

Cold wintering of coastal birds in the source and upper reaches of the Angara river: changes in abundance and species structure in the conditions of a sharp climate warming

Yuriy Mel'nikov*

Baikal Museum of the Siberian Branch of the Russian Academy of Sciences, 1, Academic St., setl. Listvjanka, Irkutsk Oblast, 664520, Russia

Abstract. Based on long-term research (1972-2023) and analysis of literature data, materials on the dynamics of the number and species structure of wintering shorebirds and waterfowl on cold wintering in the source and upper reaches of the Angara River (up to the town of Usolye-Sibirskoye) are presented. This is the largest cold wintering of coastal birds in Eastern Siberia – up to 55.0-60.0 thousand birds, the formation of which is due to very specific conditions of the upper reaches of the Angara River. This is the thermal refugium of the Upper Angara region, which ensures the accumulation of birds at the end of migration in more favorable areas of this region. It is divided into two sections: the first stretches from the source of the Angara River to the village of Taltsy, the second from the Irkutsk hydroelectric dam to the town of Usolye-Sibirskoye, and in warm winters slightly below it. On the basis of special works on the study of the dynamics of the number and species structure of birds, special methods have been developed: accounting on ice holes, accounting during the evening flight of birds to the lake Baikal (during cold periods) and accounting using a hovercraft (SVP) (during periods of severe climate warming). The basis of wintering birds is the Goldeneye *Bucephala clangula* (from 95.0% to 98.5% of their total species structure). However, the structure of secondary species can increase dramatically and we have noted new species that have never been found here before. The collected materials allow us to understand the reasons that determine the dynamics of the number and species structure of coastal birds in the “cold” wintering grounds of Inner Asia in the conditions of a sharp warming of the climate

1 Introduction

Wintering of waterfowl on the territory of Northern Asia is of the “cold” type [1]. Such wintering is formed annually in the source and upper reaches of the Angara River (Lake Baikal, Eastern Siberia). It has been known for a very long time – the first information about it was received in the XVIII century [2]. However, the materials obtained from here were very superficial until recently: the methods of accounting for birds were not worked

* Corresponding author: yumel48@mail.ru

out and not the entire wintering was examined, but only its individual sections. Meanwhile, our first works have already shown that extrapolation of data obtained at separate sites to its entire territory gives very large errors [3]. As a result, the collected materials up to the second half of the XX century allow only an approximate estimate of the main directions of population change. At the same time, on their basis, it is possible to get a fairly complete picture of the dynamics of the species composition of birds of this “cold” wintering in Eastern Siberia [2, 4-11]. The first reliable results on the number of birds were collected in the second half of the XX century. At that time, methods of accounting for birds in the polynyas over the entire wintering area, as well as during the evening flight of birds to the lake Baikal, were developed [12]. They allowed us to obtain the first reliable information about the dynamics of the number of birds in this cold wintering of Northern Asia.

The strong and rapid warming of the climate in Eastern Siberia ($1.9^{\circ}\text{C}/100\text{ years}$) led to a significant thinning of the ice on the lake Baikal and in the upper reaches of the Angara River [13-16] and ice records have become impossible. The evening flights of birds to the lake have also completely stopped. Baikal, characteristic of the upper plot wintering area (up to the village of Taltsy). However, by this time, the first hovercraft (SVP) appeared at the source of the Angara River, which allowed accounting in very difficult environmental conditions (very thin or shallow broken ice and large plots of open water). We have developed a new method of accounting for birds in such conditions using SVP. This made it possible to continue the previously started research and obtain new and full-fledged materials on the dynamics of the number and species composition of birds during a period of sharp climate warming [17-18]. This article discusses the results of long-term studies that allowed us to find out the impact of climate change on the number and species composition of shorebirds and waterfowl of very large cold wintering in Inner Asia at the source and upper reaches of the Angara River.

2 Materials and Methods

The high number of waterfowl in the source and upper reaches of the Angara River in winter in the modern period (55.0-60.0 thousand birds) was noted by many authors [3;5-12]. The first information about this wintering has been known since the end of the XVII century [2]. Considerable attention in the first studies was focused on the very harsh living conditions of birds. It should be noted that in the second half of the last century they were very complex and this made their study much more difficult.

During the entire period of studying this “cold” wintering in the second half of the XX century and in the modern period, three methods of accounting for wintering waterfowl were developed and used. At the first stage of studying this “cold” wintering (the second half of the last century), records were carried out on hiking routes on the ice of the reservoir and only at the source of the Angara River they were carried out from the right very high and steep bank. At the same time, this wintering was characterized by the evening departure of birds to Lake Baikal [3;5-12]. However, very harsh winter conditions, especially low air temperatures, forced the departing birds to return back to wintering 2.0-2.5 hours after departure. In addition, not all birds flew away and only at the end of January, during the period of complete freezing of Southern Baikal, they almost all left the upper part of the wintering area in the evening (up to the village of Taltsy). The duration of this period was about one week. From the moment of complete freezing of the lake Baikal evening movements of birds stopped [3] and this time falls on the period of a sharp decrease in the level of autumn migratory activity of birds [19].

Records on evening flights at the end of January gave a complete picture of the number of birds in the upper wintering area. However, they completely stopped in the first half of the 90s of the XX century. The main reason for this was the strong warming of the climate

and the birds did not try to leave the wintering even in the coldest January period. In part, this was undoubtedly due to the large area of open water and a good food supply for birds. However, as a result of climate warming, movement on ice, due to its very strong thinning, has become very dangerous. In this regard, the registration of birds on wintering grounds has been discontinued since 1994.

Later, with the advent of new equipment on Lake Baikal, it became possible to use a hovercraft (SVP) for accounting. We used the HIVUS-10 SVP, which has two hatches that allow simultaneous continuous accounting from both sides of the vessel by two accountants during its movement. Already the first work experience has confirmed the very high efficiency of hovercrafts for performing such work [17-18;20]. Free movement, both on open water and very thin ice, and on broken shallow ice, allows you to take records at any time. The only limitation was the weather conditions: fog and strong excitement. The latter factor in open water not only reduces the speed of the vessel, but also reduces, sometimes very much, the distance of accounting and the associated accuracy of the information received. Dark-colored females of almost all species of waterfowl are easily missed by accountants when agitated. Fogs greatly reduce the number of days suitable for accounting. Insignificant, at first glance, the soaring of water, even with complete calm, makes it very difficult to account for long distances, and at distances exceeding 700-800 m, makes them impossible. In addition, in frosty weather, taxi drivers can frostbite exposed parts of the body and hands, as well as catch a very bad cold. It is impossible to use 8-x binoculars on large polynyas - on the accounting strip of more than 500 m, the accuracy of counting birds sitting on the water is sharply reduced.

The methodology of our work is described in detail in several publications [3;12;17-18;20]. In this case, it should be noted that accounting from the shore, using binoculars and spyglasses, turned out to be ineffective for work [30-32]. Accounting with the use of SVP, in its essence, is absolute and gives the most accurate and well-interpreted results [18]. The obtained series of accounting data were processed using statistical methods (both parametric and nonparametric) [21]. The order of description and names of species are given according to the latest bird reports of Siberia, Russia, Mongolia and China [22-28].

3 Results

The first information about the existence of “cold” wintering of waterfowl in the source of the Angara River was received in the XVIII – XVIII centuries [2;4-5]. The number of wintering birds on them was estimated at several thousand individuals. Considering that this is a time of severe cold snap, the severity of climatic conditions was very high. Despite this, this wintering persisted and maintained a fairly high number of birds in a relatively small area of the upper reaches of the Angara River. Here, in some winters, the Angara River did not freeze until Irkutsk, and large polynyas were found on the rifts below the city. And, most importantly, wintering birds were observed on them even during this period of severe climate cooling [2;4;6]. It is likely that these wintering grounds have existed since the formation of the Angara slot of the modern appearance, the age of which is estimated by various authors to be at least 10.0 thousand years (the beginning of the Holocene) [34] and 15.0-20.0 thousand years [35].

In the first indication of the wintering of ducks at the source of the Angara River in the second half of the XVIII century, their species composition is not given, but a high number is emphasized – several thousand [2]. In the subsequent, more detailed work of the XIX century, the species composition of wintering birds is given, but there is no information about the abundance of different species. At this time, Goldeneye *Bucephala clangula*, Long-tailed Duck *Clangula hyemalis*, Tufted Duck *Aythya fuligula*, Red-breasted Merganser *Mergus serrator* and Smew *Mergus albellus* were noted here [5]. In the past

century, the study of wintering birds on this plot of the Angara River was carried out more intensively. In the first half of this century, in the early 30-s, A.V. Tretyakov added a Goosander *Mergus merganser* to this list [6]. He also pointed out that at this time the basis of wintering ducks were Goldeneye and Goosander. In the middle of the last century, Scaup *Aythya marila* and Mallard *Anas platyrhynchos* were added to these species [7]. T.N. Gagina gives the same list of species composition, but indicates that the basis of wintering birds is Goldeneye, and the number of Goosander reached 300 birds [8].

Much more detailed work carried out in the late 50s and early 60s of the last century by V.D. Pastukhov [9] indicates a significant decrease in the abundance of Mergansers - from 200 birds to single encounters. The total number of birds at this time ranged from 4,400 to 7,000 birds and their basis was Goldeneye [9]. However, in the second half of the 60s of the XX century, the total number of birds reached 3,500 Goldeneyes, Long-tailed Duck were marked by single individuals, and the remaining species were not found here [10]. At the same time, summing up the results of the study of waterfowl of the Angara wintering, V.D. Pastukhov points out the number of birds reaching 13 thousand here [36]. It is quite obvious that this is an extrapolation to the total area of the polynyas running in a chain from the source of the Angara River to the village of Taltsy, and the density of birds at the source of the Angara river served as the basis for the calculation. Bird counts in mid-March in the second half of the 70s only at the source of the Angara River showed a significant variation in the number of birds. It varied from 1.0 thousand (1979) to 5.0 thousand individuals (1975) and there was a clear trend towards a decrease in their total abundance [11]. The basis of wintering birds at this time was, as before, Goldeneye [11].

Despite the fact that the authors of the above publications provide data on the number of birds, its determination was carried out with great methodological errors. First of all, not all the polynyas from the source of the Angara River to the village of Taltsy were examined, and the number of birds on such polynyas often exceeded their abundance in the source [12]. The same applies to the second plot wintering, where it was necessary to examine the entire valley of the Angara River completely. As a rule, during the day, records were carried out on the polynya in the source, and in the evening during the flight of birds to Baikal [5-11]. In both cases, there is a strong underestimation of the abundance of birds. To accurately determine the number, it is necessary to examine all the polynyas, and accounting for evening flights requires the use of a special technique. In addition, under normal conditions, not all birds fly away and the period of full flight does not exceed a week, which falls at the time of complete freezing of the lake Baikal [3].

During the first stage of our work in the source and upper reaches of the Angara River (1984-1994), we worked out a method of accounting for birds, which allowed us to obtain accurate information about the number of wintering birds – multiple ice counts [3;12]. Difficult weather conditions, very frequent and strong winds and limited visibility on days with heavy fogs led to the fact that accounting started in favorable conditions ended in unacceptable working conditions. Such accounts had to be rejected. As a result, out of 9-14 accounts, it was possible to use the results of no more than three accounts. The total number of birds, taking into account special amendments, ranged from 11.7 to 15.0 thousand individuals, but in 1993 32.0 thousand birds were counted. It turned out that the distribution of birds in the polynyas varies very much even within one day and extrapolation, as a method of estimating the number, is not applicable in this case. It is necessary to account for the entire area of the polynyas [3;12].

Surveys of the second section of wintering birds – from the Irkutsk hydroelectric dam to the town of Usolye-Sibirskoye showed the possibility of recording birds from the shore using 12-15-fold binoculars. The species composition of birds here was clearly different from the upper wintering plot. The abundance of Goosander and Red-breasted Merganser found on the rifts was significantly higher. Mallard and Tufted Duck were more common,

in addition, a Pochard *Aythya ferina* was noted. It should be noted that the Mallard appeared and increased its number during the winter in Irkutsk in the course of our work. Back in 1987-88, separate birds were recorded here, but at least 25-30 birds of this species were registered in the early 90s. Taking into account Irkutsk, the share of river ducks in the total bird population is significantly higher, although Goldeneye undoubtedly dominated here. The total number of birds is very close to the upper wintering area - 13.0-14.5 thousand individuals [42]. It should be noted that in some severe winters of the mid- and late 80s of the last century, the winter mortality of birds reached 41.0% of the total number at the beginning of wintering. In extremely bleak frosty winters, when the size of the polynya at the source of the Angara River was reduced to 0.7-1.0 km, it was 69.0%. In normal years, the mortality rate of birds did not exceed 10.0-15.0%.

In the first plot, the Teal *Anas crecca*, Pochard, Scaup and Harlequin Duck *Histrionicus histrionicus* are additionally registered. The usual, but not numerous species was the Dipper *Cinclus cinclus*, which was constantly noted on the polynyas from the Legend of Baikal hotel to village Nicola. Of the other species of shorebirds, we have noted the Mongolian Gull *Larus (vegae) mongolicus* (up to 300 birds), the Common Gull *Larus canus* - about 8-15 individuals. However, the Gulls did not survive the winter and their most recent encounters were recorded at the end of January. It is also necessary to note the meeting of the Pomarine Skua *Stercorarius pomarinus* on January 25, 1988 at village Angara farms and, most likely, an accidental wintering of the Glaucous Gull *Larus hyperboreus* (in the 1994-95 season, one bird at the Irkutsk hydroelectric dam) [43-44].

Noticeable changes in the number and species composition of birds were noted at the beginning of the XXI century, while working with the use of SVP. After 1993, the abundance of waterfowl decreased sharply, but it was still higher than during the period of accounting for birds on ice. In 2012-2017, the number of wintering ducks ranged from 11.1-25.5 thousand individuals. However, there was a general tendency to decrease their abundance. The basis of the species composition of wintering coastal birds, as before, was Goldeneye, but the abundance of the Long-tailed Duck increased markedly - up to 450-500 individuals. The number of Goosander and Red-breasted Merganser varied greatly by season, and the Goosander clearly prevailed. Single individuals and pairs were marked by Scaup *Aythya marila*, Harlequin Duck, Smew and Ruddy Schelduck *Tadorna ferruginea* [18, 39]. Successful overwintering of individual individuals of the Mongolian gull - from 1 to 3 birds (2015-2017) has been established [33]. Constantly, but in small numbers, there was a Dipper - from 2-3 to 8 birds.

It is also necessary to note the presence of other species of coastal birds here. However, all of them are registered in the second plot of the "cold" wintering in the source and upper reaches of the Angara River. The total number of birds here was within the abundance recorded at the first site - 15.0-27.0 thousand individuals. A noticeable warming of the climate has also affected the success of the survival of birds during the winter period. The mortality of birds was moderate or even small - in the range of 5.0-8.0% and only sometimes it rose to 20.0% or slightly more. It should be noted that the number of Mallards in Irkutsk by this time had increased significantly and ranged over the years from 450 to 600 or even a few more birds. It has also become a common sight in the lower parts of the Angara River floodplain - from the Battery station to the town of Ussolye-Sibirskoye. However, new species were also noted here, which had not previously been encountered even by single individuals during the winter.

It is also necessary to note the presence of other species of coastal birds here. All of them are registered in the second plot of the "cold" wintering. The total number of birds here was within the abundance recorded at the first site - 15.0-27.0 thousand individuals. A noticeable warming of the climate has also affected the success of the survival of birds during the winter period. The mortality of birds was moderate or even small - in the range

of 5.0-8.0% and only sometimes it rose to 20.0% or slightly more. It should be noted that the number of Mallards in Irkutsk by this time had increased significantly and ranged over the years from 450 to 600 or even a few more birds. It has also become a common sight in the lower parts of the Angara River floodplain – from the Battery station to the town of Usolye-Sibirskoye. However, new species were also noted here, which had not previously been found even in single specimens during the winter.

First of all, there was a Ruddy Schelduck here, which was marked by single individuals in Irkutsk [39]. The Little Grebe *Tachybaptus ruficollis* was registered on January 2, 2008 on the Angara River. This is undoubtedly a wintering bird here [37]. Another individual of this species was registered in the area of warm lakes below the Irkutsk hydroelectric dam on December 20, 2020 [38]. In 2013, in the area of the Battery station in the polynyas of the Angara River, a successful overwintering of 7 Beem Goose *Anser fabalis* was registered [40]. Equations should be centred and should be numbered with the number on the right-hand side. A Harlequin Duck, a Ivory Gull *Pagophila eburnea* and a Hooded Crow *Corvus (corone) cornix* are also marked here. The meeting of the Ivory Gull on Lake Baikal is the fourth, which indicates that its appearance in this area of Eastern Siberia is not accidental [41]. The Gadwall *Anas strepera* was also included in the composition of wintering birds, the latest meeting of which was registered on January 16, 2019. Previously, it was observed only in late autumn and early winter [45]. In 2021, we established the winter stay and successful overwintering of 4 Cormorant *Phalacrocorax carbo* below the Irkutsk hydroelectric dam. Birds were recorded here from January to mid-March, but later they got lost among the migratory migrants of this species.

Birds of prey that were previously extremely rare and only single specimens began to be noted quite often: White-tailed Sea Eagle *Haliaeetus albicilla* (from 2-3 to 7 birds annually), Golden Eagle *Aquila chrysaetus* (1-2 birds), Gyr Falcon *Falco rusticolus* (separate non-annual meetings of single birds) throughout the wintering, Peregrine Falcon *Falco peregrinus* (one bird in 2023 on the first site) [3;46]. Finally, there is a fairly high number of Eastern Carrion Crow *Corvus (corone) Crow* every year (from 40-50 to 100 individuals in the upper wintering area and 25-30 individuals in the second section). In the latter case, birds registered in landfills in the areas of settlements were not taken into account. The Raven *Corvus corax* is common: on the first site up to 15-20 birds, on the second (including the city of Irkutsk) up to 45 birds.

4 Discussion

The main plot of open water on the “cold” wintering all winter was located only at the source of the Angara River. In the rest of the upper plot, a system of polynyas was preserved, the size of which was determined by the severity of the winter conditions of a particular observation season. The second (lower) section covered the floodplain of the Angara River from the Irkutsk hydroelectric dam to the town of Usolye-Sibirskoye. It included open water under the dam and a system of polynyas in plots of the river with a faster current and rifts, as well as at the mouths of its major tributaries. It was here that large flocks of wintering birds (from 50-100 or more individuals) were observed.

The collected data on the number of birds at the first stages of the wintering survey were extremely inaccurate and fragmentary, since their systematic records and special observations were not carried out. The general instructions contained information about the observations of thousands of flocks of birds and their species composition here [2;4-8]. The period of field observations was replaced by a systematic and methodically correct study of this wintering in the second half of the XX century, when the first competent approaches to the organization of bird counts were developed [3]. They made it possible to develop a monitoring system for the state of this “cold” wintering [3;12;17-18;20].

An analysis of the factors determining the overall changes in the number of wintering birds shows that their abundance is determined by the temperature and duration of the autumn period. All “cold” wintering of shorebirds and waterfowl is forced. Birds that have not managed to accumulate the necessary amount of plastic substances (fat) necessary for a long migration rush to the southern wintering grounds remain on them. Favorable conditions on this site at the beginning of winter (thermal refugium) they contribute to long delays of birds at feeding and resting places. However, by the time they are able to continue the migration, it becomes impossible. Snow falls on adjacent territories, reservoirs are covered with ice and a constant negative air temperature is established. In the early cold, birds with a certain supply of plastic substances immediately fly south in short migration throws of 100-150 km. In the long warm autumn, they manage to accumulate the necessary amount of fat and also fly south. And only in warm but short autumns (the early onset of cold weather), the main part of the birds that stayed for bait and rest are forced to stay here for the winter. With a general tendency to increase the abundance of wintering birds as the climate warms, the prolonged warm autumns of recent years have led to a reduction in their numbers on the “cold” wintering in the source and upper reaches of the Angara River.

Undoubtedly, as a result of climate warming, there is a noticeable increase in the species composition of wintering birds. However, only the Long-tailed Duck and Mallard had a well-marked tendency to increase in numbers. In some seasons, the abundance of Goosander, and sometimes Red-breasted Merganser, increases dramatically. But this feature was also traced in the previous period (before the well-pronounced warming of the climate). Consequently, the reason for the change in their numbers is some local factors at the places of their mass nesting. Most likely, this is the magnitude of the death of nests and chicks during the period of mass breeding of birds at nesting sites far beyond the wintering grounds. The remaining species occur in single specimens, pairs and small groups. The general species composition of wintering birds before the onset of climate warming and during the period of maximum warming includes 30 species, among which two are common sedentary birds of Eastern Siberia (Eastern Carrion Crow and Raven).

5 Conclusion

Due to the general warming of the climate on the “cold” wintering of shorebirds and waterfowl in the source and upper reaches of the Angara River, a gradual increase in the abundance and species composition of wintering birds was noted. At the same time, the overall structure of the bird population changes little. Its basis in any years is Goldeneye and its share in the bird population is never lower than 93.0-95.0%. At the beginning of the second half of the last century, the Long-tailed Duck was met here by individuals and small flocks of up to 10-15 birds. By now, its abundance has increased to 500 individuals and usually amounts to 350-450 birds. Mallard is another common wintering species, the number of which clearly increased at the beginning of the XXI century to 400-600 birds. The abundance of Goosander and Red-breasted Merganser varies significantly - from 10-25 to 150-400 birds, with a clear predominance of Goosander. A fairly stable group of local sedentary species that are not related to coastal birds: the Eastern Carrion Crow and Raven. All other birds are marked by single specimens and small groups, but among them there is a high proportion of species that do not belong to shorebirds and waterfowl.

The total number of birds is completely determined by the breeding conditions of the Goldeneye in the more northern parts of the range. It increases in years of high floods and significant loss of masonry. In such seasons, the proportion of late broods increases, which mainly form the main core of the last wave of migratory waterfowl. However, the total number of birds in this “cold” wintering is adjusted by autumn conditions. It is reduced in very warm and long autumns because wintering conditions in such years allow you to

accumulate a sufficient amount of plastic substances (fat) for a long migration rush and departure to the south. In the years of the early onset of cold weather or warm, but short autumn, a significant part of the late-flying birds remain on wintering grounds and the abundance of wintering birds increases dramatically. In this regard, the total number of birds at this wintering is constantly changing greatly and short trends are formed in cases of the predominance of warm or cold autumns for several years in a row. There may also be seasons of abnormally high (1993 – 32.0 thousand birds) or very low (11.1 thousand in 2017 and 11.7 in 1984) abundance. There is a general trend towards an increase in the number of rare and small species occurring in single individuals and small groups. The “cold” wintering of Shorebirds and waterfowl in the source and upper reaches of the Angara River (the first section) shows the possibilities of survival of birds in utmostly extreme habitat conditions.

References

1. Zaletaev V S 1960 Geographical types of wintering ground birds. *Proceed. IV Baltic. ornithol. conf. Riga* 36-38
2. Georgi I G 1775 Notes on a journey through the Russian State in 1772 (St. Petersburg) **1** 402
3. Mel'nikov Yu I, Shcherbakov I I and Testin A I 1988 The current state of wintering of Shorebirds at the Source of the Angara River. *Commercial animals and increasing the efficiency of hunting production Irkutsk* 65-72
4. Cherepanov S N 1859 About Siberian birds. *Library for reading St.-Petersburg* **156** 7 1-32
5. Dybovsky B and Godlevsky V 1870 Report on pursuit in 1869. *Bull. Siberian Branch IRGO* **8 (3-4)** 167-203
6. Tretyakov A V 1940 Birds wintering in the sources of the Angara river. *Avifauna of the Kalinin Oblast Kalinin* 61-71
7. Tarasov P P 1952 About wintering ground of waterfowl on Lake Baikal. *Nature* **8** 115-116
8. Gagina T N 1958 Waterfowl wintering in the Baikal region. *Bull. Irkutsk State Agricultural Institute Irkutsk* **8** 114-129
9. Pastukhov V D 1961 Observation of the Angara wintering ground of waterfowl. *Conf. young. scientists, dedicated. in memory of G.Yu. Vereshchagin Irkutsk* 23-26
10. Scriabine N G 1975 *Waterfowl of Lake Baikal* (Irkutsk: East.-Sib. Book Education) 244
11. Bogorodskiy Yu V 1989 *Birds of the Southern Predbaykalie* (Irkutsk: Publishing House of the Irkutsk State University) 206
12. Mel'nikov Yu I 2000 Features of accounting for the number of waterfowl on Angarsk wintering grounds Inventory, monitoring and protection of key ornithological territories of Russia. Issue 2. *Materials of meetings on the program "Key ornithological territories of Russia (1998-2000)" Moscow* 33-40
13. Zherebtsov G A, Kovalenko V A, Molodykh S I and Rubtsova O A 2011 Regularities of climatic changes in the XX century and the main physical processes responsible for these changes. *Bul. Irkutsk State University. Ser. Earth Sciences* **4(1)** 87-108
14. Zherebtsov G A, Kovalenko V A, Molodykh S I and Kirichenko K E 2013 Influence of solar activity on the temperature of the troposphere and ocean surface. *Bul. Irkutsk State University. Ser. Earth Sciences* **6(1)** 61-79
15. Shimaraev M N, Kuimova L N and Sinyukovich V N 2008 Global climate changes and their response in processes of lake Baikal Evolution. *Proceedings of the First All-*

- Russian scientific and practical conference "The process of life development within abiotic changes on the Earth" Novosibirsk* **1** 311-318
16. Shimaraev M N and Starygina L N 2010 Zonal circulation of the atmosphere, climate and hydrological processes on Baikal (1968-2007). *Geography and natural resources* **3** 62-68
 17. Mel'nikov Yu I, Popov V V and Zhovtyuk P I 2012 The first experience of using the SVP "KHIVUS-10" to account for waterfowl on the "cold" wintering in the source of the Angara River. *Baikal. Zool. Journ.* **1(9)** 5-10
 18. Mel'nikov Yu I, Popov V V and Zhovtyuk P I 2019 Water birds at the «cold» winter in the source and upper flow of Angara river: counting account, effective account band and accuracy of the obtained data. *Baikal. Zool. Journ.*, **1(24)** 60-73
 19. Mel'nikov Yu I 2014 Late autumn flight of shorebirds and waterfowl and its role in the formation of "cold" wintering grounds of the Upper Angara region. *Baikal. Zool. Journ.*, **1(14)** 69-84
 20. Mel'nikov Yu I 2022 Accounting for the number of waterfowl on the "cold" wintering in the source and upper reaches of the Angara River: correction for diving and its definition. *Bul. Irkutsk State University. Ser. Biology. Ecology* **39** 29-46
 21. Zaks L 1976 *Statistical evaluation* (Moscow: Statistics Publishing House) 598
 22. Ivanov A I and Shtegman B K 1978 A brief definition of birds of the USSR 2nd edition, corrected and supplemented (Leningrad: Nauka Publ.) 560
 23. Stepanyan L S 1990 Conspectus of the ornithological fauna of the USSR (Moscow: Nauka Publ.) 728
 24. Koblik E A, Red'kin Ya A and Arkhipov V Yu 2006 *Cheeklist of the birds of Russian Federation* (Moscow: KMK Scientific Press Ltd.) 256
 25. Ryabitsev V K 2014 *Birds of Siberia. Field Guide in two Volumes* (Moscow-Ekaterinburg: Armchair Scientist Publ.) **2** 452
 26. MacKinnon J, Phillips K and Fen-qi H 2000 *A field guide to the birds of China* (Oxford: Oxford University Press) 586
 27. Sundev G and Leahy Ch 2019 *Birds of Mongolia* (Helm: Bloomsbury Publishing Plc) 1314
 28. Brazil M 2009 *Birds of East Asia: Eastern China, Taiwan, Korea, Japan and Eastern Russia* (London: Christopher Helm Press) 528
 29. Mel'nikov Yu, Kupchinskiy A and Fialkov V 2021 Formation of a "cold" winter of shorebirds and waterfowl in the source and upper current of the river Angara (South Baikal) and its causes. *IOP Conf. Series: Earth and Environmental Science* **848** 012228
 30. Fefelov I V, Ryabtsev V V and Tupitsyn I I 2008 The number of wintering ducks in the upper reaches of the Angara in the 2000-s. *Casarca* **11(1)** 92-106
 31. Fefelov I V, Alekseenko M N, Ryabtsev V V and Olovyannikova N M 2017 Results of censuses of wintering waterfowl in the area of the Angara source from the coast in 2014-2017. *Materials nature reserves and national parks of Baikal Siberia "The Nature of Baikal Siberia" Ulan-Ude* 179-89
 32. Povarintsev A I and Fefelov I V 2015 Methods and results of surveys of wintering waterfowl in the area of the source of the river Angara from the shore in 2014. *Bul. Irkutsk Agricultural Academy* **66** 86-91
 33. Mel'nikov Yu I 2019 White-headed Gulls on the "Cold" wintering in the Source and upper flow of Angara river: formation of winter aggregations and survival conditions. *Bul. Irkutsk State University. Ser. Biology. Ecology* **27** 41-61
 34. Matz V D, Fujii Sh, Mashiko K, Granina L Z, Osipov E Y, Efimova I M and Klimansky A V 2002 On paleohydrology of Baikal in connection with neotectonics. *Geology and Geophysics* **43(2)** 142-154

35. Ufimtsev G F and Shchetnikov A A 2006 Rivers flowed from Baikal. *Nature* **6** 49-54
36. Pastukhov V D 1965 Angarsk wintering of waterfowl. *Hunting and hunting economy* **10** 16-17
37. Fefelov I V 2008 Wintering of the Little Grebe *Tachybaptus ruficollis* (Pallas, 1764) in Irkutsk. *Russian ornithol. journal. Express issue* **1(29)** 128
38. Ivanov M V 2021 A new meeting of the Little Grebe *Tachybaptus ruficollis* (Pallas, 1764) in Irkutsk. *Baikal. zool. journal* **1(29)** 128
39. Zhovtyuk P I 2017 Winter meeting of Ruddy Schelduck *Tadorna ferruginea* (Pallas, 1764) on the Angara River in the town Irkutsk. *Baikal. zool. journal* **1(20)** 97
40. Stepanenko V N 2015 About wintering Geese on the Angara river (Irkutsk region). *Baikal. zool. journal* **2(17)** 126
41. Sayfutdinova R V 2018 Interesting bird encounters in Irkutsk in autumn 2018. *Baikal. zool. journal*. **2(23)** 118
42. Melnikov Yu I, Shcherbakov I I, Testin A I, Boyko A V and Dakhno T G 1989 Problems of protection of Angara wintering grounds of Shorebirds. *Improvement of the economic mechanism in the hunting industry Irkutsk* 113-115
43. Mel'nikov Yu I 1998 Meetings of the Pomarine Skua *Stercorarius pomarinus* on Lake Baikal. *Russian ornithol. journal. Express issue* **7** 46 22
44. Durnev Yu A, et al 1996 Rare and poorly studied vertebrate animals of the Prebaikal region: distribution, ecology, protection (Irkutsk: Irkutsk State University Publ.) 287
45. Sayfutdinova R V, Fefelov I V and Borovskaya M K 2019 The first case of wintering of the Gadwall *Anas strepera* in Irkutsk. *Baikal. zool. journal* **1(24)** 142
46. Zhovtyuk P I 2019 Wintering of Gyr Falcon *Falco rusticolus* Linnaeus, 1758 in Irkutsk in 2019. *Baikal. zool. journal* **1(24)** 52-54