. Office of Leasing and Environment, Alaska OCS Region. 140 pp + appendices.

Cooper, L.W., Sexson, M.G., Grebmeier, J.M., Gradinger, R., Mordy, C.W. and Lovvorn, J.R., 2013. Linkages between sea-ice coverage, pelagic–benthic coupling, and the distribution of spectacled eiders: Observations in March 2008, 2009 and 2010, northern Bering Sea. Deep Sea Research Part II: Topical Studies in Oceanography 94: 31-43.

Dau, C. P. and S. A. Kistchinski. 1977. Seasonal movements and distribution of the spectacled eider. Wildfowl 28: 65-75.

Fischer, J. B. and R. A. Stehn. 2015. Nest population size and potential production of geese and spectacled eiders on the Yukon-Kuskokwim Delta, Alaska, 1985-2014. Unpublished report. U.S. Fish and Wildlife Service, Anchorage, AK. 54 pp.

Flint, P.L., Morse, J.A., Grand, J.B. and Moran, C.L. 2006. Correlated growth and survival of juvenile Spectacled Eiders: Evidence of habitat limitation? Condor 108(4): 901-911.

Flint, P.L., J. B. Grand, and M. R. Petersen. 2016. Effects of lead exposure, environmental conditions, and metapopulation processes on population dynamics of spectacled eiders. North American Fauna 81:1-41.

Fuller, T., D. P. Morton, and S. Sarkar. 2008. Incorporating uncertainty about species' potential distributions under climate change into the selection of conservation areas with a case study from the Arctic Coastal Plain of Alaska. Biological Conservation 141: 1547-1559.

Grand, J. B., P. L. Flint, M. R. Petersen, and C. L. Moran. 1998. Effect of lead poisoning on spectacled eider survival rates. Journal of Wildlife Management 62: 1103-1109.

Hodges, J. I. and W. D. Eldridge. 2001. Aerial surveys of eiders and other waterbirds on the eastern Arctic coast of Russia. Wildfowl 52:127-142.

Hollmen, T. E. and J. C. Franson. 2015. Infectious diseases, parasites, and biological toxins in sea ducks. *In* J.-P.L. Savard, D.V. Derksen, D. Esler and J.M. Eadie (editors). Ecology and conservation of North American sea ducks. Studies in Avian Biology, CRC Press, New York, NY.

Ip, H. S., P. L. Flint, J. C. Franson, R. J. Dusek, D. V. Derksen, R. E. Gill Jr, C. R. Ely, J. M. Pearce, R. B. Lanctot, S. M. Matsuoka, D. B. Irons, J. B. Fischer, R. M. Oates, M. R. Petersen, T. F. Fondell, D. A. Rocque, J. C. Pedersen and T. C. Rothe. 2008. Prevalence of influenza A viruses in wild migratory birds in Alaska: patterns of variation in detection at a crossroads of intercontinental flyways. Virology Journal 5(71).

Larned, W. W., R. S. Stehn, and R. M. Platte. 2012a. Waterfowl breeding population survey, Arctic Coastal Plain, Alaska 2011. Unpublished report. U.S. Fish and Wildlife Service, Waterfowl Management Branch, Soldotna and Anchorage, AK. 50 pp + appendix.

Larned, W., K. Bollinger, and R. Stehn. 2012b. Late winter population and distribution of spectacled eiders (*Somateria fischeri*) in the Bering Sea, 2009 and 2010. Unpublished report. U.S. Fish and Wildlife Service, Anchorage, AK. 23 pp.

Lovvorn, J.R., J. M. Grebmeier, L. W. Cooper, J. K. Bump, and S. E. Richman. 2009. Modeling marine protected areas for threatened eiders in a climatically changing Bering Sea. Ecological Applications 19(6): 1596-1613.

Lovvorn, J.R., M. F. Raisbeck, L. W. Cooper, G. A. Cutter, M. W. Miller, M. L. Brooks, J. M. Grebmeier, A. C. Matz, and C. M. Schaefer. 2013. Wintering eiders acquire exceptional Se and Cd burdens in the Bering Sea: physiological and oceanographic factors. Marine Ecology Progress Series 489: 245-261.

Lovvorn, J.R., E. M. Anderson, A. R. Rocha, W. W. Larned, J. M. Grebmeier, L. W. Cooper, J. M. Kolts, and C. A. North. 2014. Variable wind, pack ice, and prey dispersion affect the long-term adequacy of protected areas for an Arctic sea duck. Ecological Applications 24(2): 396-412.

Naves, L. C. 2011. Alaska migratory bird subsistence harvest estimates, 2009. Alaska Migratory Bird Co-Management Council. Alaska Department of Fish and Game Division of Subsistence Technical Paper No. 364, Anchorage, AK.

Petersen, M.R., W.W. Larned, and D.C. Douglas. 1999. At-Sea Distribution of Spectacled Eiders: A 120-Year-Old Mystery Resolved. Auk 1164:1009-1020.

Petersen, M. R., and D. C. Douglas. 2004. Winter ecology of Spectacled Eiders: environmental characteristics and population change. Condor 106: 79– 94.

Platte, R.M. and R. A. Stehn, 2015. Abundance and trend of waterbirds on Alaska's Yukon-Kuskokwim Delta Coast based on 1988 to 2009 aerial surveys. Unpublished annual survey report. U.S. Fish and Wildlife Service, Waterfowl Management Branch, Anchorage, AK. 40 pp.

Rothe, T. C., P. I. Padding, L. C. Naves, and G. J. Robertson. 2015. Harvest of sea ducks in North America: A Contemporary Summary. *In* J.-P.L. Savard, D.V. Derksen, D. Esler and J.M. Eadie (editors). Ecology and conservation of North American sea ducks. Studies in Avian Biology, CRC Press, New York, NY.

Safine, D. E. 2013. Breeding ecology of Steller's and spectacled eiders nesting near Barrow, Alaska, 2012. U. S. Fish and Wildlife Service, Fairbanks Fish and Wildlife Field Office, Fairbanks, Alaska. Technical Report. 64 pp.

Scribner, K. T., M. R. Petersen, R. L. Fields, S. L. Talbot, J. M. Pearce, and R. K. Chesser. 2001. Sex- biased gene flow in Spectacled Eiders (Anatidae): inferences from molecular markers with contrasting modes of inheritance. Evolution 55: 2105– 2115.

Sexson, M. G., J. M. Pearce, and M. R. Petersen. 2014. Spatiotemporal distribution and migratory patterns of Spectacled Eiders. BOEM 2014-665. Bureau of Ocean Energy Management, Alaska Outer Continental Shelf Region, Anchorage, Alaska.

Stehn, R. A., C. P. Dau, B. Conant, and W. I. Butler Jr. 1993. Decline of spectacled eiders nesting in western Alaska. Arctic 46(3): 264-277.

Stehn, R. W. Larned, R. Platte, J. Fischer, and T. Bowman. 2006, Spectacled eider status and trend in Alaska. Unpublished report, U.S. Fish and Wildlife Service, Anchorage, AK.

Stehn, R. A., W. W. Larned, and R. M. Platte. 2013. Analysis of aerial survey indices monitoring waterbird populations of the Arctic Coastal Plain, Alaska, 1986-2012. Unpublished report. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Anchorage, AK. 56 pp.

Syroechkovski E. E., Jr. and C. Zockler. 1997. Threatened waterfowl in the lower Yana River, Yakutia, Russia. Waterfowl and Wetland Trust, UK, Threatened Species Department, Threatened Waterfowl Specialist Group. TWSG News 10: 26-29.

Wentworth, C. 2007a. Subsistence Migratory Bird Harvest Survey, Yukon-Kuskokwim Delta, 2001–2005 with 1985–2005 Species Tables. U.S. Fish and Wildlife Service, Migratory Birds and State Programs, Anchorage, AK.

———. 2007b. Subsistence Migratory Bird Harvest Survey, Bristol Bay, 2001–2005 with 1995–2005 Species Tables. U.S. Fish and Wildlife Service, Migratory Birds and State Programs, Anchorage, AK.

Wilson, H. M., M. R. Petersen and D. Troy. 2004. Concentrations of metals and trace elements in blood of spectacled and king eiders in northern Alaska, USA. Environmental Toxicology and Chemistry 23(2): 408-414.

Wilson H.M., J. S. Hall, P. L. Flint, J. C. Franson, C. R. Ely, J. A. Schmutz, and M. D. Samuel. 2013. High seroprevalence of antibodies to avian influenza viruses among wild waterfowl in Alaska: implications for surveillance. PLoS ONE 8(3): e58308. doi:10.1371/journal.pone.0058308