Diet of the Steller's Sea Eagle in the Northern Sea of Okhotsk

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Abstract. Qualitative data on the diet of adult and young Steller's Sea Eagles Haliaeetus pelagicus in North Okhotia during spring (incubation period) and summer (chick rearing period) have been analyzed. The total of 177 prey samples containing 551 prey items from nests located on rivers, seacoast and on islands with large sea bird colonies were analyzed. The diet of Steller's Sea Eagles consists (in descending order of importance) of birds, fish, mammals, and carrion. Birds dominate the diet of the coastal pairs (73%, N = 107), especially in the pairs breeding at the sea bird colonies (91%, N = 211). The proportion of birds in the diet of eagles nesting on rivers is much lower (11%, N = 38). In summer fish is a dominant component of diet only in riparian pairs (77%, N = 78). In coastal pairs, as well as in pairs at the seabird colonies the proportion of fish was lower: 26% and 7% (N = 28 and 19) respectively. Carrion is very important for Steller's Sea Eagles in spring. In nests along rivers 83% (N = 6) of prey in spring is carried from traps set by trappers. In spring the eagles occupying riparian nest sites consume mostly mammals and carrion, whereas on the coast eagles feed on birds. In summer the riparian pairs switch to fish, whereas coastal nesting pairs consumed mostly birds, although the fish component increased also. The composition of the diet of chicks was dramatically different between habitats. Chicks reared in riparian nests have fish-oriented diet, whereas chicks reared in coastal nests eat mostly birds. At sea bird colonies the Steller's Sea Eagles selected species that were extremely abundant and were relatively less manoeuvrable in flight.

INTRODUCTION

Studies of Steller's Sea Eagles *Haliaeetus pelagicus* during the breeding period in Kamchatka (Lobkov & Neifeldt 1986, Ladygin 1992) and Amur (Masterov 1992) have found that fish are the most important component of the diet in these places. In other sea eagle species fish are an important part of the diet for the population as a whole, but in some areas and for some individual pairs other taxa are most important. Some pairs of Bald Eagle *H. leucocephalus* (Stalmaster 1987), White-tailed Sea Eagle *H. albicilla* are known to prey upon

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seabirds and wildfowl where they are locally abundant. This paper presents data on the diet of Steller's Sea Eagles in North Okotia. Data are from nests on rivers, along portions of sea shore, and on islands. Although data were not collected from all nests, the study area probably includes about 25% of the breeding population of Steller's Sea Eagles. The variety of situations in which nests are found in the study area means that a wide range of diet are seen. We report upon the composition of diet in the study area and highlight the importance of sea birds in the diet of some pairs.

METHODS

The diet of Steller's Sea Eagles living along the coast of the Sea of Okhotsk from Koni peninsula in the east to the Lisyanskiy peninsula in the west as well as along the rivers Yama, Tauy, Kava, Chelomdja, Ul'beya, Kukhtuy and at the sea bird colonies at the islands of Talan and Umara has been studied in 1991-1998. Only qualitative data on the diet of adults and young during spring (incubation period) and summer (chick rearing period) have been analyzed.

Prey remains were collected from nests and the area under them. In addition we recorded prey species captured by adults during hunting bouts and during food deliveries to the nests.

From direct observations of eagles and their nests, a food item is defined as: A single individual food item obtained during hunting (whether delivery to the nest was observed or not), or a single individual food item consumed by a chick.

When analyzing prey items and pellets collected from under the nest we included only items that were not recorded in the pellets and prey remains collected from the nest.

All dietary items collected in nests with chicks were classified as part of nestling diet, however portions of these items may have been eaten by adults as well. Pellets collected under perches used by adult eagles and pellets containing small items which normally are not delivered to the chicks (e.g. nuts of Siberian Dwarf Pine *Pinus pimula*, voles, *Nereidae* worms, small squid and chitons) were considered to be from adults.

Prey species were identified by comparing the remains with a collection of prey items made during fieldwork as well as collections from the Zoological Museum, Russian Academy of Sciences, St. Petersburg, collections of the Institute of Biological Problems of the North, Russian Academy of Sciences (Magadan), and the collection of the Magadan State Reserve.

A total of 177 prey samples containing 551 prey items were analyzed. We analyzed diet from nests located on rivers, seacoast and on islands with large sea bird colonies (i.e. Umara and Talan islands) separately. Collection date was also noted. In this paper we analyze diet of spring (mostly incubation period) and summer (mostly chick) rearing period separately.

Index of selectivity was calculated using Ievlev index, which has been used for bird of prey diet analysis by Galushin (1982):



Fig. 1. Diet of Steller's Sea Eagles in Northern Okhotia.

$$E = \frac{p}{r+p}$$

where E - index of selectivity, r - percent of prey species in diet, p - percent of the same species in the wild.

With this index, preferred species have positive values, whereas the species that are avoided have negative values. A zero value means that the species is preyed upon in proportion to its availability in the wild.

RESULTS

General overview of diet

The diet of the Steller's Sea Eagles consists (in descending order of importance) of birds, fish, mammals, and carrion (Fig. 1). 'Other' items are taken, but these are of relatively little importance. Detailed data on diet from all nests are given in Appendix.

Amongst birds the Thick-billed and Thin-Billed Murres *Uria aalge* and *lomvia* dominated the diet, followed by gulls (Black-legged Kittiwakes *Rissa tridactyla* and Slatey-backed Gulls *Larus schistisagus*), Crested Auklet *Aethia cristatella* and Pelagic Cormorant *Phalacrocorax capillatus*. The fish portion of the diet consisted largely of Pink *Onchorynchos gorbuscha* and Chum Salmon *O. keta*, Dolly Varden Charr *Salvelinus malma*, *S. leucomaenis* and various cod species *Gadidae*. Mammals were represented by Red Fox *Vulpes vulpes*, Muskrat *Ondatra zibethicus*, and Okhotian Ringed Seal *Phoca hispida ochotensis*. The eagles also consumed carrion. Including animals taken from gin-traps set by fur trappers, remains of dead seals and on one occasion a dead swan (possibly *Cygnus bewickii*). Other items on the diet list include pieces of Siberian Dwarf Pine cones, Nereis Worm *Nereis* sp., squid and chiton.



Fig. 2. Difference between diets of coastal and riparian pairs. Nests at sea-bird colonies are excluded.

Birds

Birds dominate in the diet of eagles at coastal nests (73%, N = 107), and especially in the diet of pairs breeding at sea bird colonies (91%, N = 211). The proportion of birds in the diet of eagles nesting on rivers is much lower (11%, N = 38). The bird portion of the diet of eagles nesting in riparian areas is diverse, including ducks *Anas* sp., Black-headed *L. ridibundus* and Slatey-backed Gulls, crow *Corvus* spp., and passerines. In coastal nests the species composition of birds in the diet was different. Apart from ducks, remains of Short-Eared Owl *Asio flammeus*, Snowy Owl *Nyctea scandiaca*, Carrion Crow *Corvus corone* and Raven *C. corax*. were also found. Pairs at sea bird colonies consumed many kittiwakes, murres, Pelagic Cormorants, Slatey-backed Gulls, Tufted *Lunda cirrhata* and Horned Puffins *Fratercula corniculata*, Ancient Murrelets *Synthliboramphus antiquus* and Crested Auklets.

In spring (before hatching) birds are the mainstay of the diet of eagles using coastal nests (64%, N = 23), however in the diet of riparian pairs we did not record birds (Fig. 2).

At seabird colonies eagles take many nestlings and recent fledglings, concentrating, mostly of those species whose young do not hide in borrows and do not go to sea during the early fledgling stages. These species include Pelagic Cormorant, Slatey-backed Gull, and kittiwake. In most instances of eagles preying upon young seabirds at colonies that we observed, eagles were seen to walk between nests and collect chicks or eggs. Eagles are very delicate in transporting small prey items to their nest, using their beaks rather than in feet. On an eagle nest on Umara Island we found an undamaged egg of murre, and live chicks of kittiwake (body weight 120-200 g) and cormorant (body weight 200-300 g). Chicks brought in as prey sometimes remain alive for more than a day, sometimes feeding on the remains of fish in the eagle's nest.

Fish

In summer, fish dominates only in the diet of riparian pairs (77%, N = 78). In coastal pairs, as well as in the pairs at sea-bird colonies the proportion of fish was lower: 26 and 7% (N = 28 and 19) respectively. Pairs breeding in riparian areas feed mainly on Pink Salmon, Chum Salmon, Dolly Varden Charr, and Grayling *Thymallus arcticus*. Sometimes we observed intensive bouts of feeding on Stickleback *Gastrossteus aculeatus*. In coastal nests fish species living in the littoral zone comprise half (50%) the diet, followed by coastal (27%) and pelagic species (23%). The most common species found in the diet of coastal pairs was Wolfish *Anarchichas orientalis*, but *Hemitripterus villosus*, *Aptocyclus ventricosus*, *Myoxocephalus* spp., and *Cottidae* were also consumed. Species found relatively rarely include Mintai *Theranga chalcogramma*, Cod *Gadus macrocephalus*, and Pacific Herring *Clupea pallasi*. In pairs nesting at sea bird colonies we recorded only Navaga *Eleginus gracilis*.

Mammals and carrion

Amongst mammal prey items Red Fox, American Mink *Mustela vison* and Dog Puppy *Canis familiaris* were noted in the diet of eagles in riperian areas. In some instances we recorded remains of Red Bank Vole *Clethrionomys rutilus* and Root Vole *Microtus oeconomus*. On the coast young Ring Seal *Phoca hispida ochotensis* was found. This is the smallest of the resident seals.

Carrion is very important for Steller's Sea Eagles in spring. In nests along rivers 83% (*N* = 6) of prey in spring is carrion from traps set by trappers. These species include Sable *Martes zibellina*, Red Fox, and American Mink. At coastal sites carrion includes seals of various species, and in one instance Snow Sheep *Ovis nivalis*.

In summer the most common mammal in the diet of pairs using riparian nests was muskrat *Ondatra zibethicus*, however the overall proportion of mammals in the diet is rather small.

Diet of coastal and riverine pairs

The diet of Steller's Sea Eagles breeding on seacoasts and along rivers is fundamentally different (Fig. 2). In spring eagles occupying riparian nest sites consume mostly mammals and carrion, whereas on the coast eagles feed on birds. In summer the riparian pairs switch to fish, whereas at coastal nests the majority of items consumed were birds, although the fish component increased also. Birds dominated the diet of eagle pairs breeding at large sea-bird colonies (90.6% N = 178), at nest of eagles on the sea coasts the bird portion the diet is somewhat lower (73%, N = 99), whereas at riparian nests the proportion of birds is much lower (10.7%, N = 6).

Diet composition of chicks was dramatically different between the habitats (Fig. 3). Chicks reared in riparian nests have a fish-oriented diet, whereas chicks reared in coastal nest



Fig. 3. Diet of chicks in diffrent habitats.



Fig. 4. Diet in comparison to the composition of available birds.

chicks eat mostly birds.

Selectivity of prey species

At sea bird colonies the Steller's Sea Eagles selected a higher proportion of Thick and Thin-billed Murres, Ancient Murrelets and Parakeet Auklets and kittiwakes (in one island of two) than other birds. Despite the high numbers of Slatey-backed Gulls, Tufted and Horned Puffins, Pelagic Cormorants and Crested Auklets, their proportion in the diet was lower (See Table 1, Fig. 4). Eagles preferred species that were extremely abundant and were relatively less manoeuvrable in flight. However, the proportions of different species in the diet of eagles at

	Talan Island	Umara Island
Rissa tridactyla	0.8	-0.1
Uria spp.	0.8	0.8
Phalacrocorax pelagicus	-1	0.4
Larus schistisagus	-1	-0.6
Cerrphhus carbo	-1	-0.2
Lunda cirrhata + Falcedo corniculata	-0.4	-0.6
S. antiquus + C. psittacula	0.2	0.5
A. cristatella	-0.7	-1

Table 1. Indicies of use of prey species of Steller's Sea Eagle nesting on two islands that have large breeding colonies of sea birds.

coastal nests and at seabird colonies differ. Slatey-backed Gull is the most abundant bird on the seacoast (Golubova & Pleshenko 1997) and it is dominant in the diets of the coastline pairs. However, eagles breeding at large bird colonies avoid Slatey-backed Gull (Fig. 4, Table 1) and prefer kittywakes and murres.

DISCUSSION

Most researchers that have studied the diet of Steller's Sea Eagles have noted a significant seasonal shift in diet (Babenko *et al.* 1988, Lobkov & Neifeldt 1986, Shibnev 1981, Wunderlich 1980). Our findings are consistent with these. In addition, we recorded differences in dietary shift between eagles nesting in riparian and coastal areas.

The dietary shift in riparian areas is more dramatic, than in coastal areas. This seems to be because with the break up of the river ice, and the spawning of large numbers of salmonids, fish resources are generally more available on the rivers than in coastal areas. In coastal pairs the beak-up of the sea ice has similar effect, but the bird proportion of the diet stays high because suitable avian prey is available both before and after the ice break-up, and the relative availability of fish does not increase to the same extent as it does on the rivers.

Seabird colonies attract many eagles, some of which do not breed there. In spring 1998 we observed about 20 eagles feeding at Talan Island, which has only 2 breeding pairs. It appears that these eagles fly to Talan from the mainland (some 7 km away). The constant crossing of the strait between Talan Island and the mainland by eagles was observed from end of April to mid May, when the sea ice had drifted away. During that time we observed eagles feeding on birds on the island, as well as carrying prey to the mainland. In summer, when the numbers of seabirds on the island increases, no eagle concentrations are observed there. The movement of eagles from the mainland in spring is probably linked to the fact that ice cover makes hunting unprofitable in coastal waters, and is facilitated by the fact that eagles are not yet territorial.

The spring diet of the Steller's Sea Eagle has been most completely described by Lobkov & Neifeldt (1986). Our observations agree with their findings. In our study we have more data

to compare diet between riparian and coastal nesting pairs. In spring at riparian sites the diet is more or less balanced across taxa, whereas at coastal sites diet is composed mostly of birds. In Magadan region rivers are blocked by ice until mid-May, and at that time only dead fish left from last year's spawning are available to eagles. This source of food is absent at the seacoast. Fish in the diet of coastal pairs in early spring was noted only once.

Carrion and live mammals play an important role in spring, whereas their proportion in summer time diet dramatically decreases. In spring there were direct observations of successful hunting by eagles of American Mink and Red Fox (Miroshkin, G., Sokolov, A., Arshiev, E. pers. comm.). Arshiev, E. (pers. comm.) complained that an eagle had preyed upon a puppy at his hunting hut in the Kava river valley. However, at sea bird colonies there were no reported cases of eagles attacking foxes. In Talan Island we observed eagles and foxes in close proximity to one another, but did not see eagles attacking foxes. On one occasion we observed a fox approaching an eagle sitting on sea ice. As the fox approached the eagle started to take off, while the fox made several jumps towards it. The eagle then landed on the nearby ice sheet, and the fox continued on its way. Researchers working for more than a decade on Talan Island have not noted foxes mortality caused by eagles (Kondratiev *et al.* 1992). Lobkov & Neifeldt (1986) did describe cases of eagles attacking foxes in winter, but said that eagles do not pay attention to foxes in summer. We noted foxes in the diet of one riparian pair (Chelomdja River) and of one coastal pair (Motykley Bay).

In spring we found hair of Red Bank Vole in pellets from one nest on the Chelomdja River, and on two occasions the hair of Root Vole (Malakchan estuary and Motykley Bay coast).

Seal pups play an important role in the diet of coastal pairs (57% N = 4). The predation of seal pups by Steller's Sea Eagle was reported by Tikhomirov (1966) and Belopolskiy (Belopolskiy & Rogova 1947). All reported cases refer to the Okhotsk Ringed Seal or Akiba *Phoca hispida ochotensis*. This is the smallest seal amongst 4 resident species. Other species include Bearded Seal *Erignathus barbatus*, Largha *Okhotian common seal*, *Phoca vitulina largha* and Winged Seal *P. fasciata*. The pupping areas of Akiba are the closest of all resident seals to the coastline. Akiba pups weigh 3.5-4 kg, which puts them within the weight range of prey for Steller's Sea Eagle, and in contrast to the Largha Seal, Akiba Seals (both pups and mothers) are not aggressive at the rookeries (Bukhtiayarov, pers. comm.).

In spring eagles are opportunists and feed upon what they can find, even in the presence of humans. A. Krechmar (pers. comm.) observed the eagle trying to fly away with a dead swan *Cygnus* sp. A.L. Fedorov (pers. comm.) observed an eagle walking c. 50 m to get to a gin-trap in which a hare was held, as it was not possible to fly close to the trap. N. Turin (pers. comm.) observed an eagle taking Mink from the gin trap. E. Arshiev (pers. comm.) described an eagle taking a goose just been shot by him, but before he had managed to retrieve it. A similar observation was made by A. Krechmar on the Chukcha River, where an eagle picked up a Red-breasted Merganser *Mergus serrator* just wounded by a hunter.

On the coastline Steller's Sea Eagles were seen to eat dead adult seals on the ice. Rangers of the Magadan State Reserve regularly see eagles feeding close to concentrations of seals that have hauled out onto the ice. However, there is no direct evidence that the eagles kill adult seals.

In summer both carrion and mammals are rare in the diet of eagles, both at riparian and coastal sites. This is consistent with observations by Ladygin (1992) made in Kamchatka.

The concept that Steller's Sea Eagles specialize on Pacific salmon comes from observations in Kamchatka (Stenchenko 1974, Lobkov 1978, Lobkov & Neifeldt 1986, Ladygin 1992), made mostly on inland nests. In our study, the fish proportion in the diet of eagles breeding at the sea bird colonies was only 7%, and at sites along the coastline 26%. It was only on the rivers that fish was the main source of food (77%). Masterov (1992) and Babenko *et al.* (1988) give similar figures for the proportion of fish in the diet of Steller's Sea Eagles on inland water bodies of southern Khabarovsk District. The difference between there and the study in Magadan is only that the local ichthyofauna differs. Coastal nests were not studied in detail in Kamchatka or southern Khabarovsk District.

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Species	Latin name	Ν	%
Birds	Unia ann	114	20
Mullie Block looped Vittimelre	<i>Uria</i> spp.	114	20
Slaty backed Cull adult	KISSA IFIAACIYIA	40	5
Black lagged Kittiwaka young	Larus schistisagu aa Biaca tuida atula	20	5
Grante de Arrelatet	Rissa triaactyla	28	3
Crested Aucklet	Aethia cristatella	24	4
Turted Purrin	Lunda cirrhata	23	4
Unidentified birds	Aves spp.	13	2
Slaty-backed Gull chick	L. shistisagus Subadult	12	2
Pelagic cormorant juvenile	Phalacrocorax pelagicus	11	
Slaty-backed Gull young	L. schistisagus	9	1
Ancient Murrilet	Synthliboramphus antiquus	9	1
Spectacled Guillemot	Cerphus carbo	8	1
eggs		8	1
Guilemot sp	Cerphus spp.	7	1
Pelagic cormorant	Phalacrocorax pelagicus	6	1
Gull	Larus spp.	5	0
Parakeet Aucklet	Cyclorrhynchus psittacula	3	(
Fulmar	Fulmaris glacialis	3	(
Duck sp	Anas spp.	3	(
Black-headed Gull	L. ridibundus	2	(
Red-breasted Merganser	Mergus serrator	2	(
Raven	Corvus corax	2	(
Crow	Corvus corone	2	(
Black-legged Kittiwake chick	Rissa tridactyla pull.	1	(
Gull fledgling	Larus sp	1	(
Murrie fledgling	Uria sp	1	Ì
Horned puffin	Fratercula corniculata	1	Ì
Crested Aucklet subadult	A ethia cristatella	1	Ì
Marbled murrelet	Brachvramphus marmoratus	1	Ċ
Cormorant subadult	Phalaerocoray palagieus	1	Ì
Shoveler	Ange ehreate	1	
Molland inv	Ands clypedia	1	
Dintoil	Ands platymynchos	1	
Pintan David internet	Anas acuta	1	
Kaven juv	Corvus corax	1	
Showy Owl	Nyciea scanalaca	1	(
Short-eared Owi	Asio fiammeus	1	
Passerine	Passeriformes sp.	1	(
Mammals			
Carrion	Mammalia spp.	11	
Muskrat	Ondatra zybethica	8	1
Vole	Clethrionomys sp.	4	(
Akiba seal juv	Phoca hispida ochotensis	4	(
Red Fox	Vulpes vulpes	4	(
American Mink	Mustela vision	1	(
Sable	Martes zibellina	1	(
Dog puppy	Canis familiaris	1	(
Fish			
Pink salmon	Onchorynchos gorbuscha	37	6
Stickleback	Gastrossteus aculeatus	19	3
Wolfish	Anarchichas orientalis	11	
Salmon	Onchorynchos spp.	10	1
Chum	O. keta	10	1
Mintai	Theranga chalcogramma	9	1
Fish sp	Pisces spp.	9	1
Dead salmon	Onchorinchus spp.	8	1
Cottdae	Cottidae	4	(
Sea fish	Pisces spp.	.3	(
Kerchak	Myoxocephalus sp	3	Č
Hairfish	Hemitripterus villosus	2	Č

Appendix. Continued.

Species	Latin name	Ν	%
Grayling	Thymallus arcticus	1	0.2
Cod	Gadus macrocephalus	1	0.2
Frog-fish	Aptocyclus ventricosus	1	0.2
Pacific Herring	Ĉlupea pallasi	1	0.2
Others			
Nereis worm	Nereis sp.	4	0.7
Pine cones	Pinus pimula	4	0.7
Junk		1	0.2
Squid		1	0.2
Khiton	Khiton spp.	1	0.2
Total aves		376	68.2
Total Fish		130	23.6
Total mammals		34	6.2
Total others		11	2

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