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For further information please write to:

Mongolian Ornithological Society
P.O.Box 537, Ulaanbaatar 210646A, Mongolia.

Email address:
info@mos.mn, mongolianbirds@mail.com

Web site:
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SOURCE-SINK POPULATIONS OF THE STELLER'S SEA-EAGLES (*Haliaetus pelagicus*) IN THE NORTHERN PART OF THE SEA OF OKHOTSK: ECOLOGICAL TRAPS AND THEIR CONSERVATION IMPLICATIONS

***Eugene Potapov[1], Irina Utekhina[2], Mike McGrady[3], Rimlinger David[4]**

[1]Bryn Athyn College, Pennsylvania, USA
[2]Magadan State Nature Reserve, Magadan, Russia
[3]Natural Research Ltd, Scotland
[4]San Diego Zoo, USA
E-mail: eugenepotapov@gmail.com
*(*Corresponding author)*

Abstract: For the past 18 years, we have monitored the numbers and breeding output of the Steller's Sea-eagles in Magadan District and the adjoining administrative territories. Every year, we checked 20–133 territories in constant 'model' study areas located near Magadan, amassing data from a total of 1,130 potential breeding attempts, 490 at home ranges which produced eggs (at least) in most years. The majority of eagle nests were found along the sea coasts (70%), the rest along rivers. The eagles breed more successfully along the sea coast than on the rivers, suggesting the existence of source-sink population dynamics. The total number of chicks fledged per successful pair was more or less stable across the years, with lower values along the rivers. The net chick output from all constantly monitored areas showed a statistically insignificant increase in the coastal environment, while on the rivers chick output declined significantly. We documented zero breeding success in the Kava- Chelomdja portion of the Magadan Reserve and along the upper stretch of the Tauy River in 2009. In view of these long-term data it appears that the breeders along the rivers are a 'sink', as they continuously produce fewer offspring than needed to maintain a constant population level. In contrast, the sea coast territories are a 'source' population, producing more chicks than necessary for population stability. Satellite tracking of young eagles revealed presence of naturally occurring ecological traps along the migration routes. These traps were areas of the fish-rich rivers which remained open while other sections of the rivers and the sea froze over as winter progressed. The eagles that stayed too long in these places were eventually unable to feed themselves due to diminishing food availability and were cut off from the wintering grounds by the frozen sea, and died. Conservation implications of these findings are discussed.

Key words: *Steller's Sea-eagle, Sea of Okhotsk, ecological traps, source-sink, satellite telemetry, population dynamics.*

Introduction

The Steller's Sea-eagle (Steller's Sea Eagle) *Haliaetus pelagicus*, as one of few true endemics of the Russian Federation, enjoys a state and international protection status. It is listed in the Red Data Book of the Russian Federation and Appendix II of CITES. Its range is limited to a narrow strip along the coast of the Sea of Okhotsk and of Kamchatka. Nests in coastal territories are on trees and cliffs, while riverine nests are exclusively on trees (Potapov *et al.* 2000a, Lobkov 1986). Relatively small population size and limited breeding range mean that Steller's Sea Eagle is potentially vulnerable. The human population within the breeding range concentrates near the major rivers and in many cases these are places where intensive salmon fishing occurs. This situation poses a risk to this species in the form of potential persecution and long-term reduction in food availability.

Methods and Materials

We carried out annual surveys along the sea shore and rivers of the Magadan District on foot, using a motor-boat (and image stabilizing binoculars) and from a micro-light aircraft (Utekhina 1995). We determined whether territories were occupied and whenever possible determined the number of chicks produced. The latter usually involved climbing into nests. Every year, we surveyed breeding eagles within the Kava-Chelomdja and Koni Peninsula portions of the Magadan State Reserve. When possible, we extended the surveys to areas surrounding these model areas. As a result, we checked 20 - 133 territories per year near Magadan. Areas surveyed in most years included the Tauy River, Motykley Bay and the coastline adjoining it and Odyan Bay (for a detailed description of the study area see Potapov *et al.* 2000b).

Satellite telemetry was used on 22 nestling and one adult eagles using Toyocom (Toyocom Inc. Japan), North Star (Maryland, USA) and Microwave (Maryland, USA) Doppler PTTs (Platform Terminal Transmitters) (n=17) and Microwave GPS PTTs (n=6). All transmitters were fitted as backpacks using Teflon ribbon (Bally Ribbon Mills, USA). Some results of the satellite telemetry have been published earlier (McGrady et al. 2000 and 2003). Import of both GPS and Doppler fixes and subsequent processing were carried out within ArcGIS 9.2 (Redlands, CA, USA) using the Argos-tools extension (Potapov and Dubinin 2003, Potapov and Hronusov 2005). The tracks of eagle movements were overlaid with ice data provided as shape files by the National Ice Center, NOAA (http://natice.noaa.gov).

Results

Since 1991, we have recorded occupancy and productivity from 1,130 potential breeding attempts, including data from 490 attempts at territories that were occupied in most years and usually produced eggs.

In the northern part of the Sea of Okhotsk, the majority of eagle nests were found along the sea coasts (70%), while the rest were along rivers. Eagle breeding rate was higher for coastal territories than for those on rivers, F=9.04, p<0.01 (Figure 1) and coastal eagles had larger broods (Figure 2).

Figure 1. Average number of chicks fledged per successful pair on the sea coasts and rivers of Magadan District, Russia

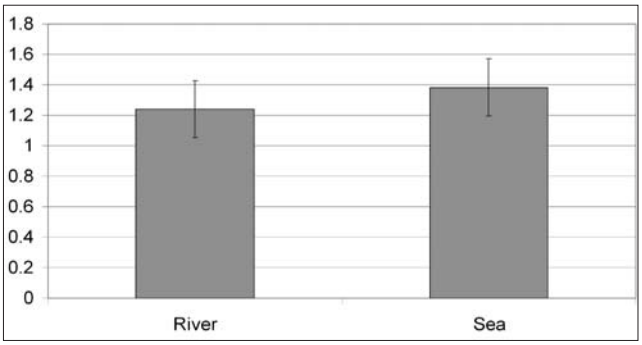
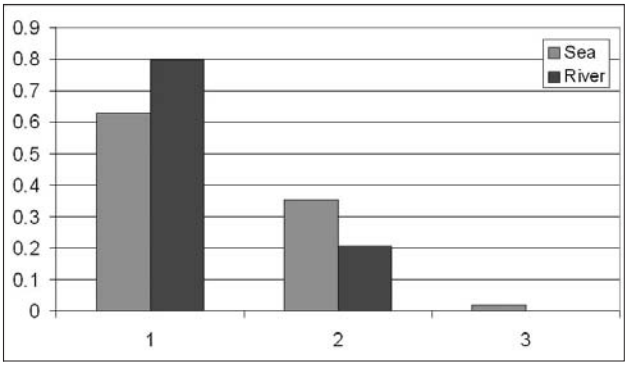
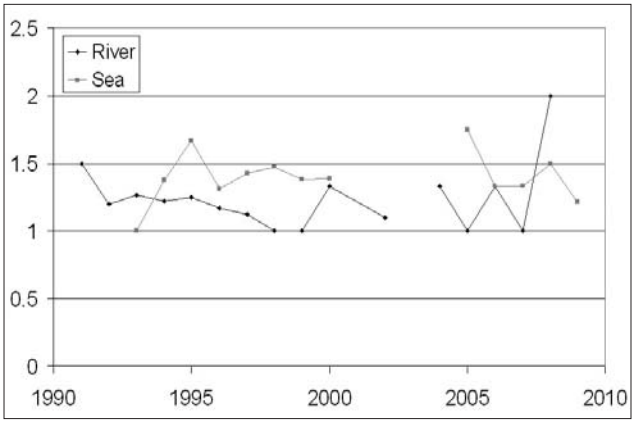


Figure 2. Brood size distribution for rivers and the sea coast in Magadan District, Russia



The total number of chicks fledged per successful pair was more or less stable across the years, with lower values being recorded for pairs nesting on rivers (Figure 3).

Figure 3. Number of fledglings per successful pair at coastal and riverine nests in Magadan District, Russia.
In 2008 there was a single successful nest along the rivers (in the Kava-Chelomdja portion of the Magadan Reserve) and it produced two fledglings.



The percentage of pairs that attempted to breed was lower on rivers than along the coast area (Figure 4) and consequently the number of chicks fledged on rivers was lower than on the coast (Figure 5). The percentage of territory holding eagles that attempted to breed declined significantly over time on the rivers ($y = -2.4817x + 57.356$, $R^2 = 0.4652$, F=9.7, p<0.01); the percentage of breeders on the sea coast also declined, but that decline was not significant.

Figure 4. Percent of territorial pairs that attempted to breed on the coast and along rivers

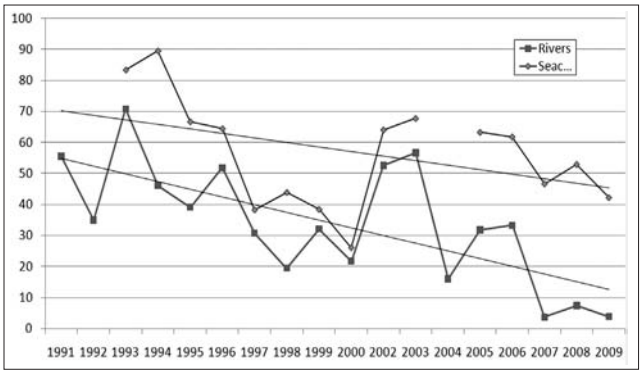
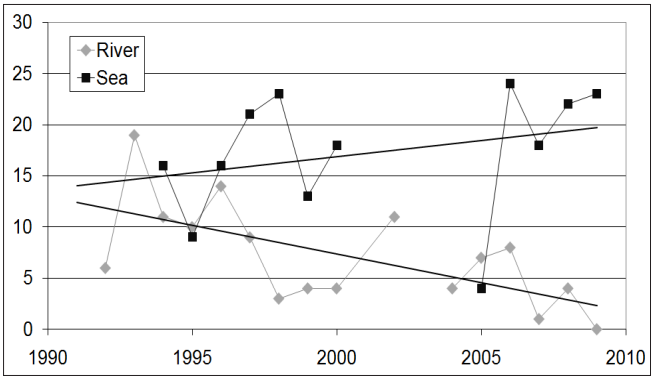


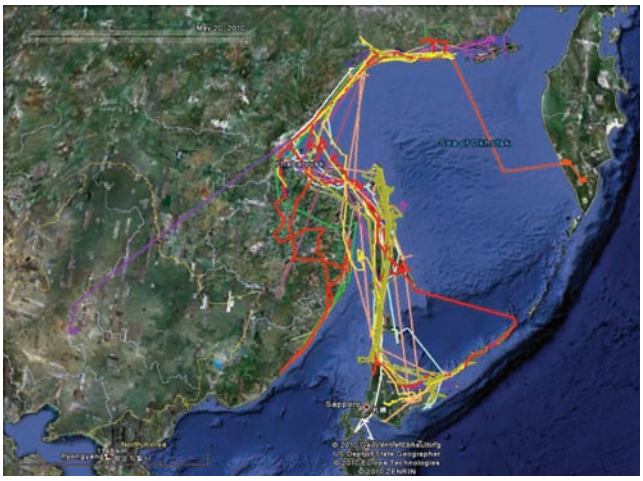
Figure 5. Total number of young fledged along the rivers and sea coast



Net annual chick production from all constantly monitored areas (Figure 5) showed an increase (not significant) in the coastal environment, while on the rivers chick output declined significantly ($F=9.08$ $p<0.01$). In 2009, no successful breeding occurred in the Kava-Chelomdja portion of the Magadan Reserve (river) or along the upper stretch of the Tauy River, although most territories were occupied and nests were refurbished.

The migration routes of satellite-tracked eagles are shown in Figure 6. Most eagles migrated through or spent their winters on Sakhalin Island, the continental coasts of the Tatar Strait, Hokkaido and the Kuril Islands. Migration was mostly along the coast, but the routes of some birds included some inland stretches.

Figure 6. Tracks of the one adult and 22 young Steller's Sea Eagles



We lost contact with instrumented birds when they either died from apparently natural causes or when to batteries expired. Some eagles died from human-related causes. For some eagles, we were able to determine the cause of death (Table 1).

Table1. Causes of transmitter losses

Causes	Number
Bear predation	1
Wire collision	1
"Natural traps"	3
Shot	6
Natural causes or expected battery depletion	10

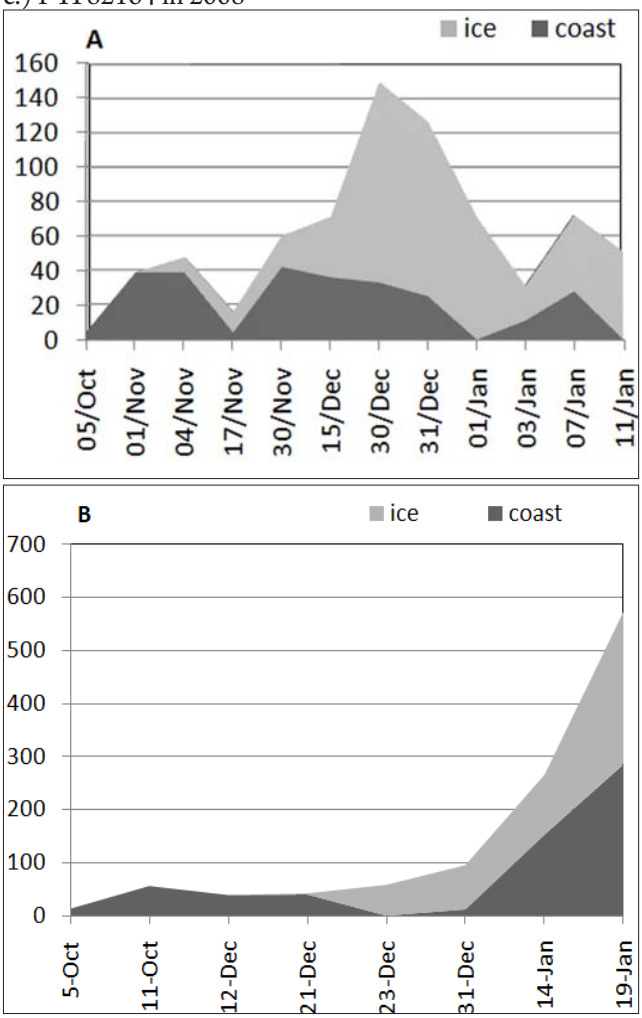
In one case a bear climbed into the nest prior to the eaglets fledging, removed a chick with a transmitter and possibly wounded its sibling. One bird lost its way during migration and ended up in inland China, where it collided with an electric wire. An alarming total of 6 birds are believed to be have been shot, as the last transmitted fixes were close to settlements. We are confident that at least two birds in Magadan District (one in Motykley Bay another at Yana river fishing camp) were shot since we recovered one transmitter which had been cut from the eagle and discarded, and the other was carefully moved from the fishing camp and placed in a remote valley in January. Transmittered eagles were shot near Fedorovskoye (2) and Chumikan villages (2) in the Khabarovsk Administration District. At Fedorovskoye an eagle died in 1998 and later a transmission was detected in the open sea, suggesting the PTT was on a boat. Another GPS PTT was placed at a cliff near a settlement. Birds killed in the Chumikan area were shot at a fishing camp some 15 km NW, and later placed at a lighthouse near the village. One PTT sent a signal from an oil platform off the Sakhalin coast some months after its signal being initially lost.

Three birds were apparently lost when they stopped over on a river where salmon were migrating and where the river does not freeze over until late winter due to hot springs, much later than most rivers in the region. When this river did freeze over and food became unavailable the eagles moved to the coast in an apparent attempt to continue their migration. However, by the time this happened the sea was also frozen and the eagles were trapped. The three eagles showed different responses to their predicaments: one flew back to its natal grounds and died in January, another flew south along the shore, and died in late December (probably starvation), and the third flew inland, presumably in search of food, and died in the mountains on 14 January. In all three cases when the eagles left the river area and moved to the shore there was at least 10-20 km of sea ice already formed (Figure 7 and 8). All birds which migrated before the formation of sea ice made it to the wintering grounds, unless they were shot.

Discussion

We attribute the decline in productivity of the river-breeding part of the population to the increase in the frequency, duration or intensity of spring floods, which in some years lasted until the end of July. High river levels and murky waters caused by the floods prevented eagles from hunting efficiently (even though we do not think overall abundance of food declined). In 2009, the snow accumulation in the coastal zone of the Magadan/ Khabarovsk Districts reached unprecedented levels. Official figures (Bulygina *et al.* 2010) showed a +200 cm anomaly in the region contrasted with negative anomalies in the European parts of the country. Given the documented marked increase in the snow depths in eastern part of Siberia since 1966 (Bulygina *et al.* 2009) as a result of global warming (Bulygina *et al.* 2009 and 2010), we predict that the increased snow depth in winter will cause more frequent spring flooding, which might disrupt the breeding of Steller's Sea Eagles, and may also affect the spawning conditions of the Pacific salmon on the rivers of the region.

Figure 7. Distance (km) from the instrumented birds to the coast and from the coast to open water in autumn and winter. a.) PTT42680 in 2007, b.) PTT82512 in 1998, and c.) PTT82164 in 2008



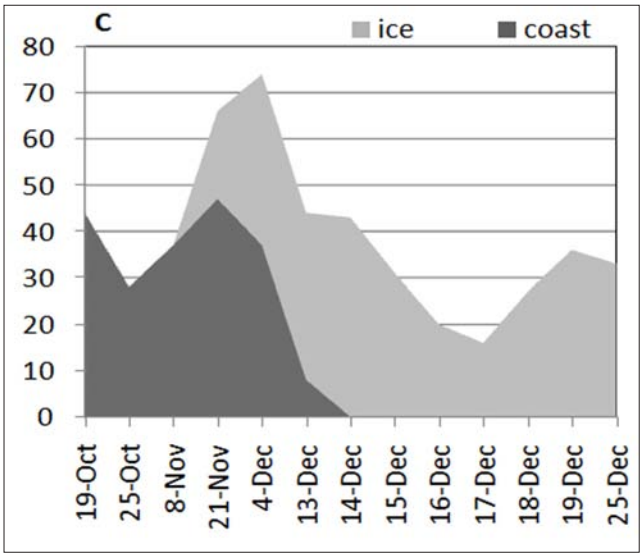


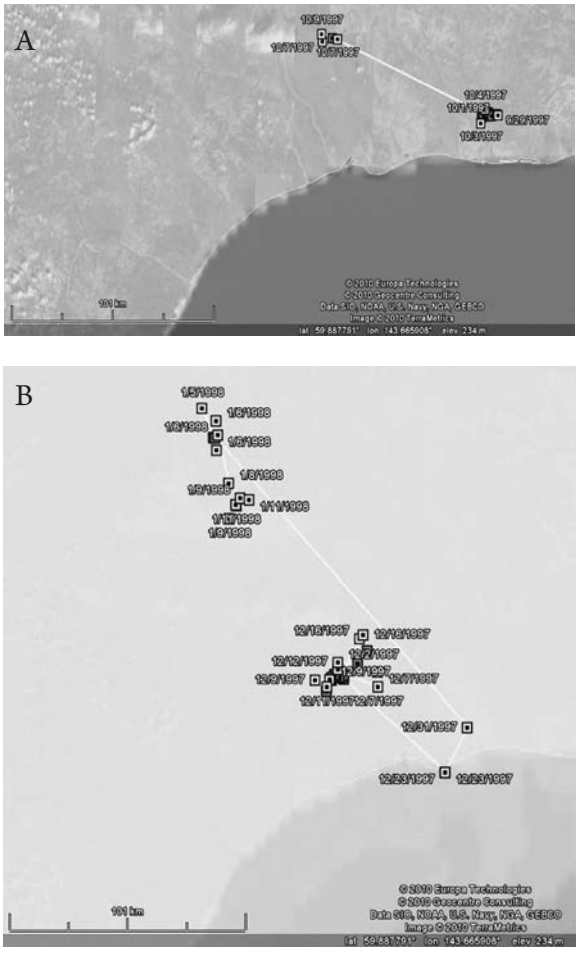
Figure 8. Movements of eagle 82512 as it stops over on the Okhta and Kukhtuy Rivers, flies to the coast after sea ice formation and flies back inland

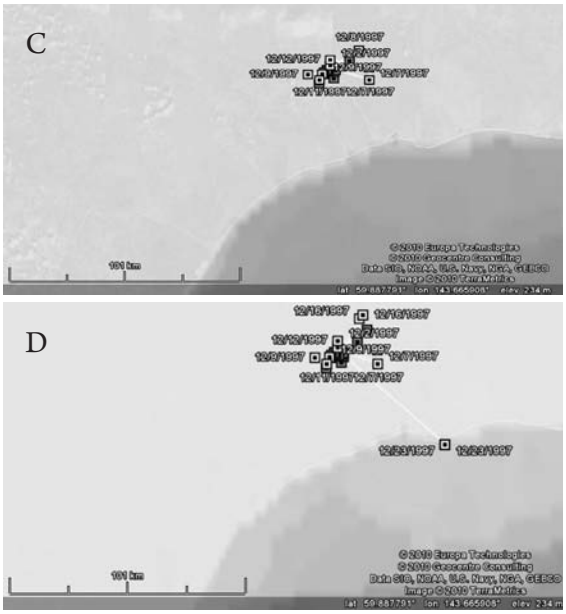
A. September – October, bird disperses from the Ulbeya River to Kukhtuy River.

B. October-November, bird stays at the Okhota and Kukhtuy Rivers. Ice starts to form at the coastline.

C. 23 December: bird moves to the shore (as river ice and snow cover increase) only to encounter a 58 km strip of coastal sea ice.

D. Bird flies inland and settles in mountains where it dies on 14 January).





Most surprising is the suggestion of a link between increasing snow deposition trends in North-Eastern Siberia and spring flooding on the rivers where Steller's Sea Eagles breed and the resulting poor productivity that results from such flooding. If flooding becomes more common, the riverine part of the population will contribute less and less in terms of breeding output, which might affect the vulnerability of the species.

Romanov and Masterov (2008) showed that because Steller's Sea Eagle must survive for many years before reaching a reproductive age (5 years) and because of their low breeding rate, the overall population balance is exceptionally fragile. Even with the adult survival rate of 0.95, small decrease in the breeding rate to 0.42 individuals per pair might reduce numbers by half in <50 yrs. If the model suggested by Romanov and Masterov (2008) is applied to our data, it turns out that the population that breeds along the sea is just about at the break-even point, meaning slight population increase. However, the low productivity of the eagles which we observed on the rivers pushes the overall population growth coefficient down, so overall balance of the population is negative, which, in turn suggests the population shrinkage according to the Moffat's principle (Hunt 1998).

In the view of this long-term data set it appears that the breeders along the rivers currently comprise a 'sink' population, as they continuously produce fewer offspring than needed to maintain a constant population level. In contrast, the sea coast territories are a 'source' population, producing more chicks than necessary for population stability. This conclusion provides solid evidence for the hypothesis first expressed by Lobkov and Zuyeva (1983), which stated that the inland territories are more susceptible to the impacts of natural variation in environmental conditions, such as deep snow cover and floods which affected the breeding performance of the eagles. This hypothesis was formulated based on a relatively limited dataset from Kamchatka, which covered predominantly inland eagles. The wide spread breeding of the Steller's Sea Eagles at the Magadan sea coast suggests that the sea offers more stable conditions for eagle breeding. If this is indeed the case, then a decline in numbers of occupied territories in the 'sink' area may potentially mean that the eagles are not doing well in the (more extensive) 'source' part of the population. Therefore, monitoring occupancy of the river portions of the population may provide an early warning system for the population as a whole.

Satellite telemetry revealed several areas where migrating Steller's Sea Eagles are illegally shot. The remoteness of these places makes it difficult to enforce any protection and since fishing will continue there it is likely that this problem will persist for some time.

Satellite tracking also demonstrated the existence of apparent "ecological traps" where eagles settle at a site of plentiful food only to be trapped later when food supplies are reduced and sea ice hinders feeding and migration.

The idea of ecological traps has been recently discussed in detail (Battin 2004). Most typically ecological traps are defined as low quality habitats that animals prefer over high-quality habitats (Dwernychuk and Boag 1972), and the majority so far identified are related to human activity (Battin 2004). In our study we found evidence of another sort of ecological trap, one in which temporally good quality habitat (high availability of food) is surrounded by areas of habitat of rapidly deteriorating quality (which blocks migration to the wintering grounds and access to more local feeding areas). Other existing ecological traps similar to the one at the Okhota River elsewhere remain unclear.

The existence of natural ecological traps is not totally surprising, but that the one that we identified has trapped such a large proportion (3 of 23) of the birds we tracked is. Lack of infrastructure in such a location makes it difficult to assess the feasibility of undertaking conservation action aimed at ameliorating this problem. Theoretically the problem might be solved by organising a feeding station at the Okhota river, but lack of an active human population and the remoteness of the region makes this an extremely difficult task.

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Хураангуй

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The purpose of the discussion is to interpret and compare the results.
o The discussion provides an opportunity for interpreting data and making literature comparisons.
o Begin the discussion by synthesizing your results with regard to your objectives and then relate your work to other literature and research.
o Please consider the following; relate your results to current knowledge in the issue and to your original purpose in undertaking the project: have you resolved the problem? What exactly have you contributed? Briefly state the logical implications of your results. Suggest further study or applications if warranted.
o Present your results and discussion either as two separate sections or as one combined section if it is more logical to do so.

Conclusion (if needed) (Arial 12, Bold)
o The purpose of the Conclusion section is to put the interpretation into the context of the original problem.
o Do not repeat discussion points or include irrelevant material. Your conclusions should be based on the evidence presented.

Acknowledgements (Arial 12, Bold)
o The Acknowledgments section appears immediately before References section. As simply as possible, thank those persons, other than coauthors, who added substantially to the work, provided advice or technical assistance, or aided materially by providing equipment or supplies.

References (Arial 12, Bold)
Each entry in the list should use the style Reference.
o The reference list follows The Chicago Manual of Style, fifteenth edition (Chicago: University of Chicago Press, 2003) and is organized alphabetically by the author's name.
o Article titles use the "Sentence case" style from MSWord.
o Italicize the name of a book or journal. Where URLs (web addresses) are cited, the web address may be set in Courier font. Note the following examples:
-Chiva-Gomez, R. 2003. The facilitating factors for organizational learning: Bringing ideas from complex adap-

tive systems. *Knowledge and Process Management* 10 (2): 99–114.
-Holt, J. 2004. UML for systems engineering. *A pragmatic guide to business process modelling.* Swindon: The British Computer Society. INCOSE 2006 systems engineering handbook - a guide for system life cycle processes and activities, Version 3. ed. Cecilia Haskins.
-Kamlani, D. 2005. ICT standards and the new arms race: The rule of 3 (+N). In *The standards edge: Future generation*, ed. S. Bolin, 261–68. Ann Arbor, MI: Bolin Communications.
-Temple, P., R. Witt, and C. Spencer. 2005. Standards and long-run growth in the U.K. In *The empirical economics of standards.* UK.
-Urie, A. 2005. The standardization ecosystem: Understanding organizational complexity. In *The standards edge,* ed. S. Bolin. Ann Arbor, MI: Bolin
- Bold, A. Birds of Ugii lake, Mongolia. *Amphibians, Reptiles and Birds* 2:45-51. (in Mongolian)

CITATION

(Mankins 1995); (Temple *et al.* 2005) or Temple *et al.* (2005); (Urie and Sheard 2005) or Urie and Sheard (2005)

TABLES AND FIGURES

Tables

o Submit only essential tables and figures.
o Use a Microsoft Word tabe.
o Use Arial font if use different software for the table.
o The Table shall be placed at the end of text with a title above the table.
o Each table, numbered with Arabic numerals in the order in which they are to appear, must be on a separate page with the table number and an appropriate stand-alone caption.
o Tables should have titles and sufficient experimental detail in a legend immediately following the title to be understandable without reference to the text.
o Do not submit tables if the information overlaps with information presented in the text, can be easily printed in the text with less journal space, or presents the same data in another table and a figure.
o Number tables and figures independently.
o Reference tables and figures parenthetically (Table 1, Figure 3) and avoid statements such as, "The results are shown in Tables 2-9."
o Table and figure titles must include the species or subject of the data studied and when and where (region/state and country) the data were collected.
o Do not include statistics (e.g. p-values) or other statements of results in the titles.
o Do not prepare tables for small data sets, those containing many blank spaces, zeros, repetitions of the same number, or those with few or no significant data. Put such data or a summary of them in the text.
o For data that must be shown in a table, items that provide the most important comparisons usually read vertically, not horizontally.
o Construct tables for column-width no wider than 85 mm (~3.5 inches) printing.
o Do not combine multiple tables or figures on one page.

Figures

o Should have titles and legends containing sufficient detail to make the figure easily understood.
o Begin figure on a new page immediately following the References. Each figure should have its own title, placed on the top of the figure.
o Figure size for a maximum width is 210 mm. A maximum page length would be 290 mm.
o For lettering use Arial font, 14 pt (12-14 pt inside figures is acceptable).
o Thickness of lines (including boxes) should be 0.5 pt (vary for contrast if necessary).
o Contrast between grey shades/patterns must be distinct.
o Graphs and histograms should preferably be two-dimensional with scale marks turning inwards. Most figures are either line (or computer) drawings or pictures.
o Do not submit color figures unless you are able to pay for printing. Figure captions tend to be longer than table titles because figures are not footnoted. The caption may be several sentences and include brief suggestions for interpreting the figure content.

LINE DRAWINGS AND PICTURES

o Line drawings, and scanned pictures must have sharp focus in the most important parts of the image, have high tonal contrast, and have a reference scale if size is important (if it is essentially needed).
o Letters, scales, or pointers can be drawn on the prints, but they must be of professional quality.
o All image files must have a resolution of >300 dots per inch (dpi) and for black line drawings must be 600 dpi. We will tend to not retouch or resize photos, so submit only print-quality images.

REVIEW PROCESS

o Upon receipt, the editorial staff examines a manuscript for proper style, format, and appropriate subject matter.
o If style and format are seriously flawed, the paper likely will be returned for revision. Editor's reviews are submitted electronically to authors via Scientific Committee (SC).

ACCEPTANCE AND REJECTION POLICIES

o Decision on final acceptance of manuscripts is made by editors and SC. Once a manuscript is accepted, it enters the queue for publication.

o Based on editors and SC members decision, a manuscript that is seriously flawed, poorly written, and improved after more than two revisions will be published as abstract only (not full paper).

o Page proofs of each paper are created by the Mongolian Ornithological Society and National University of Mongolia and sent to each corresponding author.

o During the page proof stage, press deadlines are fast approaching and author corrections to page proofs are urgently needed, preferably within 48 hours of their receipt.

o It is important that authors clearly communicate their recommended changes, mark proofs clearly, or describe changes in detail. Make only essential changes to page proofs.

TAXONOMY AND NOMENCLATURE

Use English and scientific names as presented in Dickinson, E. C. (ed.) 2003: The Howard and Moore Complete Checklist of the Birds of the World: Third Edition. — Princeton University Press. 1056 pp. or check BirdLife international website.

AFTER ACCEPTANCE

All manuscripts within the scope of the journal are reviewed by at least two reviewers. Authors will generally be notified of provisional acceptance or rejection within two months. The Author(s) should consider all suggestions proposed by the referees and the Editor, and make appropriate changes. Major changes pre-suppose a new review process. The Editor retains the right to modify the style and length of a manuscript; for major changes the Author(s) will be consulted. The correspondence author will receive a page proof for approval. Extensive alterations are not allowed at this stage. The journal provides a free electronic offprint in PDF format.

SAKER FALCON -NATIONAL BIRD FOR MONGOLIA



This is the first announcement of the National Bird vote result in Mongolia.
Saker Falcon (*Falco cherrug*) is the National Bird for Mongolia.

Members of the Mongolian Ornithological Society and Ornithological Laboratory of the National University of Mongolia organized a vote to decide the National Bird covering Mongolian citizens living in different provinces and cities with different age, sex and education for the last 3 years.

The results of the vote indicate Saker falcon was favored (47.5%), Mongolian Lark (15%), Gyr Falcon (12.2%), White-naped Crane (4.6%), Steppe Eagle (3.2%), Whooper Swan (2.7%), Golden Eagle (2.2%), Cinereous Vulture (1.0%), Northern Raven (0.8%), Pallas's Sandgrouse (0.6%) etc...



























