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The Importance of Hauling Grounds in the Life of the Baikal Seals (*Pusa sibirica* Gmelin 1788, Pinnipedia): 2. Behavior on Hauling Grounds

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Abstract—Based on the literature record, some forms of the behavior of the Baikal seal (*Pusa sibirica*) are described, both on coastal hauling grounds and in their immediate vicinity. This includes territorial behavior, social relationships, thermoregulation behavior, play, and other forms of behavior on the hauling grounds; the animals making feeding trips are characterized. Special attention is paid to sleep and nutrition, as well as molting. An attempt is made to assess the use of different sensory organs (vision, smell, hearing, etc.) in their life on the hauling grounds. The effectiveness of preying on fish is noted to be determined by using both vision and vibrissae. Several characteristic postures of the seal are described.

Keywords: Baikal seal, coastal summer haul-outs, forms of behavior, sensory organs

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The majority of the Baikal seal (*Pusa sibirica* Gm.) population occupies the pelagic (limnetic) zone of the open lake for several ice-free months during the year and does not need a solid substrate. Presently, this (feeding) period extends to approximately 210 days from about mid-May through December, whereas it was shorter and did not exceed six months 20–30 years ago. Over the summer, a large quantity of Baikal seals haul out ashore for some period of time. The peculiarities of the behavior of these seals will be addressed in this communication. We made an attempt to embrace all aspects of the Baikal seal behavior during the period when the animals dwell on hauling grounds and the period that precedes hauling-out of seals onto the solid substrate, and we present what has been already known on the topic before we proceed to familiarize the reader with the actual facts obtained from analysis of our video footage.

The first to characterize behavior of the seal on shore was A.I. Martos who reported that, "During sealing [on summer hauling grounds], old seals wail, while the young are oohing like people. They are quizzical, timorous, and hasty; sleep tight; when awakened from sleep get skittish in an instant, rush off to run and then spit water before you so the road will be as slick as possible for the one following close on its heels" (Martos, 1823, cited after Ivanov, 1938). The present review offers a critical analysis of the modern publications.

Territorial Behavior or Choice of Place for Hauling-Out Ashore

Choice of place for the hauling ground. The location of any particular hauling site apparently must be in some way different from neighboring sites, which the seals in their wisdom avoid (i.e., the latter are not part of the hauling grounds). So, in what way are they? We cannot tell, but if nothing else, it is not the availability of better food supply compared to other areas, inasmuch as providing that unless one or two hundred kilometers separate the sites, the presumptive feeding place of animals from these hauling grounds would still overlap. It is indubitable, however, that there are hauling grounds that the seal prefer to any other and, therefore, utilize them more frequently, such as the hauling grounds on the Ushkan Islands. But even on these islands, there are sites much sought after by the seals and sites less frequented or not visited altogether (Petrov, 2009). That is not to say that in choosing a place the seals predominantly gravitate toward a stable substrate sheltered from waves; this is not the case in the conditions of the Ushkan Islands. Thus, the most favored hauling site, Kamushek, which is a boulder on the northernmost end of Tonkii Island, is located at the end portion of the cape, which is the most unpredictable in terms of hydrometeorological conditions. Under the actions of wind and wave, this haul-out is frequently destroyed, flowing to the leeward side of the island, or the animals migrate to hauling grounds on neighboring islands. But as the inclement weather

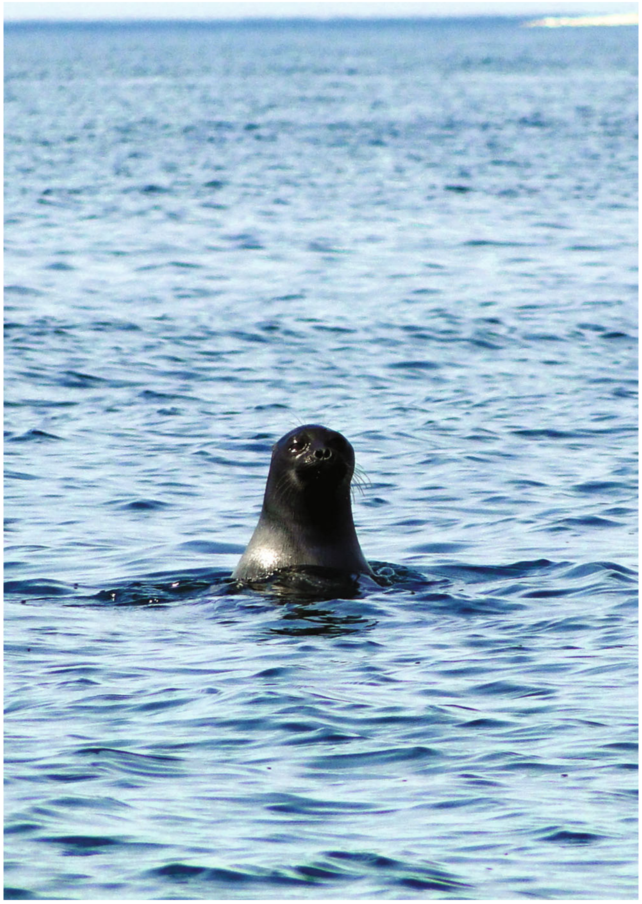

Fig. 1. Typical posture for thorough examination of the hauling grounds or any suspect object (photo by E.A. Petrov).

subsides, the seals return to Kamushek. This selectivity becomes more evident in choosing large (by area) stretches of shoreline. Therefore, the motivation of the animals in choosing a place for a hauling ground remains a mystery.

After the disappearance of floating (pack) ice, "almost each hauling ground is continually held by a limited number of seals," which are considered "local residents." These are young animals, which, so to speak, are on the watch for the "next rest break ... of sexually mature seals," but do not haul out on shore themselves (Ivanov, 1938, p. 54). But even before the rest break, adult males ("heaters") appear at the hauling grounds, which likewise do not haul out. Then, the adult females "roll up," and the hauling ground starts being exploited though the ritual described by T.M. Ivanov (1938, p. 54) at length. Similar situations, primarily with protections of the boulder from incursions on the part of "kinsmen" were also observed later on (Petrov, 2009), but other elements of the ritual of "the grand opening of the hauling ground" had not been mentioned by anybody. Thus, on July 14, 1936, the first debouches were accompanied by "slightly refashioned play," during which, among other things, an adult female "every now and then ... leaped from the water, exposing her full body, plunged back with a loud splash (surge), and continued her rapid movement under the water. Six seals were attracted to this playful activity, whereafter the first female made it back ashore and settled on the boulder" (Ivanov, 1938, p. 55). Similar play actions were considered by Ivanov to be exclusively characteristic of the first rest break of the animals (about the rest breaks, see communication no. 1).

Aquatic behavior and hauling out ashore. It was repeatedly mentioned that the first visitors to Kamushek and the adjacent hauling ground places occupy their space early in the morning. "As early as at 6 am, dozens of already dried-off animals may be lying on them [stones]" (Petrov, 2009, p. 36). Generally, single animals (or a few individuals) seem to run afloat rather rapidly (in fact, continually resurfacing and diving to minimum depth) to the shore from Bol'shoi Ushkan Island or the open "sea." Coming close, the seals start carefully scanning the area, sometimes popping high out of the water (by craning their necks). While the seal examines the hauling grounds, it often "holds an upright (postlike) position" with only one half exposed and sways to and fro in time with the hind-flipper strokes (Fig. 1) (Ivanov, 1938). If there is no one on the rocks, the reconnaissance can take a while; with somebody lying there, the examination and decision-making gain pace. Pastukhov (1993) believed that seals are equipped with an "imitation reflex," making itself evident in the fact that every time one or two individuals haul out ashore and establish themselves, they are emulated by other animals. This is undoubtedly true, but the degree to which this reflex has evolved is not clear. In any case, seals, arriving to the place of intended haul-out (even providing that there are two or three seals lying there), take time to inspect it thoroughly, dive under, and do not always immediately debouch on land (Petrov, 2009). The community structure in animals is known to be maintained on the basis of a set of behavioral responses, most commonly manifesting themselves during conflict between conspecific individuals. This includes attacks against rivals, escape from them, pursuit, mutual intimidation, displays (submissive, threats, etc.), and other elements of aggressive (antagonistic) behavior. The dispersed existence of the seal during the open water period entails some hostility toward its kind; however, aggression is hardly possible and appropriate in the "open sea." The confined space on a solid substrate and hauling grounds is a completely different story. Importantly, in the latter case, aggression is not associated with starvation or other physiological needs, while serving no other purpose than to occupy a place on the hauling ground.

On the other hand, cooperative rest of animals is considered to contribute to maintenance of amicable relationships on the hauling ground among all participants of haul-outs. But in the Baikal seal, competition for territory incontrovertibly exists and more commonly makes itself evident in competing for particular boulders and stones, which cannot concurrently and comfortably accommodate several individuals. According to the available data, aggression in the Baikal seal is more commonly displayed by those that had already found lodgment on the stone (Petrov, 2009) (Fig. 2); the latter most frequently "strikes (slaps) hard" a competitor with fore-flippers vocalizing them with "roaroinking"[1]; accounts even exist on the advantages of a defensive position (on a stone or rock) (Ivanov, 1938). Aggression is often displayed toward the female seal first to occupy the haul-out place by other seals wishing to haul out on the same stone and by some means or another forcing her to leave the stone or share the place. This involves false alarms, concurrent flank attacks from both sides, and nipping or biting each other; however, "the almost done deal" resorted to by an inconsiderable number of the individuals is splashing with water: the attacker flaps the water with its fore-flippers in front of the seal lying on the stone, so that the splashes come at her; not a single seal can endure such an attack and after two or three successful flaps of the persistent competitor, the former dislodges herself into the water" (observed on the Ushkan Islands in 1935) (Ivanov, 1938, p. 55).

Publications create the impression that the seals, overall, are not aggressive animals. But if someone attempts to take over the "old haunt" on a stone, the owner (master) of the stone may very well not only swing its flipper, but also slap, though rarely succeeding in it, since the "stone-crasher" has stellar reflexes to escape just-in-time. The same applies to another widespread practice: a sudden and threatening forward thrust of the head toward the "bad guy" demonstrates that the seal is on alert to defend its territory (Ivanov, 1938; Petrov, 2009). This is usually sufficient to send the opponent "packing."[2]

Generally, in pinnipeds, the process of movement to the hauling ground of every new animal is accompanied by postural, mimic, and vocalization displays, the forms of manifestation of which depend on the status in the hierarchy of the participants (Lisitsyna, 1978). She was referring to eared seals, while in our case it would be better say that it is related to the size–weight category: it is more difficult for young (weaker) individuals to occupy and hold a haul-out place among stout counterparts; the former are commonly shoved to the edges of hauling grounds.

The animals are constantly on alert on the coastal (or ice) haul-outs, despite their seeming tranquility and appearing "sleepy." To provide fuller description of the species, it should be added that the seal drops its guard only while molting. "During this stage, one can approach the molting animal very closely (on a boat with white sails) and without any sudden movements even touch it. Some seals become surprisingly "fearless" and, while watching the humans, a seal will just turn its back on them or submerge (hide) its head in the water" (Petrov, 2009, p. 159). But that is on ice (Fig. 3). The animals, molting ashore, behave the same way as the molted, although they are similarly reluctant to enter the water.

Duration of stay on land. Speaking about the population as a whole, the coastal hauling grounds function from July to August (Ivanov, 1938), sometimes beginning in July and going through September (Pastukhov, 1993). At an individual level, if the animals are not disturbed by anything or anybody, the majority of them spend several hours a day on land (observed on the Ushkan Islands) and from one to four days in total in the vicinity of the hauling grounds (Ivanov, 1938). Particular individuals leave the hauling ground for no apparent reason (it is unknown, whether they return); others arrive from hauling grounds lying to the north (Ivanov, 1938). Notwithstanding these data, this does not appear to clarify whether or not there is a rotation of the membership among the seals hauling on the grounds, or if these are the same individuals, lying day after day on the shore. Some individuals remain on the hauling ground for several days (Pastukhov, 1993, p. 123), but the latter appears to be an exposition of Ivanov's data; hence, it is not clear from the text whether they leave the shore for, e.g., a night to return afterwards or hang on rocks never budging from their place.

In case of panic, the seals immediately leave their place, running into the water (Ivanov, 1938; Pastukhov, 1993). The "exodus" occurs at a particularly rapid rate when the animals haul out on large stones (boulders), rather than the shoreline. But they "escape" in an unusual way. When viewed from above, the frightened seals (especially, if the reason for fright is not understood) from a haul-out place located on coastal, partly submerged stones (rocks) directly under the cliffed abrasion coast were seen (owing to the perfect water clarity) to calm down rapidly once in their natural element. This shows in the way that the seals, initially having rushed into water and streamed seaward, do not swim far. Just a few meters away, they suddenly as if on cue stay put (with the orientation of heads toward the shore) and remain under water for a while almost perfectly still. After one to three minutes they return to the place of haul-out to begin the ritual of exploration anew. Although this time, hauling out ashore proceeds faster (Petrov, 2009).

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[1] "Roaroinking" is vocalizations produced by the adult seal when defending its site on a stone or rock; it is something between a bull roar and the oinking of large frightened suids (definition by Ivanov) (coined by the translator).

[2] One example of true aggression is displayed by males: during the season of "heat," they sometimes inflict on the skin of an annoying pup (while shooing it) real wounds (Pastukhov, 1993), which, although not life-threatening, may remain for life (it is entirely possible that a female, not a male, is at fault; no observations were made).

Fig. 2. A small nearly submersed stone is also for haul-out, but the space is limited. This display of aggression looks more like "airs and graces," but, nevertheless, the larger seal failed to supersede the smaller (photo by E.A. Petrov).

Some Behavior Patterns in the Baikal Seal

Social relationships. Ivanov considered "sociality in the Baikal seal to be explicit" and that "there is no ... period in the annual life cycle of these animals without sizeable hordes of the animals of various age groups" (Ivanov, 1938 p. 28). However, "we cannot consider at liberty any horde of animals as the community" (Tinbergen, 1969, p. 149); and we may find it difficult to dispute this. Even though haul-outs (groups) of seals on hauling grounds prove to be large

Fig. 3. During the spring molt, seals become surprisingly "fearless" and, at times, appear to be blind to danger; they hide their heads in the water or turn their backs on it (photo by E.A. Petrov).

(Fig. 4), the observed interactions of the animals do not appear strictly hierarchical (Petrov, 2009). If the emergence of hierarchy as indispensable attribute is disregarded, the behavior of the seals ashore is unquestionably a full-fledged social (communal) behavior.

Thermoregulation behavior. The seals cannot remain under the baking sun for an extended period of time; they become overheated and uncomfortable (Pastukhov, 1993; Petrov, 2009). Under these conditions, to disperse excess heat to the environment, redistribution of blood flow occurs in the seal organism in the peripheral tissues (Baranov et al., 1988, 1988a, 1992). If the hemodynamic responses prove to be insufficient, the seal utilizes the so-called thermoregulation behavior. It could include rolling over (a colder body part is exposed to the sunlight, while the overheated parts are hidden in the shadows), as well as a return to the water (Petrov, 2009). If the seal has no desire to leave, it utilizes other processes, such as to spread out the hind-flippers and maintain them in this position for a while. This increases their area, so that heat dissipation (emission) through the flippers is also increased. Commonly, the seal waves with spread-out flippers to enhance heat removal (Petrov, 2009).

Sleep is a form of brain activity required for body functioning in the waking state. Sleep appears to be the main activity and primary form of behavior in the seals on coastal hauling grounds (Figs. 5, 6). Similar to terrestrial mammals, two phases are physiologically differentiated in true seals. The first is slow-wave (slow) sleep, synchronously involving the cortex of two hemispheres and subcortical regions (bilaterally symmetrical slow-wave sleep). In slow sleep, the

Fig. 4. On June 5, 2018, 400–500 seals were hauling out on the northern site of the grounds on Dolgii Island (low water level). The background shows the southernmost end of Tonkii Island, which is not used by the seal for hauling out (photo by E.A. Petrov).

sleeping subject lies immobile; in other words, true seals cannot sleep when in motion (Lyamin et al., 2006, 2014). In Pusa, the slow sleep is followed by the second phase of sleep, which is rapid eye movement (REM) sleep, but the deepest paradoxical sleep. In true seals, paradoxical sleep can occur both in an aquatic environment (that is, they can sleep in the water) and in air. But episodes of paradoxical sleep in true seals are generally shorter than in eared seals (Lyamin et al., 2006), in which this phase can last at least ten minutes (Kosenko et al., 2012). Another paper asserts that Cetaceans and pinnipeds (apparently referring to the Northern fur seal) completely lack or have a considerably reduced paradoxical sleep phase (Lyamin et al., 2014). According to Lyamin, in paradoxical sleep of the Baikal seal, the tone of the neck muscles is suppressed, the pulse rate drops, and "when the seal body or at least its nostrils remain under water, the animal holds its breath for a few minutes until termination of the sleep episode, when it emerges to take the next breath," whereupon the next sleep episode may start (cited after Petrov, 2010, p. 161). Therefore, the Baikal seal can sleep both in the underwater position (holding its breath) and afloat (then its snout remains above the water surface) or on land. In captivity, young Baikal seals submerge or lie on the bottom and sleep in a phase of paradoxical sleep (more deeply). The adults display similar behavior, but less commonly. During the slow sleep, seals sleep in the water column in a belly-down orientation or in upright "bottling" (float posture) position (Lyamin, cited after Petrov, 2010, p. 162).

The latter aquatic sleeping posture was mentioned previously as a typical sleep position referred to as "post-like" (in the vertical orientation, head shrunk into blubber, nostrils outside). The second characteristic sleep posture is when the body in horizontal orientation is "suspended" in the water column at a shallow depth (dorsal surface is often visible) (Petrov, 2009). During sleep underwater, they, however, have to wake up each time when it is necessary to stick its head out or However, judging by the closed eyes, the seal does not need to wake up for lung ventilation in both cases.

In the wild, as soon as the Baikal seal "sets a flipper" on a solid substrate, it appears to do nothing except try to sleep. An immobile body with the eyes closed is considered a typical sleep posture. The seal rarely has a chance to have good sleep, partly due to disturbances caused by neighbors, partly due to the

Fig. 5. Quietly resting (and sleeping) seals, long-lying on a stone, display utter satisfaction (photo www.i.pinimg.com). Scratching is among the most commonly observed elements of seal behavior.

extreme caution of the animals themselves: even seemingly sleeping seals raise their heads and scan around for no apparent reason at regular intervals. In air on the solid surface, the seal neck cranes during sleep due to the postural tone of the neck muscles, while the head of the sleeping animal "drops" (touching the substrate) (Petrov, 2010). The seal sleeps soundly on land with the body relatively immobile for a prolonged period of time. In captivity, seals, sleeping on the pool's nosing, were observed so soundly asleep that they did not hear people coming into the small room containing the pool (Petrov, 2009). In true seals, parameters of the functioning of the respiratory and cardiovascular systems change during sleep. Interrupted breathing (with pauses) during sleep in air can be noticed in seals even on visual inspection. As though they performed short dives, the breathing pauses (apnea), lasting for few minutes, alternate with short periods of hyperventilation. The amount of time the Baikal seal spends sleeping in the wild is unknown, but, according to some estimates, during the ice-free period, sleep time accounts for not more than two to four hours a day, more precisely during daylight, since darkness is the time for foraging (Petrov, 2009). The Caspian seals sleep for approximately the same amount of time, that is, 15% of a day (in other words, approximately four hours). There is no need for animals to ensure sustenance in captivity; therefore, the Caspian seals sleep nearly 12 hours daily (Mukhametov, 1986), whereas the Baikal seal refrains from this even in captivity, based on our observations.

Feeding behavior. The animals hauling out on the coastal grounds periodically make trips to sea, apparently to forage. The duration and extent of these feeding trips to sea are unknown; however, the impression is that, as long as the seals have hauled out on the coastal grounds, they would stay there for the major part of the daylight hours. A part of haul-out is assumed to be take-off to sea by evening, while by the night all animals leave the hauling grounds for foraging (Gurova and Pastukhov, 1974; Petrov, 2003, 2009). The same authors, however, give an account of daytime sealing both near the shore and at a distance of 500–700 m from the hauling grounds. It is more difficult to assume that, in the day-time, animals perform hundreds of deeper submergences than at night for no purpose (Petrov et al., 1993; Stewart et al., 1996). Apparently, the time of feeding, as well as its duration, may vary to a greater or lesser extent (Gurova and Pastukhov, 1974).

Fig. 6. It is drawing a deep breath (yawning), rather than screaming. Seals yawn repeatedly with jaw wide open. Note the tucked flippers: the seal is reluctant to immerse them in water (avoid cooling) (photo www.fs3.fotoload.ru).

Four seals captured in summer 1990 on the coastal hauling grounds of the Ushkan Islands and released in the same place after a satellite-linked transmitter was glued on rapidly left that area. Until Lake Baikal freezes, the seals moved extensively and repetitively dived for 2–6 min predominantly to shallow depths (10–50 m). Here, between September and early May, each of the four seals covered a distance of 400–1600 km if estimated in linear segments (Petrov, 2003; Petrov et al., 1993; Stewart et al., 1996). Short dives, not exceeding the aerobic dive limits, take place in the aerobic mode and have no implications for the seal in terms of their energetics. It may stay in this mode for a prolonged period of time, while spending underwater up to 90% of its time daily (Petrov, 2009). The maximum dive depth of juvenile individuals exceeded 300 m with duration of a dive >40 min (Petrov et al., 1993). Recently, new data have become available about the seal behavior in the limnetic zone of the lake, e.g., with respect to the so-called drift dives, during which the seal presumptively rests and digests food (see Watanabe et al., 2004, 2015). Observations in the wild over two free-ranging seals have shown that being far offshore for 24 hours, the animals spent approximately 80% of the time underwater and, apparently, continuously performed dives (average depth 69 m) with a mean duration of 6 min (n = 315). During sunset and sunrise, dives were deeper (up to 245 m) and longer (up to 13.5 min) (Watanabe et al., 2004, 2004a).

The seals can be assumed to appear on hauling grounds precisely after the dives. At night, the dives were shallower and characterized by a lower speed. In the daytime, the seals repetitively dived in a tranquil regime sometimes characterized by acceleration events attributed by the observers to predation on fishes (Watanabe et al., 2004, 2004a). In other research, four free-ranging Baikal seals performed short dives (mean duration 7 min, maximum 15.4) every 1.2 min, on average. Dive depths were 6 m on average with a maximum depth of 324 m (Watanabe et al., 2006, 2006a). The high-rate diving activity is surely linked to foraging; however, of 1315 images taken with a digital camera attached to the animal, only one image shows a pelagic sculpin (*Comephorus* sp.) at a depth of 54 m at 2:32 a.m. (Watanabe et al., 2004). The diving behavior pattern is attributed by the Japanese authors to the fact that in the daytime the seals feed on fish while relying on vision, whereas during the nighttime they capture crustaceans, forming dense aggregations in the upper pelagic layers and, allegedly, use nonvisual sensory mechanisms, "such as whiskers" (Watanabe et al., 2004).

In our opinion, this assertion is unfounded and debatable. The seal is considered to date to feed primarily at sunset and nighttime (a series of author, see Petrov, 2003), which is in contradiction to Ivanov (1938). In any case, the diet appears to be deficient for seals ranging around the Ushkan Islands in the summer (Egorova et al., 1992). The food bolus of seals caught by netting in the immediate proximity of the hauling grounds of the islands predominantly contained (in all individuals) the Little Baikal oilfish (*Comephorus dybowski*), not that many Big Baikal oilfish (*C. baicalensis*), and even fewer longfin Baikal sculpin (*Cottocomephorus inermis*) and Baikal yellowfin (*C. grewinki*) (total reconstructed mass of consumed fish average 635 g, $n = 15$); while the freshwater whitefish otolith was recorded from 20% of individuals. The intestine was literally stuffed with crustaceans only in 35% of animals. The crustacean diet was recorded from all analyzed current-year young and 67% of immature individuals; adult individuals accounted just for 9% of "crustacean consumers" (Egorova et al., 1992). An old publication dealing with the summer diet of the seal in the vicinity of the Ushkan Islands points to the large proportion of Little Baikal oilfish and Longfin Baikal sculpin and the absence of Big Baikal oilfish and omul (Ivanov, 1938). In his other publication, the author factitiously (in our opinion) splits the obtained data by, so to say, "inverse calculus" into two groups of individuals feeding in the open Lake Baikal, if the sample displayed many otoliths of deepwater oilfish, and individuals feeding within the nearshore-*sor* (local name for shallow-water secluded sandy bays) zone, providing a small amount of the oilfish (Pastukhov, 1993). It takes, notably, 20–30 min (or even less) for the seal to reach the open Baikal waters from the nearshore-slope zone. Despite this fact, the significant presence of benthic gobiids and the absence of freshwater whitefish was noted in the diet of the seals allegedly feeding in the nearshore-slope zone (Pastukhov, 1993).

Even based on the scarce data above, it is conceivable that the food supply of the seals is rather limited and not steady in the vicinity of the Ushkan Islands. This fact is corroborated by the crustacean diet of the animal in that the latter is not typical of the seal, but might suggest very large concentrations of *Macrohectopus branickii* in the vicinity of the Ushkan Islands (no other crustaceans occur in the Baikal pelagic zone). The role of the low-calorie *Macrohectopus* is overall difficult to assess for sustenance of the Baikal seal population. But relatives of the seal, such as the spotted seal, ringed seal, ribbon seal, and bearded seal, consume thousands of tons of invertebrates (largely, crustaceans and mollusks); thus, this food item plays a significant role in the diet of the latter species (Bukhtiyarov, 1986). These species, however, inhabit the seas. The shortage of the main food items in the "Ushkan" seal diet is also supported by the presence of freshwater whitefish. Additionally, data is available that "as the omul comes closer, the seal leaves the hauling grounds, avoiding the warm and turbid 'omul' water" (Ivanov, 1938, p. 60).

The assumption is that the mean dive depth of approximately 70 m may imply the maximum depth (with allowance for an error of the estimate) at which the seal can detect its prey visually (Watanabe et al., 2004). The statement is ambiguous, although vision might be of great significance for prey detection in the seals, considering the high water clarity. Thus, under irradiance of the night sky with a full moon, the spotted seal can detect a moving object at a depth of 360 m in the marine medium and of 80 m in the nearshore waters (Wartzook, 1979, cited after Andreev, 1986). Remarkably, Japanese scientists attach great importance to crustaceans, while contemplating how and where the seal can feed on them without turning to the Russian sources and, thus, make "false" discoveries. Based on papers dealing with the harbor seal (Dehnhardt et al., 1998, 2001, cited after Watanabe et al., 2004), they assume the use by the Baikal seal of vibrissae to detect food items. This presumption for the Baikal seal, however, was made approximately one hundred years ago (Ivanov, 1938), while the fact of the vibrissae (sensing) being a "tool for detection" of edible items has already been shown experimentally (Petrov, 2003, 2009). Utilization of crustaceans by the seal has also been a known fact for a while (Egorova et al., 1992; Pastukhov, 1993), but apparently not to the Japanese researchers.

Behavior of molting animals. Apparently, the molting animals, hauling out onto the solid substrate, must make use of it somehow. This indeed holds for ice (Pastukhov, 1993; Petrov, 2009). According to Ivanov, the same is also true for the coastal hauling grounds in that, when not disturbed by other individuals attempting to occupy its place, a molting seal "rolls off the stones on one side or another to 'rub off' the old fur" (Ivanov, 1938, p. 56). The animals infested with fleas (*Echinophthirius horridus* var. *baicalensis* Ass), occurring in the hair and skin of the animals, are the most tenacious. Surprisingly, this behavior pattern of the seal is disregarded by other researchers (Pastukhov, 1993; Petrov, 2003, 2009).

Senses

The extent of the use by the Baikal seal of the capacities of its senses differs on land and in the aquatic environment.

Vision. In the Baikal seal, the vision system functions in specific conditions, that is, not only in two mediums (fresh clear water and air), but also in the conditions of extreme luminance levels, ranging from bright sunlight (on ice) to almost entire darkness in the descent to low depths (down to 400–500 m). From the first description of senses, we learn that that the eye lens of the animal is enormous in relation to its size (47 mm in diameter, weighing approximately 200 g in a five-year-old female); the eyes are equipped with a nictitating membrane; the vertical pupil is able to widen (Ivanov, 1938). In air, the eyes of the Baikal seal cannot remain open for a prolonged period of time due to the commonly observed "lacrimation" (Petrov, 2009), though it lacks lacrimal glands. The function of tears is fulfilled by protein mucous secreted by the Harderian gland, which is well-developed in phocids. The mucous has the same refractive index as water, which allows the seals to see objects underwater without distortion. Ashore, the seal opens its eyes to scan the surroundings; otherwise, they either remain closed or "squinted." Therefore, closed eyes in the seal do not indicate sleeping. The seal vision is estimated as satisfactory in air and very good in the aquatic medium (but inferior to olfaction in life); thus, the seal can detect a dismounted hunter on ice from a distance of 1.5–2 km and a white sail employed by the hunter to stalk the prey at a distance of 150–200 m (Ivanov, 1938). Other data, however, exist suggesting that the seal has little vision in air. In summer on the coastal hauling grounds, it can detect a moving person on shore from afar, but fails to distinguish the person from stones even from a few meters, providing the former remains still (Petrov, 2009, p. 21). The seal haul-out can be approached very closely on the leeward side, if one moves slowly and intermittently, while carefully keeping an eye on the animal behavior. In the daytime, the seal can perfectly see the set gillnets in clear water near the Ushkan Islands, the more so if they are anchored in the surface layer. It skillfully avoids them by diving down just under a meter under the gillnet without touching its canvas. But at nights, animals of all ages become trapped in these nets. The seal might be caught in the net even during the daylight (though commonly this happens at night) when the water is turbid, e.g., in Chivyrkuiskii Bay in the fall. In April, gill nets under ice rarely display nursing females, whereas the pups account for 50% of the individuals trapped in them (Petrov, 2009).

The dorsal and forward facing position of the seal eyes ensures simultaneous perception of an object with two eyes, after which the two images overlap into one (binocular vision). At present, as new data has become available, the visual organs of pinnipeds are viewed by researchers as a highly organized sensory system that fulfills a major role in the life of these animals, particularly in the aquatic medium; mechanisms of ambivalent vision have been described in pinnipeds (Mass, 2014), although many things still need to be explored. The retina of phocids is predominantly populated with rods, functioning in the conditions of insufficient light. In pinnipeds, the number of these photoreceptors are 20–40 times as great as cones (Hanke et al., 2009), in other words, compared to generalist carnivorans or, according to different data, it accounts for as little as 1% of all photoreceptors (Griebel and Peichl, 2003). Whether the true seal possesses color vision is still unknown. The harp seal, ringed seal, and great seal can be conditioned to discriminate several colors (e.g., Pakhomov, 2019), but in the opinion of the author, this does not mean the existence of color vision in these animals.

A recently conducted study on the morphology and histology of seal eyes has shown that the Baikal seal possesses a higher retinal resolution (correspondingly, visual acuity) than the spotted, harp, and Caspian seals. Providing that the clarity of the Baikal surface water layers extends down to 40 m, visual acuity of 2.3′ allows recognition of details 2.7 cm in size at a distance of 40 m; in other words, their vision allows distinguishing not only the environmental objects, but also items of prey. Since high visual acuity is functionally useless in turbid (low-clarity) water, the enhanced visual acuity of the Baikal seal is considered an adaptation to the clear Baikal waters (Mass, 2019).

Olfaction and olfactory signaling (behavior) of the Baikal seal remains among the least studied aspects, although this type of interactions might play a significant role in the social life of animals. Thus, the female northern sea lion recognizes its pup only after sniffing (Belonovich et al., 2006). Based on observations of the behavior directly on the Baikal ice, the same occurs in the Baikal seal in nursing females and pups (Petrov, 2009), although it is not very difficult to distinguish one's own pup from the neighbor's in this case. Importantly, the female seal does not display aggression on coming in contact with other pups and may even nurse them (Petrov, 2003, 2009). From the practical experience of hunters, we know that the seals (including sleeping ones), leisurely lying on ice, periodically raise their heads higher than normal to not only scan the surroundings, but also to perceive and smell the moving air; even if the lightest wind is blowing off the hunter toward the seal, the former will bag no trophies (Ivanov, 1938).

The occurrence of a distinctly noticeable unpleasant if not downright foul to a human nose smell is known to emanate from adult Baikal seal males (Ivanov, 1938; Pastukhov, 1993). The specific smell even comes out from ice holes used by the males for breathing (Petrov, 2009). In this way, the male is assumed not only to scent-mark the territory (which is rather obvious), but also attract females in estrus. No specialized research, however, has been conducted on the matter; it even remains obscure which of them is attracted and sought (between females and males); but the presumption is that males find females when the latter are still in the nursing period (Pastukhov, 1993; Petrov, 2003, 2009). Scent glands function continuously (and not merely during the time of "heat"); the odor persists even on the stones where males were lying.

Touch sensing. Sniffing (nose) appears to be aided by the vibrissae (sensing mechanoreceptive long stiff hair) on the seal's face (Ivanov, 1938). They straighten when preying on sculpins and sniffing an object (Petrov, 2003). Experiments in a pool revealed that for object (food item) recognition, the seal simultaneously employs both vision and vibrissae. Providing there was no opportunity existing beforehand for "touching," e.g., an inedible fake fish, the seal did grip it with its teeth; if such an opportunity arose, the seal identified inedibility by the vibrissae (Petrov, 2003) and did not attempt to "kill" the modeling clay dummy. During molting, seals rapidly shed off the vibrissae, which "by the moment of the onset of pelage replacement, have time to accrue about one-third of their ultimate length" (Ivanov, 1982, p. 35), which evidences their important role. Presently, vibrissae structure is actively being investigated in pinnipeds in an attempt to determine the role and significance of these mechanoreceptors, including hydrodynamic perception, etc. (see Hanke et al., 2013).

Sound (acoustic) signaling is widely utilized by eared seals, that is, the pinnipeds that form harems and complex haul-out structures. This is not typical of true seals; the Baikal seal is not an exception. But the seals do produce noises. In the conditions of overcrowding on shore, the seals exchange acoustic signals, which can be described as groans, "whistles" at stiffing, snorts, "roaroinking" (at discontent), etc. (Pastukhov, 1993 p. 122). These may be extended to include threatening vocalizations commonly made by large individuals toward their smaller fellows having decided to move too close to seniors. Females and their pups are known to exchange sound signals similar to mooing, while the pup "whimpers" and "weeps," when calling the mother or when hungry (Petrov, 2009), but there are no mother and pup interactions ashore. Acoustic signals intensify under a high density of the animal hauling, which is attributed to an increased probability of conflict arising. One can be exposed to a complex noise repertoire on the hauling grounds of the Baikal seal; but it is difficult to identify the seal vocalization aurally since their signals are drowned in the thunder of waves, the shrill call of seagulls, and the incessant splashes of water caused by movements of the animals (though groans and snorts can be distinguished).

Vocalization appears to be even more remarkable underwater than in air. Regretfully, the results of investigation of the underwater sounds made by the Baikal seal conducted by the American scientists in Lake Baikal as early as in the 1980s (R. Elsner and J. Thomas), as well as scientists from the Shirshov Institute of Oceanology, Russian Academy of Sciences, have not become available to the academic community (Petrov, 2009). Loud noises have been described for the Baikal seal made in captivity above and underwater, when it "forcefully blows air out of the lungs through tightly closed nostrils" (Baranov et al., 2014). With these sounds, the animals in captivity are assumed to draw attention to them and express negative emotions (indignation, protest, or impatience), while females ready for mating use them to attract males during mating plays. Scientists compared the physical characteristics of these sounds with those they were able to record under ice and arrived at a conclusion about the seal-initiated origin of the sounds studied, which are considered an effective way of communication. The females allegedly produce signals to facilitate males in their search for them; therefore, the overwhelming majority of adult females manage to mate successfully. The scientists believe that these sounds propagate over large distances though the under-ice acoustic channel, occurring in Lake Baikal during winter–spring period (it was described by P.P. Sherstyankin and L.N. Kuimova in 1992, cited after Baranov, 2014), which is more effective than the summertime near-surface channel.

Hearing is very well-developed in the Baikal seal. Unusual noises in air (not associated with swelling or caused by ice movement or decay) can be heard by the seal at a distance of dozens of meters (Ivanov, 1938). Incontrovertibly, true seals can also hear sounds underwater, despite the fact that, as water wets the vibrissae, face, lower part of the neck, or the head region around the auditory inlet (to say nothing of actually diving), the external auditory meatuses close. In true seals, pinnae are reduced, while the auditory meatus appears as an S-like tube located directly under the skin. To prevent water from penetrating into the auditory meatus, the latter becomes bent at the curved knee through contraction of external and internal muscles, which was confirmed experimentally. Closure of the auditory meatus has been shown to occur reflexively, even before the submergence of the animal underwater and that normal conduction without loss of sensitivity takes place when the auditory canal is closed. The experiments conducted with the Caspian seals demonstrated that noise, the source of which is ahead of the animal, can be conducted through the head tissues, but in this case, the signal attenuates by a factor of 1.5–2 compared to the sound perception through the hearing organs (see the review by Solntseva, 2017). In the Baikal seal, the closure occurs due to shifting of the outer cartilaginous plate back down. It constricts the initial elastic portion of the auditory meatus, while forcing the anterior upper wall of the meatus against the opposite wall. In some individuals, the plate shifts laterally, while forming outside the "small ears," appearing as projections 1–3 mm high (Lipatov, 1986), which sometimes are rather prominent. Closure of the auditory canals occurs reflexively and almost instantaneously. To the best of our knowledge, "underwater" hearing in phocids is understudied, but the anatomical structures that pro-

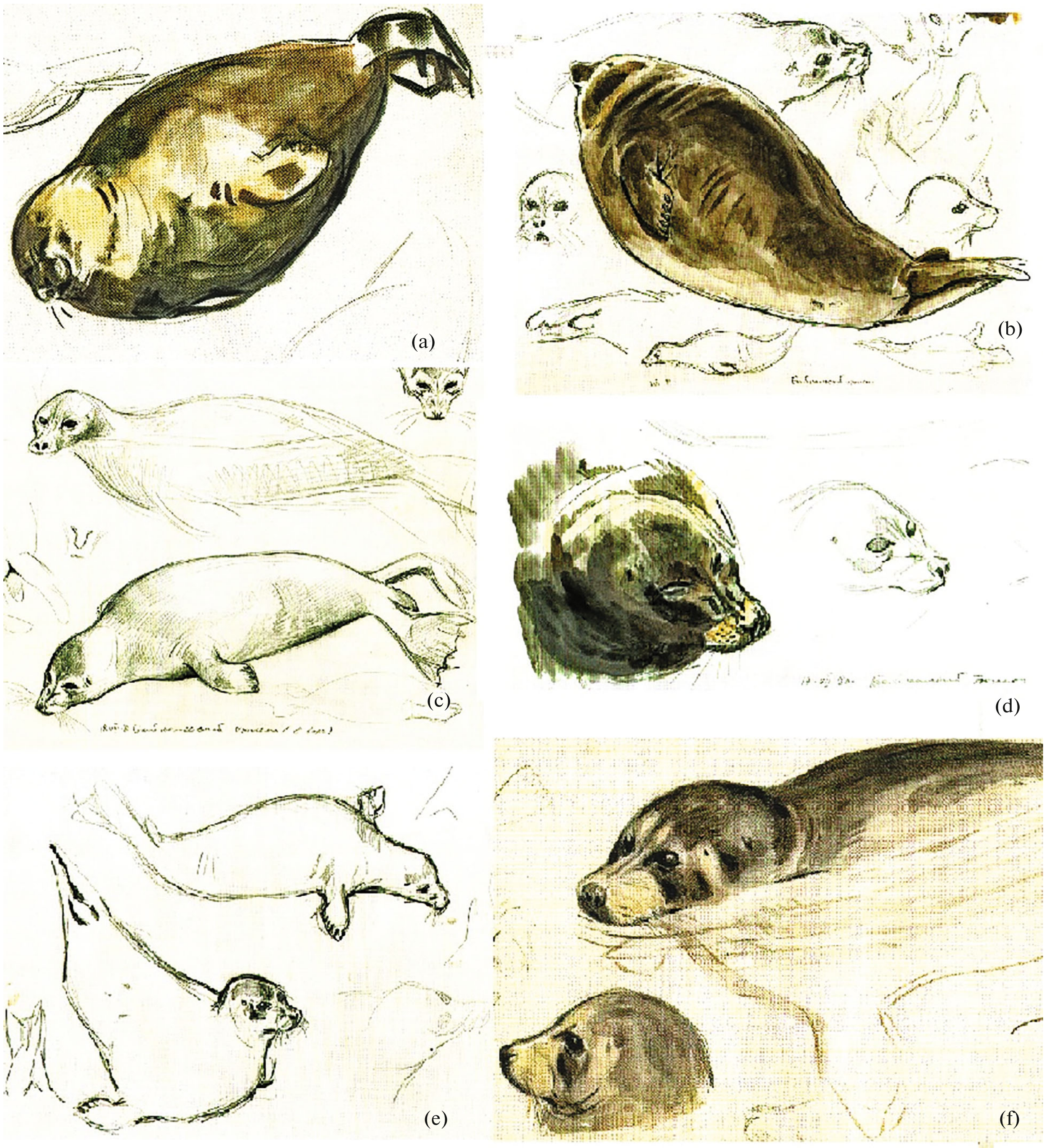

Fig. 7. Some characteristic postures of the Baikal seal (drawings by Smirnov (2010) with comments by E.A. Petrov (2010)); with the source pages. (a) "Seal sleeping on its side. In this position, sleep would not last long, as the head drops. Therefore, the seal oftentimes slightly raises its head, scans around, and returns to the same posture. Hind-flippers are folded, which helps to reduce heat loss" (p. 162) (drawing by V.M. Smirin). (b) "Male seal is undernourished, which is evident from the "Shar-Pei"-like skin on the neck and scruff of the neck..." (p. 160) (drawing by V.M. Smirin). (c) "Above is a leisurely floating or, rather, swimming adult seal, surveying the "shore." Below is a posture characteristic of the animal entering water. The seal sniffs air above the water, just in case (watch its vibrissae straightening), pushes off with fore-hinders, and its body sharply jerks forward with high flapping of the fore-flippers" (p. 156) (drawing by V.M. Smirin). (d) "Dosing male, its head slightly drawn in the "neck" (left). Its face elongated, cheeks show characteristic wrinkles... The animal may, possibly, be asleep, therefore it holds its breath (nostrils are closed). Sketch on the right sort of continues the one on the left. The seal overheard something, abruptly opened the eyes, while simultaneously starting the olfaction" (p. 150) (drawing by V.M. Smirin). (e) Above is a sharp bend of the lower part of the body, multidirectional body movement along the tail–head axis, which is a typical escape when panicking or from fright... Fore-flippers are also involved at least for "fend-off." This posture is very typical of the Baikal seal. Little seal pups exactly in this way escape on ice if suddenly pulled out from the den. Below is a posture of heightened awareness. The seal attempts to discern something ahead, while slightly its raising upper body and craning the neck. To maintain stability, it also raises the lower part" (p. 154) (drawing by V.M. Smirin). (f) "Above is ... a lazily floating seal.... It appears ... to be "suspended" in water..., indolently waving fore-flippers to maintain the selected body position.... Below, apparently, the animal scrutinizes something ashore" (p. 153) (drawing by V.M. Smirin).

vide for sound perception in marine mammals have been described. Thus, it has been shown that due to the anatomical features of the middle ear in pinnipeds, their coefficient of the acoustic pressure transmission is 1.5–2 times as great as in terrestrial species. This determines the effectiveness of the peripheral auditory system functioning during orientation of mammals in the aquatic environment and considerably expands the range of perceived frequencies (see the review by Solntseva, 2017).

Characteristic Postures

The Baikal seal has evolved characteristic postures with different types of behavior. No special studies were conducted on this matter, but some data is reported in the monograph by Petrov (2009). Sketches of the Baikal seal during various life stages can be found in the book *Portraits of Therian Mammals of Northern Eurasia* by Smirnov (Smirnov, 2010) (Fig. 7).

CONCLUSIONS

In conclusion it can be said that little is known about the summer period in the Baikal seal life and its behavior on coastal hauling grounds where part of the population spends a considerable amount of time. In addition, little if any information is available about the social life of the animals and motivation in the formation of the large-scale haul-outs ashore.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest. The authors declare that they have no conflict of interest.

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