HABITAT USE BY WINTERING STELLER'S EIDERS *POLYSTICTA STELLERI* IN NORTHERN NORWAY

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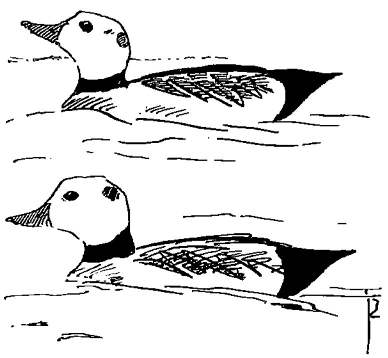
Habitat use of Steller's Eiders *Polysticta stelleri* was studied in Varangerfjord, northern Norway, during three winter periods (November, January and April) in 1996/97. We partitioned habitats based on water depth and benthic conditions, and compared the benthic characteristics in known feeding areas to nearby areas avoided by Steller's Eiders. On average 88% of the birds were in natural habitats, outside of harbours. Mean water depth at feeding areas varied from 3.7 m in November to 2.5 m in April. Overall 89% of eiders foraged by diving at locations where water depths were less than 5 m. Steller's Eiders foraged in areas with underwater vegetation, predominantly in kelp beds. Two factors were positively associated ($P < 0.05$) with the probability that an area was used by Steller's Eiders: the proportion of the area covered by the kelp species *Laminaria hyperborea* and the vegetation density. Shallowly flooded kelp beds are the prime habitat for Steller's Eiders in Varangerfjord, and protection of these habitats is probably of great importance for preserving the species in the area.



Key words: *Polysticta stelleri* - habitat use - winter ecology - Norway - Varangerfjord

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INTRODUCTION

Steller's Eiders *Polysticta stelleri* breed along the arctic coasts of Siberia and Alaska and winter in near-arctic waters in Alaska, East-Asia and northern Europe. During recent decades a serious decline has occurred in the breeding and wintering population in Alaska (Kertell 1991), leading to the status of this population being listed as Category 1 threatened by the U.S. Department of the Interior (Anonymous 1997). In the 1960s the world population was estimated to number 400 000-500 000 birds (Palmer 1976) while the present estimate is 220 000 birds (Pihl in press). About 15-25% (30 000-50 000 birds) of the world population winters in northern Europe, the majority (> 80%) in Varangerfjord and Kola Peninsula (Fig. 1), and few birds migrate further west. Surveys carried out since the early 1980's indicate that the population is fairly stable (Nygård *et al.* 1995a).

Sea ducks generally feed on sessile or slow moving organisms on the seabed. Benthic conditions, however, vary greatly and are usually divided into hard- and soft bottoms (Tait 1982). Hard substrates often support large algae growing on rocks and stones, while most soft bottom communities support little vegetation. This leads to very different animal communities (Mann 1982; Tait 1982) and feeding conditions for predators such as sea ducks. Although preferred foraging depths are known to vary among sea duck species, little is known about the preferences for benthic conditions among species (Nilsson 1972; Stott & Olson 1973; Goudie & Ankney 1988; Guillemette *et al.* 1992, 1993; Bustnes & Lønne 1995, 1997; Bustnes *et al.* 1997). There have been no quantitative studies of the underwater habitats used by the Steller's

Eider, but it has been suggested that it prefers to forage in shallow waters close to shore (McKinney 1965; Petersen 1980; Metzner 1993; Fox & Mitchell 1997). Thousands of Steller's Eiders moult and overwinter in Izembek Lagoon and Nelson Lagoon in Alaska (Petersen 1980; Metzner 1993). Izembek Lagoon is dominated by soft substrates with Eelgrass *Zostera marina* (McCroy 1968; Metzner 1993), whereas Nelson Lagoon has little underwater vegetation (Gill & Jorgenson 1979).

In Varangerfjord, Fox & Mitchell (1997) found that Steller's Eiders preferred gently shelving coastal profiles, but gave no information about the depth and bottom characteristics in the feeding areas. Part of the population in this area is also found in habitats greatly influenced by man, such as harbours (Fox & Mitchell 1997). A large proportion of the subtidal area in Varangerfjord is dominated by the sugar kelp species *Laminaria hyperborea* (Lein *et al.* 1987). Such kelp beds are known to support high densities of potential prey for sea ducks (Guillemette *et al.* 1992; Christie 1995; Skadsheim & Rinde 1995; Norderhaug 1998). This may also be the case for Steller's Eiders, since they to a large extent feed on swimming prey (e.g. some crustaceans) or organisms that may be found on the kelp plants (e.g. gastropods, bivalves and some crustaceans) (Bustnes *et al.* 2000). The purpose of this study was to obtain quantitative information about the natural underwater habitats used by Steller's Eiders wintering in Varangerfjord. First, we documented the depth and benthic conditions of habitats used by feeding flocks, hypothesising that the birds would select vegetated areas because of better feeding conditions. Second, we compared the benthic characteristics (substrates, vegetation types and vegetation density) in known feeding areas to areas avoided by birds to identify factors important for habitat selection.

STUDY AREA AND METHODS

The study area was the northern side of Varangerfjord (Fig. 1) from Varangerbotn (70°11'N, 28°34'E) to Kiberg (70°16'N, 31°00'E). The area consists of about 110 km of shoreline of varying topography (Lein *et al.* 1987; Fox & Mitchell 1997). Most of the area is visible from the road adjacent to the fjord, and all bird observations were made from this road in a vehicle. The outer part of Varangerfjord (Kiberg to Vadsø) is dominated by gently shelving coastal profiles with shallow water (< 50 m) that may extend several km from shore. In the inner part of the fjord (Vadsø to Varangerbotn) some stretches are somewhat deeper along the shore, while shallow waters and large bays dominate other stretches. The study area is sparsely populated. There are two large fishing ports with fishing industry (Vadsø and Kiberg), and four small ones (Nesseby, Vestre Jacobselv, Ekkerøy, Krampenes), where fishing vessels > 20 feet may land. These harbours are encircled by breakwaters and have facilities to bring fish ashore.

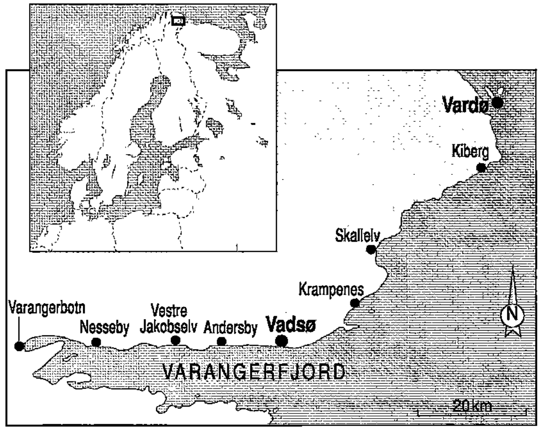

Fig. 1. The study area (between Varangerbotn and Kiberg) in Varangerfjord, Finnmark, northern Norway.

The study was conducted in the winter 1996-97. Steller's Eiders were surveyed in three periods representing different events in the annual cycle of the ducks: mid November (shortly after the arrival of the birds), early January (close to the darkest period) and mid April (shortly before migration). Counts were conducted independent of tidal cycles, during daylights hours (four days in November, three days in January, and two days in April). Behaviour of each flock observed was classified as feeding (any number of birds in the flock observed to feed) or non-feeding (no feeding birds), and only feeding flocks were used in subsequent analyses. All flocks and individuals were plotted on 1:25 000 maps using topographical features and estimated distances from shore. Birds in the centre of the flock were used as centre point to estimate distance. To improve our ability to estimate distances of flocks from the shore, we regularly checked the distances to selected flocks using a Leica Geovid laser range finder pointed at the birds or at nearby land structures.

Underwater habitats were examined in August 1997. In the area from Andersby (2 km west of Vadsø) to Kiberg (Fig. 1) water depths (rounded to the nearest metre) at the location of each feeding Steller's Eider flock were obtained from a bathymetric map (1:10 000) with depth measurements taken at 25 m intervals. For the area between Andersby and Varangerbotn no bathymetric maps were available and we used a 1:50 000 nautical map. Water depths on both map types are related to the Equinoctial Spring Low Water, which is equal to the Norwegian Chart Datum. In areas where Steller's Eiders foraged, we used aerial photographs to classify benthic conditions to depths of about 8 m as vegetated (dark areas) or non-vegetated areas (light areas). Feeding areas were classified as vegetated even if there were mosaic patches of sand/mud or bare rock within the vegetation. To verify photographic interpretation and determine if vegetation occurred in areas not visible on photographs, we also inspected feeding sites from a boat (also using a video camera: see below), and from the shore. Vegetation was plotted on 1:25 000 nautical maps, which were used to identify bottom types for all feeding areas. We consider the accuracy of the aerial photographs and the on-site classification similar, since we used the same criteria for classification and plotted data from both methods on the same type of maps.

To identify benthic factors influencing habitat preference we placed transects in areas where flocks of Steller's Eiders had been observed foraging during the preceding winter (> 50 birds at each location) and compared them to areas where no birds had been observed within 2.5 km of a feeding area. The distance between transects was > 500 m. The transects were placed in the area from Varangerbotn to Skallelv (Fig. 1), covering on average 50% (range among periods 42-55%) of the Steller's Eiders in the study area. Location of transects in non-feeding areas were selected based on shore topography, i.e. gently shelving profiles typical for sites where Steller' Eiders are found in the study area (Fox & Mitchell 1997; J.O. Bustnes pers. obs.), and lack of steep cliffs with deep water close to shore. At each predetermined location, transects were randomly placed. Since Steller's Eiders were foraging in waters shallower than 10 m we placed no sampling stations deeper than 10 m. The underwater transects ran perpendicular from the shore, starting at distances from 10 to 100 m (depending on the shore profile and tidal level), and extending from 100 to 300 m from the upper tidal level. Sampling stations were at 10 meters intervals, measured by the Leica Geovid laser range finder, aimed at the shore. Bottom conditions were examined with an underwater video camera. The camera was attached to a rig that was placed on the bottom at each station, and was connected to a monitor placed in a small boat. The area covered by the camera was 0.25 m^2.

We recorded three variables at each sampling station along the transect: substrate type (when visible through the vegetation), vegetation type (kelp or other vegetation), and type of kelp. Substrates were defined as soft (mud/sand/silt) or hard (pebble, cobble and bed rock) (Tait 1982). Vegetation types were classified as kelp or other algae (mostly seaweed such as *Fucus* spp. and *Ascophyllum nodosum*, some red and other brown algae). Sugar kelp was further divided into two groups of species: *Laminaria hyperborea*, which also contained small proportions of the similar species *L. digitata*, and *L. saccharina*. We established 35 transects with a total of 456 sampling stations: 24 transects ($x \pm SE = 13.04 \pm 0.81$, range 4-22, n = 333 stations) in feeding areas; and eleven transects (13.0 ± 1.38, range 4-19, n = 143 stations) in avoided areas. Analyses were carried out using SAS (SAS 1990, 1993). We used logistic regression (PROC GENMOD: SAS 1993) to test if the following predictors influenced the probability of a site being a feeding area or not: (1) the proportion of the visible substrate in a transect that was soft bottom; (2) the proportion of stations along a transect where vegetation was kelp; (3) the proportion of the kelp in a transect that were *Laminaria hyperborea*; and (4) the proportion of a transect with substrates covered by the vegetation (vegetation density). We used a backward elimination procedure to fit the model, starting with all main effects and interactions, and removing insignificant effects sequentially until all remaining variables were significant (Likelihood ratio statistics; Kleinbaum *et al.* 1998). Standard errors (SE) are given for all means.

RESULTS

A total of 5000, 5400 and 7500 Steller's Eiders were observed in the study area in November, January and April, respectively. Of these 84%, 58% and 46% were in foraging flocks at the time of observation. Twelve percent of the birds in the study area were observed in harbours (range 9-16%). The distribution of birds within the fjord was similar among periods (Fig. 2). Mean water depths at feeding sites differed among observation periods (χ^2_2 =15.32, P < 0.001, Kuskal-Wallis test). In November the water depth at foraging sites was 3.7 ± 0.4 m (mean ± SE flock size: 75 ± 12.5, n = 42), whereas in January and April they were 3.2 ± 0.2 ($\bar{x}$ = 26 ± 4.7, n = 76) and 2.5 ± 0.2 m ($\bar{x}$ = 38 ± 5.9, n = 85), respectively. In November, January and April, about 88%, 83% and 93% of the birds foraged in water < 5 m deep, respectively (Fig. 3). In April more flocks (55%) foraged in < 2 m than in the other periods (45%). Only 0.16% of the birds were seen feeding in waters > 10 m deep.

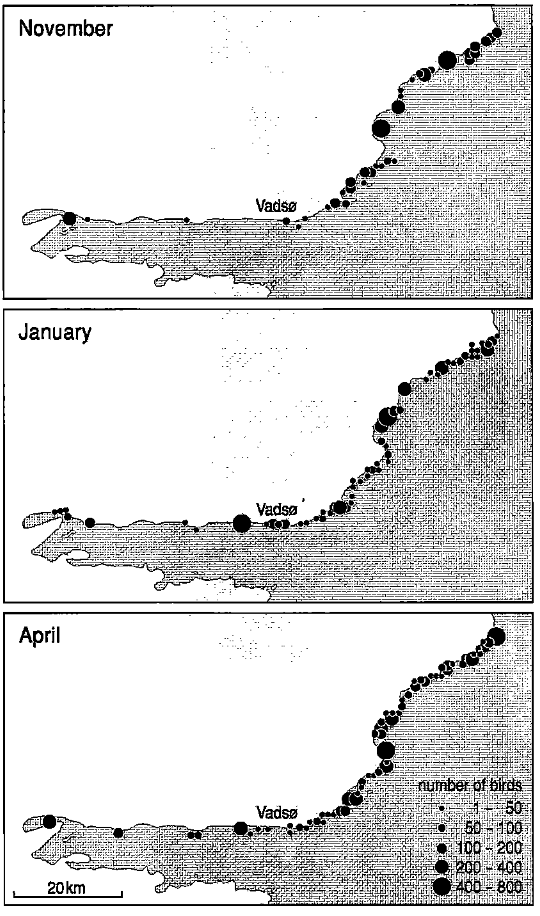

Fig. 2. The distribution of Steller's Eiders in the study area in winter 1996/97.

Independent of period, all feeding flocks (n = 203) outside the harbours occurred in areas classified as vegetated. Hard bottom substrates dominated foraging areas (61.5%) whereas soft substrates dominated non-foraging areas (80%; Fig. 4). The vegetation in both foraging and non-foraging areas was dominated by kelp (Fig. 4), but in the feeding areas 60.5% of the kelp was *Laminaria hyperborea*, while in avoided areas 92% was *L. saccharina* (Fig. 4). The vegetation cover was greater in foraging areas (54%) than in the non-foraging areas (24%) (Fig. 4). Two variables were significantly associated with the probability

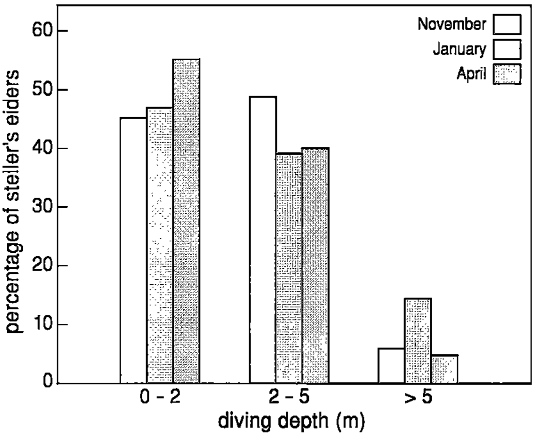

Fig. 3. Proportions of Steller's Eiders diving at different depths in the study area in winter 1996/97.

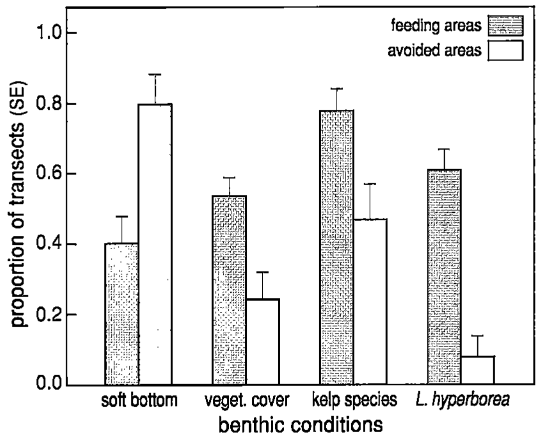

Fig. 4. Comparison of feeding areas and areas avoided by Steller's Eiders in terms of the mean (± SE) proportion of bottom transects with soft versus hard bottom, the proportion of the transects where the vegetation covered the substrate (vegetation cover), the proportion of transects where the vegetation along the transects consisted of kelp, and the proportion of the kelp along the transects consisting of *Laminaria hyperborea* compared to *L. saccharina*.

of a transect running through a feeding area. Both the proportion of vegetation consisting of *Laminaria hyperborea* compared to *L. saccharina* (LR statistics $\chi^2_1 = 15.49$, $P < 0.0001$), and vegetation density ($\chi^2_1 = 3.79$, $P = 0.05$) showed positive relationships. The relationship is given by the logistic equation (E_{logit}): probability of a transect running through a feeding area = -3.03 (± 1.50 SE) + 6.38 (± 2.18) *L. hyperborea* + 4.16 (± 2.44) vegetation density.

DISCUSSION

All Steller's Eiders in Varangerfjord fed in shallow waters, in accordance with other studies (McKinney 1965; Metzner 1993; Fox & Mitchell 1997). Petersen (1980) found that Steller's Eiders in Nelson Lagoon, Alaska were diving to depths of 6 m, similar to our finding that 89% of the birds fed in water < 5 m deep. The energetic costs of diving increase with depth, but different sea duck species may experience different costs and may have different physiological abilities for diving (Ydenberg & Clark 1989; Lovvorn & Jones 1991ab; de Leeuw 1996; Boyd 1997). Whether the preference for shallow waters in Steller's Eider is a result of poor physiological capability for diving is unknown. The reason why Steller's Eiders foraged in areas with shallower waters late in the season compared to early is not understood, but may relate to changes in prey distribution, either through prey depletion during winter or prey movement.

A central finding in this study was that Steller's Eiders preferred to forage in areas with vegetation. However, our observations on bird distribution in relation to vegetation are relatively coarse, and we could not distinguish exactly where birds fed in relation to the often complex mosaic pattern of sand/mud or bare rock patches within the kelp (Guillemette *et al.* 1993). However, in bays dominated by sand beaches, feeding flocks fed along the edges of patches of vegetated rocky intertidal or submerged hard bottom ridges with, and avoided the sand. Moreover, in the inner part of Varangerfjord, where many of the subtidal areas were not vegetated and dominated by sand and/or mud, we did not observe Steller's Eiders.

Other sea ducks such as Common Eider *Soma-*

teria mollissima (Guillemette *et al.* 1993; Bustnes & Lønne 1995, 1997), Long-tailed Duck *Clangula hyemalis* (Goudie & Ankney 1988; Bustnes *et al.* 1997), Goldeneye *Bucephala clangula* (Nilsson 1972; Stott & Olson 1973) and Harlequin Duck *Histrionicus histrionicus* (Goudie & Ankney 1988) have been found to feed among underwater vegetation, but not as consistently as we found for the Steller's Eiders. The most important factors associated with feeding areas were dense vegetation, particularly of *Laminaria hyperborea.* Areas avoided by the birds had far more scattered vegetation, mostly dominated by *L. saccharina*, a species that often is attached to small rocks on soft substrates. On soft bottoms, *L. saccharina* usually does not form dense vegetation (Kain 1962; Lein *et al.* 1987). *Laminaria hyperborea* beds were probably preferred because they support high densities of potential prey for sea ducks (Guillemette *et al.* 1992; Christie 1995; Skadsheim & Rinde 1995; Norderhaug 1998).

Earlier studies have not considered the vegetation itself as an important habitat component for wintering Steller's Eiders, although Metzner (1993) assumed that Eelgrass beds were important since many wintering birds in Alaska are found in such habitats. However, Steller's Eiders also exploit other habitats such as soft mud in Vadsø harbour (Fox & Mitchell 1997), where we observed up to 600 birds. These birds were commonly feeding by digging in soft mud, either through diving in very shallow water (< 1 m), up-ending or picking. Both in Kiberg and Vadsø, many of the birds were feeding on offal from the fish industry close to and under the quays, in addition to natural prey. However, some of the birds staying in Vadsø harbour sometimes moved to feed in nearby areas where the bottom was vegetated (pers. obs. J.O. Bustnes). Fox & Mitchell (1997) observed that Steller's Eiders in spring often were found close to inflowing freshwater streams. Moreover, the large numbers of birds moulting in the largely non-vegetated Nelson Lagoon in Alaska Peninsula (Gill & Jorgensen 1979; Petersen 1980,1981) show that they do exploit different habitats. It would thus be of great interest to examine habitat use in detail in other wintering areas. If the Steller's Eider has a low flexibility in habitat use, it may be vulnerable to small scale changes in habitats, which may have been a contributing factor to the decline in the world population.

Laminaria hyperborea beds are common along the whole coast of northern Norway (Lein *et al.* 1987), but Varangerfjord is the only site in Norway where large numbers of Steller's Eiders occur. Thus, the distribution of *Laminaria hyperborea* cannot alone explain the wintering distribution of the population. Fox & Mitchell (1997) suggested that gently shelving coastal profiles were of importance, and that such habitats were generally rare in northern Norway. In our opinion this explanation is not supported since similar habitats are found in many areas on the outer coast of eastern Finnmark between Vardø (Fig 1) and Nordkynn Peninsula, and in fjords such as Porsangerfjord and Tanafjord (Lein *et al.* 1987). Some of these places have small numbers of wintering Steller's Eiders suggesting that the species may use the areas (Systad & Bustnes 1999). Varangefjord may well represent the limit of the winter range of Steller's Eider, and the available habitats, including those on the Russian side, are sufficient to support the existing population.

One potential threat to the habitats is harvesting of kelp and seaweed, which is an important industry, especially in the southwestern part of Norway (Bustnes *et al.* 1997). Plans still exist for kelp and *Ascopyllum nodosus* harvesting in Finnmark, including Varangerfjord (Lein *et al.* 1987). We would not recommend such activity at the northern side of the fjord, especially at water depths < 10 m. The outer part of the fjord supports a dense concentration of wintering sea ducks (Nygård *et al.* 1995b), and removing the underwater vegetation will probably have effects on these populations (Bustnes *et al.* 1997). We believe that Steller's Eiders and other sea ducks in the area would benefit from habitat protection (see also Fox *et al.* 1997).

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REFERENCES

Anonymous 1997. Endangered and threatened wildlife and plants: threatened status of the breeding population of Steller's Eider. Federal Register 62: 31748-31757.

Boyd I.L. 1997. The behavioural and physiological ecology of diving. TREE 12: 213-217.

Bustnes J.O. & O.J. Lønne 1995. Sea ducks as predators on sea urchins in a northern kelp forest. In: Skjoldal H.R., C. Hopkins, K.E. Erikstad & H.P. Leinås (eds). Ecology of fjords and coastal waters: 599-608. Elsevier Science, Amsterdam.

Bustnes J.O. & O.J. Lønne 1997. Habitat partitioning among sympatric wintering Common Eiders *Somateria mollissima* and King Eiders *S. spectabilis*. Ibis 139: 549-554.

Bustnes J.O., S-H. Lorentsen & H. Christie 1997. Sjøfugl, tareskog og taretråling: en kunnskapsstatus. Norw. Inst. Nat. Res. (NINA) Report 472: 1-43.

Bustnes J.O., M. Asheim, T.H. Bjørn, H. Gabrielsen & G.H. Systad 2000. The diet of Steller's Eiders wintering in Varangerfjord, northern Norway. Wilson Bull. 112: 8-13.

Christie H. 1995. Kartlegging av faunaen knyttet til tareskogen i Froan; variasjon i en eksponeringsgradient. Norw. Inst. Nat. Res. (NINA) Report 368: 1-22.

De Leeuw J.J. 1996. Diving costs as a component of daily energy budgets of aquatic birds and mammals: generalizing the inclusion of dive-recovery costs demonstrated in Tufted Ducks. Can. J. Zool. 74: 2131-2142.

Fox A.D. & C. Mitchell 1997. Spring habitat use and feeding behaviour of Steller's Eider *Polysticta stelleri* in Varangerfjord, northern Norway. Ibis 139: 542-548.

Fox A.D., C. Mitchell, G. Henriksen, E. Lund & B. Frantzen 1997. The conservation of Steller's Eider *Polysticta stelleri* in Varangerfjord, Norway. Wildfowl 48: 156-165.

Gill R.E. & P.D. Jorgenson. 1979 A preliminary assessment of timing and migration of shorebirds along the northcentral Alaska Peninsula. Stud. Avian Biol. 2: 110-120.

Goudie R.I. & C.D. Ankney 1988. Patterns of habitat use by sea ducks wintering in southeastern Newfoundland. Ornis Scand. 19: 249-256.

Guillemette M., R.C. Ydenberg, & J.H. Himmelman 1992. The role of energy intake rate in prey and habitat selection of Common Eiders *Somateria mollissia* in winter: a risk-sensitive interpretation. J. Anim. Ecol. 61: 599-610.

Guillemette M., J.H. Himmelman, C. Barette, & A. Reed 1993. Habitat selection by Common Eiders in winter and its relation with flock size. Can. J. Zool. 71: 1259-1266.

Kain J.M. 1962. Aspects of the biology of *Laminaria hyperborea* 1. Vertical distribution. J. Mar. Biol. Ass. U.K. 42: 377-385.

Kertell K. 1991. Disappearance of the Steller's Eider from the Yukon-Kuskokwim delta, Alaska. Arctic 44: 177-184.

Kleinbaum D.G., L.L. Kupper, K.E. Muller & A. Nizam 1998. Applied regression analysis and multivariable methods. 3rd Edition. Duxbury Press, Pacific Grove, California.

Lein T.E., K. Sivertsen, J.R. Hansen & K. Sjøtun 1987. Tare- og tangforekomster i Finnmark. The Research Foundation at University of Tromsø (FORUT) Unpublished report: 1-118.

Lovorn J.R. & D.R. Jones 1991a. Effects of body size, body fat, and change in pressure with depth on buoyancy and costs of diving in ducks (*Aythya* spp.). Can. J. Zool. 69: 2879-2887.

Lovvorn J.R. & D.R. Jones 1991b. Body mass, volume and buoyancy of some aquatic birds, and their relation to locomotor strategies. Can. J. Zool. 69: 2888-2892.

Mann K.H. 1982. Ecology of coastal waters. A system approach. Studies in Ecology, 8. University of California Press, Berkely.

McCroy C.P. 1968. The distribution and biogeography of *Zostera marina* (Eelgrass) in Alaska. Pacific Sci. 22: 507-513.

McKinney F. 1965. The spring behavior of wild Steller's Eiders. Condor 67: 273-290.

Metzner K.A. 1993. Ecological strategies of wintering Steller's Eider on Izembek Lagoon and Cold Bay, Alaska. M.Sc.-Thesis, University of Missouri, Missouri.

Nilsson L. 1972. Habitat selection, food choice and feeding habits of diving ducks in coastal waters of south Sweden during the non-breeding season. Ornis Scand.3: 55-78.

Norderhaug K.M. 1998. Mobility in kelp forest fauna: dispersion of invertebrate fauna to artificial substrates in kelp forest at the coast of Møre. Cand.Sc.-Thesis University of Oslo, Oslo.

Nygård T., B. Frantzen & S. Svazas 1995a. Steller's

Eider *Polysticta stelleri* wintering in Europe: number, distribution and origin. Wildfowl 46: 140-155.
Nygård T., P. Jordhøy, A . Kondakov & Y. Krasnov 1995b. A survey of waterfowl and seals on the coast of the southern Barents Sea in March 1994. Norw. Inst. Nat. Res. (NINA) Report 361: 1-24.
Palmer R.S. 1976. Handbook of North American Birds, 3. Yale University Press, New Haven.
Petersen M. 1980. Observations of wing-feather moult an summer feeding ecology of Steller's Eider at Nelson Lagoon, Alaska. Wildfowl 31: 99-106.
Petersen M. 1981. Populations, feeding ecology and molt of Steller's Eiders. Condor 83: 256-262.
Pihl S. In press. European species action plan for the Steller's Eider (*Polysticta stelleri*). Prepared by Birdlife International on behalf of the European Commission.
SAS 1990. SAS/STAT user's guide, Release 6.04. SAS Institute Cary, NC.
SAS 1993. SAS Technical Report P-243 SAS/STAT Software: The GENMOD Procedure. Release 6.09. SAS Institute Inc. Cary, NC.
Skadsheim A. & E. Rinde 1995. Økologisk kartlegging av taresamfunn i Foran. Norw. Inst. Nat. Res. (NINA) Report 354: 1-38. In Norwegian with English summary.
Stott R.S. & D.P. Olson 1973. Food-habitat relationships of seaducks on the New Hampshire coastline. Ecology 54: 996-1007.
Systad G.H. & J.O. Bustnes 1999. Kartlegging av kystnære sjøfugler på Finnmarkskysten utenom hekketida: kartlegging ved hjelp av flytellinger. Norw. Inst. Nat. Res. (NINA) Report 605: 1-66
Tait R.V. 1981. Elements of marine ecology, third edition. Butterworths, London.
Ydenberg R.C. & C.W. Clark 1989. Aerobiosis and anaerobiosis during diving by Western Grebes: an optimal foraging approach. J. Theor. Biol. 139: 437-449.

SAMENVATTING

De ruimtelijke verdeling van foeragerende Steller's Eidereenden *Polysticta stelleri* werd in de winter van 1996/97 bestudeerd in de Varangerfjord, Noord-Noorwegen. De ruimtelijke verdeling van de eiders in de fjord werd in kaart gebracht en vervolgens werd gekeken hoe de verspreiding zich verhield in relatie tot waterdiepte, bodemtype, begroeiing van de bodem met zeewier, en de soort zeewier (*Laminaria hyperborea* of *L. saccharina*). Vogels die in havens werden aangetroffen (12%) werden van de analyses uitgesloten. Waterdiepte was een zeer belangrijk gegeven voor de vogels: over de hele winter foerageerden 89% van de eenden op dieptes < 5 meter. Opvallend was dat de vogels relatief diep begonnen te duiken in het winterseizoen, maar in de loop van de winter opschoven van een gemiddelde diepte van 3,7 m in november, naar 2,5 meter in april. Omdat het prooiaanbod over de dieptespreiding onbekend was, evenals een eventuele prooi-uitputting over de winter, is de achterliggende reden niet bekend. Behalve diepte was begroeiing zeer belangrijk, want een grote meerderheid foerageerde binnen het aanbod van ondiepe delen van de fjord in zeewiervelden, met name in *Laminaria hyperborea*.. Ondiep gelegen zeewiervoorkomens zijn dus de belangrijkste habitat binnen de Varangerfjord voor deze eider-soort. (MFL)

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