



Original Article

Foraging areas of streaked shearwater *Calonectris leucomelas* nesting on the Karamzin Island (Peter the Great Bay, East Sea)Ivan Tiunov^{a,*}, Igor Katin^b, Hansoo Lee^c, Siwan Lee^c, Eunhong Im^c^a Federal Scientific Center of the East Asia Terrestrial Biodiversity FEB RAS, Laboratory of Ornithology, Vladivostok, Russia^b National Scientific Center of Marine Biology FEB RAS, Laboratory of Marine Mammals, Vladivostok, Russia^c Korea Institute of Environmental Ecology, Daejeon, The Republic of Korea

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ABSTRACT

Karamzin Island (the Peter the Great Bay, the East Sea) is the only nesting point of streaked shearwaters in Russian Federation. To understand and determine distribution patterns of streaked shearwaters along the Eastern Sea waters during nesting period, the Trackers WT-300 were set to 10 adult birds. Over the observation period (from 5 July 2016 to 7 January 2017), 4812 locations were registered. Analysis of data obtained revealed that main feeding points of colony studied were situated in the Peter the Great Bay along 50 m isobath and, to the less extension, near the eastern coast of Korean Peninsula. It was determined that streaked shearwaters most frequently visited waters with circular flows or zones of junctions of multidirectional flow. It was also shown that these zones had high concentrations of zooplankton.

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Streaked shearwater is a numerous subtropical species that breeds exclusively in Northwestern part of the Pacific Ocean. In Russia, the only breeding colony of this species is situated on the Karamzin Island (the Peter the Great Bay). Population of this colony numbers 80–150 pairs (Shuntov 1998; Litvinenko et al 2000). The species is included in the Red book of the Russian Federation and is under state protection (Red book of the Russian Federation, 2001).

Study of streaked shearwater began in 1959 by Yoshida (Yoshida 1962). At the same time, ringing of nestlings and adults was organized in Japan (McClure 1969). Beside Japan (Yoshida 1981), further investigations of streaked shearwater biology was carried out in the Republic of Korea (Lee & Yoo 2002, 2004; Nam et al 2014). From 2006 to 2008, the use of geolocators allowed to determine foraging areas of birds nesting at Sangan and Mikura Islands, located near the Honshu Island (Yamamoto et al 2011).

In Russia, a study of breeding biology of streaked shearwater using ordinary metallic rings was conducted by Litvinenko (Litvinenko 1976) in 1967–1970. It shows that frequent arrival of

birds with food may indicate the possibility of sufficient food supply not too far from the colony, and border of expansion is identified as, in most species of petrels, with radius of 200 miles (Litvinenko 1976). According to the studies performed in the last half years of 20th century, the Northwestern part of the East Sea's feeding conditions favorable for birds appear in the summer, and particular great mass of zooplankton accumulates in June that consequently attracts squids and different pelagic fish (Meshcheryakova 1960; Shuntov 1965).

Data on streaked shearwater distribution in the East Sea in summer are limited to ship observation by Shuntov (1998) and reduced to registration of significant number of adult and immature birds without specification of meeting areas and connection to specific colonies.

Karamzin Island is situated in the well-developed area of the Russian Far East, and for this reason experiencing significant anthropogenic pressure. Because of low number of breeding birds as well as the proximity to large center Vladivostok city and the industrial districts of Primorsky region with high population density, the danger that any accident can cause the death of the colony and the disappearance of the species in Russia is exist. Knowledge about the biology of this species in conditions of the Russian Far East including peculiarities and patterns of spatial distributions of streaked shearwaters in the Eastern Sea during nesting period is

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essential to prevent negative consequences, minimize possible damage, and work out the most efficient measures for protection of this unique Russian colony. Clarification of these issues was the main goal of this work.

Materials and methods

Karamzin Island is a part of the south archipelago of the Peter the Great Bay (N 42 50 32 E 131 41 20). Approximate area of the island is 0.09 km² and the highest point is 107 m. A few colonies of marine birds (total amount not less than 10,000 pairs) inhabit the island.

An international agreement between the Institute of Biology and Soil science FEB RAS (2017—Federal Scientific Center of the East Asia Terrestrial Biodiversity) and the Korea Institute of Environmental Ecology (KoEco) was signed in 2016. In the frames of this agreement, studies on the character of space use during nesting time of streaked shearwater with the aid of Trackers WT-300 (KoEco (Korea Institute of Environmental Ecology), Republic of Korea) were carried out.

Ten adults of streaked shearwater were captured in the nesting colony at Karamzin Island on 5 July 2016. Trackers WT-300 (NN 1601–1610) were attached to the bird backs. After that birds were returned to nests. Gender of birds was not identified. All sensors were adjusted to define the coordination every 4 hours.

Trackers WT-300—a telemetry device, which is based on the GPS (Global Positioning System) combined with WCDMA (Wideband Code Division Multiple Access) mobile phone network with global roaming system (<http://www.wi-tracker.com>). Data on 4812 locations were obtained over the study period from 5 July 2016 to 7

January 2017, when the last tracker had stopped the information translation.

Results

Data from one of the birds (Tracker N 1610) were obtained only once on the next day after Tracer installation. The information flow from the other bird (N 1609) stopped on August 3, when the bird was in the eastern part of the bay. Most of the time, the bird spent in the frames of the Peter the Great Bay with the exception of July 20–22, when it was registered in the Eastern Sea at the latitude of Chongjin and Gilju cities of the Democratic People's Republic of Korea.

Four streaked shearwaters (N 1602, 1605, 1607, and 1608) stayed near the colony till the end of the second decade of July and left the nesting region after that. It was registered that birds moved along the Korean Peninsula and spent most of the time in the frames of triangle Pohang city – Ulleung Island – Sokcho city. Numbers 1605, 1607, and 1608 returned back to the Peter the Great Bay on August 4, 10, and 5, respectively. Tracker N 1605 ceased to send signal, and further location of this bird is unknown. Streaked shearwaters N 1607 and 1608 fed in the Peter the Great Bay till the August 28 and 25 correspondingly. Then, birds moved to the Korean Peninsula, where signal from 1608 Tracker was lost near the Uljin city on September 13 and signal from 1607 was lost in the area of Korea Strait on September 14. In contrast to the latter three birds, streaked shearwater N 1602 headed to the South, to Korean Strait, and further to the Yellow Sea, and fed there till September 12. After it moved southward and reached the South China Sea. The last signal from that bird was received from the waters located south of the Chang Jiang river mouth on September 16.

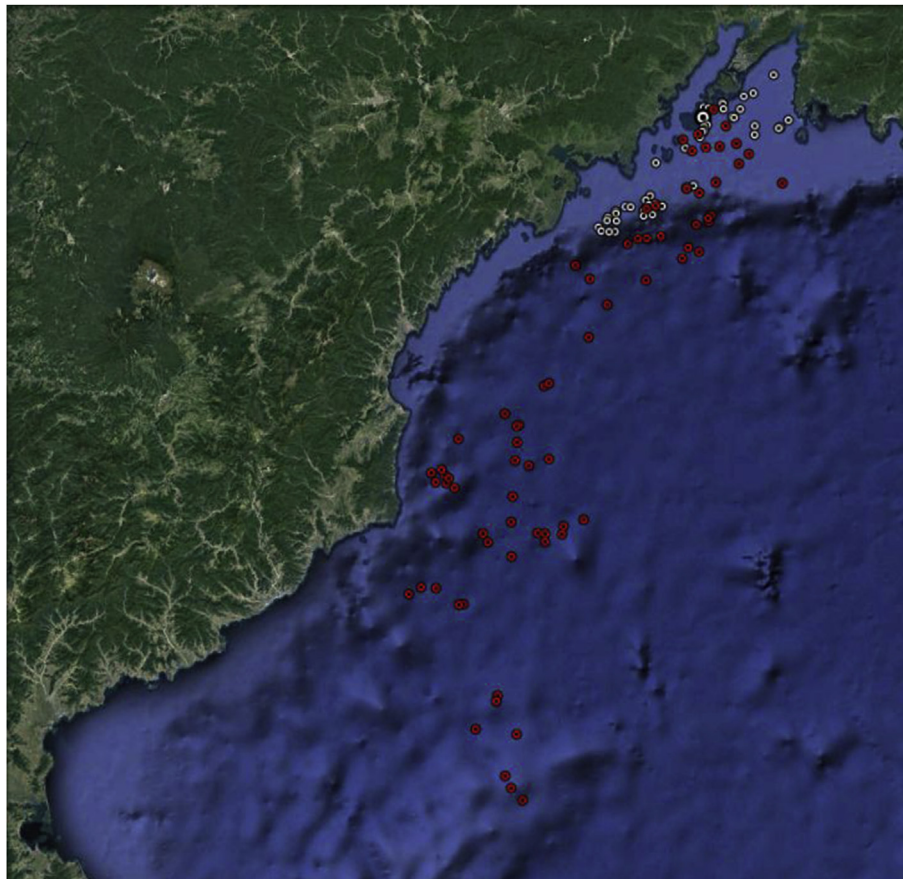


Figure 1. Map of feeding sites of the streaked shearwater N 1604 (white dots) and N 1601 (red dots) in July.

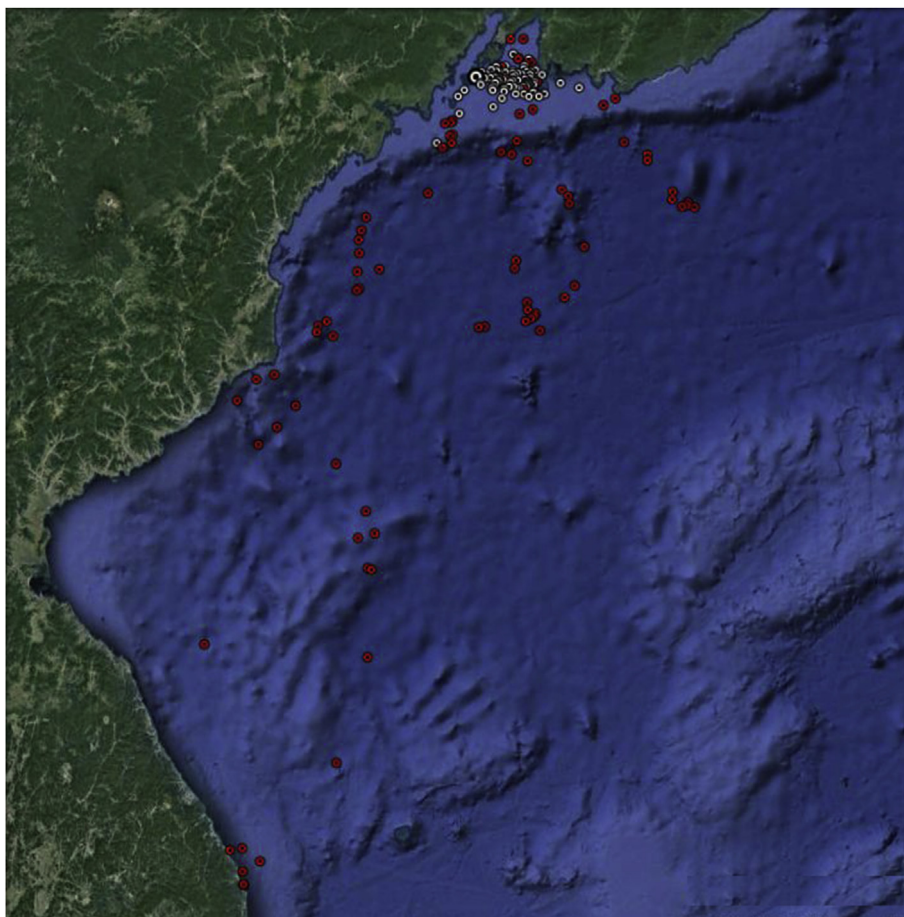


Figure 2. Map of feeding sites of the streaked shearwater N 1604 (white dots) and N 1601 (red dots) in August.

Streaked shearwater N 1603 fed exclusively in the Peter the Great Bay till the August 25. The bird was registered in the colony on August 21 for the last time; after that the bird held on the waters of the bay for a few days, and then moved to the Korean Peninsula along the coast. It fed near the eastern coast of Korean Peninsula between Sokcho and Pohang cities till the middle of October. After October 20, the bird crossed Korean Strait and headed to the central parts of the East China Sea. The last signal from this bird was received from the waters located south of the Chang Jiang river mouth on November 8.

The main feeding sites of the streaked shearwater N 1606 situated along continental terrace to the south up to Ulleung Island, where it spent 36 days in total. In the Peter the Great Bay, the bird fed rare and spent here 21 days in total. The maximum period of incubating laying was 8 days (July 15–23). The streaked shearwater fed near the colony from August 17–19, and came back to the nest at night. It may indicate that a nestling has hatched at that time. After another night at the colony, the bird headed to the south to the Korean Peninsula on September 20, thus leaving the nesting area.

Two streaked shearwaters (N 1601 and 1604) stayed near the colony the longest. They migrated to the south on October 3 and 5, respectively.

During July, the main feeding spots of the streaked shearwater N 1604 were situated in the waters of the Peter the Great Bay and its vicinity at a distance of 60 km from colony. Periods of continuous incubation were 9, 4, and 3 days (July 7–15, July 21–25, and July 27–29, respectively). In contrast with this bird, the main feeding

sites of the streaked shearwater N 1601 were situated in the continental terrace to the south up to the Korean Plateau at a distance of 400 km from colony (Figure 1).

In August, the streaked shearwater N 1604 adhered to the same strategy feeding close to the colony in the frames of the Peter the Great Bay, mostly in the waters of the Ussuri Bay at a distance of 5–83 km from colony. During that period, it visited the colony every night with the exception of August 1–2, 22–23, and 27–28, when it continuously fed. In August 13–15, the shortest fly distances from colony were registered. Moreover, these days it visited the colony during day light. This may indicate that hatching of nestling took place these days. The streaked shearwater N 1601 spent 2–3 days at the nest and preferred to move in the food searching at large distances (up to 520 km from colony) and fed on the waters at sea-mounts Ostrovnyaya, Sibir, Koltso, and at the continental terrace to the south up to Korean Plateau (Figure 2).

The main feeding sites of two birds situated in the waters of the Peter the Great Bay in September. At the same time, both birds took flights far to the south up to Korean Plateau in search of food (Figure 3).

Discussion

Based on the analyses of spatiotemporal scheme of birds moving, it may be assumed that nest of the streaked shearwaters N 1602, 1605, 1607, and 1608 were destroyed at the laying stage, whereas the birds N 1603 and 1606 lost their nestlings. Nesting season was successful for birds N 1601 and 1604 because they most

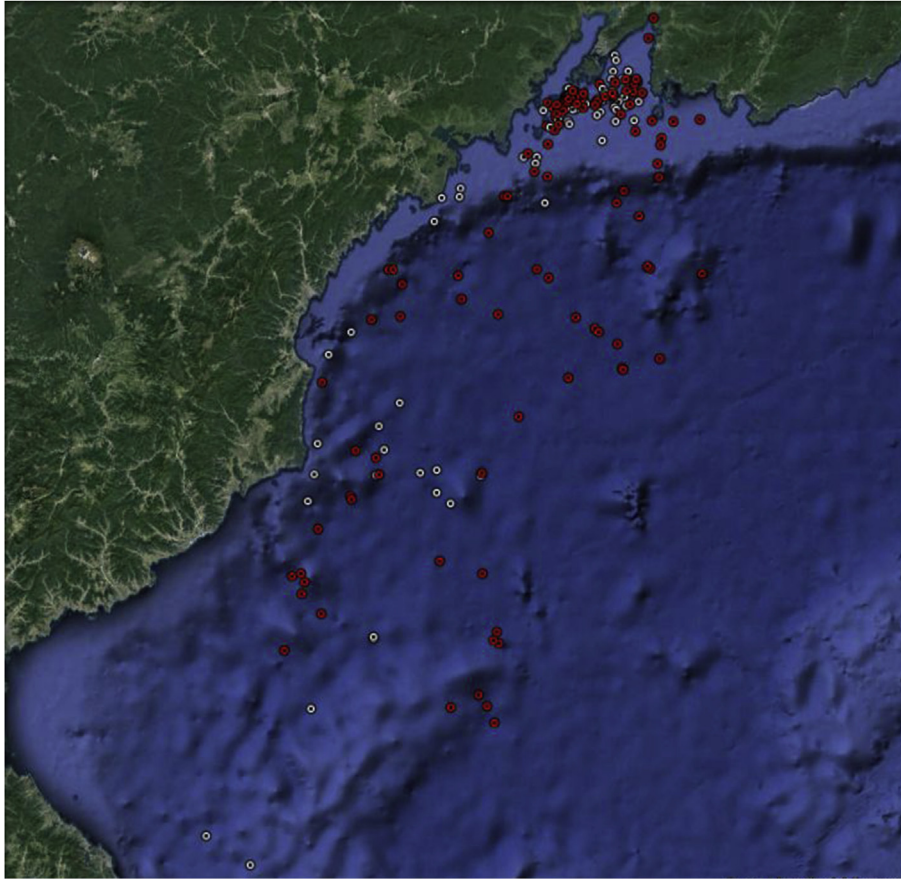


Figure 3. Map of feeding sites of the streaked shearwater N 1604 (white dots) and N 1601 (red dots) in September.

probably left colony after fledging. This is in agreement with Litvinenko's data (1976). According to her, young birds leave the colony in the period between the third decade of October and the first decade of November. Nestlings stay in the nest 10–19 days after the last feeding.

Loss of laying and nestlings from marked birds is connected with relative availability of nests. Thus, some specimens were found in nests situated in small niches under stones and were

almost naked. Such places are easy to access, but they are more often exposed to destruction by predators, the role of which is played by Slaty-backed Gull, Black-tailed Gull, and Large-billed Crow. Considering these circumstances and also the high death rate (up to 54%) at the island (Litvinenko 1976), data obtained were quite expectable.

Data about the feeding time of adult birds, brooding frequency, and the duration of the lack of feeding birds greatly expand the

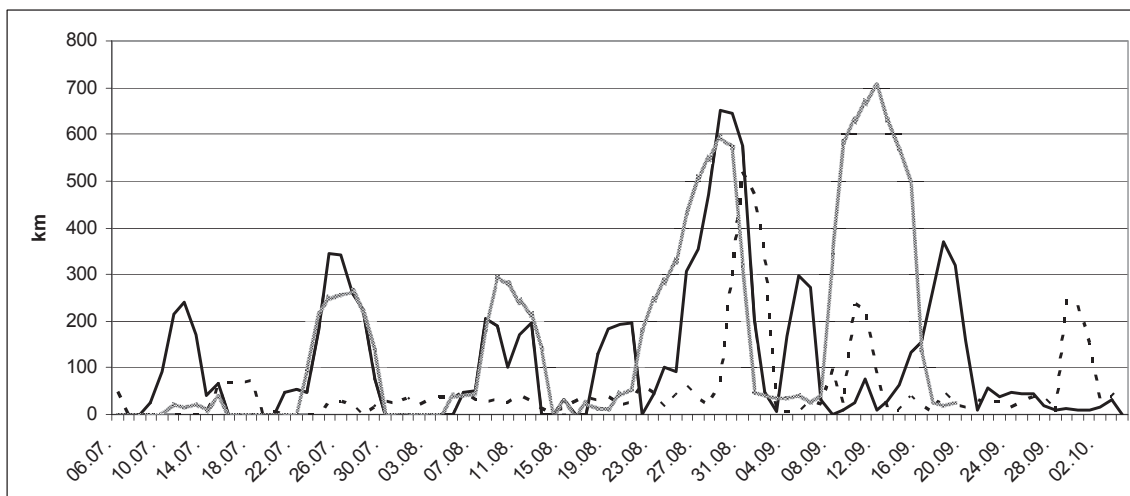


Figure 4. The average distance of feeding expansion of three streaked shearwaters. Dashed line—N 1604, solid line—N 1601, and gray line—N 1606.

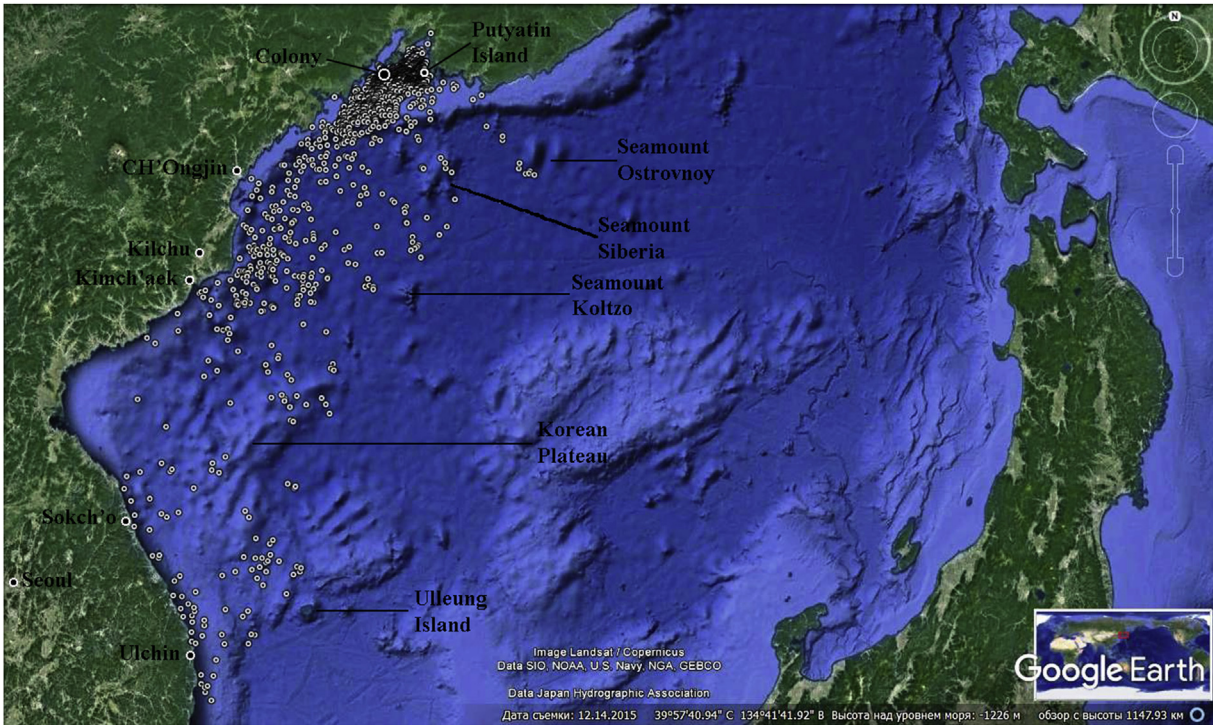


Figure 5. Feeding sites of streaked shearwaters from the Karamzin Island colony.

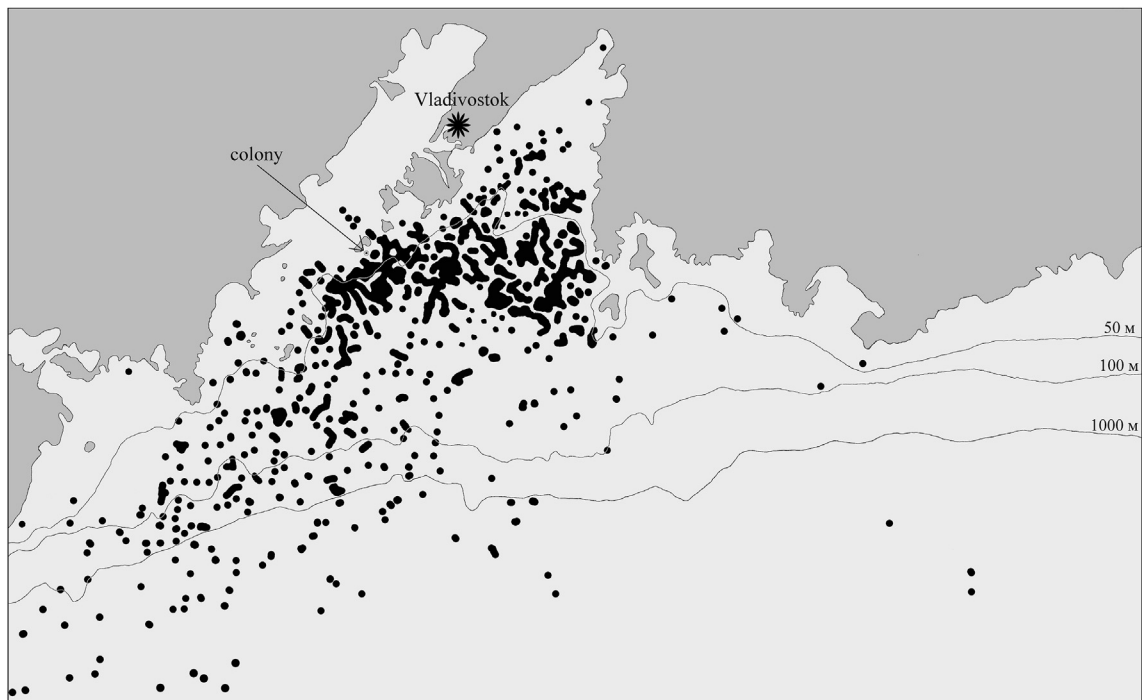


Figure 6. Main foraging areas of the streaked shearwaters from the Karamzin Island colony in the Peter the Great Bay.

available information (Litvinenko 1976). Author indicates that one of the partners may spend a few days (up to 8 days) out of nest while the other one ever-present brood nests. According to our data, birds can spend up to 12 days out of colony (6–8 days usually) while the maximum of ever-present brooding time was 9 days.

Significant difference in behavior, flying distance, and feeding time on the example of three birds (Figure 4) may be explained by both differences in the gender as well as personal peculiarities. According to existing data (Yamamoto et al 2011), there are slight differences in flying distances and duration of feeding time

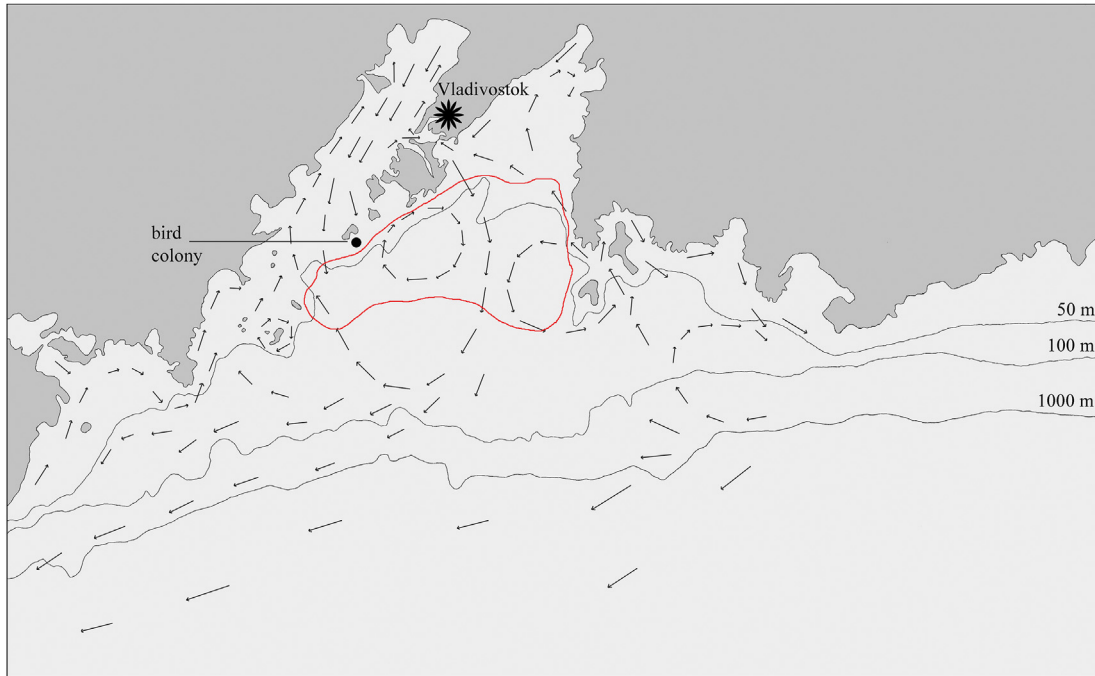


Figure 7. Map of regular surface currents in the Peter the Great Bay and adjacent waters of the Eastern Sea (Sailing direction 1996). Red line indicates main feeding area of streaked shearwaters.

between birds, but these differences were registered only during the preparation of egg laying in April and May. During the incubation period, this difference was not such obvious.

Data analyses show that the main feeding area of streaked shearwaters during nesting period was situated in the Peter the Great Bay and to the less extension in the region of continental terrace of Korean Plateau waters (Figure 5). The most visited feeding spots in the Peter the Great Bay are situated in region with 50-meter depth and the South in the direction of increasing depth (Figure 6). A comparison of the main feeding spots of streaked shearwaters with the scheme of surface currents (Figure 7) shows that they are well superimposed on the zones of circular currents and places where multidirectional currents converge. It is necessary to mention that circular currents and multidirectional currents are situated near the Korean Peninsula (Leonov 1960), where streaked shearwaters fed as well.

Japanese colleges (Yamamoto et al 2011) that studied feeding sites of streaked shearwaters from the Honshu Island colonies using geolocators have found the correlations between the region of feeding and zooplankton concentration. The latter attract different species of pelagic fish that are the main food source for streaked shearwaters. It was also shown that the main feeding sites were situated at a distance of 240–500 km from the colony, and the maximum expansion of birds in food search can reach 800 km (Yamamoto et al 2011).

During nesting period, the main feeding areas of streaked shearwaters from Karamzin Island are located at a distance of 1–80 km from the colony and connected with the neritic zones with about 50-m depth. These zones are characterized with the most density of zooplankton (Figure 8) (Dolganova and Nadtochii 2015). Beside these waters, the streaked shearwaters from Karamzin Island colony were regularly flying to the Korean Peninsula up to

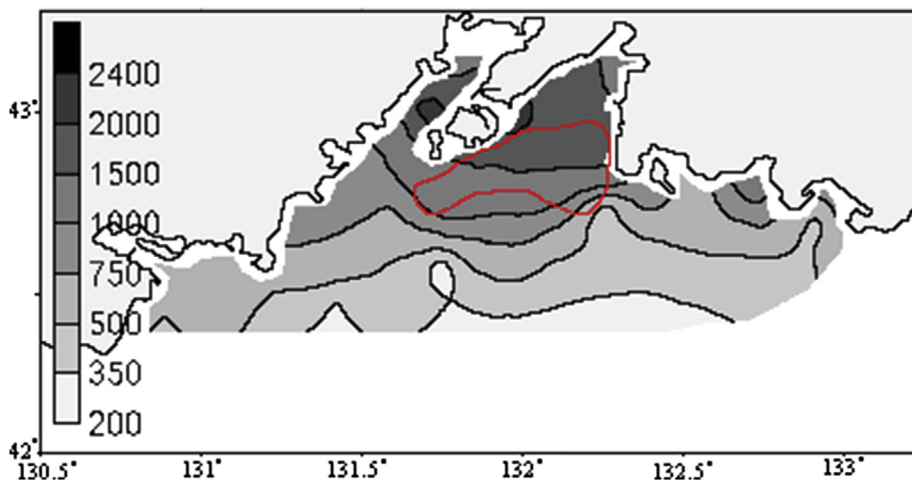


Figure 8. Map of distribution of zooplankton biomass in the Peter the Great Bay in summer (Dolganova and Nadtochii 2015). Red line indicates main feeding area of streaked shearwaters.

36 km parallel (N 36 32), i.e., 720 km from the colony. In addition, the birds were flying to the Eastern Sea at a distance up to 250 km reaching underwater mountains Koltso, Sibir, and Ostrovnaya (Figure 5).

Conclusions

The border of feeding area of the northwest colony of streaked shearwater was defined solely through the use of Trackers WT-300. It was also shown that in the food search, birds may reach the southern part of the Korean Peninsula. Although the main feeding areas are situated in the immediate vicinity of the colony at the distance 1–80 km, it is revealed that the most visited feeding spots are situated in region with 50-meter depth that is also characterized with the presence of circular currents and joints of multidirectional currents. The most biologically important feature of such areas is the high concentration of zooplankton.

Conflicts of interest

The authors declare that there is no conflicts of interest.

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