1871
ИнБЮМ – IBSS

Морской биологический журнал
Marine Biological Journal
2026, vol. 11, no. 1, pp. 35–49
https://marine-biology.ru/mbj/article/view/512

UDC 599.745.3-151-161.2

SEASONAL CHANGES IN THE ACTIVITY OF THE HARP SEAL *PAGOPHILUS GROENLANDICUS* (ERXLEBEN, 1777) (CARNIVORA: PHOCIDAE) IN AN AVIARY

© 2026 **A. Zaitsev, Yu. Litvinov, M. Pakhomov, A. Troshichev, and A. Yakovlev**

Murmansk Marine Biological Institute of the Russian Academy of Sciences, Murmansk, Russian Federation
E-mail: *yanmos@yandex.ru*

Received 04.02.2025; revised 09.07.2025;
accepted 21.11.2025.

The harp seal *Pagophilus groenlandicus* (Erxleben, 1777) is one of the most common marine mammals in the northern seas and plays an important role in ecosystem of the Arctic region. At the same time, this species remains insufficiently studied in terms of behavioral features, particularly in captivity. The analysis of seasonal changes in the harp seal activity aimed at understanding its behavioral responses to external stimuli is essential for predicting the species adaptation strategies in a changing habitat. Experimental surveys of animal behavior in an aviary provide data that is hard or impossible to obtain under natural conditions. This work was carried out in the aquatic complex of the Murmansk Marine Biological Institute of the Russian Academy of Sciences. The main research method was the registration of individual behavioral manifestations. To assess the activity of the harp seals, we selected three behaviors: surfacing, diving, and going to a platform. The analysis of the obtained data allowed revealing consistent differences in the behavioral patterns of the harp seals throughout the year. The study showed statistically reliable differences in the behavioral activity of the animal between seasons. The most significant differences were recorded between the spring–summer period and autumn–winter one. In particular, a drop in the harp seal activity in the autumn–winter period was noted, accompanied by an increase in the time spent on the water surface during the cold season.

Keywords: behavior, motor activity, harp seal, aviary complex, captivity

The harp seal, or the Greenland seal, *Pagophilus groenlandicus* (Erxleben, 1777) is one of the most common marine mammals of the North Atlantic and the Polar Basin [Erokhina, 2003; Lavigne, 2018; Mishin, 2001; Svetochev, Svetocheva, 2018]. To date, its population is about 7.5 million ind. in the Northwest Atlantic [Hammill et al., 2014] and approximately 9–11 million ind. within entire range [Svetochev, Svetocheva, 2018]. Undoubtedly, such a large population is important for the Arctic marine ecosystem. According to various estimates, harp seals can consume 3.5–5 million tons of prey *per* year in the Barents Sea; some authors believe that it is comparable to food consumption of such predators, as the Atlantic cod *Gadus morhua* (Linnaeus, 1758) and the common minke whale *Balaenoptera acutorostrata* Lacépède, 1804 [Bogstad et al., 2015; Lindstrøm et al., 2013; Nilssen et al., 1997, 2000; Nordøy et al., 2008].

There are papers discussing *P. groenlandicus* seasonal migration routes [Haug et al., 1994; Sergeant, 1973] and diet [Kapel, 2000; Mårtensson et al., 1994; Svetochev, Svetocheva, 2009; Svetocheva, Svetochev, 2015], and works analyzing morphophysiological parameters [Grenlandskii tyulen', 2001; Kavtsevich, Minzyuk, 2017; Kavtsevich et al., 2020; Nordøy et al., 1993; Svetochev, Svetocheva, 2018]. At the same time, publications devoted to the behavioral characteristics of the harp seal are rare: not all aspects of the life of marine mammals can be investigated in their natural environment, and surveys on the behavior of other seals do not always allow extrapolation of data to other species. Many questions remain unanswered when studying animals in the wild; therefore, captive marine mammals are still a major source of information for several fields, including psychology, immunology, bioacoustics, and physiology [Corkeron, 2018]. Housing marine animals in captivity is associated with certain difficulties; only some species are kept in very limited numbers in zoological collections around the world, and even they are not always available for research [Haug et al., 1994]. This also applies to the harp seal: as of the beginning of 2025, only one specimen was housed in captivity in the entire territory of Russia – in the Murmansk Oceanarium. Studies which describe the effect of weather and other abiotic factors on pinnipeds (in captivity) mostly cover analysis of the haul-out behavior of seals, and have little to do with parameters of their activity in water [Moulton et al., 2000], despite swimming is the main form of behavior of the harp seal.

As a rule, the range of seasonal fluctuations in environmental conditions becomes wider with increasing latitude. Accordingly, the annual cyclicality of biological processes, including behavior, is most pronounced in animals in temperate and arctic zones [Gwinner, 1981]. In higher latitudes, pinnipeds have clearly defined annual cycles, and strict adherence to cycle timing is crucial for their existence (this applies in particular to pagophilic species whose life is strongly linked to processes of seasonal ice formation). Seasonal changes in animal behavior occur around milestones: reproduction, molting, and migration (in some species). Corresponding changes in behavior have been often described in terms of activity level [Moulton, 1997].

Understanding behavior of earless seals and variations of their activity throughout the year is essential for predicting both their response to external stimuli and changes in behavior driven by endogenous biological rhythms. Many earless seals are very mobile predators performing long migrations, and this makes research on their behavior even more relevant.

The aim of this study was to reveal behavioral changes throughout the year in harp seals housed in an open-air aviary.

The objectives of this study were:

1) to determine quantity indicators of the active forms of behavior of the harp seal in captivity;
2) to evaluate the statistical reliability of differences in quantitative indicators of the harp seal behavior in various seasons;
3) to identify changes in various forms of the harp seal behavior depending on the time of year based on quantitative indicators.

MATERIAL AND METHODS

The harp seal *P. groenlandicus* belongs to the family of earless seals Phocidae Gray, 1821 and the order Carnivora Bowdich, 1821 [Committee on Taxonomy, 2026; Mammals of Russia, 2019; The Mammals of Russia, 2012].

The study covered two immature male harp seals, each aged one year. The animals were caught on ice of the narrow entrance to the White Sea in April 2010, after the end of juvenile molting (age of 25–30 days). The harp seals were different in their appearance: the male nicknamed Malen'kii (literally 'Small') had a lighter body color (Fig. 1) and had practically no spots on its belly, while the male nicknamed Bol'shoi (literally 'Large') had many sports on its belly.

Before the start of the experiment, the animals were examined externally to confirm the absence of characteristic symptoms of diseases (blood samples were not taken). The harp seals had no changes in their skin condition, and also no discharge from eyes and nasal cavity. They showed no such behavior, as refusal to feed, "hanging" in water, or staying on a platform for a long time after feeding.

Fig. 1. Male harp seals: Bol'shoi (literally 'Large') on the left and Malen'kii (literally 'Small') on the right

The harp seals were kept at the MMBI biotechnical aquatic complex in Polyarny city, near Tonya Cape in the Kola Bay [Morskie mlekopitayushchie, 2010]. The animals were housed in a rectangular aviary made with polyethylene pipes (Fig. 2) and equipped with 1.5 m high guardrails along its perimeter. Before the start of observations, both seals had been living in this aviary for about a year. Over the entire study period, aggressive interaction between the animals was minor.

On the guardrails, an open net cage was secured. Its parameters were as follows: length of 8 m; width of 4 m; depth of underwater part of 3 m; height of above-water part of 1 m; and mesh size of 5 cm. The bottom of this open cage had a frame made of metal bars 1 cm in diameter; those were welded together in a rectangle. This structure provided vertical tension and alignment of the cage. There was a wooden platform with a wooden gate, 1 × 1 m, where the animals could rest and where researchers could easily approach the harp seals.

At one corner of the open net cage, a 4 m long wooden mast was installed, with a surveillance camera. Its view angle covered the entire aviary area. The aviary complex was roped to a fixed berth which housed laboratory premises with equipment for recording the footage of surveillance cameras. A 250 W high-intensity discharge lamp located on the berth allowed recording the animals' behavior at night as well. This lamp was on around-the-clock before the start of observations and for their total duration; accordingly, it was not considered an irritating factor as its effect was constant.

Video recording equipment was used to register behavior: to record all changes in the animals' activity over the observation period and later highlight the aspects of our interest (analog black-and-white outdoor surveillance camera MVK-08, bullet D 60 × 75 mm, 40 TVL, 01 LK-F2, lens M12). When processing

the video material, the method of registering individual behavioral manifestations was applied. During observation, all cases of manifestation of the studied activities were recorded [Popov, Il'chenko, 1990; Zaitsev et al., 2018].

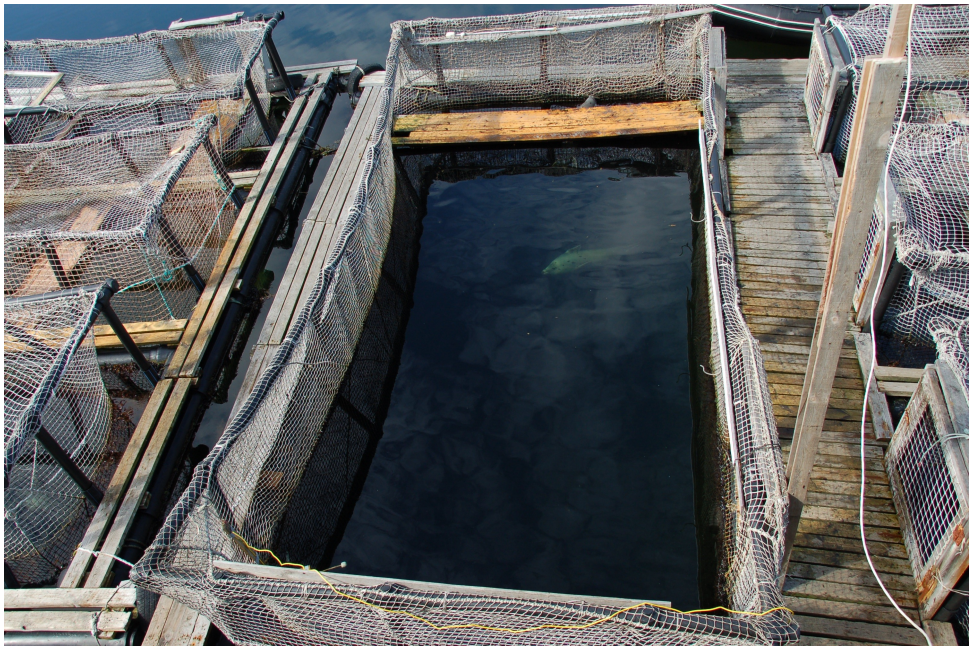

Fig. 2. The aviary used to house the harp seals under the study

The following behavioral manifestations were registered:

- active underwater swimming (AUSw), when the harp seal was making forward movements or was held in place by the movement of its flippers, with its nostrils underwater;
- active surface swimming (ASSw), when the animal was making forward movements or was held in place by the movement of its flippers, with its nostrils above water;
- resting on the platform, haul-out behavior (HB), when the harp seal was partially or completely on the platform.

The time of several actions was recorded in the table: ascent moment, diving moment, moments of entering the platform and leaving it, moment of start of resting in water when flippers stopped moving, and moment of start of motion after resting in water.

As quantitative characteristics of the motion behavior of harp seals, we used:

- mean duration of underwater apnea;
- mean duration of staying on the surface;
- ascent rate;
- share (%) of time spent underwater and on the surface relative to the total time budget;
- percentage ratio of being on the platform and resting in water to the total time budget.

Since the marine mammals participating in this study were immature, we can claim that we could not have observed any sexual behavior (a seasonal phenomenon for most pinnipeds). Therefore, assumably, their most significant behavioral responses associated with seasonal biological processes are molting in spring and migration to feeding grounds and back during summer and autumn [Svetochev, Svetocheva, 2009].

The time before feeding is the most distinct period of the harp seal activity: the animal is mainly swimming in water, and it shows practically no other forms of behavior (play behavior, sleep, *etc.*) [Zaitsev et al., 2018]. That is why we selected time segment between 09:00 and 10:00 to assess seasonal changes in motion behavior of the animals. This was also explained by the lack of cleaning or technical work in the aviary during that time. The harp seals were fed twice *per* day every day: in the morning (10:00–11:00) and in the evening (17:00–18:00). The composition of the feed and its quantity (4 kg *per* day for each animal) remained constant throughout the year.

The observations were organized in such a way as to cover all seasons, but also to reduce the volume of processed data to a statistically acceptable level. At least four-day-long video footage of activity of the harp seals was obtained for each month. March 2011 was the exception, and its data was provided as diagrams and tables but not used for statistical analysis. No material was collected for September, October, and February due to technical reasons. In total, we had video footage for specified time segments of 51 days for every animal. As the data was processed, 16,544 behavioral acts were registered for the harp seals: 7,874 for Bol'shoi and 8,670 for Malen'kii.

The results (recorded parameters and descriptive statistics) are given in Table 1.

The Shapiro–Wilk test showed that the data did not fit to a normal distribution; therefore, the statistical significance of differences between indicators of behavioral activity of the harp seals in various seasons was assessed with the Kruskal–Wallis H test (for general comparison across four seasons) and the Mann–Whitney U test (for pairwise comparison). In calculations for both tests, Statistica 12 software was used ($p = 0.05$). The calculations were made both for comparison of four categorical variables (H test) and for pairwise comparison (U test) [Unguryanu, Grjibovski, 2014].

Table 1. Behavior parameters of two harp seals (B, Bol'shoi; M, Malen'kii) by month

Parameter	Harp seal	03.2011	04.2011	05.2011	06.2011	07.2011	08.2011	11.2011	12.2011	01.2012	03.2012
Active underwater swimming (AUSw)											
Mean ($\bar{x}$), s	B	23.2	26.1	42.2	47.4	55.4	28.9	31.4	55.6	21.4	24.7
	M	22.9	27.6	31.5	27.6	38.4	29.1	36.0	35.3	32.6	25.1
Median, s	B	10	14	19	19	23	19	18	30	12	14
	M	14	19	19	22	25	17	19,5	19	16	16
Mode, s	B	9	2	7	8	11	11	7	14	7	7
	M	14	13	12	11	15	14	10	10	13	11
CV, %	B	126	114	116	117	116	106	132	133	117	127
	M	82	89	105	87	113	106	104	121	134	95
%*	B	80	66	83	84	84	80	51	84	58	58
	M	89	53	89	91	90	82	83	66	72	41
Number of ascents *per* minute	B	2.1	1.8	1.2	1.1	0.9	1.7	1.3	0.9	1.9	1.8
	M	2.3	1.9	1.7	2.0	1.4	1.8	1.4	1.3	1.3	1.8
Number of registrations	B	250	640	432	323	333	403	216	332	469	492
	M	281	487	610	599	507	410	322	402	376	339

Contunued on the next page…

Parameter	Harp seal	03.2011	04.2011	05.2011	06.2011	07.2011	08.2011	11.2011	12.2011	01.2012	03.2012
Active surface swimming (ASSw)											
Mean ($\bar{x}$), s	B	5.7	7.4	7.6	8.8	9.0	6.6	14.5	10.4	11.8	8.9
	M	2.8	3.7	4.1	2.6	4.0	5.2	7.2	9.5	12.9	8.5
Median, s	B	4	5	4	5	5	5	8	5	6	4
	M	2	3	2	2	2	3	6	8	9	7
Mode, s	B	1	2	1	2	4	1	1	1	1	1
	M	1	1	1	1	1	1	1	1	1	1
CV, %	B	109	137	106	95	97	102	115	117	124	142
	M	129	87	114	110	142	107	109	105	130	117
%*	B	19	17	14	15	13	18	22	16	29	20
	M	11	7	11	9	9	14	17	17	28	13
Number of registrations	B	241	582	395	313	320	389	207	329	426	477
	M	279	445	607	596	493	392	321	401	377	312
Haul-out behavior (HB)											
Mean ($\bar{x}$), s	B	5.9	46.6	14.2	12.9	57.4	17.9	154.8	–	29.5	168.5
	M	–	231.7	2.0	7.0	11.1	27.4	–	–	–	321.0
%*	B	1	17	3	1	3	2	27	–	13	22
	M	–	40	–	–	1	4	–	17	–	46
Number of registrations	B	13	92	41	7	11	18	23	–	73	27
	M	1	44	2	1	16	19	–	1	1	30
n, days	B, M	2	7	6	5	6	4	4	6	5	6

Note: *, share in the total time budget.

RESULTS

Share of the total duration of apnea has a minor difference (73% for the harp seal Bol'shoi and 74% for Malen'kii). The parameter of ASSw has a more pronounced difference (18% for Bol'shoi and 13% for Malen'kii), and this is reflected in time each animal is resting on the platform. Thus, Bol'shoi spent there 9% of total time, and Malen'kii spent 13% (Fig. 3).

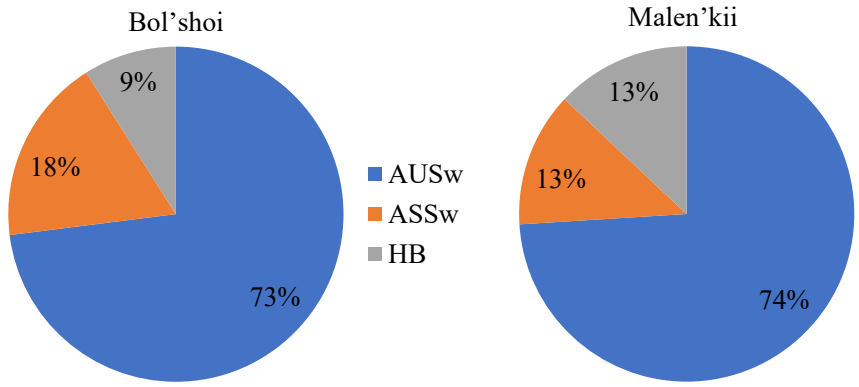

Fig. 3. The share of recorded behaviors in the total time budget for two seals (ASSw, active surface swimming; AUSw, active underwater swimming; HB, rest on a platform, haul-out behavior)

Certain differences between the two animals are also clear in the distribution of the total duration of active forms of behavior and rest in various months within the year. For the harp seal Bol'shoi, rest on the platform was noted in nine out of ten time periods, with longer resting time in April and November 2011, and January and March 2012 (Table 1, Fig. 4). Malen'kii rested on the platform less frequently, in five out of ten time periods of observation (April, July, August, and December 2011, and March 2012), but its resting time was longer (40% in April 2011 and 46% in March 2012) (Table 1, Fig. 5). Total duration of ASSw was longer for Bol'shoi not only as a mean value within the overall period, but also in each month. The only exception was December, when the value was 1% higher for the harp seal Malen'kii than for Bol'shoi (Table 1, Figs 3–5).

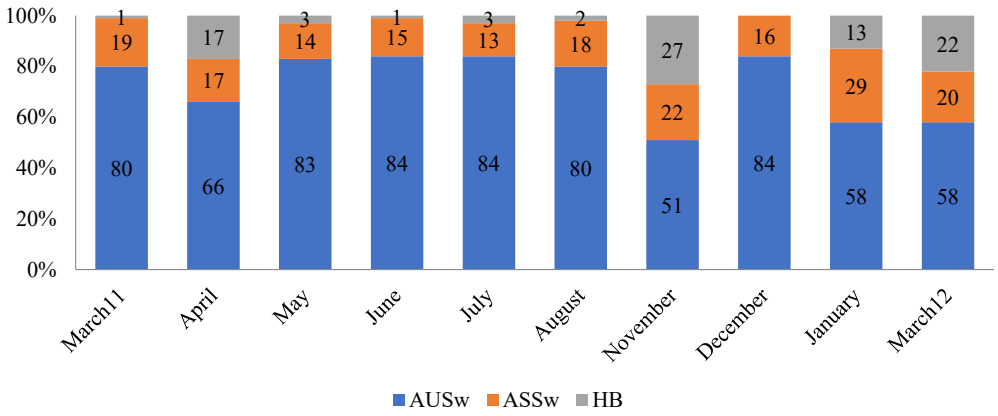

Fig. 4. The ratio of recorded behaviors to the total monthly time budget for the harp seal Bol'shoi

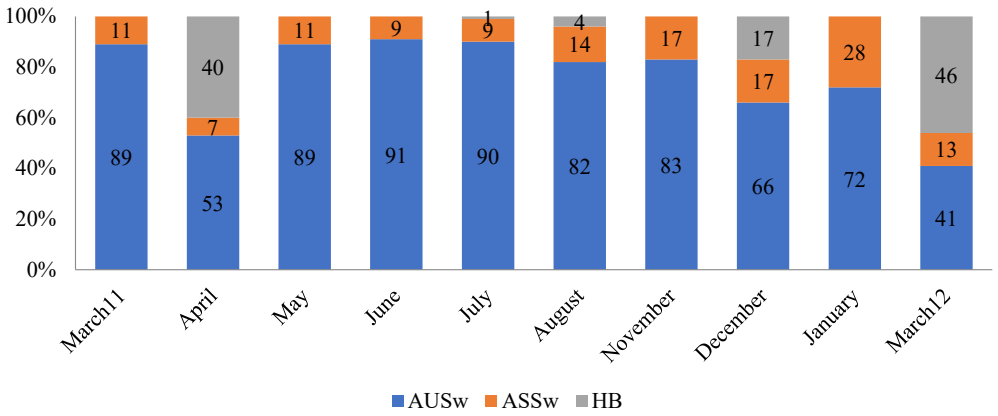

Fig. 5. The ratio of recorded behaviors to the total monthly time budget for the harp seal Malen'kii

The ascent rate shows how many times *per* unit of time (1 min) an animal rises to the surface, with the moment of entering the platform counted in. The mean ascent rate was 1.5 acts *per* minute for Bol'shoi and 1.7 acts *per* minute for Malen'kii. To a great extent, changes in the ascent rate of the harp seals throughout the year were comparable. Specifically, both animals showed a drop between March and May 2011: to 1.2 and 1.7 acts *per* minute, respectively. In June, the value for the harp seal Bol'shoi continued to decrease, while the value for Malen'kii rose to 2 acts *per* minute, and later fell to 1.4. Then, there was a boost to 1.7 and 1.8 acts *per* minute in August 2011 for Bol'shoi and Malen'kii, respectively. By December, a decrease was recorded, and by March 2012, an increase was registered (Fig. 6).

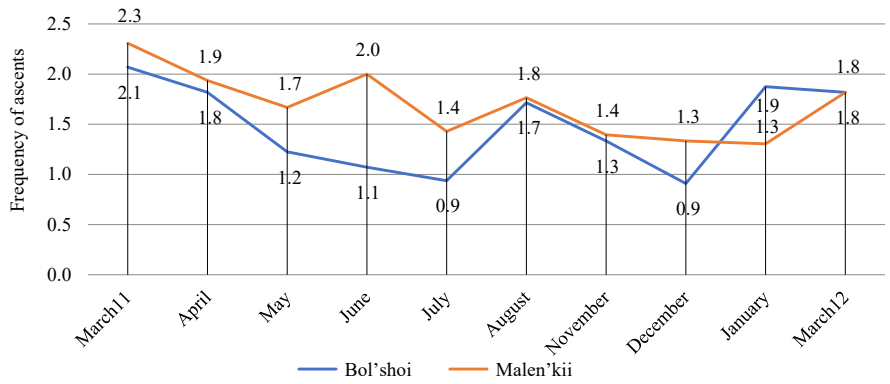

Fig. 6. Ascent rate *per* minute for two harp seals

Notably, the total duration of apnea for both animals had a minor difference (within 1%), while its mean duration had a more pronounced difference. The mean time spent by the harp seal Bol'shoi underwater was 36 s (with the minimum of 21 s in January and the maximum of about 55 s in July and December). The mean time spent by the harp seal Malen'kii underwater was 31 s (with an apnea range of 23–38 s). The difference in the mean duration of ASSw for the two animals was greater than that in the mean duration of apnea. The mean time spent on the surface was 9 s for Bol'shoi and 6 s for Malen'kii, with ranges of 5.7–14.5 and 2.6–12.9 s, respectively (Table 1, Figs 7, 8).

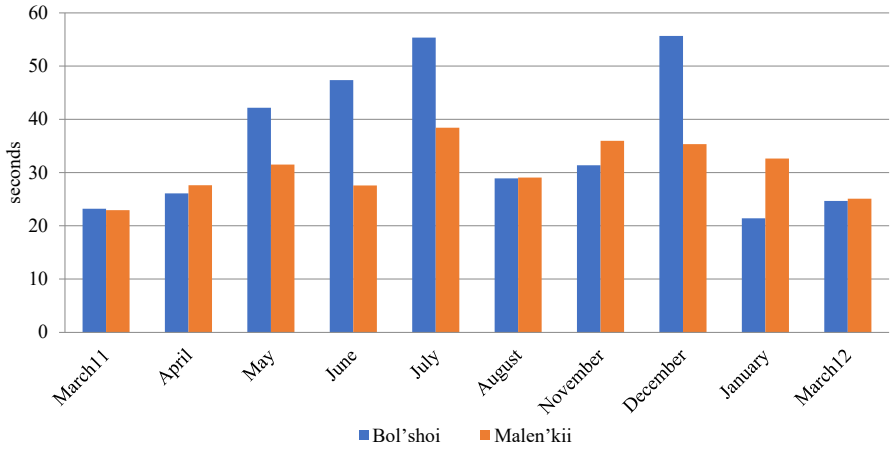

Fig. 7. The mean duration of apnea for two harp seals

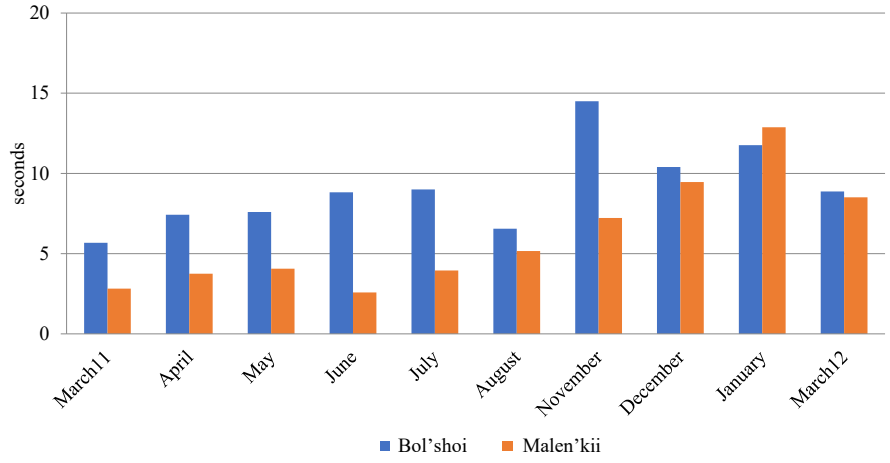

Fig. 8. The mean duration of swimming on the surface for two harp seals

We compared the results of evaluation of statistical significance (p) for the indicators characterizing the analyzed forms of behavior for four seasons: spring, summer, autumn, and winter (Table 2).

Table 2. The results of assessing the statistical significance of differences (p) between indicators of various behaviors of the harp seals (B, Bol'shoi; M, Malen'kii) for four seasons (autumn is represented by one month, November)

Parameter	Harp seal	Total for all seasons	Spring/summer	Spring/autumn	Spring/winter	Summer/autumn	Summer/winter	Autumn/winter
Active underwater swimming (AUSw)								
Mean ($\bar{x}$)	B	0.0762	**0.0058**	0.9704	0.5000	0.2937	0.2758	0.6477
	M	0.0540	**0.0227**	**0.0415**	0.1081	0.4533	0.6780	0.9480
%*	B	**0.0127**	**0.0058**	**0.0495**	0.8118	**0.0032**	0.1462	0.1704
	M	**0.0009**	**0.0077**	0.9115	0.2114	**0.0143**	**0.0002**	0.1333
Ascent rate	B	0.1923	0.4355	**0.0268**	0.9704	0.5518	0.3421	0.3241
	M	0.1423	0.9233	0.3170	0.1038	0.1211	**0.0379**	0.4727
Active surface swimming (ASSw)								
Mean ($\bar{x}$)	B	**0.0007**	0.1399	**0.0106**	**0.0007**	**0.0245**	**0.0334**	0.3961
	M	**0.0004**	0.6303	**0.0288**	**0.0024**	**0.0032**	**0.0005**	0.0584
%*	B	0.1721	0.2227	0.1946	0.2666	0.1770	0.0968	0.6477
	M	**0.0004**	0.5421	**0.0289**	**0.0012**	**0.0060**	**0.0009**	0.3275
Haul-out behavior (HB)								
Mean ($\bar{x}$)	B	0.1929	0.1399	0.5782	0.1316	0.1936	0.9173	0.1704
	M	0.1018	0.3690	0.1110	0.1266	0.1770	0.2993	0.6477
%*	B	0.0519	**0.0200**	0.5047	0.0956	0.1096	0.7555	0.2149
	M	0.0970	0.3521	0.1110	0.1266	0.1770	0.2758	0.6477

Note: *, share in the total time budget. Values of $p < 0.05$ are highlighted in bold.

For both harp seals, differences in the mean duration of AUSw in spring and summer were significant. Malen'kii also featured statistically reliable differences between spring and autumn. However, no significant differences were revealed for both animals across four seasons. The share of AUSw relative to the total time budget differed for spring/summer and summer/autumn for both marine mammals, with differences in spring *vs.* autumn shown by Bol'shoi and summer *vs.* winter shown by Malen'kii. The differences in the total value of AUSw were significant for both animals. The ascent rate had no reliable differences in most cases, except for spring/autumn for Bol'shoi and summer/winter for Malen'kii (Table 2).

The pattern for ASSw was different. The mean duration of staying on the surface for both seals had no significant differences between spring/autumn and autumn/winter. Interestingly, Bol'shoi featured the lack of statistically reliable differences in the share of ASSw relative to the total time budget for all four seasons, while Malen'kii had no such differences only between spring/summer and autumn/winter, the same as in the case of the mean duration of ASSw (Table 2).

Both indicators of HB, its mean duration and the share in total time budget, had practically no significant differences. The only exception was HB share in the total time budget between spring and summer for the harp seal Bol'shoi (Table 2).

DISCUSSION

The choice of the time period for this survey is justified by the fact that the harp seal shows the most of its motion behavior right before morning feeding [Kavtsevich et al., 2007; Zaitsev, 2011], which is due to increased food motivation (as a result of a long break between evening and morning feeding). Compared to the animals' behavior during other periods, their behavior during the chosen period is primarily swimming in circles, and this is reflected in a more grouped structure of data than in other periods of activity. That is why the total share of activity of the harp seals Bol'shoi and Malen'kii in the presented data was 91 and 87%, respectively (see Fig. 3).

Both animals spent time mostly underwater in spring and summer, with the exception of molting periods (April 2011 and March 2012), when they preferred to stay on the platform. The duration of ASSw rose precisely in autumn and winter (Figs 4, 5). The share of active forms of behavior was higher in summer months, but the decreased ascent rate provided evidence for the fact that the animals became less mobile. This indicator dropped March to July for both harp seals, increased in August, and declined in autumn. The animals featured different levels of activity in winter.

While analyzing mean values of AUSw and ASSw, we noted that those stand out sharply in August (Figs 7, 8), the same as ascent rate. First of all, this concerns the harp seal Bol'shoi. March to July, AUSw had a tendency for increase in both animals; by August, there was a decrease. We saw an intriguing pattern when comparing these values with ascent rate and total share of swimming: while the total share of activity stayed the same, the animals became more active, dived more often, and spent less time underwater between their dives. The differences in the mean duration of apnea were apparently rooted in the individual characteristics of the marine mammals. Its fluctuations for the harp seal Malen'kii seemed to be minor, in contrast to those for Bol'shoi; this was expressed, among other things, in values of the above-considered total duration of AUSw in relation to the total time budget. This might result from a difference in physical characteristics of the studied animals: Bol'shoi is larger than Malen'kii [(43.5 ± 0.2) kg *vs.* (40 ± 0.2) kg].

As for the mean duration of ASSw, there was a distinction between spring-summer period and autumn-winter one. Both animals showed an almost doubled mean duration of ASSw in autumn-winter period than in spring-summer one. It increases until January and decreases by March, which means that a rise of the mean duration of staying on the surface was seasonal. When comparing mean values of water and air temperature for above-mentioned periods, we found out that air temperature drops below the water one in November. As this gap is widening by January, the mean duration of ASSw increases; the opposite process occurs in March (Fig. 9). Therefore, despite comparable water temperatures in spring-summer and autumn-winter, there are pronounced differences in the mean duration of animals' staying on the water surface. When comparing the mean duration of ASSw and ascent rate, we recorded an inverse relationship between these parameters.

HB (staying on the platform) is considered a fairly versatile form of behavior, chiefly depending on physical and physiological characteristics of a certain animal, which are expressed in the strength of response to environmental changes [Kavtsevich et al., 2007; Moulton et al., 2000; Zaitsev et al., 2018]. Our initial assumption was that this form of behavior would be observed primarily in spring when harp seals molt. According to the results obtained, our assumptions were only partly correct. Both animals exhibit clearly defined, long periods of HB in spring. However, the harp seals also entered the platform throughout the year, and such a behavior of Bol'shoi in November and January and Malen'kii in December was comparable to that during spring. In case of individual characteristics, the pattern was as follows:

the harp seal Malen'kii entered the platform less frequently throughout the year (in five months out of ten) but spent there more time. The harp seal Bol'shoi behaved in the opposite way: it entered the platform more frequently (in nine months out of ten) but spent there less time.

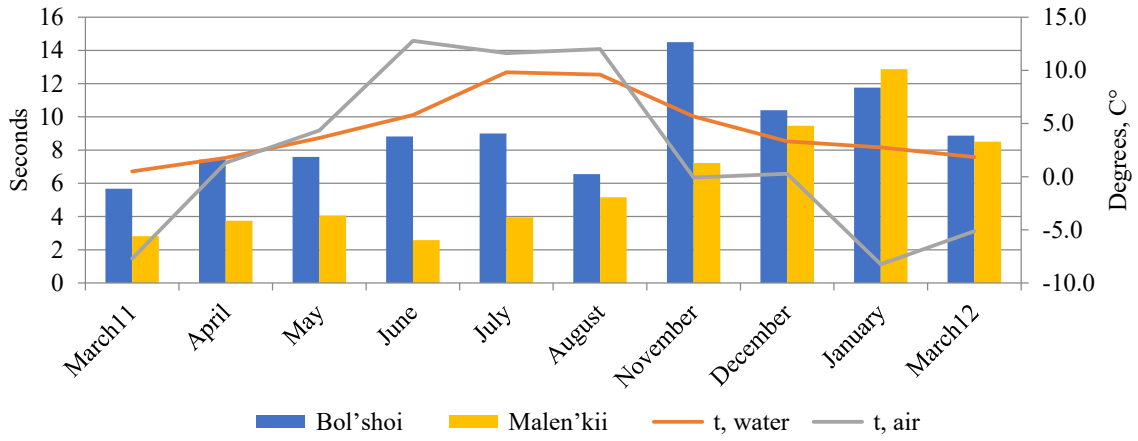

Fig. 9. The mean duration of swimming on the surface for two harp seals with graphs of water and air temperatures

To compare the animals' behavior in various seasons, we applied statistical criteria. Those showed that the differences between spring and summer for the mean duration of apnea and for the share of AUSw in the total time budget can be considered significant for both harp seals. Apparently, this is governed by the fact that the animals spent most of their time actively swimming underwater in summer and on the platform in spring. The same reason mediated the difference between summer and autumn for both harp seals and between summer and winter for Malen'kii. Increased duration of time spent underwater in summer might be explained by avoidance of hyperthermia: swimming is the most effective way of preventing overheating in seals.

Differences in the mean duration of ASSw are significant between most seasons. The comparability of such behavior of the harp seals in summer and spring seems to result from the absence of noticeable fluctuations in this parameter. The same applies to autumn-winter period. Due to a more even distribution of periods of staying on the platform for Bol'shoi, statistical analysis did not show any significant differences between seasons in terms of the share of ASSw. Interestingly, for Malen'kii, the differences were statistically reliable (except for two compared pairs: spring/summer and autumn/winter).

No significant differences were recorded for the duration of staying on the platform depending on the season. This is mediated by the insufficient number of times this form of behavior was registered.

Therefore, we could assume that the behavioral changes of the harp seals associated with AUSw, HB, and ascent rate are more individually dependent parameters than ASSw.

Conclusions:

1. Significant differences were revealed in behavioral activity of two studied harp seals in various seasons. These differences were not caused by an exogenic factor, such as food availability, since feeding was human-controlled.
2. It was shown that the behavioral differences between spring-summer and autumn-winter periods are the most significant in both animals, especially in terms of active surface swimming.

3. An increase in the mean duration of active surface swimming and a drop in the ascent rate in autumn-winter provide evidence for the fact as follows: in this time of year, the harp seals are noticeably less active, spend on average more time on the surface, and less often rise to the surface. The mean duration of apnea also reduces.
4. Further research should focus on the considerable differences in animal behavior between spring-summer period and autumn-winter one. When assessing the effect of various exogenous factors on the behavior of the harp seals in captivity, it is reasonable to take into account data on the differences revealed.

The work was financially supported by the Ministry of Education and Science of the Russian Federation within the framework of the state research assignment "Theriofauna of the Arctic seas: Physiology, ecology and ethology" [No. 124013000720-4 (30.01.2024), FMEE-2024-0015].

Experiments with animals followed the Guide for the Care and Use of Laboratory Animals by the National Institutes of Health. The material which involved animals was approved by the bioethics commission at the Murmansk Marine Biological Institute of RAS (conclusion No. 3 of 15.02.2024).

REFERENCES

1. *Grenlandskii tyulen': sovremennyi status vida i ego rol' v funktsionirovanii ekosistem Belogo i Barentseva morei* / G. G. Matishov (Ed.). Murmansk : OOO "MIP-999", 2001, 220 p. (in Russ.). https://elibrary.ru/trhqjb
2. Erokhina I. A. K otsenke sovremennogo sostoyaniya belomorskoi populyatsii grenlandskogo tyulenya (biokhimicheskie issledovaniya). In: *Current Problems of Physiology and Ecology of the Sea Animals* : sbornik nauchnykh trudov / G. G. Matishov (Ed.). Apatity : Kol'skii nauchnyi tsentr RAN, 2003, pp. 284–289. (in Russ.). https://elibrary.ru/trjkaj
3. Zaitsev A. A. Struktura sutochnogo povedeniya grenlandskogo tyulenya v usloviyakh vol'ernogo soderzhaniya. In: *Morskie issledovaniya ekosistem Evropeiskoi Arktiki* : materialy XXIX konferentsii molodykh uchenykh Murmanskogo morskogo biologicheskogo instituta, posvyashchennoi 140-letiyu so dnya rozhdeniya G. A. Klyuge (Murmansk, Mai 2011 g.). Murmansk : MMBI KNTs RAN, 2011, pp. 74–78. (in Russ.)
4. Zaitsev A. A., Yakovlev A. P., Zavoloka P. A. Changes in activity of harp seal (*Pagophilus groenlandicus*) in the spring–summer period in conditions of aviary keeping. *Vestnik MGTU. Trudy Murmanskogo gosudarstvennogo tekhnicheskogo universiteta*, 2018, vol. 21, no. 2, pp. 319–327. (in Russ.). https://elibrary.ru/xtttsh
5. Kavtsevich N. N., Erokhina I. A., Minzyuk T. V. Phagocytic activity of leukocytes in harp seals. *Doklady Rossiiskoi akademii nauk. Nauki o zhizni*, 2020, vol. 495, no. 1, pp. 562–566. (in Russ.). https://doi.org/10.31857/s2686738920060116
6. Kavtsevich N. N., Minzyuk T. V. Age features of blood cellular composition of seals. *Trudy VNIRO*, 2017, vol. 167, pp. 78–95. (in Russ.). https://elibrary.ru/zrqtdj
7. Kavtsevich N. N., Mikhailyuk A. L., Berezina I. A., Yurko A. S. Eksperimental'noe izuchenie povedeniya tyulenei. In: *Eksperimental'nye issledovaniya morskikh mlekopitayushchikh v usloviyakh Kol'skogo zaliva*. Rossiiskaya akademiya nauk, Kol'skii nauchnyi tsentr, Murmanskii morskoi biologicheskii institut. Apatity : Izd-vo Kol'skogo nauchnogo tsentra RAN, 2007, pp. 194–229. (in Russ.). https://elibrary.ru/trjjlj

8. Mishin V. L. Rasprostranenie. In: *Grenlandskii tyulen': sovremennyi status vida i ego rol' v funktsionirovanii ekosistem Belogo i Barentseva morei* / G. G. Matishov (Ed.). Murmansk : OOO "MIP-999", 2001, pp. 13–16. (in Russ.). https://elibrary.ru/trhqjb
9. *The Mammals of Russia* : a taxonomic and geographic reference / I. Ya. Pavlinov, A. A. Lisovsky (Eds). Moscow : KMK Scientific Press, 2012, 604 p. (Issledovaniya po faune Sovetskogo Soyuza : sbornik trudov Zoologicheskogo muzeya MGU ; vol. 52). (in Russ.)
10. *Mammals of Russia: Species List and Applied Issues.* Moscow : KMK Scientific Press, 2019, 191 p. (Issledovaniya po faune Sovetskogo Soyuza : sbornik trudov Zoologicheskogo muzeya MGU ; vol. 56). (in Russ.). https://elibrary.ru/kekuuc
11. *Morskie mlekopitayushchie v biotekhnicheskikh sistemakh dvoinogo naznacheniya* : metodicheskoe posobie. Murmansk : Murmanskii morskoi biologicheskii institut Kol'skogo NTs RAN, 2010, 131 p. (in Russ.). https://elibrary.ru/vmohvt
12. Popov S. V., Il'chenko O. G. *Metodicheskie rekomendatsii po etologicheskim nablyudeniyam za mlekopitayushchimi v nevole.* Moscow : Izd-vo Moskovskogo zooparka, 1990, 76 p. (in Russ.)
13. Svetochev V. N., Svetocheva O. N. Ecology of the harp seal feeding in spring in the White Sea. *Doklady Akademii nauk*, 2009, vol. 429, no. 4, pp. 571–573. (in Russ.). https://elibrary.ru/kygofp
14. Svetochev V. N., Svetocheva O. N. *The Harp Seal: Biology, Ecology, Harvesting* / N. N. Kavtsevich (Ed.). Apatity : Murmanskii morskoi biologicheskii institut KNTs RAN, 2018, 174 p. (in Russ.). https://elibrary.ru/xyibox
15. Unguryanu T. N., Grjibovski A. M. Analysis of three independent groups using non-parametric Kruskal–Wallis test in Stata software. *Ekologiya cheloveka*, 2014, no. 6, pp. 55–58. (in Russ.). https://elibrary.ru/sepulv
16. Bogstad B., Gjøsæter H., Haug T., Lindstrøm U. A review of the battle for food in the Barents Sea: Cod *vs.* marine mammals. *Frontiers in Ecology and Evolution*, 2015, vol. 3, art. 29 (17 p.). https://doi.org/10.3389/fevo.2015.00029
17. Committee on Taxonomy. 2026. *List of Marine Mammal Species and Subspecies* / Society for Marine Mammalogy : [site], 2026. URL: https://marinemammalscience.org/ [accessed: 09.01.2026].
18. Corkeron P. Captivity. In: *Encyclopedia of Marine Mammals.* 3rd edition / B. Würsig, J. G. M. Thewissen, K. M. Kovacs (Eds). London ; San Diego, CA ; Cambridge, MA : Academic Press, 2018, pp. 161–164. https://doi.org/10.1016/b978-0-12-804327-1.00084-4
19. Gwinner E. Annual Rhythms: Perspective. In: *Biological Rhythms* / J. Aschoff (Ed.). Boston, MA : Springer, 1981, pp. 381–389. https://doi.org/10.1007/978-1-4615-6552-9_20
20. Hammill M. O., Stenson G. B., Mosnier A., Doniol-Valcroze T. *Abundance Estimates of Northwest Atlantic Harp Seals and Management Advice for 2014.* Ottawa : Fisheries and Ocean Canada, 2014. 33 p. (DFO. Canadian Science Advisory Secretariat. Research Document ; 2014/022).
21. Haug T., Nilssen K. T., Øien N., Potelov V. Seasonal distribution of harp seals (*Phoca groenlandica*) in the Barents Sea. *Polar Research*, 1994, vol. 13, no. 2, pp. 163–172. https://doi.org/10.3402/polar.v13i2.6690
22. Kapel F. O. Feeding habits of harp and hooded seals in Greenland waters. In: *Minke Whales, Harp and Hooded Seals:*

Major Predators in the North Atlantic Ecosystem / G. A. Víkingsson, F. O. Kapel (Eds). Tromsø : North Atlantic Marine Mammal Commission, 2000, pp. 50–64. (NAMMCO Scientific Publications : vol. 2). https://doi.org/10.7557/3.2971

23. Lavigne D. M. Harp seal: *Pagophilus groenlandicus*. In: *Encyclopedia of Marine Mammals*. 3rd edition / B. Würsig, J. G. M. Thewissen, K. M. Kovacs (Eds). London ; San Diego, CA ; Cambridge, MA : Academic Press, 2018, pp. 455–457. https://doi.org/10.1016/b978-0-12-804327-1.00146-1
24. Lindstrøm U., Nilssen K. T., Pettersen L. M. S., Haug T. Harp seal foraging behaviour during summer around Svalbard in the northern Barents Sea: Diet composition and the selection of prey. *Polar Biology*, 2013, vol. 36, iss. 3, pp. 305–320. https://doi.org/10.1007/s00300-012-1260-x
25. Mårtensson P. E., Nordøy E. S., Blix A. S. Digestibility of crustaceans and capelin in harp seals (*Phoca groenlandica*). *Marine Mammal Science*, 1994, vol. 10, iss. 3, pp. 325–331. https://doi.org/10.1111/j.1748-7692.1994.tb00486.x
26. Moulton V. D. *Activity and Haul out Behaviour of Captive Harp Seals (Pagophilus groenlandicus)*. Masters thesis / Department of Biology, Memorial University of Newfoundland. St. John's, Newfoundland, 1997, 142 p. https://hdl.handle.net/20.500.14783/4030
27. Moulton V. D., Miller E. H., Ochoa-Acuña H. Haulout behaviour of captive harp seals (*Pagophilus groenlandicus*): Incidence, seasonality, and relationships to weather. *Applied Animal Behaviour Science*, 2000, vol. 65, iss. 4, pp. 367–378. https://doi.org/10.1016/s0168-1591(99)00062-3
28. Nilssen K. T., Haug T., Grotnes P. E., Potelov V. Seasonal variation in body condition of adult Barents Sea harp seals (*Phoca groenlandica*). *Journal of Northwest Atlantic Fishery Science*, 1997, vol. 22, pp. 17–25. https://doi.org/10.2960/j.v22.a1
29. Nilssen K. T., Pedersen O. P., Folkow L. P., Haug T. Food consumption estimates of Barents Sea harp seals. In: *Minke Whales, Harp and Hooded Seals: Major Predators in the North Atlantic Ecosystem* / G. A. Víkingsson, F. O. Kapel (Eds). Tromsø : North Atlantic Marine Mammal Commission, 2000, pp. 9–27. (NAMMCO Scientific Publications : vol. 2). https://doi.org/10.7557/3.2968
30. Nordøy E. S., Aakvaag A., Larsen T. S. Metabolic adaptations to fasting in harp seal pups. *Physiological Zoology*, 1993, vol. 66, no. 6, pp. 926–945. https://doi.org/10.1086/physzool.66.6.30163747
31. Nordøy E. S., Folkow L. P., Potelov V., Prischemikhin V., Blix A. S. Seasonal distribution and dive behaviour of harp seals (*Pagophilus groenlandicus*) of the White Sea–Barents Sea stock. *Polar Biology*, 2008, vol. 31, iss. 9, pp. 1119–1135. https://doi.org/10.1007/s00300-008-0453-9
32. Sergeant D. E. Transatlantic migration of a harp seal, *Pagophilus groenlandicus*. *Journal of the Fisheries Research Board of Canada*, 1973, vol. 30, no. 1, pp. 124–125. https://doi.org/10.1139/f73-020
33. Svetocheva O. N., Svetochev V. N. Analysis of seasonality in trophic relationships of true seals (Phocideae) in the White Sea. *Czech Polar Reports*, 2015, vol. 5, no. 2, pp. 230–240. https://doi.org/10.5817/cpr2015-2-20

СЕЗОННЫЕ ИЗМЕНЕНИЯ АКТИВНОСТИ ГРЕНЛАНДСКОГО ТЮЛЕНЯ *PAGOPHILUS GROENLANDICUS* (ERXLEBEN, 1777) (CARNIVORA: PHOCIDAE) В УСЛОВИЯХ ВОЛЬЕРНОГО СОДЕРЖАНИЯ

А. А. Зайцев, Ю. В. Литвинов, М. В. Пахомов, А. Р. Трошичев, А. П. Яковлев

Мурманский морской биологический институт Российской академии наук,
Мурманск, Российская Федерация
E-mail: *yanmos@yandex.ru*

Гренландский тюлень *Pagophilus groenlandicus* (Erxleben, 1777), являющийся одним из наиболее распространённых видов морских млекопитающих в северных морях и играющий важную роль в экосистеме Арктического региона, остаётся недостаточно исследованным в аспекте поведенческих особенностей, в том числе в условиях неволи. Изучение сезонных изменений активности тюленя с целью понимания его поведенческих реакций на внешние раздражители имеет существенное значение для прогнозирования адаптационных стратегий вида в изменяющейся среде обитания. Экспериментальные исследования поведения животных в условиях вольерного содержания предоставляют данные, которые трудно или невозможно получить при наблюдении в естественных условиях. Настоящая работа выполнена в аквакомплексе Мурманского морского биологического института РАН. Основным методом исследования стала регистрация отдельных поведенческих проявлений. Для оценки активности тюленей выбраны такие формы поведения, как всплытие, погружение и выход на помост. Анализ полученных данных позволил выявить закономерные различия в поведенческих паттернах гренландского тюленя на протяжении года. Исследование показало достоверные различия в поведенческой активности животного между сезонами. Наиболее значимые различия обнаружены между весенне-летним и осенне-зимним периодами. В частности, установлено снижение активности гренландского тюленя в осенне-зимний период, сопровождающееся увеличением времени пребывания на поверхности воды в холодное время года.

Ключевые слова: поведение, двигательная активность, гренландский тюлень, вольерный комплекс, условия неволи