male subadult plumage in Purple Martins: plumage dyeing experiments. Behav. Ecol. Sociobiol. 29:297–306.
WEGGLER, M. 1997. Age-related reproductive success and function of delayed plumage maturation in male Black Redstart *Phoenicurus ochruros*. Ph.D. diss., Univ. Zurich, Zurich, Switzerland.
WILLIAMS, J. M., AND P. J. B. SLATER. 1993. Does Chaffinch *Fringilla coelebs* song vary with the habitat in which it is sung? Ibis 135:202–208.
YASUKAWA, K., J. L. BLANK, AND C. B. PATTERSON. 1980. Song repertoires and sexual selections in the Red-winged Blackbird. Behav. Ecol. Sociobiol. 7: 233–238.

The Condor 101:694–698

DISTRIBUTION AND DIURNAL BEHAVIOR OF STELLER'S EIDERS WINTERING ON THE ALASKA PENINSULA[1]

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Abstract. We studied the distribution and activities of adult Steller's Eiders (*Polysticta stelleri*) during winter and spring on a deep-water embayment and a shallow lagoon along the Alaska Peninsula from September 1980 to May 1981. During the remigial molt, eiders were observed on Izembek Lagoon but not on Cold Bay. Following the flightless period, Izembek Lagoon continued to support 63–100% of eiders encountered during surveys. As ice cover on Izembek Lagoon increased, the number of birds decreased on Izembek Lagoon but increased on Cold Bay, suggesting that some eiders disperse to nearshore, deep-water habitats in close proximity to Izembek Lagoon during severe weather. Diurnal activity budgets indicated that the amount of time resting or engaged in aggression and alert activities was similar among locations, seasons, tidal stages, and sexes. In contrast, time spent foraging differed among seasons and locations but did not differ among tidal stages or sexes. Although time spent foraging was similar during winter and spring on Izembek Lagoon, eiders on Cold Bay foraged more during winter compared to spring. Synchronous diving was the dominant foraging strategy.

Key words: Alaska Peninsula, Izembek Lagoon, Polysticta stelleri, *population distribution, Steller's Eiders, winter habitat use.*

Steller's Eiders (*Polysticta stelleri*) winter in three geographic areas: Alaska, northeast Asia, and northern Europe. Of these, the Alaskan population is the largest. Jones (1965) estimated 200,000 Steller's Eiders once wintered along the Alaska Peninsula, but estimates declined to less than 65,000 in 1991 (Kertell 1991). In 1997 the U.S. Fish and Wildlife Service (USFWS) listed the Alaska breeding population as threatened (USFWS 1997).

The Alaskan wintering range extends from Kodiak Island (Islieb and Kessel 1973) west along the northern and southern sides of the Alaska Peninsula (Jones 1965, Petersen 1981) to the eastern Aleutian Islands (Troy and Johnson 1987). Within this region, most Steller's that breed in Siberia molt in the shallow embayments of Nelson Lagoon and Izembek Lagoon (Petersen 1981). Izembek Lagoon also is one of the major wintering areas in the world (Jones 1965).

This study was conducted on Izembek Lagoon and adjacent Cold Bay from September 1980–May 1981. The objectives were to (1) use aerial surveys to document the chronology of use and importance of different wetland types (bays, shallow lagoons) for postbreeding Steller's Eiders and (2) determine whether diurnal activities of adult Steller's Eiders differed among wetland types. Although shallow lagoons are heavily used by postbreeding eiders (Jones 1965, Petersen 1980, 1981), bays also are utilized (Bauer and Glutz von Blotzheim 1969, Troy and Johnson 1987) but have received little research emphasis. In particular, investigations regarding the use of eelgrass (*Zostera marina*) lagoons and bays in close juxtaposition have not been published, and detailed studies of the world's largest postbreeding population of Steller's Eiders are lacking (Jones 1965).

METHODS

STUDY AREA

Izembek Lagoon, a shallow embayment on the north shore of the Alaska Peninsula, is 41 km long, varies

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from 4–10 km wide, and has a surface area of 218 km^2 (McRoy 1966, Barsdate et al. 1974). Tidal flats and channels comprise 78% and 22% of the lagoon, respectively (McRoy 1966). Tides are semi-diurnal and mixed diurnal (U.S. Dept. Commerce 1980). The mean tidal excursion is 1.6 m during a typical semi-diurnal tidal cycle with a second excursion that is 23% of the principal tidal range (Environmental Science and Engineering Inc. 1989). Water depths are greatest in channels, ranging from 9–13 m, and salinity of the water is about 31‰ (parts per thousand; Barsdate et al. 1974). The lagoon supports one of the largest (150–160 km^2) total crops (2.3×10^9 kg) of eelgrass in the world (McRoy 1970, Ward et al. 1997). Eelgrass occupies both intertidal and subtidal zones (Biebel and McRoy 1971), and many tidal flats (60–70%) support eelgrass beds, and associated macroinvertebrates, that become large pools during the slack tide (McRoy 1970). Ice is common between December and March and often covers >75% of the lagoon for up to 1–2 months each winter (Ward et al. 1997).

Cold Bay, composed of a deep-water embayment and shallow Kinzarof Lagoon, lies on the south side of the Alaska Peninsula and is connected to the Western Gulf of Alaska. Five kilometers separate Izembek Lagoon and Cold Bay, but markedly different environmental and physical conditions occur at the two sites. Tides are semi-diurnal and range from 7–8 m, but are not synchronous with tides in Izembek Lagoon (U.S. Dept. Commerce 1980). Water depths gradually increase from the shoreline to about 6 m within 500 m of shore. Beyond 500 m the bottom slopes more rapidly and water depths 1 km from shore approach 60 m. Mud, probably high in organic content, is the dominant sediment (Feder and Jewett 1987). Kinzarof Lagoon, which comprises the northern portion of Cold Bay, supports eelgrass, but total crop (153×10^6 kg) and area (8.7 km^2) are much less compared to Izembek Lagoon (Metzner 1993). The remainder of Cold Bay is largely unvegetated.

DATA COLLECTION

Aerial surveys were flown monthly from September 1980–May 1981. Surveys encompassed all of Izembek Lagoon and Kinzarof Lagoon, but only the nearshore areas of Cold Bay. Flights were conducted in a Piper Super Cub at an altitude of 30–50 m and an average ground speed of 148 km hr^{-1}. Two observers, one on each side of the plane, counted all waterbirds visible, estimated total ice cover, and noted general flock size.

We used focal sampling procedures (Altmann 1974) to quantify adult eider activity from November 1980 to May 1981. Observation sites (one on Izembek Lagoon and four on Cold Bay) were selected based on accessibility and were located on the Alaska Peninsula at 2–20 m above the water to permit sufficient visibility. Thus, only the west side of Cold Bay and east side of Izmebek Lagoon were sampled. The site on Izembek Lagoon allowed sampling of both tidal channels and pools. Observations were conducted from a truck using a 15–60× spotting scope or 10× binoculars. We initiated each observation by directing the spotting scope toward flocks and selecting the adult bird nearest the center of the field of view. A metronome was used to record behavior at 10-sec intervals (Wiens et al. 1970). Activities were assigned to one of six categories: (1) forage (synchronous and asynchronous dive [including time spent on surface between dives], head-dip, up-end), (2) locomotion (swim, walk), (3) comfort (preen and other comfort movements), (4) rest (loaf, sleep), (5) courtship, and (6) other (aggression, alert). Location (Cold Bay, Izembek Lagoon), season (winter [September–March], spring [March–May]), tidal stage (low [<1.0 m], high [>1.0 m]), and sex were recorded at the beginning of each observation.

DATA ANALYSIS

The proportion of time each bird spent engaged in an activity was determined for each observation period. Arc-sine transformations were performed prior to analysis because data did not meet the assumptions of normality based on the Shapiro-Wilk statistic (Neter et al. 1985). Due to lack of independence among activity categories, the effects of location, season, sex, and tide were assessed using multivariate analysis of variance (MANOVA) and the Wilk's Lambda test criterion. For significant ($P < 0.05$) main effects, one-factor analysis of variance (ANOVA) was used to test for differences between means (PROC GLM, SAS Institute 1987). Because activities were intercorrelated, we divided α by the number of variables (e.g., 0.05/5 = 0.01) tested by ANOVA to control the Type I experiment-wise error rate at $P = 0.05$. Significant ($P < 0.05$) interaction terms could not be partitioned to assess relative importance; therefore, interactions were evaluated by testing all combinations using one-factor ANOVA. Values reported in the results are means ± SE. Data presented in tables are untransformed.

RESULTS

SURVEYS

Steller's Eiders began arriving 18 August, 1980, and increased to 79,311 individuals on 10 September (Table 1). Initially, birds concentrated on Izembek Lagoon and no eiders were observed on Cold Bay or Kinzarof Lagoon. Eiders were first observed using Cold Bay and Kinzarof Lagoon on 1 October following completion of molt (Table 1). The majority (63–99%) of birds were observed on Izembek Lagoon during all surveys, but distribution and numbers varied with the extent of ice cover (Table 1). The number of Steller's Eiders decreased on Izembek Lagoon and increased on Cold Bay and Kinzarof Lagoon during surveys ($n = 3$) when >10% ice cover was present on Izembek Lagoon, but insufficient data prevented detailed analysis.

ACTIVITY BUDGETS

Adult Steller's Eiders ($n = 182$) were observed for 65 hr. Average observation time was 21 min (range = 10–99 min). MANOVA indicated foraging and comfort activities differed among seasons ($F_{5,156} = 3.97$, $P < 0.05$), and locations within season ($F_{5,156} = 2.22$, $P = 0.05$). Time spent foraging was greater in winter compared to spring. Within location, foraging was similar among seasons on Izembek Lagoon, but was greater during winter than spring on Cold Bay (Table 2). Diving (98.7%) was the dominant foraging mode, whereas surface feeding (i.e., head-dip, up-end) was infrequent

TABLE 1. Number of Steller's Eiders and extent of ice cover on Izembek Lagoon and Cold Bay, Alaska, from September 1980–April 1981.

Date	Cold Bay Number	Cold Bay Ice (%)	Kinzarof Lagoon Number	Kinzarof Lagoon Ice (%)	Izembek Lagoon Number	Izembek Lagoon Ice (%)	Total
10 Sep 1980	0	0	0	0	79,731	0	79,731
01 Oct 1980	103	0	234	0	57,064	0	57,401
11 Nov 1980	274	0	2,167	0	48,998	0	51,439
30 Dec 1980	2,988	0	1,989	5	8,300	75	13,357
26 Jan 1981	1,142	10	2,043	0	15,100	10	18,285
12 Feb 1981	1,434	0	0	0	4,464	70	5,898
09 Mar 1981	1,941	0	2,299	0	22,922	0	27,162
14 Apr 1981	231	0	2,281	0	88,898	0	91,410
27 Apr 1981	30	0	30	0	50,000	0	50,060

(1.3%). Among dive types, synchronous diving was most prevalent (55.7 ± 1.5%), followed by dive-pause (37.4 ± 0.9%), and asynchronous diving (5.6 ± 1.2%).

Comfort activities occurred more in spring than winter only on Cold Bay. During winter, comfort activities occurred more on Izembek Lagoon than Cold Bay ($F_{1,49} = 5.92$, $P < 0.01$; Table 2). However, in spring, the amount of time allocated to comfort activities was similar between locations, primarily because comfort activities increased from winter to spring on Cold Bay (Table 2). Eiders also engaged in courtship to a greater extent in spring than winter, which resulted from an increase in courtship from winter to spring at both locations (Table 2). An interaction between season and tidal stage was the only factor that influenced locomotion ($F_{5,156} = 2.2$, $P = 0.05$). During winter, eiders moved more ($F_{1,49} = 8.1$, $P < 0.01$) at high tide (6.9 ± 5.6%) than at low tide (6.1 ± 1.8%). In contrast, locomotion was similar ($F_{1,118} = 0.91$, $P > 0.3$) among high (6.9 ± 1.9%) and low (8.7 ± 1.4%) tides in spring.

DISCUSSION

Behavioral strategies during winter are not merely oriented to survival, but require an individual to obtain foods important for molt, migration, and reproduction (Raveling 1990). When ice cover reduced availability of Izembek Lagoon, eiders shifted to other habitats including Cold Bay. Although estimates on Cold Bay are conservative because only nearshore habitats were surveyed, increasing numbers on Cold Bay and Kinzarof Lagoon when numbers are decreasing on Izembek Lagoon lends support to the possibility that at least some birds using Izembek Lagoon move across the peninsula to Cold Bay. As soon as Izembek became ice free, eiders returned in abundance, which suggests dispersal during severe weather may be localized to wetlands that remain open and are in close proximity to Izembek Lagoon.

Foraging was the dominant activity on both Cold Bay and Izembek Lagoon indicating considerable time is required to meet the energetic and nutritional requirements of annual cycle events above 50°N latitude. Comparable allocations of time to foraging have been reported for sea ducks at similar latitudes. Foraging was the dominant activity of wintering Steller's Eiders during both day (52.3%) and night (37.8%) in Varangerfjord, Norway (Fox and Mitchell 1997b), Common Goldeneye (*Bucephala clangula*) and Oldsquaw (*Clangula hyemalis*) spent 86% and 79% of time foraging, respectively, along the southern coast of Sweden during winter (Nilsson 1970), and foraging was the most prevalent activity of Oldsquaw (83%) and Common Eider (*Somateria mollissima*; 56%) at Cape St. Marys, Newfoundland (Goudie 1984).

During winter, eiders foraged for similar amounts of time in both Cold Bay and Izembek Lagoon. The Steller's Eider is among the most arctic of ducks (Nygård et al. 1995), and the winter climate along the Alaska Peninsula is severe (McKinney 1959). Consequently, small species such as the Steller's Eider may have little flexibility to adjust their time-activity budgets to such

TABLE 2. Univariate ANOVA tests of percent time (mean ± SE) Steller's Eiders engaged in different activities during winter and spring on Izembek Lagoon and Cold Bay, Alaska, 1980–1981.

Activity	Izembek Lagoon Winter	Izembek Lagoon Spring	Cold Bay Winter	Cold Bay Spring
Comfort	14.9 ± 6.0	11.5 ± 2.7	4.2 ± 2.3	22.5 ± 2.6***
Court	0.3 ± 0.2	7.3 ± 1.8***	0.8 ± 0.6	10.1 ± 1.5***
Forage	70.2 ± 7.2	66.4 ± 5.3	80.0 ± 4.7	51.3 ± 3.7***
Locomotion	7.9 ± 1.8	11.4 ± 2.8	13.8 ± 4.0	7.0 ± 1.3
Rest	5.2 ± 4.7	0.0 ± 0.0	0.6 ± 0.4	7.9 ± 2.3
Other[a]	1.4 ± 0.5	3.4 ± 1.3	0.6 ± 0.5	1.1 ± 0.2

[a] Aggression, alert.
*** $P \leq 0.001$.

adverse conditions (Goudie and Ankney 1986). The time available to acquire the foods necessary to maintain thermal balance during cold weather is particularly critical when shallow, food-rich waters are unavailable. Foraging birds may be forced to obtain food in other habitats when ice covers shallow lagoons. During our study, eiders appear to have offset energetic requirements when Izembek Lagoon was unavailable by foraging in Cold Bay rather than minimizing energy expenditure by seeking thermal cover. In Norway, a gently shelving, shallow coastline with sand-mud substrate was the primary criterion for site use by foraging Steller's Eiders, accounting for 79% of variation in distribution (Fox and Mitchell 1997b). Cold Bay conforms to these characteristics, with water depths gradually increasing to about 6 m within 500 m of shore, and a substrate dominated by mud. Thus, wetlands with these physical traits that remain ice-free and are in close juxtaposition to shallow lagoons may provide crucial foraging habitats during periods of ice cover. The decreased use of Cold Bay as a foraging site in spring may be related to the lack of ice cover and greater availability of foods on Izembek Lagoon, or may reflect reduced energetic requirements as climatic conditions became more favorable.

Previous studies have documented that Steller's Eiders forage primarily within 2–3 hr of low tide, and surface feeding is the dominant foraging strategy (Petersen 1981, Fox and Mitchell 1997b). In contrast, synchronous diving was the preferred foraging strategy exhibited by eiders during our study, and time spent foraging was similar at high and low tide. Differences between our study and others may be related to the distribution of eelgrass meadows. Izembek Lagoon is the only location in the Bering Sea where eelgrass grows in both intertidal and subtidal habitats (Phillips et al. 1983). Intertidal eelgrass plants typically are located in shallow areas (McRoy 1970, Short 1981), whereas subtidal plants typically occupy the sides of deeper channels (Ward and Stehn 1989). Thus, macroinvertebrate communities associated with eelgrass meadows are available at varying depths during both high and low tides. However, during our study, ice cover in late December may have reduced the availability or value of intertidal eelgrass beds because leaves of intertidal plants can be frozen into ice and torn loose leaving roots and rhizomes in the sediments (McConnaughey 1977). Thus, macroinvertebrates associated with subtidal beds that are accessible primarily by diving may have provided more reliable foods regardless of tidal stage. In addition, formation of large flocks and synchronous diving also are good strategies for avoidance of aerial predators, such as Great Black-backed Gulls (*Larus marinus*) (Fox and Mitchell 1997a), Bald Eagles (*Haliaeetus leucocephalus*) and Gryfalcons (*Falco rusticolus*) (McKinney 1965). The increased time spent in locomotion at high tides is consistent with the amount of time likely required to locate foods in deeper water when tides are high as compared to the relative availability of foods when eelgrass is exposed on mudflats or shallowly flooded.

Courtship increased on Cold Bay and Izembek Lagoon during spring. Pairing before arrival on breeding grounds likely is an important strategy to assure that nest selection and laying can begin as soon as possible during the short summer breeding period. Why comfort activities such as preening increased on Cold Bay in spring is difficult to explain. However, because rough seas are more characteristic of conditions on Cold Bay, more preening may be required to keep feathers arranged for signal function in the pairing process or for thermal regulation.

The diverse diet of small marine foods consumed by eiders (Petersen 1981, Metzner 1993), in combination with multiple foraging strategies, are characteristics that have allowed Steller's Eiders to be successful in northern environments. Previous studies have concentrated on lagoon systems because of the documented value of these habitats. Additional information on the importance of other wetland habitats in close proximity to shallow lagoons may provide critical insights to the winter distribution of Steller's Eiders along the Alaska Peninsula. Of particular importance is more detailed knowledge regarding the types and seasonal availability of foods in different wetland types, and clarifying patterns of differential use among shallow lagoons and adjacent wetlands to identify habitats that may be temporally valuable for Steller's Eiders.

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LITERATURE CITED

ALTMANN, J. 1974. Observational study of behavior sampling methods. Behaviour 49:227–267.

BARSDATE, R. J., M. NIEBERT, AND C. P. MCROY. 1974. Lagoon contributions to sediments and water of the Bering Sea, p. 553–576. *In* D. W. Hood and E. J. Kelley [eds.], Oceanography of the Bering Sea. Inst. Mar. Sci., Univ. Alaska Occ. Publ. No. 2.

BAUER, K., AND U. GLUTZ VON BLOTZHEIM. 1969. Handbuch der Vogel Mitteleuropas. Bd. 3. Frankfurt am Main, Germany.

BIEBEL, R., AND C. P. MCROY. 1971. Plasmatic resistance and rate of respiration and photosynthesis of *Zostera marina* at different salinities and temperatures. Marine Biol. 8:48–56.

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC. 1989. Physical oceanography, p. 40–98. *In* Outer Continental Shelf Environmental Assessment Program. Vol. 60. Natl. Oceanic and Atmospheric Assoc., U.S. Dept. Interior, Anchorage, AK.

FEDER, H. M., AND S. C. JEWETT. 1987. The subtidal benthos, p. 347–396. *In* D. W. Hood and S. T. Zimmerman [eds.], The Gulf of Alaska physical environment and biological resources. Bureau Land Manage./Natl. Oceanic and Atmospheric Assoc., Minerals Management Service Office, Anchorage, AK.

FOX, A. D., AND C. MITCHELL. 1997a. Rafting behaviour and predator disturbance to Steller's Eiders *Polysticta stelleri* in northern Norway. J. für Ornithologie 138:103–109.

FOX, A. D., AND C. MITCHELL. 1997b. Spring habitat use and feeding behaviour of Steller's Eider *Polysticta stelleri* in Varangerfjord, northern Norway. Ibis 139:542–548.

GOUDIE, R. I. 1984. Comparative ecology of Common Eiders, Black Scoters, Oldsquaws, and Harlequin Ducks wintering in southeastern Newfoundland. M.Sc. thesis, Univ. Western Ontario, London, Ontario, Canada.

GOUDIE, R. I., AND C. D. ANKNEY. 1986. Body size, activity budgets, and diets of sea ducks wintering in Newfoundland. Ecology 67:1475–1482.

ISLIEB, M. E., AND B. KESSEL. 1973. Birds of the North Gulf Coast—Prince William Sound Region, Alaska. Univ. Alaska Biol. Papers No. 14, Fairbanks, AK.

JONES, R. D., JR. 1965. Returns of Steller's Eiders banded in Izembek Bay, Alaska. Wildfowl 16:83–85.

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

MCCONNAUGHEY, T. 1977. Ecosystems naturally labeled with carbon-13: applications to the study of consumer food-webs. M.Sc. thesis, Univ. Alaska, Fairbanks, AK.

MCKINNEY, F. 1959. Waterfowl and Cold Bay, Alaska, with notes on the display of the Black Scoter. Wildfowl 10:133–136.

MCKINNEY, F. 1965. The spring behavior of wild Steller's Eiders. Condor 67:273–290.

MCROY, C. P. 1966. The standing stock and ecology of eelgrass (*Zostera marina*) in Izembek Lagoon, Alaska. M.Sc. thesis, Univ. Washington, Seattle.

MCROY, C. P. 1970. Standing stocks and other features of eelgrass (*Zostera marina*) populations on the coast of Alaska. J. Fish. Res. Bd. Canada 27: 1811–1821.

METZNER, K. A. 1993. Ecological strategies of wintering Steller's eiders on Izembek Lagoon and Cold Bay, Alaska. M.Sc. thesis, Univ. Missouri., Columbia, MO.

NETER, J., W. WASSERMAN, AND M. K. KUTNER. 1985. Applied linear regression models. 2nd ed. R. D. Irwin, Homewood, IL.

NILSSON, L. 1970. Food seeking activity of South Swedish diving ducks in the nonbreeding season. Oikos 21:145–154.

NYGÅRD, T., B. FRANTZEN, AND S. ŠVAŽAS. 1995. Steller's Eiders *Polysticta stelleri* wintering in Europe: numbers, distribution and origin. Wildfowl 46: 140–155.

PETERSEN, M. R. 1980. Observations of wing-feather moult and summer feeding ecology of Steller's Eiders at Nelson Lagoon, Alaska. Wildfowl 31:99–106.

PETERSEN, M. R. 1981. Populations, feeding ecology, and molt of Steller's Eiders. Condor 83:252–256.

PHILLIPS, R. C., W. S. GRANT, AND C. P. MCROY. 1983. Reproductive strategies of eelgrass (*Zostera marina* L.). Aquatic Bot. 16:1–20.

RAVELING, D. G. 1990. Coping with winter: behavioral strategies of waterfowl, p. 59–81. *In* F. G. Whoriskey, R. D. Titman, and D. T. Brown [eds.], Behavioral strategies for coping with winter. Société Québécoise Pour L'étude Biologique Du Compartement Special Publ. 1, Montreal.

SAS INSTITUTE. 1987. SAS/STAT user's guide. Version 6.1. SAS Institute, Inc., Cary, NC.

SHORT, F. T. 1981. Nitrogen resource analysis and modeling of an eelgrass (*Zostera marina* L.) meadow in Izembek Lagoon, Alaska. Ph.D. diss., Univ. Alaska, Fairbanks, AK.

TROY, D. M., AND S. R. JOHNSON. 1987. Marine birds, p 322–422. *In* J. C. Truett [ed.], Environmental characterization and biological utilization of the North Aleutian Shelf nearshore zone. LGL Ecol. Res. Assoc., Bryan, TX.

U.S. DEPARTMENT COMMERCE. 1980. Tide tables for the west coast of North and South America, including the Hawaiian Islands. U.S. Govt. Printing Office, Washington, DC.

U.S. FISH AND WILDLIFE SERVICE. 1997. Endangered and threatened wildlife and plants; proposed rule to list Spectacled Eider as threatened and notice of 12-month finding for a petition to list two Alaskan Eiders as endangered. Federal Register 57: 19852–19856.

WARD, D. H., C. J. MARKON, AND D. C. DOUGLAS. 1997. Distribution and stability of eelgrass beds at Izembek Lagoon, Alaska. Aquatic Bot. 58:229–240.

WARD, D. H., AND R. A. STEHN. 1989. Response of Brant and Canada Geese to aircraft disturbance at Izembek Lagoon, Alaska. Final Rep. US Fish and Wildl. Serv., Alaska Fish and Wildl. Res. Ctr., Anchorage, AK.

WIENS, J. A., S. G. MARTIN, W. R. HOLTHAUS, AND F. A. IWEN. 1970. Metronome timing in behavioral ecology studies. Ecology 51:350–352.