how is this relationship expressed in both ecological groups, the aquatic and semi-aquatic mammals? In this scheme we have attempted to examine simultaneously the structure of a typical rete mirabili of the dolphin, taking into account the possible pathology, the structure of the mesenteric artery and of some of the lymphatic nodes, representing in this case portions of the lymphatic system.

MATERIALS AND METHODS

We had four dolphin specimens available to us: three common porpoises, Phocaena phocaena, and one bottlenose dolphin, Tursiops truncatus, from the Black Sea, and also four fur seals, Callorhinus ursinus, two Steller's sea lions, Bumetopius jubatus, and two harbour seals, Phoca vitulina, obtained on Robben Island in 1968.

Two of the investigated dolphins (one common porpoise and the bottlenose dolphin) died from different diseases, while the remaining two were dissected after an acute physiological experiment.

Morphological and histological methods were used to study sections of the intercostal, supraclavicular, axillary, lumbar and iliac portions of the retia mirabilia, sections of the mesenteric artery, the mesenteric, axillary, pancreatic, cervical and other lymph nodes. The sections were stained with haematoxylin and eosin and resorcin-fuchsin.

The lymph nodes were measured in the fresh state; some of them were weighed.
THE RETIA MIRABILIA OF DOLPHINS

Common porpoises No. 2 and No. 3. The arterial network in the intercostal region was investigated. The animals were dissected after narcotization. The intercostal vascular network is represented by a spongy tissue, composed of extremely coiled hollow vessels - the arterioles. Variations in the diameter of these vessels are not great, from 200 to 1000 μ. The lumen is gaping and filled with blood. The structure of the walls of the vessels is typical of vessels of this category (Figure 1). The internal layer is well developed, after this comes a distinct thick-layered elastic membrane. In the tunica media the circular smooth musculature is very dense and abundant. It is bounded on the outside by a second elastic membrae, which is also of considerable thickness and uninterrupted. The tunica externa of the vessel is maximally reduced, it does not contain collagen and is not firmly accreted to the surrounding tissue. In this manner, the vessel is composed as it were of a two-layered elastic tube, capable of withstanding high pressure both from the inside as well as from the outside.

The tissue surrounding the retia mirabilia contains lymphatic vessels, sometimes covering the arterioles as it were with a sheath. The veins form sometimes small sometimes wide, very thin-walled sinuses. In places extravasations are evident in the dilated lymphatic capillaries and in the connective tissue.

The erythrocytes which fill the arterioles are biconcave and sometimes crescent-shaped, which may indicate anaemia. In places arteritis obliterans was diagnosed, but no infiltrates in the walls of the vessels were found.
Figure 1. Rete mirabile from the supraclavicular region of porpoise No. 2.

1 - inner elastic membrane;  
2 - outer elastic membrane;  
3 - tunica media of vessel;  
4 - lymphatic vessels.  

X 8.

Next was studied the arterial "network" from the lumbar and iliac aorta (ventrally to this is situated the venous "rete mirabile"). The general structure of the "network" is similar to that in the thoracic cavity. All of the layers are found in the walls of the arterioles. It seems, however, that the elastic portions are here less strongly developed and that the vessels are in a somewhat more collapsed state. The cause of this is not clear; of significance in this respect may be the lowered pressure in the abdominal cavity, in comparison with the thoracic cavity, the effect of the narcosis on the autonomic centers, leading to spasms of the vessels, or the proximity of nidi of helminth infestation.
In the lumbar "network" there appear sections, where the walls of the vessels are basophilic. From the tunica interna, in the composition of which there are present muscle fibres, cells are desquamated and fill the lumen of the vessel. However alongside the described section there lie normal full-value arterioles, typical of the retia mirabilia.

Common porpoise No. 1. The animal was dissected after death, which occurred from an unknown cause. The thoracic section of the retia mirabilia was traced from the intercostal artery. The artery was not very elastic, the walls were friable and the aorta itself was deformed. The rete mirabile starts from the intercostal artery. Both of the elastic membranes in the vessels of the network were damaged and the picture resembled that of typical sclerosis. In the tunica media of the arterioles there is clearly evident the large-mesh elastic basis, while the continuity of the circular musculature is infringed in places. Basophilia of the walls and the occurrence of collagen fibres in the tunica externa was noted.

Around the arterioles of the network there are clearly expressed and very dilated lymphatic vessels. The veins here are small and thin-walled. Within the thickness of the structure are encountered lymphoid follicles.

The bottlenose dolphin. This dolphin died of pneumonia, which was confirmed by the dissection of the lungs. In the arterial retia mirabilia the vessels lie in a very dense mass. The diameter of the arterioles ranges within the same limits as in the common porpoise. In their walls are represented all of the elements, including both of the elastic membranes.
Around the artery there are lymphatic vessels, though these are very narrow, and much fat tissue. The circular musculature in the tunica media of the arterioles is dense, abundant and stains intensively with eosin. Collagen fibres were not evident and, consequently, the vessel was in a state of full tension and retained its elasticity. Apparently, the above-described picture of arteriosclerosis was created by some other pathological conditions.

The venous rete mirabile of dolphins. The venous network is situated in the lumbar region ventrally to the aorta, between the suprarenals. This structure is composed of small calibre veins and venules. While the arterial network has the form of a cushion of twisted vessels, the venous network is composed of numerous anastomoses, braided into a lattice. The vessels are sinuous, with compact walls. The normal layering of the venous wall is here indistinctly expressed. Around the veins are situated lymphatic vessels.

THE MESENTERIC ARTERY

It is known that the mesenteric artery of man has a mainly circular arrangement of the musculature in its tunica media. In the mammals there are also found bundles of longitudinal smooth muscles. The longitudinal musculature in the wall of the vessel provides for its peristaltic contractions, giving rise to the so-called "peripheral hearts" (Zavarzin, 1939). In the animals studied by us the walls of this were not uniformly constructed (Table 1, Figures 2-4).
Table 1.

Thickness of the layers of the wall of the mesenteric artery, μ.

<table>
<thead>
<tr>
<th>Elements of the wall</th>
<th>Harbour seal</th>
<th>Steller sea-lion</th>
<th>Fur seal</th>
<th>Bottlenose dolphin</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Внутренний слой без мускулатуры</td>
<td>60</td>
<td>30</td>
<td>40</td>
<td>32</td>
</tr>
<tr>
<td>B Продольная мускулатура в средней оболочке</td>
<td>100</td>
<td>280</td>
<td>162</td>
<td>*Отдельные редкие волокна</td>
</tr>
<tr>
<td>C - Циркулярная мускулатура в средней оболочке</td>
<td>340</td>
<td>400</td>
<td>720</td>
<td>480</td>
</tr>
<tr>
<td>D - Наружная оболочка:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e плотная</td>
<td>180</td>
<td>100</td>
<td>240</td>
<td>140</td>
</tr>
<tr>
<td>f рыхлая</td>
<td>180</td>
<td>400</td>
<td>100</td>
<td>—</td>
</tr>
</tbody>
</table>

A - Inner layer without musculature
B - Longitudinal musculature in tunica media
*Individual sparse fibres
C - Circular musculature in tunica media
D - Tunica externa:
  e - dense
  f - loose

Bottlenose dolphin. The wall of the mesenteric artery is compact. Its thickness in the bottlenose dolphin is about 620 μ, which is about 6.5 times smaller than the outer diameter of the artery. The tunica media is composed of circular musculature, while the longitudinal musculature is very sparsely interspersed in the form of individual fibres or bundles (Figure 2). The tunica externa has a thickness of 140 μ in all. There are few collagen fibres; the elastic part is clearly expressed.
Seals. The overall thickness of the wall of the artery is within the same limits as in the bottlenose dolphin; in the fur seal and the harbour seal it is one sixth, and in Steller's sea lion one fifth of the diameter of the artery. Longitudinal musculature in these animals is found in all of the layers of the wall of the vessel. This musculature may lie in separate bundles in the center of the circular musculature (Figure 3), in a continuous layer along the periphery.
Figure 3. Wall of the mesenteric artery of a fur seal (No. 3):
1 - circular musculature of tunica media;
2 - longitudinal musculature of tunica media;
3 - tunica externa. X 8.

of this or in both sections simultaneously, as it were "squeezing" the circular musculature and elastic base (Figure 4).
In those places where the longitudinal musculature is stronger the elastic base is weak and barely evident.

The thickest layer of longitudinal musculature was found in the Steller's sea-lion, in which the ratio of its thickness to the thickness of the circular musculature was
Figure 4. Wall of the mesenteric artery of Steller's sea-lion:

1 - tunica interna;
2 - elastic membrane;
3 - longitudinal musculature in tunica media;
4 - circular musculature in tunica media.  X 8.

7:10. In the harbour seal this ratio was 3:10, while in the fur seal it was 2:10 (see Table 1).

It is possible that the tunica externa of the vessel is also dependent on the strength of the contraction of the longitudinal musculature. The thickness of the tunica externa is greatest in the Steller's sea-lion (only one tenth that of the diameter of the artery, while in the harbour seal it is
one thirtieth the diameter, and in the fur seal - one twenty-seventh). However, in the last two seals the tunica externa is compact and is closely accreted to the tunica media. In the Steller's sea-lion, however, the dense layer of the tunica externa is not thick, in all being about 100 μ in thickness; over this there lies freely a thick and loose collagen layer, which in some sections is 4 times as thick as the dense layer. Probably, within this loose layer there may be accomplished contractions of the vessel in the longitudinal direction.

LYMPHATIC NODES

The lymphatic nodes as a constituent part of the vascular system are not homogeneous in the animals of the two groups of animals under comparison. A marked difference is evident in the dimensions of the nodes of the dolphins and of the seal (Table 2). For example, the packet of mesenteric nodes of the dolphin is considerably smaller than that of any of the seals. The weight of such a node in the dolphin is 170 - 200 gm, while in Steller's sea-lion it is 750 gm. In the dolphin the nodes are dense and lie in the mesentry; in the seals they are loose and enclosed in a sac, similarly to the kidneys, ovaries and other organs.

Common porpoise No. 1. The cervical lymphatic nodes were studied. In the nodes there were found abundant extraneous inclusions (possibly the eggs of helminths) about 12 μ in diameter. The nodes were hyperemic. Plasmocytes were evident in the parenchyma, while in the sinuses there could be seen typical reticular cells with processes, histiocytes with
Table 2.

Comparative characteristics of the mesenteric lymphatic nodes.

<table>
<thead>
<tr>
<th>Species</th>
<th>A - Body length, cm</th>
<th>B - Greatest length of &quot;packet&quot; of nodes</th>
<th>C - % of body length</th>
<th>D - % of length of kidney</th>
<th>F - Weight of &quot;packet&quot;, gm</th>
<th>G - Total number of nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>107</td>
<td>12.0</td>
<td>11</td>
<td></td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>103</td>
<td>11x5</td>
<td>10.6</td>
<td>139</td>
<td>700</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>203</td>
<td>28x10</td>
<td>13.8</td>
<td>260</td>
<td>700</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>195</td>
<td>28x9</td>
<td>14.3</td>
<td>147</td>
<td>170</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>120</td>
<td>10x8</td>
<td>15.8</td>
<td>158</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>168.5</td>
<td>10x5</td>
<td>6.1</td>
<td>71</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>114</td>
<td>9x3</td>
<td>7.8</td>
<td></td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>

A - Body length, cm
B - Greatest length of "packet" of nodes
C - % of body length
d - % of length of kidney
F - Weight of "packet", gm
G - Total number of nodes

1 - Harp seal
2 - Fur seal No. 3
3 - Fur seal No. 5
4 - Steller's sea-lion No. 1
5 - Harbour seal No. 1
6 - Bottlenose dolphin
7 - Common porpoise

large nuclei and cells with elongate rod-like nuclei. In the trabeculae, infiltrated with cells, there were present collagen and elastic fibres and musculature, which here was somewhat weaker than in the other nodes.
Common porpoise No. 2. The lumbar lymphatic node was studied. The structure of the node was not typical of the mammals: the cortical substance was arranged along the periphery of the node, however the follicles did not have a spherical form but were rather thickened zig-zag shaped cords. The capsule of the node is dense, over this is the muscular mesenteric membrane, in which the node lies. The trabeculae in the nodes are not wide, but they are dense and are composed mainly of muscle and elastic fibres. The sinuses of the node are compressed by the densely branching trabeculae, they are completely choked up with histiocytes. Possibly, these are modified reticular cells which have rounded up and lost their processes. In this organ phagocytic properties of these cells were not noted.

The nuclei of such cells of the node were light coloured. The chromatin was disposed in a reticulum and fine clusters. There were many large and medium-sized lymphocytes. There were no reactive centers. In the sinuses there were found free erythrocytes and eosinophilic leucocytes.

The mesenteric lymphatic nodes were studied. The whole "packet" of nodes was 9 cm in length and 3 cm in width. The nodes were irregular in form: in places the medullary layer was found at the surface and was pierced by a mass of blood-carrying vessels. Spherical secondary nodules were also not found in these nodes. Trabeculation was strikingly expressed in these nodes. The trabeculae branched so densely and so finely that they occupied all of the free spaces in the node. Thus, the sinuses of the node here also were not free, but were
filled with histiocytes and a fibrous reticulum (Figure 5), not at all similar to that which is formed by the reticular syncitium in other animals. In rare places there could be seen portions of the central sinus with an area of no more than 70 X 40 μ. The histiocytes have a frothy cytoplasm and extraneous inclusions. There were few true lymphocytes but many eosinophils with strongly segmented nuclei.

Common porpoise No. 3. This dolphin, like No. 2 also, was the freshest of our material and therefore the structure of the nodes should be the most typical that can be obtained under conditions of captivity.
The mesenteric lymphatic nodes were studied. The cortical and medullary layers had the normal proper relationship, but spherical follicles were not found. The trabeculae were dense and thick; in these there were found more smooth muscles and elastic fibres, than were found in the preceding animals. The sinuses were filled with a fibrous mass and cells, which were similar to endothelial cells. All of the arteries and veins are of the same caliber. Arteries without a lumen, with a closed cavity. They resemble the arterial sleeves of the spleen, which end blindly.

The pancreatic lymphatic node is complex: it is composed of several nodes of regular form. Secondary nodules of zig-zag form are present, but there are also spherical nodules in which proliferation centers are evident.

The bottlenose dolphin. The overall structure of the nodes is similar to that described above for the common porpoise. A distinction is found in the finer branching of the trabeculae and the richness of the musculo-elastic base in these. The trabeculae surround the secondary nodules and cellular cords. In cross-section the trabecula is composed of several concentric layers of connective and musculo-elastic tissue.

Pinnipeds. The harbour seal. The mesenteric lymph nodes form a "packet". The form of each node is regular; the spherical secondary nodules may be arranged in a crowded manner in the surface portions of the node; in the center is an extensive portion of medullary substance. The capsule of the node is relatively thin. The trabeculae do not branch extensively, they are thin, composed of connective and muscle tissue,
with a moderate content of collagen fibres and a very poor elasticity. Both the central sinus of the node as well as all of the other sinuses are free of any fibrous elements. The reticular cells form a weak syncitium within these sinuses. There are many monocytes, as well as myelocytes and typical plasma cells with a "cap-like" nucleus and strongly basophilic cytoplasm. In some sinuses there is a mass of free erythrocytes.

The pancreatic lymph node was studied. The parietal sheet of the capsule of the node is abundantly furnished with vessels. This comprises the branched venous "rete mirabile" of the seal, described earlier on other organs (Sokolov, 1959; Harrison and Tomlinson, 1956).

In the secondary nodules there can be seen the proliferation centers. In the medullary cords there are many medium-sized and large lymphocytes. Every secondary nodule on some sections is enclosed by a trabecular membrane. Within the sinuses there are found erythrocytes; there are also cells phagocytizing the erythrocytes. The latter fill the cytoplasm of the cells.

Steller's sea-lion. The axillary lymphatic node is of the regular form, but the secondary nodules may be somewhat indistinct. The capsule of the node is very thick, in it, as well as in the trabeculae, there are very many large collagen fibres. In some places the collagen acquires basophilic properties. Individual collagen fibres may be encountered also in the sinuses of the node. Elastic fibres are distinct in the walls of the trabecular arteries.
Figure 6. Mesenteric lymph node of Steller's sea-lion.

Central sinus

1 - sinus; 2 - medullary cords; 3 - trabeculae. X 8.

The thick and coarse-fibred trabeculae of the node form large loops (Figure 6), as a result of which the sinuses are free for the lymph, both in the middle of the node as well as in the region of the hilus. The cellular composition of the sinuses is the same.

The fur seal (adult male No. 3). The mesenteric lymph nodes are of the regular form: the follicles lie around the periphery. The form is spherical. The capsule is very thick, but the trabeculae are not as thick as in the Steller's sea-lion. They do not permeate the whole node and do not surround the follicles. The collagen content in the trabeculae is more moderate than in the trabeculae of the nodes of the Steller's
sea-lion. In the capsule of the node there were many sclerosed vessels. Fatty sections were found in the nodes. The sinuses of the node are wide and free. Free lymphocytes and eosinophilic leucocytes were noted.

CONCLUSIONS

To account for the structure of the retia mirabilia E. Slijper (1962) put forward the proposal that in the thoracic cavity of the dolphin there is developed a high pressure, which is considerably higher than that in the abdominal cavity and other parts of the body. In addition, the arterial pressure on the walls of the arterioles of the network from the side of the heart is also great (Nagel, Morgane, McFarland and Galliano, 1968). In such a case the presence of the double elastic membrane in the walls of the arterioles would be understandable. The poorly developed tunica externa of these vessels and the exceptional paucity of collagen are, in all probability, conditioned by the extreme lability of this structure.

The arterioles of the rete are surrounded by lymphatic vessels; in the normal organ they are narrow, collapsed, while in edema they are dilated. A similar picture is found in the lungs of the dolphin, where the lymphatic vessels enclose, as it were with a sheath, the pulmonary veins (Baudrimont, 1955), which have a great capacity for contraction, since they carry arterial blood and, possibly, regulate its flow. In this case a heavy tunica externa of the vessel is superfluous, while the surrounding lymphatic vessels facilitate movement, playing the
role of a hydraulic shock-absorber. This shock-absorber may also protect the rete mirabile from the aspect of the intra-thoracic pressure.

The fact that in one and the same animal the walls of the vessels of the rete mirabile in the abdominal cavity are less elastic than those of the thoracic cavity may, to a certain extent, demonstrate a difference in pressure in the mentioned parts of the body. Besides the natural pathology (pneumonia, arteritis, helminthoses etc.), the loss of elasticity by the vessels of the retia mirabilia is, most probably, a common phenomenon when aquatic animals are held in close and shallow enclosures. This leads, in the end, to a deformation of the vessels and to death.

The vessels of the venous rete mirabile, taken by us from the lumbar region, in all probability are not typical. They should be studied on more extensive material.

In seals under water the activity of the heart is slowed down (Harrison and Tomlinson, 1962; Elsner, Franklin, Citters and Kenney, 1966). By vasoconstriction and peristaltic contractions the peripheral vessels may set up an extra pressure in these conditions. Among such vessels may be included also the mesenteric artery, which possibly functions even more intensively in this respect in the seals, which is indicated by the abundant longitudinal musculature in its wall. The active operation of this artery as a "peripheral heart" organ (Zavarzin, 1939) should be expressed more clearly in Steller’s sea-lion than in the other seals and dolphins. This morphological feature is probably connected with the peculiarities of the ecology of this species of seal.
The mesenteric artery supplies both the intestine and the lymph nodes which lie in the mesentery of the small intestine. Undoubtedly there exists some sort of relationship between the structure of the vessel and the organs which that vessel supplies.

Slijper (1962) wrote that whales have an exceptionally large number of very large lymph nodes. Rakhimov (1968) described 7 groups of nodes in the dolphin. Not long ago a detailed study was carried out of five lymph nodes in Black Sea dolphins (Moskov, Schiwatschewa and Bonew, 1969).

In the Caspian seal Kurdyumov (1962) noted a small number of large lymph nodes. We found 18 groups of lymph nodes in seals and a somewhat smaller number in dolphins. There is no doubt however as to the difference in the size of the nodes in the two groups of mammals (Table 2). On account of what structural characteristics and tissues are the nodes of seals enlarged in comparison to the nodes of dolphins? In the first place, apparently, this is due to the free dilated sinuses and lymphatic vessels, which is not found in the dolphins, where the sinuses are narrow and filled with densely-fibrous tissue of the musculo-elastic type. In addition, the nodes of the seals, and especially of Steller's sea-lion, are exceptionally rich in connective tissue (in the form of large loose collagen fibres), which is scarcely noted at all in the dolphins. A third cause of the differences is the non-uniform disposition and composition of the lymphoid tissue and its disposition in the nodes. In the dolphins the nodes are most frequently of an irregular structure, the cortical substance
does not form the usual spherical follicles but is concentrated in the zig-zag shaped sections, which occupy various positions in the nodes, including also a central position. The medullary portion of the nodes is considerably reduced.

There is little typical lymphoid tissue in the form of small lymphocytes within the nodes of dolphins, it is frequently replaced by plasmocytes and eosinophils. Such a picture is observed both in dead animals as well as in those that have been specially narcotized. Histiocytes predominate in the sinuses. Our observations are also confirmed by other data (Moskov, Schiwatschewa and Bonew, 1969).

The nodes of seals are richer in actual lymphoid tissue, but here also there is a completely different picture from that found in the nodes of the majority of terrestrial mammals.

Within the sinuses of the lymph nodes of both dolphins and seals there are frequently present free erythrocytes and eosinophilic leucocytes. In the seals here there are found macrophages with erythrocytes in their cytoplasm. Slijper (1962) observed, under a microscope, the process of the breaking down of the erythrocytes in the lymph nodes of the dolphin, and in connection with this he proposed that the nodes partially take on the role of the spleen in this process. However the size of the spleen, according to our data, is larger in those animals with larger lymph nodes. For example, the length of the spleen in fur seal No. 3 was 43 cm, in the harbour seal - 23 cm, in the bottlenose dolphin - 7.5 cm and only 2 cm in the common porpoise.
The role of the mesenteric nodes in the deposition of lymph has been mentioned more than once in the literature (Bouviere and Valette, 1933; Horstmann, 1952; Zhdanov, 1952; Rusnyak, Fel'di and Sabo, 1958). It is possible that in the seals a large part of the lymph is deposited in the lymphatic nodes, while the lymph nodes of dolphins, which have a great contracting capacity in their trabecular base, may regulate the movement of the lymph.

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PECULIARITIES OF THE DEVELOPMENT OF THE BLOOD-VASCULAR SYSTEM DURING THE EARLY EMBRYOGENESIS OF CETACEANS

The aquatic mammals differ from the terrestrial mammals by several characteristics, associated with the adaptations to the aquatic medium and, above all, with the periodic arrhythmic breathing and with the blood circulation. In the blood-vascular system of the cetaceans there are known several adaptations, which serve for providing the tissues with an uninterrupted supply of oxygen. Many authors have noted the considerable development and peculiarity of the vascular plexuses in cetaceans, that are disposed from the base of the skull along the thorax and form the so called "retia mirabilia". Also characterized by having a considerable development in the cetaceans is the subcutaneous network of blood vessels (B. A. Zenkovich, 1938; A. G. Tomilin, 1946, 1951; V. E. Sokolov, 1958, 1963; V. M. Bel'kovich, 1961; Utrecht, 1958, and others), while in the region of the flippers there have been described specific complex vessels (A. G. Tomilin, 1946-1962). To the latter is allotted an important role in the processes of thermo-regulation.

The adaptations of the cetacean embryos to supplying the tissues with oxygen, in connection with the peculiarities of the respiration and blood circulation of the mother, as was noted by P. A. Korzhuev and N. N. Bulatova (1951), present an "even greater puzzle". According to the data of these authors,
in cetacean embryos there is noted a high oxygen capacity of the blood and a high concentration of haemoglobin, representing an adaptation to unfavourable conditions for embryonic development. It is natural to assume that such adaptations are not the only ones, and are reflected in several morphological characteristics of cetacean embryos. In this connection we conducted studies of the vascular system in cetacean embryos and directed our attention to adaptations for ensuring a regular supply of oxygen to the tissues.

Serving as materials for these studies were complete series of sagittal and transverse sections of cetacean embryos: of the sperm whale—from 8.5 to 105 mm in length, of the humpback whale—from 11.5 to 125 mm, and of the fin whale—from 54 to 73 mm, stained by the Bielschowsky-Buke method, the Nissl method and with haematoxylin-eosin. The value of silver staining methods for revealing vascular networks has been confirmed on more than one occasion in the laboratories of V. V. Kupriyanov, D. M. Golub, D. A. Zhdanov and others. The material for the study was obtained thanks to the cooperation of V. A. Zemskii, G. A. Budylenko and D. D. Tormosov, staff members of the Atlantic Research Institute of Marine Fisheries and Oceanography.

The results of the study show that the formation of the vascular plexuses in cetaceans already occurs during very early stages of embryonic development. At the same time the vascular plexuses are formed in their most clearly expressed form around the brain and spinal cord and around the spinal ganglia. In a sperm whale embryo 14.5 mm in length, along the periphery of the spinal cord there was developed a network of
thin-walled capillaries, filled with the formed elements of the blood. Spreading out cranially, this network surrounds the developing brain and initially is more clearly expressed in the region of the posterior cranial fossa at the base of the brain. The enrichment of the vascular networks proceeds very intensively, and in the sperm whale embryo 16.2 mm in length there appear at the base of the skull a considerable number of large thin-walled veins, surrounded by a network of finer vessels (Figure 1). Then the vascular system in the cavity of the skull is constantly represented by very extensive plexuses. At the same time there occurs an enlargement of the diameter of the large venous trunks and an increase in the number of small vessels in the network. In the older group of sperm whale embryos (95 - 105 mm) there are found extensive vascular plexuses in the cavity of the skull, that are formed of both the large main veins as well as by the network of small vessels of various diameters (Figure 2). The vascular plexuses attain a considerable development in the region of the base of the hypophysis, where they form the basis of the sinus cavernosus. An intensive development of the vascular networks in the region of the brain and spinal cord is also characteristic of the embryos of the baleen whales. Thus, in a humpback whale embryo 95 mm in length the vascular plexus around the brain was formed of thin-walled veins and arteries, located in all parts of the skull and also extending out onto the outer base of the skull through its openings.

A second zone of the extremely strong development of the vascular plexuses is the region where the intervertebral nodes and the initial sections of the spinal nerves are located.
Figure 1. Vascular plexus at the base of the skull in a sperm whale embryo 16.2 mm in length. Photomicrograph. Objective 2, ocular 7.

Here there are formed extensive venous plexuses, surrounding the spinal ganglia. These plexuses, which connect up with the internal plexuses of the vertebral canal, are considerably developed in all of the cetaceans (in both the toothed and the baleen whales), and are characteristic also of other mammals and man. Thus, in a humpback whale embryo 95 mm in length the venous plexuses are formed of blood vessels of various diameter, the branches of which penetrate even right into the ganglia (Figure 3). In the sperm whale such plexuses in the region of the spinal ganglia are found in an embryo 23 mm in length, while later they become more and more extensive. A characteristic feature of the blood vessels which form the networks and plexuses in the region of the central nervous system is the very small thickness of the vascular wall of both the arteries as well as the veins. This phenomenon, which was noted in a dolphin embryo in the region of the
branching of the internal carotid and vertebral arteries by E. S. Yakovleva (1951), is probably common to all of the cetaceans and leads to a convergence of the conditions of gaseous interchange in the arteries and veins.

Vascular networks and plexuses also develop along the course of the large trunks of the cranial and spinal nerves, where they are considerably expressed. The vascular plexuses which accompany the spinal nerves are continuations of the vascular plexuses of the vertebral canal. They are revealed, for example, in a sperm whale embryo 65 mm in length, in the form of a dense network surrounding the intercostal nerves. A similar picture is found in a fin whale embryo 55 mm in length. In the region of the trigeminal nerve and its branches
in sperm whale embryos 97 and 105 mm in length there is formed an extensive network of vessels, entwining the trunks of the nerves and giving rise to branches which penetrate into the trunks. An extensive vascular network is developed also along the course and within the trunk of the vagal nerves. The vascular networks within the trunks of the vagal nerves are also manifested in the embryos of the baleen whales; thus, in a fin whale embryo 55 mm in length they were traced along the course of the nerves over a considerable distance. The sympathetic trunks are surrounded by developed vascular plexuses, connected with the plexuses of the vertebral canal. In the 55 mm long fin whale embryo there are here formed wide-looped
networks. The circum-sympathetic vascular plexuses are very well expressed in the sperm whale embryos. Already in the early stages of development of the sperm whale (in embryos 14.5 mm in length) along the course of the sympathetic trunk there is found a network of blood vessels, having thin walls, which surrounds the sympathetic trunk and its branches. Subsequently, for example, in a 55 mm long sperm whale embryo there develops around the sympathetic trunk an extensive network of venous and arterial vessels. A similar vascular network is also retained in the adult cetaceans. In the Atlantic white-sided dolphin along the vertebral trunk there extend two strands of vascular plexuses, within which are situated the sympathetic trunks. In their structure these vessels resemble the structure of vessels with endarteritis obliterans, when the flow of blood is very considerably hindered (A. B. Khodos, 1967).

Thus, during the embryogenesis of cetaceans (of both the toothed and the baleen whales) there is manifested in a regular fashion the formation of the very strongly developed and widely distributed vascular plexuses, formed by arterial and venous vessels in the region of the brain and spinal cord, of the cranial and spinal nerves, and of the sympathetic trunk. We believe that such a localization of the vascular plexuses is not fortuitous but is connected with the necessity for ensuring the supply, in the first place - of oxygen, to the centers of the nervous system and nerve trunks.

As has been noted by several investigators, in the cetaceans the vascular networks and plexuses are also considerably developed in other parts of the body. We directed
Figure 4. Topography of the extracardial vascular plexus in a sperm whale embryo 55 mm in length:

1 - vascular plexus;
2 - lung rudiment;
3 - heart rudiment;
4 - blood vessels in ventral wall of body.

Transverse section. Photomicrograph. Objective 2, ocular 5.

attention to the richness of the vascular system, especially of the venous part, primarily in the sub-pleural space of the thoracic cavity. L. B. Slavochinskaya (1965) considers that the abundance of veins is explained by the level of metabolism in the pleurae: the veins in the pleura participate in the regulation of the metabolic processes in the thoracic cavity. Under the parietal pleura in the region of ribs I - III and the ventral part of the mediastinal pleura, commencing from comparatively early stages (sperm whale embryos 34-35 mm in length), there is formed a network of blood vessels, which takes the form of an extensive plexus. In the region of the dome of the pleura this plexus passes over onto the mediastinal
pleura and extends ventrally to the root of the lung to the ventral wall of the body, connecting up ventrally with the plexuses which are situated under the costal pleura (Figure 4). Caudally a similar plexus extends down onto the diaphragm and is distributed on its thoracic surface (Figure 5). As a result of this the ventral section of the thoracic cavity, in which is situated the heart in the pericardial sac, is found to be surrounded by the practically continuous extracardial vascular plexus, which is situated on the surface of the pericardium. In its structure this network is composed of vessels of two types: smaller vessels with a gradually forming wall
(of the arterial or venous type) which anastomose extensively among themselves; the second type of vascular structures has the form of thin-walled lacunae, characteristic of microcirculatory adaptations for increasing the capacity of the vascular stream (V. V. Kupriyanov, 1969). In our preparations these were found to be empty or only partially filled with blood. Venous sinusoids of this type are considered in the literature as a part of the cavernous-like formations (A. N. Tikhomirov, 1967). Both types of vessels appear comparatively early and can be distinctly found in embryos 55 and 65 mm in length and larger. They are more markedly developed in embryos 97 - 105 mm in length (Figure 6). It should be noted that the vascular network in the region of the parietal pleura is distinguishable by its content of vessels of the arterial and venous type. Characteristic of the mediastinal region, on the other hand, is the presence of a large number of venous lacunae and cavernous-like formations alongside the rich network of arterial and venous vessels. It is interesting that this region in other mammals is also distinguished by having a characteristic structure of the vascular system, which has been noted by several authors (V. V. Kupriyanov, 1969; R. M. Petrova, 1967; L. B. Slavochinskaya, 1967). Well expressed and widespread extra-organic vascular plexuses are found in the region of the heart and especially along the course of the large vessels which run out of the heart, and further along the course of the aorta and its branches (Figure 7). These pericardial and periarterial venous plexuses anastomose extensively with the extracardial vascular network in many sectors.
Thus, the disposition of the vascular plexuses in the thoracic cavity of the sperm whale embryo is distinguished by the marked peculiarity of the topography and the character of the blood vessels. Within the thorax of the embryos of the baleen whales (humpback whale, fin whale) the picture of the disposition of the vascular networks differs markedly from that described above. In the subpleural layer of a fin whale 55 mm in length we also find a fairly considerable network of blood vessels, though this is more localized, primarily in the dorso-cranial sectors of the thorax. This network is formed mainly of arteries and veins. In the mediastinal pleura the vascular plexus is considerably poorer and is represented by a considerably less well expressed network of arteries and veins.
Figure 7. Vascular plexus in the region of the arch of the aorta of a sperm whale embryo 97 mm in length:

1 - wall of aorta;
2 - vascular plexus.

Photomicrograph. Objective 2, ocular 5.

Among the ecological characteristics of both the baleen as well as the toothed whales, which have been noted by many authors (A. G. Tomilin, S. E. Kleinenberg, V. M. Bel'kovich, V. E. Sokolov and others), belongs the considerable development of the network of subcutaneous vessels. The vascular pattern can be seen distinctly through the integument of the embryo, commencing from the earliest stages of development. The architecture of the vascular pattern is especially well marked out in the region of the head, the base of the flippers, the base of the tail and the trunk. Only the development of the pigment layer of the skin gradually conceals this vascular pattern. With histological studies the development of vascular networks is found at the base of the flippers and around the
Figure 8. Subcutaneous vascular network in the region of the lateral wall of the trunk of a sperm whale embryo 105 mm in length. Photomicrograph. Objective 2, ocular 5.

Phalanges of the fingers, along the course of the bundles of muscle fibres and under the skin of the flippers (sperm whale embryos 72 - 105 mm in length). Extensive vascular networks are formed under the skin also in the muscle layers of the trunk (Figure 8).

The data from our studies demonstrate the considerable richness of the vascular system in cetacean embryos, especially of the toothed whales (sperm whale), manifested in the development of vascular plexuses in various parts of the body, mainly in the zones where vitally important organs are situated: the central and peripheral nervous systems and the heart. In this connection, naturally, the question arises as to the biological significance of such adaptations, their role in the development of the embryo and, subsequently, in the functions
of the adult animals. The concept exists in the literature that the vascular networks and plexuses in the body of cetaceans fulfil an important, if not fundamental, role in supplying the tissues with blood during diving, functioning as a store of blood that is rich in oxygen and shortening the pathway of the blood to the tissues (B. Howell, 1930; F. Ommaney, 1932; A. Krog, 1930; P. Schollander, 1940 - cited by S. E. Kleinenberg, 1946).

Sharing this point of view, S. E. Kleinenberg emphasizes that during diving there is a decrease in the number and strength of the cardiac contractions and, consequently, the vascular store permits the blood reserve of oxygen to be more economically expended and facilitates the work of the heart during prolonged apnea. Our data permit one to consider that such adaptations to a prolonged shut-down of external breathing and the creation of stores of oxygen in the blood are formed already during the early stages of embryonic development. It should be borne in mind, however, that the marked development of vascular plexuses in the region where the centers of nervous regulation are situated is characteristic not only of the cetaceans but also of other mammals, including also man (A. S. Leontyuk, 1969), which are not characterized by having extended periods of apnea. Therefore it is possible to somewhat expand the concept of the role of the vascular plexuses, which are formed already in the embryos of the cetaceans and are retained in the adult animals.

The character of the extra-organic, mainly venous, plexuses in the region of the brain, spinal cord and peripheral
nerves is similar to those in tissues with an increased exchange (A. B. Khodos, 1967), since for obtaining the optimal exchange the rate of the blood-flow should be reduced to a minimum. It is probable that the developing vascular plexuses are adapted in their structure primarily to the relative hypoxia and moderate metabolic acidosis that is so characteristic of developing embryos (I. A. Arshavskii, 1960; L. S. Persianinov, 1967, and others). That this is actually the case is convincingly indicated by the data of several authors on the effect of hypoxia on the structure of the vascular system (V. I. Voitkevich, 1958; E. N. Domontovich, 1958; E. Van-Lir and K. Stiknei, 1967; V. V. Kupriyanov, 1969, and others), which is manifested in an increased vascularization of the tissues, a hypertrophy of existing vessels and a growth of newly formed vessels. The resulting hyperemia leads to an increased diffusion of oxygen, food substances and metabolites. The changing conditions of the regional circulation of blood favour a more complete assimilation of the oxygen in the blood and the excretion of metabolic products, since the diffusion of the oxygen from the blood is related to the area of the diffusion and the partial pressure of oxygen in the venous part of the vascular flow (A. I. Shik, 1966). V. V. Kupriyanov (1969) emphasizes that the length of the venous pathways, the diversity of their directions and the extensive roundabout connections predetermine the pattern of the microcirculatory system and, in a decisive manner, influence the hemodynamics in the organs. Convincing data on the considerable reconstruction of the intra-organic vascular stream in cases of hypoxia
under high mountain conditions were presented by Ya. A. Rakhi-
mov and L. E. Etingen and co-authors (1968).

Thus, the extra-organic network of blood vessels, mainly of venous vessels with a retarded blood flow, which appears in the early stages of development of cetaceans may be considered as an adaptation for supplying blood to the tissues in the specific conditions of the intra-uterine development of the foetus. In this connection the development of the special vascular structures during the embryogenesis of the cetaceans becomes understandable, and these may be considered not only as storage structures in places with a maximal requirement for oxygen but also as adaptations for the more complete assimilation of the oxygen in the blood and for the excretion of metabolites in the zone of the disposition of the vitally important organs and systems - the nervous system and the heart.

Taking into consideration the conditions of the life of the toothed whales and the baleen whales, the more clearly expressed development of the vascular plexuses in the toothed whales, as compared to the baleen whales, is understandable as corresponding to their ecology. It is evident that the adaptive characteristics of the vascular system, which are set down in early embryogenesis, retain their significance and also, probably, acquire new properties in the adult animals.
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THE PROBLEM OF THE OXYGEN RESERVES IN THE ORGANISM 
OF AQUATIC MAMMALS

One of the most weakly elaborated problems of the biology of aquatic mammals is the problem of respiration, or more precisely, the problem of the shutting-off of the external respiration during the period of diving. Up to the present time in the literature there are present contradictory data on the time spent by the animals under water. While the time of the shutting-off of external respiration during diving in the diving birds is measured in minutes, then for the aquatic mammals this period is measured in tens of minutes, and for the large whales - even in hours (Korzhuev, 1964). According to Pastukhov's data (1969), the Baikal seal may spend more than an hour under the water. It is true that this record duration of stay under water, equaling one hour and eight minutes for one of the test seals, was observed by the author only once, and later these seals shut-off their breathing for only 5 - 8 minutes.

The author of the present paper happened to be a witness to an experiment, conducted on a young seal in the Northern Caspian in September of 1965, when after a forced stay under water of 7 minutes the seal had a very lamentable appearance. Experiments on the shutting-off of breathing in the Black Sea dolphins, the white-sided dolphin and the bottlenose dolphin (Korzhuev and Bulatova, 1952), when the animals were on dry land, showed that the white-sided dolphin calmly endured such an experiment for only two minutes, while the bottlenose
dolphin endured this for four minutes. After the expiration of this period there commenced a very violent reaction, accompanied by vomiting, which was indicative of a very obvious disturbance of the organism. It may be assumed that, if these experiments had been conducted in water, the duration of the experiment may possibly have been increased by a factor of two or three, but at any rate for the white-sided dolphin this would not be more than 6 minutes, while for the bottlenose dolphin it would not exceed 12 minutes. Visual observations indicate periods of about this order.

Apparently the periods of shutting-off breathing for the pinnipeds are more prolonged than for the small cetaceans, though these also measure 15 - 20 minutes (Mordvinov, 1969). Set somewhat apart is one of the Antarctic species of seals, the Weddell's seal, which in one experiment dived to a depth of 600 m and stayed under water for 43 minutes and 20 seconds.

As to the representatives of the large whales, the duration of the stay under water of which is measured in hours (sperm whale - up to 75 minutes, bottlenose whale - up to two hours, Irving, 1939), these data are purely visual and therefore require confirmation. Apparently, the problem of the prolonged diving of aquatic mammals will obtain an effective resolution only when a thorough quantitative determination is made of those reserves of oxygen which the organism of these animals has at its disposal.

It is scarcely possible to consider as convincing the arguments of those investigators who consider that the duration of diving is related to the capability of the animals to change over to the anaerobic type of respiration during the period of
diving. It seems to us that the basic condition affecting the duration of diving and, by the same token also, the cutting-off of breathing for some period or other is the presence of oxygen reserves and their rational utilization.

However the problem of the oxygen reserves in aquatic mammals has been very weakly elaborated. On this subject there are more assumptions than precise facts. As an illustration of this, one may point to the studies of Scholander (1940) and Robinson (1939), who determined the oxygen reserves in cetaceans and pinnipeds, for which determinations they assumed that the probable amount of blood in the organism of the dolphin, for example, equalled 15.0% of the body weight or that the quantitative characteristics of the body musculature could be taken as being equal to 35.0% of the body weight, although these values were not precisely determined.

In this connection it may be noted only that for the terrestrial animals also the problem of the oxygen reserves is one that has not been worked out at all. Only the attitude that in these animals these reserves are negligible may be considered as indisputable.

This fact is often obscured, since during the process of the evolution of life on our planet the problem of the reserves of various vitally important substances has been resolved very successfully. In different stages of the ontogeny of various groups of animals there are formed reserves of proteins, fats, carbohydrates and vitamins; it is known that the egg cells of various animals (fishes, amphibians, reptiles, birds, insects) contain the entire assortment of substances necessary for normal development; for the period of hibernation
heterothermal animals lay down reserves of fat, attaining up to 35.0% of the body weight, while in the aquatic mammals the fat reserves may be as high as half of the body weight.

However oxygen, which is one of the most important elements, without which the organism cannot manage to exist, is practically not stored at all by the organism. Terrestrial mammals, including man, may cut-off their breathing for only one to two minutes. This circumstance is quite incomprehensible since oxygen reserves could protect the organism from many undesirable and sometimes also catastrophic consequences.

Apparently there exist some very weighty reasons which prevent the setting up of considerable oxygen reserves within the animal organism; the small group of aquatic mammals and birds forms a certain exception to this rule.

To decypher the specific mechanisms, determining the possibilities by which animals may shut-off their breathing for some period or other, is a problem which still awaits its solution. All the same, with respect to the terrestrial vertebrate animals it may be said that one of the most fundamental causes, preventing the setting up of oxygen reserves, is to be found in the properties of oxygen itself.

The fact is, as was shown by Professor A. L. Chizhevskii (1960), that it is not a matter of indifference as to what air we breath. Up to the present time it has been considered that for respiration it is important that the air should have in its composition a certain amount of oxygen, nitrogen and carbon dioxide; however not only the chemical composition of the air turns out to be important but also the physical
state of its molecules and, in the first place, of the oxygen. Among the factors determining this physical state, the first place belongs to electricity: the saturation of the air with electrical charges and the degree of its electrostatic charging, as a consequence of which the oxygen molecules become ionized. Particularly important for respiration are molecules of oxygen having a negative electric charge. If the molecules of the air are not ionized, then animals rapidly die in such an atmosphere, in spite of the presence of oxygen molecules in the respired air. These investigations of A. I. Chizhevskii shed light on the causes which determine the absence of any considerable reserves of oxygen within the organism of animals.

A characteristic feature of the ionized oxygen molecules is the fact that they exist for a very short period of time, of the order of ten minutes or a little more, after which the charge is lost and the oxygen reverts into the inactive form. This circumstance, apparently, is the fundamental cause which deprives the animal organism of the possibility of storing the ionized oxygen, which has a negative charge. The negatively charged oxygen ion possesses several characteristics, such as, for example, the presence of nine electrons (as in fluorine) and a changed spin of its nucleus. Apparently these physical changes, occurring at the level of the electrons and of the nucleus, play a decisive role in the evolution of the animal world, as a consequence of which also there is found the absence of considerable reserves of oxygen even in the higher representatives of the vertebrate animals.
This is a very fundamental circumstance, which has not been adequately considered by biologists. Nevertheless the properties of the basic chemical elements, which play an important role in the life of animals, determine the character of their evolution. Practically all of the characteristic features of the organs of aeration and of the haemodynamics are determined by the properties of oxygen.

As to the aquatic mammals, it seems that here there occurs a deviation from this principle. It cannot be ruled out that in the case of the marine mammals there may be some kind of supplementary adaptations, directed towards overcoming these properties of oxygen, as a consequence of which there may be set up within the organism oxygen reserves that are more powerful than is characteristic of the terrestrial mammals. However, until precise data are obtained on the actual periods of the cutting-off of breathing in the large cetaceans and pinnipeds in their natural habitats, there are no grounds for speaking of deviations from this principle.

The experimental data that are available at the present time permit one to say only that a real basis for the prolonged cutting-off of breathing is the presence of certain oxygen reserves, i.e. the retention of the aerobic type of respiration. And this means that without a precise knowledge of the oxygen reserves it is impossible to definitively resolve the question of the duration of diving.

Unfortunately there are very few precise data available on the amount of oxygen that is found within the organism of animals. In Table 1 are presented data on the oxygen reserves
Table 1.

Oxygen reserves in the organism of man, certain mammals and birds, cm³
(Robinson, 1939; Scholander, 1940; Korzhuev, 1964)

Резервы кислорода в организме человека, некоторых млекопитающих и птиц, см³
(Робинсон, 1939; Шоландер, 1940; Коржук, 1964)

<table>
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<tr>
<th>Вид</th>
<th>Вес, кг</th>
<th>Лёгкие</th>
<th>Кровь</th>
<th>Мышцы</th>
<th>Межтканевая жидкость</th>
<th>Всего кислорода, A</th>
<th>В</th>
<th>С</th>
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<tr>
<td>1 Финвал</td>
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<td>300000</td>
<td>140000</td>
<td>1400000</td>
<td>2500000</td>
<td>3350</td>
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<tr>
<td>2 Бутылковос</td>
<td>1400</td>
<td>6000</td>
<td>45000</td>
<td>540000</td>
<td>40000</td>
<td>109</td>
<td>78,0</td>
<td></td>
</tr>
<tr>
<td>3 Дельфин</td>
<td>19</td>
<td>250</td>
<td>600</td>
<td>180</td>
<td>60</td>
<td>1,09</td>
<td>57,0</td>
<td></td>
</tr>
<tr>
<td>4 Тюлень</td>
<td>29</td>
<td>500</td>
<td>1100</td>
<td>270</td>
<td>100</td>
<td>1,52</td>
<td>52,4</td>
<td></td>
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<tr>
<td>5 Тюлень</td>
<td>70</td>
<td>545</td>
<td>2055</td>
<td>2530</td>
<td>245</td>
<td>5,37</td>
<td>77,0</td>
<td></td>
</tr>
<tr>
<td>6 Человек</td>
<td>70</td>
<td>900</td>
<td>1160</td>
<td>335</td>
<td>245</td>
<td>2,64</td>
<td>38,0</td>
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<tr>
<td>7 Пингвин</td>
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<td>120</td>
<td>90</td>
<td>40</td>
<td>20</td>
<td>0,27</td>
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A. - Inter-tissue fluid
B. - Total oxygen, l
C. - Oxygen per 1 kg body weight, cm³

1 - Fin whale
2 - Bottlenose whale
3 - Dolphin
4 - Seal
5 - Seal
6 - Man
7 - Penguin

in the organism of certain representatives of the mammals and birds. For these the structures of the organism that contain oxygen are the organs of respiration - the lungs; the blood, as a liquid tissue, contains physically dissolved oxygen, as does also the inter-tissue fluid. However these structures have a relatively small part of the oxygen. The main portion of this is contained in the form of chemically bound oxygen in the respiratory pigments of the blood and muscles in the
form of oxyhaemoglobin of the blood and muscles. At least, in the large cetaceans the portion of oxygen contained in the organs of aeration and tissue fluids in the form of physically dissolved oxygen comes to about 10 - 15%, while the portion of oxygen bound by the haemoglobin of the blood and muscles comprises about 84% in the fin whale, about 90% in the bottlenose whale, from 85 to 90% in seals, and about 70% in the dolphin. In man the respiratory pigments bind about 55% of the total oxygen that is present in the organism. It should be borne in mind that, in spite of the relatively large amount of oxygen that is bound by the haemoglobin of the blood and the muscles, in man, for example, the tissues utilize a comparatively small amount of this, since the venous blood of man contains much unutilized oxygen (about 12 - 14 percent by volume). It is true that such a character of the utilization of oxygen has its advantages, since the pressure gradient of oxygen in the capillaries of the body is very high, which favours a more effective supply of this to the tissues.

In this respect the cetaceans and pinnipeds occupy a special place, since they utilize the oxygen of the arterial blood more completely, so that in the venous blood there remains a very small amount of this, of the order of one to two percent.

Thus, a characteristic feature of the adaptation of the cetaceans and the pinnipeds is their higher capability for removing practically all of the oxygen from the blood, in contrast to the terrestrial mammals.
If it is considered that the aquatic mammals find themselves under conditions that approximate to a state of weightlessness and, consequently, expend practically no energy for supporting the weight of their own body, then it becomes understandable that the energy losses in these are considerably smaller than in their terrestrial relatives. It is very strange that this circumstance has been completely ignored in comparisons of the characteristic features of the biology of aquatic and terrestrial mammals, since in actuality it is very essential.

Some investigators turn their attention only to the fact that aquatic mammals may shut-off their breathing for more prolonged periods, as compared to the terrestrial mammals; however the rest is accepted as being quite adequate to terrestrial conditions. It is considered that the energetics of the organism are completely the same in both terrestrial as well as aquatic conditions. However it is precisely in this that there is a basic difference between the aquatic and terrestrial mammals.

Of course, a very important form of adaptation is the lowering of sensitivity of the respiratory center to the accumulation of carbon dioxide in the blood. The behaviour of the vascular system in the aquatic mammals at the time of diving (the redistribution of the blood supply to various parts of the body) is completely different from that in the terrestrial animals. It seems to us, however, that the cause of this is not the necessity of ensuring a supply of oxygen only to the vitally important organs (heart, brain) at the
expense of other parts of the body, which might seemingly be deprived of the necessary amounts of oxygen, at the same time changing to an anaerobic type of respiration, but something quite different.

From our point of view, the crux of the matter lies in the fact that this redistribution of the blood supply during the period of diving occurs only because in the aquatic conditions the requirement for oxygen is smaller than under terrestrial conditions.

The correctness of this assumption finds confirmation in the fact that the aquatic mammals, in contrast to the terrestrial mammals, possess many times greater reserves of haemoglobin, localized both in the blood and in the muscles of the body. It is quite obvious that the large amounts of haemoglobin are the main condition of the creation of the oxygen reserves during the period of diving. Evidently the expenditure of these reserves is more economical than is the case under terrestrial conditions, where energy is expended not only for locomotion but also for supporting the weight of the body itself.

In other words, life under terrestrial conditions is linked with the necessity of surmounting the forces of the earth's attraction, or the forces of gravitation, and this surmounting presupposes losses of considerable amounts of energy, while under aquatic conditions, as a consequence of the high density of the water, the effect of the gravitational forces is practically eliminated, although the gravitational field is retained in the water, as on dry land. The data presented in Table 1 confirm the stated positions.
It may be thought that, if the cetaceans and pinnipeds, in the process of their adaptation to the aquatic conditions of existence, had changed over to a gill-type of respiration, i.e. if they could obtain the oxygen directly from their surrounding medium, as is the case in the fishes, then they would not have such large reserves of haemoglobin and, by the same token, of oxygen.

The fishes, as primarily aquatic animals, are characterized by having a very small amount of blood in the organism and a small amount of haemoglobin per unit weight of the body. Thus, for example, in fishes on average there are about two grams of haemoglobin per kilogram of body weight, while in diadromous fishes, which accomplish extensive migrations to their spawning sites, generally against currents, the degree of provisioning of the organism with haemoglobin comprises about 3 grams per kilogram of body weight. It is true that in addition to this there is present in these a small amount of physically dissolved oxygen, contained in the blood and perivisceral fluids, while in some fish species there is present a small amount of oxygen that is bound by the muscle haemoglobin. However, these additional amounts scarcely change the total figures named above.

If one compares with these figures the degree of provisioning of the organism with haemoglobin in the dolphins and seals, then it is found that in the white-sided dolphin this value is approximately equal to 25 g of haemoglobin per kilogram of body weight, while in the seal it attains a level of 40 g. This is almost 15 times greater than in fishes.
These huge reserves of haemoglobin, required by cetaceans and pinnipeds for binding oxygen for the periods of diving, would be superfluous with the gill-type of respiration.

However, since in nature there is found the principle of the irreversibility of evolution, first discovered and formulated by the French paleontologist Louis Dollo in 1893, the change to a gill-type of respiration is impossible. The cetaceans and pinnipeds are forced to employ the lung-type of respiration, with all of the consequences arising from this. This means that the entire evolution of the aquatic mammals was directed, in the first place, to providing for one of the most basic functions, the function of respiration. From this derive: the change in the rhythm of respiration, the lowering of the sensitivity of the respiratory center to the accumulation of carbon dioxide in the blood, the redistribution of the blood-supply to the organs during the period of diving, and the marked stimulation of the synthesis of haemoglobin not only in the bone marrow but also in the muscles of the body. And all of this occurred so that it would be possible to do without breathing during the period of diving.

The aerial type of respiration turned out to be the only thread which ties in the cetaceans, the group which has moved furthest in its evolution to the aquatic way of life, with the terrestrial animals.
ЛITERATURA


REFERENCES

QUANTITATIVE EVALUATION OF THE HAEMATOPOIETIC FUNCTION OF THE SKELETON OF THE BLACK SEA DOLPHINS

It is considered that in the terrestrial vertebrates the function of the skeleton consists of supporting the body in a particular position, and also of strengthening and retaining the musculature. In the aquatic vertebrates, according to the opinion of E. Slijper (1962), the function of the skeleton that consists of supporting the body does not have a great significance, since in the water the body is acted on by an upward pushing force, which alleviates this function. The importance of the latter circumstance is also emphasized by P. A. Korzhuev (1963), who notes that the organism in the water is as it were suspended and therefore its energy is expended only for locomotion, while under terrestrial conditions the animal must expend considerable energy not only for locomotion but also for supporting the weight of its body.

In both the aquatic and terrestrial conditions one of the basic functions of the skeleton is the haematopoietic function. From this point of view there is a special interest in the study of the weight characteristics of the skeleton and bone marrow of adult dolphins, as animals which shut-off their breathing for prolonged periods, and also in the study of dolphin embryos, which are subjected to difficulties in acquiring oxygen not only in particular stages of their development but also at the time of the shutting-off of breathing by the mother.
In the literature there exists a fairly considerable amount of data on the weight of the skeleton of the large cetaceans (Khar’kov, 1940; Brochkov, 1953; Sleptsov, 1961; Bjarnason, 1954). These data are not precise and at times are greatly exaggerated in connection with a lack of thorough cleaning of the skeleton. Probably, more precise data on the weight of the skeleton of the large cetaceans are to be found in E. Slijper’ s (1962) study. Characteristics of the weight of the skeleton of representatives of the small cetaceans have been presented in the studies of P. A. Korzhuev and co-authors (1964, 1967). In these studies there are data on the weight of the bone marrow in the adult cetaceans and their foetuses, and also on the weight of the skeleton of the latter.

The aim of the present study was to show up the weight relationships of the skeleton and bone marrow of the developing embryos and sexually mature Black Sea dolphins.

There were studied embryos of different ages and adult individuals of the bottlenose dolphin (Tursiops truncatus Mouf), of the common dolphin (Delphinus delphis L.) and of the common porpoise (Phocaena phocaena L.). The skeleton and bone marrow was examined in 7 embryos of the bottlenose dolphin, with a weight of from 184 g to 16.5 kg and an age of from 4-5 to 11-12 months*; 4 adult individuals, weighing from 30 to 67 kg, and 10 embryos of the common dolphin weighing from 2.65 to 7.00 kg and aged 8-10 months; 11 adult individuals of the common porpoise weighing from 13 to 47 kg and 11 embryos weighing from

* The age of the embryos was determined with an accuracy of to 0.5-1 months on the basis of the length of the body.
$884 \text{ g to } 1,996 \text{ kg and an age of } 5 - 8 \text{ months, and also one embryo weighing } 3.07 \text{ kg aged } 9-10 \text{ months.}$

For obtaining the weight characteristics of the skeleton, after the weighing of the whole body there were removed the muscles, tendons, brain and spinal cord, and the cleaned skeleton was weighed in sections. The volume of the bone marrow was determined by a method based on Archimedes' principle (Petrov, 1952). For calculating the weight of the bone marrow there was employed the specific weight of this in only the sexually mature dolphins, in which it was possible to find individual sections of cylindrical form in the ribs.

Knowing the specific weight and volume of the bone marrow, its weight was calculated as a percentage of the body weight, and the percentage relationships in the different sections of the skeleton were also calculated.

According to the literature data (E. Slijper, 1962), in the large crustaceans, such as the sei whale, fin whale and blue whale, the weight of the skeleton comprises correspondingly 13, 16 and 17% of the body weight. In the Black Sea dolphins, according to the data of P. A. Korzhuev et al. (1964), the weight of the skeleton was half as great.

On thorough treatment of the skeleton it was found that its weight relative to the weight of the body comprised, on average, 6.5% in the common dolphin and 5.2% in the common porpoise (Tables 1 and 2). In the quantitative characterization of the skeleton of the two species of dolphins there were not found any statistically significant sex differences.
The axial skeleton takes up the main part of the skeleton of the dolphins. Thus, this comprises about 90% of the weight in the skeleton of the common dolphin, while the skeleton of the limbs comprises only 10%. The relationship of the parts of the skeleton does not remain constant: with increasing weight and length of the dolphin (for example, of the common porpoise) there is found a decrease in the relative weight of the skull of from 32.6 to 24.0% of the total weight of the skeleton, and an increase in the weight of the vertebral column of from 46.0 to 53.7% (Table 2). It is interesting that the relative weight of the ribs and sternum remains at almost the same level.

While the fraction taken up by the anterior girdle and free fore limbs in the common porpoise and the common dolphin is 9 - 10%, the fraction falling to the posterior limbs, which in dolphins are reduced to two short narrow bones lying within the muscles, is measured in tenths of a percentage point.

The bones of cetaceans are filled with bone marrow. E. Slijper (1962) notes that the skeleton of young animals contains red bone marrow but that with age there occurs a replacement of this fraction by the yellow bone marrow.

According to our data, all of the studied dolphin individuals, including also the sexually mature individuals, possessed only the red fraction of the bone marrow, i.e. the haematopoietic fraction. The weight of the bone marrow in the adult dolphins comprises about 2% of the body weight (Tables 3 and 4). No sex differences were found in the weight of the bone marrow in the dolphins. The bone marrow is localized identically in both species of dolphins. The greatest
Table 1.

The relative weight of sections of the skeleton of adult common dolphins, as % of the total weight of the skeleton.

<table>
<thead>
<tr>
<th>Total body weight, kg</th>
<th>Body length</th>
<th>A.</th>
<th>Weight of skeletal sections, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sex</td>
<td>Длина тела, cm</td>
<td>% от веса тела</td>
</tr>
<tr>
<td>31.2</td>
<td>самка</td>
<td>128</td>
<td>6.2</td>
</tr>
<tr>
<td>41.8</td>
<td>самец</td>
<td>157</td>
<td>6.9</td>
</tr>
<tr>
<td>58.3</td>
<td>самка</td>
<td>167.5</td>
<td>6.2</td>
</tr>
<tr>
<td>65.3</td>
<td>самец</td>
<td>174</td>
<td>6.7</td>
</tr>
<tr>
<td>X±Sx</td>
<td>самка</td>
<td>156.0±10.2</td>
<td>6.5±0.2</td>
</tr>
<tr>
<td></td>
<td>самец</td>
<td></td>
<td></td>
</tr>
<tr>
<td>48.9±7.95 f and m.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

f - female
m - male

A. - Weight of skeleton, as % of body weight.

1 Translator's note. Sic. Should be %, rather than kg.
Table 2.
The relative weight of sections of the skeleton of adult common porpoises, as % of the total weight of the skeleton.

<table>
<thead>
<tr>
<th>Total body weight, kg</th>
<th>Body length, cm</th>
<th>A. Weights, % of total weight</th>
<th>B. Weight of skeletal sections, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.00</td>
<td>114</td>
<td>6.3</td>
<td>7.7</td>
</tr>
<tr>
<td>23.00</td>
<td>116</td>
<td>5.1</td>
<td>3.5</td>
</tr>
<tr>
<td>29.40</td>
<td>120</td>
<td>5.4</td>
<td>6.3</td>
</tr>
<tr>
<td>32.00</td>
<td>127</td>
<td>4.9</td>
<td>3.5</td>
</tr>
<tr>
<td>13.10*</td>
<td>92</td>
<td>7.2</td>
<td>10.5</td>
</tr>
<tr>
<td>37.45**</td>
<td>133</td>
<td>5.2</td>
<td>4.1</td>
</tr>
<tr>
<td>38.20**</td>
<td>129</td>
<td>5.2</td>
<td>2.5</td>
</tr>
<tr>
<td>40.00**</td>
<td>136</td>
<td>5.0</td>
<td>3.5</td>
</tr>
<tr>
<td>40.00</td>
<td>136</td>
<td>4.9</td>
<td>3.8</td>
</tr>
<tr>
<td>40.00**</td>
<td>137</td>
<td>5.1</td>
<td>3.4</td>
</tr>
<tr>
<td>47.00**</td>
<td>138</td>
<td>4.6</td>
<td>4.2</td>
</tr>
<tr>
<td>x±Sx</td>
<td>129±3</td>
<td>5.2±0.2</td>
<td>4.4±0.5</td>
</tr>
</tbody>
</table>

Female

<table>
<thead>
<tr>
<th>Total body weight, kg</th>
<th>Body length, cm</th>
<th>A. Weights, % of total weight</th>
<th>B. Weight of skeletal sections, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.61±2.64</td>
<td>129±3</td>
<td>5.2±0.2</td>
<td>4.4±0.5</td>
</tr>
</tbody>
</table>

* Sexually immature individual, not taken into account in the statistical treatment.

** Pregnant female

A. - Weight of skeleton, as % of body weight.

B. - Weight of cartilage, as % of weight of:

1 Translator's note. Sic. Should be %, rather than kg.
amount of this is concentrated in the vertebral column: averaging 56.7 and 61.6% of the total weight of the bone marrow.

The minimal amount of bone marrow is found in the posterior limbs of sexually immature animals. In a young common porpoise weighing 13.1 kg the pelvic bones contained 0.2% (Table 4). In the rudiments of the posterior limbs of the sexually mature forms there was no bone marrow. In the skull it is mainly localized in the occipital bone and is completely absent in the lower jaw. The average relative weight of the bone marrow in the skull comprises 20.6 and 15.5%. In both species of dolphins about 12% is contained in the ribs and sternum, and also in the bones of the fore limbs.

Before passing on to the description of the weight characteristics of the skeleton and bone marrow in the embryos of the Black Sea dolphins, in comparison with the adult forms, we will give a short account of the regularities revealed for each species of a particular age.

The greatest period of pre-natal development was covered in the bottlenose dolphin, the embryos of which were represented, on the one hand, by 3-4 month old individuals and, on the other, by 11-12 month old individuals, i.e. just prior to birth.

The relative weight of the skeleton of the embryos of the bottlenose increases, in step with their growth, from 6.75% in the 3-4 month old embryo to 10.40% of the body weight in the foetus just before birth (Table 5). A positive correlation is marked between the weight of the skeleton, on the one hand, and the size of the foetus, on the other: the relative weight
Table 3.

The relative weight of the bone marrow of adults of the common dolphin, as % of total weight of the bone marrow.

Относительный вес костного мозга взрослых обыкновенных дельфинов, % от общего веса костного мозга

<table>
<thead>
<tr>
<th>Total body weight, kg</th>
<th>Length of body, cm</th>
<th>Sex</th>
<th>Weight of bone marrow in skeleton, kg</th>
<th>Ribs and vertebral column</th>
<th>Fore</th>
<th>Hind</th>
</tr>
</thead>
<tbody>
<tr>
<td>30,2</td>
<td>128</td>
<td>f</td>
<td>23,0</td>
<td>7,5</td>
<td>57,6</td>
<td>11,8</td>
</tr>
<tr>
<td>41,8</td>
<td>157</td>
<td>m</td>
<td>14,4</td>
<td>16,7</td>
<td>58,2</td>
<td>10,3</td>
</tr>
<tr>
<td>58,3</td>
<td>167,5</td>
<td>f</td>
<td>22,5</td>
<td>8,2</td>
<td>55,5</td>
<td>13,7</td>
</tr>
<tr>
<td>65,3</td>
<td>174</td>
<td>m</td>
<td>22,6</td>
<td>9,3</td>
<td>55,4</td>
<td>12,3</td>
</tr>
<tr>
<td>(x\pm Sx)</td>
<td>156,6±10,2</td>
<td>f and m</td>
<td>20,6±2,1</td>
<td>10,4±2,1</td>
<td>56,7±0,7</td>
<td>12,0±0,7</td>
</tr>
</tbody>
</table>

f - female  
m - male

A. - Total weight of bone marrow, as % of body weight.

1 Translator's note. Sic. Should be % of total weight of bone marrow.
Table 4.

The relative weight of the bone marrow of adults of the common porpoise in various sections of the skeleton, as % of total weight of bone marrow.

<table>
<thead>
<tr>
<th>Total body weight, kg</th>
<th>Sex</th>
<th>Length of body, cm</th>
<th>A.</th>
<th>Weight of bone marrow in skeleton, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>skull</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>114</td>
<td>2,3</td>
<td>13,8</td>
</tr>
<tr>
<td>23,00</td>
<td>»</td>
<td>116</td>
<td>2,0</td>
<td>10,6</td>
</tr>
<tr>
<td>26,40</td>
<td>»</td>
<td>120</td>
<td>1,8</td>
<td>17,9</td>
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<td>32,00</td>
<td>»</td>
<td>127</td>
<td>1,9</td>
<td>13,6</td>
</tr>
<tr>
<td>13,10*</td>
<td>female</td>
<td>92</td>
<td>2,9</td>
<td>18,3</td>
</tr>
<tr>
<td>37,45**</td>
<td>female</td>
<td>133</td>
<td>2,2</td>
<td>18,4</td>
</tr>
<tr>
<td>38,20**</td>
<td>»</td>
<td>129</td>
<td>2,2</td>
<td>17,7</td>
</tr>
<tr>
<td>40,00**</td>
<td>»</td>
<td>136</td>
<td>1,8</td>
<td>15,1</td>
</tr>
<tr>
<td>40,00</td>
<td>»</td>
<td>136</td>
<td>1,9</td>
<td>13,8</td>
</tr>
<tr>
<td>40,00**</td>
<td>»</td>
<td>137</td>
<td>2,2</td>
<td>14,4</td>
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<tr>
<td>47,00**</td>
<td>»</td>
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<td>14,0</td>
</tr>
<tr>
<td>±Sx</td>
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<td></td>
<td></td>
<td>2,0±0,1</td>
</tr>
<tr>
<td>34,61 ±2,64</td>
<td>male and female</td>
<td>129±2,9</td>
<td>2,0±0,1</td>
<td>15,5±0,6</td>
</tr>
</tbody>
</table>

* Nеполовозрелая особь при статистической обработке не учитывалась.
** Самия беременна.
* Sexually immature individual, not considered in the statistical treatment.
** Pregnant female

Translator's note. Sic. Should be %.
of the skeleton increases with the increase in the weight and length of the embryo. With the growth of the embryo, the relative weight of the skull, which comprises a considerable fraction of the total weight of the skeleton of the embryos of the bottlenose dolphins, decreases from 44% in the 4-5 month foetus to 31% in the 11-12 month foetus, i.e. just before birth. The largest part of the skeleton consists of the vertebral column, the relative weight of which increases from 38 to 53%.

The data characterizing the relative weight of the ribs with the sternum, and also of the girdle and free anterior limbs, did not display a change with age. It was found that these parts of the skeleton were about the same in the bottlenose dolphin embryos of different ages.

The relative amount of cartilage decreases with the growth of the embryo. This decrease is manifested most strikingly when the weight of the cartilage is expressed as a percentage of the weight of the skeleton. While in the 4-5 embryo weighing 4 kg 55% of the skeleton consists of cartilage, just before birth in an embryo weighing 15.0 kg the cartilage fraction comprises only 29%, which values are correspondingly equivalent to 4.2 and 2.8% of the body weight (Table 5).

The bone marrow of the embryos of the bottlenose dolphin consists of the active red fraction. In step with the growth, the total weight of the bone marrow in the skeleton of the embryos of the bottlenose dolphin increases in both absolute and relative terms: the weight of the bone marrow of the 4-5 month embryo comprises 1.7%, while in the embryo in the last stages of intrauterine development it comprises 4.6% of the body weight (Table 6).
Table 5.
The relative weight of sections of the skeleton of embryos of the bottlenose dolphin, as % of the total weight of the skeleton.

<table>
<thead>
<tr>
<th>A</th>
<th>Б</th>
<th>С</th>
<th>D</th>
<th>Е</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Общий вес тела, кг</td>
<td>Пол</td>
<td>Длина тела, см</td>
<td>Возраст, месяцы</td>
<td>Вес скелета, % от веса тела</td>
<td>Вес черепа, % от веса скелета</td>
<td>Вес ребер и грудных позвонков</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
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<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>0,184</td>
<td>самка</td>
<td>21,5</td>
<td>3—4</td>
<td>6,8</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>4,0</td>
<td>самка</td>
<td>65</td>
<td>4—5</td>
<td>7,3</td>
<td>4,2</td>
<td>55,2</td>
</tr>
<tr>
<td>7,0</td>
<td>самка</td>
<td>95</td>
<td>5—6</td>
<td>9,1</td>
<td>4,3</td>
<td>47,5</td>
</tr>
<tr>
<td>11,0</td>
<td>самец</td>
<td>96</td>
<td>5—6</td>
<td>9,8</td>
<td>3,2</td>
<td>31,4</td>
</tr>
<tr>
<td>12,0</td>
<td>самка</td>
<td>110</td>
<td>11—12</td>
<td>10,4</td>
<td>3,5</td>
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</tr>
<tr>
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<td>самка</td>
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<td>около 12</td>
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<td>2,8</td>
<td>28,8</td>
</tr>
<tr>
<td>16,5</td>
<td>самец</td>
<td>114</td>
<td>11—12</td>
<td>10,2</td>
<td>3,2</td>
<td>31,4</td>
</tr>
</tbody>
</table>

A. — Total weight of body, kg
B. — Sex
C. — Length of body, cm
D. — Age, months
E. — Weight of skeleton, as % of body weight
F. — Weight of cartilage, as % of weight of:
   a - body
   b - skeleton
G. — Weight of sections of the skeleton, kg
   w - skull
   x - ribs and sternum
   y - vertebral column
   z - pectoral girdle and fore limbs.

f - female
m - male

1 Translator's note. Sic. Should be %.
Table 6.

The relative weight of the bone marrow of embryos of the bottlenose dolphin in various sections of the skeleton, as % of the total weight of the bone marrow.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
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<tbody>
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<td>Нов</td>
<td>Длина тела, см</td>
<td>В возраст, месяцев</td>
<td>Общий вес костного мозга, % от веса тела</td>
<td>Вес костного мозга в скелете, кг</td>
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<td>-------------------</td>
<td>---------------------------------------------</td>
<td>---------------------------------</td>
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<td>31,8</td>
</tr>
<tr>
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<td>120</td>
<td>Около 12</td>
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<td>26,4</td>
</tr>
<tr>
<td>16,5</td>
<td>САМЕЦ</td>
<td>114</td>
<td>11-12</td>
<td>4,6</td>
<td>26,1</td>
</tr>
</tbody>
</table>

A. - Total weight of body, kg
B. - Sex
C. - Length of body, cm
D. - Age, months
E. - Total weight of bone marrow, as % of body weight
F. - Weight of bone marrow in the skeleton, kg

w - skull
x - ribs and sternum
y - vertebral column
z - pectoral girdle and fore limbs
f - female
m - male

1 Translator's note. Sic. Should be %.
Table 7.

The relative weight of sections of the skeleton of embryos of the common dolphin, as % of the total weight of the skeleton

<table>
<thead>
<tr>
<th>A. Общий вес тела, кг</th>
<th>B. Пол</th>
<th>C. Длина тела, см</th>
<th>D. Возраст, месяцы</th>
<th>E. Вес скелета, % от веса тела</th>
<th>F. Вес хрящей, % от веса тела</th>
<th>G. Вес отделов скелета, кг</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,65</td>
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<td>7-8</td>
<td>9,4</td>
<td>40,0</td>
<td>42,7</td>
</tr>
<tr>
<td>3,00</td>
<td>самец</td>
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<td>7-8</td>
<td>8,5</td>
<td>42,9</td>
<td>47,4</td>
</tr>
<tr>
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<td>самец</td>
<td>72</td>
<td>7-8</td>
<td>9,6</td>
<td>47,5</td>
<td>52,5</td>
</tr>
<tr>
<td>4,20</td>
<td>самец</td>
<td>72</td>
<td>8-9</td>
<td>8,5</td>
<td>33,8</td>
<td>6,0</td>
</tr>
<tr>
<td>4,90</td>
<td>самка</td>
<td>81</td>
<td>8-9</td>
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<td>41,4</td>
<td>6,0</td>
</tr>
<tr>
<td>5,30</td>
<td>самка</td>
<td>84</td>
<td>около 10</td>
<td>10,2</td>
<td>27,3</td>
<td>5,4</td>
</tr>
<tr>
<td>5,60</td>
<td>самка</td>
<td>83</td>
<td>9-10</td>
<td>9,6</td>
<td>26,7</td>
<td>5,5</td>
</tr>
<tr>
<td>6,00</td>
<td>самка</td>
<td>81</td>
<td>9-10</td>
<td>8,3</td>
<td>41,2</td>
<td>6,4</td>
</tr>
<tr>
<td>6,30</td>
<td>самка</td>
<td>90</td>
<td>10</td>
<td>11,2</td>
<td>40,1</td>
<td>4,9</td>
</tr>
<tr>
<td>7,00</td>
<td>самец</td>
<td>84</td>
<td>9-10</td>
<td>8,7</td>
<td>34,5</td>
<td>7,1</td>
</tr>
</tbody>
</table>

A. - Total weight of body, kg
B. - Sex
C. - Length of body, cm
D. - Age, months
E. - Weight of skeleton, as % of body weight
F. - Weight of cartilage, as % of weight of:
   a - body
   b - skeleton
G. - Weight of sections of skeleton, kg:
   w - skull
   x - ribs and sternum
   y - vertebral column
   z - pectoral girdle and anterior limbs.

1 Translator's note. Sic. Should be %.
By the 4-5th month of intra-uterine life about 50% of all of the bone marrow of the bottlenose dolphin embryos is concentrated in the bones of the skull, but towards the end of intra-uterine development the greater part of the bone marrow, comprising about 60%, is localized in the vertebral column.

The weight of the skeleton of the embryos of the common dolphin in the second half of their intra-uterine development comprises, on average, 9.4% of the body weight. As the embryo grows there is found the same pattern of change of the relative weight of the different parts of the skeleton and of the cartilage, as occurs in the embryos of the bottlenose dolphin. Thus, with the growth of the embryo there can be traced a tendency towards a decrease in the fraction of the cartilage in the skeleton: from 4.6 to 2.8% of the body weight or from 47.5 to 26.7% of the weight of the skeleton (Table 7). In a manner similar to that in the bottlenose dolphin embryos, there is manifested a pattern of change with age of the growth of the skull, the weight of which decreases from 46 to 28% of the weight of the whole skeleton with the increase in the size of the embryo. In contrast to the development of the skull, in step with the growth of the embryo there occurs an increase in the weight of the bones of the vertebral column from 42 to 59% of the weight of the skeleton. Age fluctuations of the remaining bones of the skeleton are insignificant. The weight of the bone marrow of the embryos comprises, on average, 3% of the body weight (Table 8). On examining the data on the distribution of the bone marrow in the different sections of the skeleton of the embryos there is found a tendency towards
decreasing the amount of this in the bones of the skull (from 55 to 25% of the total weight of the bone marrow) and an increase in the vertebral column (from 32 to 61%). A similar pattern is found in the embryos of the bottlenose dolphin. Unfortunately, the absence of material on embryos in the first months of intra-uterine development, when there occurs the formation of the bone marrow as a center of the synthesis of haemoglobin, does not give us the opportunity of characterizing this. However in the second half of the embryonic development there is found only a gradual build-up in the mass of the haematopoietic tissue, which to a considerable degree depends on the individual characteristics of the developing organism.

On the whole, the distribution of the bone marrow in the skeleton of the embryos proceeds in such a manner that the largest amount of this is localized in the vertebral column - about 50%, then in the skull - about 35%, in the bones of the fore limbs - about 9%, and in the ribs and sternum - about 6% of the weight of all of the bone marrow.

In the 5 - 8 month embryos of the common porpoise the average weight of the skeleton, of which half is composed of cartilage (53% of the weight of the skeleton), is equal to 8.4% of the body weight (Table 9). We note that the weight of the cartilage in the skeleton of the adult common porpoises comprises, on average, only 4.4% of the weight of the skeleton. In the embryos of this age the relative weight of the skull and of the vertebral column is about the same (42 and 44% correspondingly). In the embryo just prior to birth the weight of the skull skeleton decreases to 31%, while the weight of the vertebral column, conversely, increases to 54% of the
Table 8.

The relative weight of the bone marrow of embryos of the common dolphin in in various sections of the skeleton, as % of the total weight of the bone marrow.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Общий вес тела, кг</td>
<td>Половой пол</td>
<td>Длина тела, см</td>
<td>Возраст, месяцы</td>
<td>Общий вес костного мозга, % от веса тела</td>
<td>Вес костного мозга в скелете, кг</td>
</tr>
<tr>
<td>2,65</td>
<td>самка</td>
<td>66</td>
<td>7—8</td>
<td>3,2</td>
<td>40,2</td>
</tr>
<tr>
<td>3,00</td>
<td>самка</td>
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<td>7—8</td>
<td>2,2</td>
<td>54,6</td>
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<tr>
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<td>7—8</td>
<td>2,9</td>
<td>40,4</td>
</tr>
<tr>
<td>4,20</td>
<td>самец</td>
<td>72</td>
<td>8—9</td>
<td>2,5</td>
<td>33,5</td>
</tr>
<tr>
<td>4,90</td>
<td>самка</td>
<td>81</td>
<td>8—9</td>
<td>2,7</td>
<td>33,9</td>
</tr>
<tr>
<td>5,30</td>
<td>самка</td>
<td>84</td>
<td>около 10</td>
<td>3,8</td>
<td>28,1</td>
</tr>
<tr>
<td>6,00</td>
<td>самка</td>
<td>83</td>
<td>9—10</td>
<td>3,9</td>
<td>20,3</td>
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<tr>
<td>6,30</td>
<td>самка</td>
<td>81</td>
<td>9—10</td>
<td>2,5</td>
<td>34,4</td>
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<td>7,00</td>
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<td>90</td>
<td>10</td>
<td>3,6</td>
<td>27,5</td>
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<tr>
<td>7,00</td>
<td>самка</td>
<td>84</td>
<td>9—10</td>
<td>2,7</td>
<td>27,9</td>
</tr>
</tbody>
</table>

A. - Total weight of body, kg
B. - Sex
C. - Length of body, cm
D. - Age, months
E. - Total weight of bone marrow, as % of body weight
F. - Weight of bone marrow in the skeleton, kg

w - skull
x - ribs and sternum
y - vertebral column
z - pectoral girdle and fore limbs
f - female
m - male

* about 10

1 Translator's note. Sic. Should be %.
Table 9.
The relative weight of parts of the skeleton of embryos of the common porpoise, as % of the total weight of the skeleton.

<table>
<thead>
<tr>
<th>A</th>
<th>В.</th>
<th>С</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
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<tr>
<td>Общ. вес тела, кг</td>
<td>Пол</td>
<td>Длина тела, см</td>
<td>Возраст, месяцы</td>
<td>Вес скелета, % от веса тела</td>
<td>Вес черепа, % от веса тела</td>
<td>Вес головы, груди, позвоночника, %</td>
</tr>
<tr>
<td>0,884</td>
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<td>42</td>
<td>5-6</td>
<td>8,1</td>
<td>4,3</td>
<td>53,0</td>
</tr>
<tr>
<td>1,290</td>
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<td>48</td>
<td>5-6</td>
<td>8,5</td>
<td>4,6</td>
<td>53,5</td>
</tr>
<tr>
<td>1,392</td>
<td>самка</td>
<td>49</td>
<td>6-7</td>
<td>8,8</td>
<td>4,7</td>
<td>53,2</td>
</tr>
<tr>
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<td>46</td>
<td>5-6</td>
<td>8,4</td>
<td>4,3</td>
<td>50,9</td>
</tr>
<tr>
<td>1,508</td>
<td>самка</td>
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<td>6-7</td>
<td>8,5</td>
<td>4,5</td>
<td>53,4</td>
</tr>
<tr>
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<td>6-7</td>
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<td>4,3</td>
<td>53,7</td>
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<tr>
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<td>4,4</td>
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<td>самец</td>
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<td>6-7</td>
<td>7,8</td>
<td>4,1</td>
<td>52,8</td>
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<tr>
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<td>7,7</td>
<td>4,2</td>
<td>54,6</td>
<td>40,7</td>
</tr>
<tr>
<td>1,906</td>
<td>самец</td>
<td>57</td>
<td>7-8</td>
<td>9,5</td>
<td>5,1</td>
<td>53,0</td>
</tr>
<tr>
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<td>самка</td>
<td>70</td>
<td>9-10</td>
<td>9,9</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

A. - Total weight of body, kg
B. - Sex
C. - Length of body, cm
D. - Age, months
E. - Weight of skeleton, % of body weight
F. - Weight of cartilage, % of weight of:
a - body
b - skeleton
G. - Weight of sections of the skeleton, kg
v - skull
w - ribs
x - sternum
y - vertebral column
z - limbs
f - female
m - male
Table 10.

The relative weight of the red bone marrow of the embryos of the common porpoise in various sections of the skeleton, as % of the total weight of the bone marrow.

| A | Общая масса, кг | B | Пол | C | Длина тела, см | D | Возраст, месяцы | E | Общий вес костного мозга, % от массы тела | F | Вес костного мозга в скелете, кг | G | Табл. | H | H | I | H |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.884 | самка | 42 | 5-6 | 2.3 | 59.2 | 8.6 | 0.2 | 26.1 | 6.0 | 0.2 | | | | |
| 1.290 | самец | 43 | 5-6 | 2.7 | 54.0 | 10.8 | 0.3 | 26.9 | 7.0 | 0.1 | | | | |
| 1.392 | самец | 49 | 6-7 | 2.9 | 52.2 | 9.3 | 0.4 | 29.5 | 7.7 | 0.1 | | | | |
| 1.485 | самка | 46 | 5-6 | 2.6 | 55.9 | 4.6 | 0.2 | 29.1 | 10.3 | 0.1 | | | | |
| 1.508 | самка | 48 | 6-7 | 2.7 | 54.8 | 8.1 | 0.02 | 31.5 | 5.5 | 0.1 | | | | |
| 1.528 | самец | 48 | 6-7 | 2.4 | 55.3 | 9.1 | 0.3 | 27.3 | 7.8 | 0.2 | | | | |
| 1.647 | самка | 47 | 6-7 | 2.6 | 54.7 | 10.0 | 0.5 | 26.7 | 8.0 | 0.1 | | | | |
| 1.652 | самец | 50 | 6-7 | 2.7 | 54.7 | 6.9 | 1.4 | 29.4 | 7.2 | 0.3 | | | | |
| 1.833 | самец | 51 | 6-7 | 2.4 | 56.7 | 8.4 | 0.3 | 27.1 | 7.2 | 0.3 | | | | |
| 1.847 | самка | 52 | 7 | 2.6 | 50.4 | 11.1 | 0.4 | 28.3 | 9.7 | 0.1 | | | | |
| 1.906 | самец | 57 | 7-8 | 3.2 | 57.1 | 6.7 | 0.3 | 29.0 | 6.6 | 0.3 | | | | |

A. - Total weight of body, kg
B. - Sex
C. - Length of body, cm
D. - Age, months
E. - Total weight of bone marrow, as % of body weight
F. - Weight of bone marrow in the skeleton, kg
v - skull
w - ribs
x - sternum
y - vertebral column
z - limbs
1 - fore, 2 - hind
f - female
m - male
weight of the skeleton. The relative weight of the ribs and sternum of the 5 - 8 month embryos comprises about 7% of the weight of the skeleton, approximately equally divided between the bones of the girdle and of the free fore limbs. The smallest fraction in the skeleton is taken up by the rudimentary bones of the hind limbs (averaging 0.1% of the weight of the skeleton).

The amount of the bone marrow in the embryos ranges from 2.3 to 3.2% of the body weight (Table 10). With the growth of the embryo the fraction of the bone marrow in the skeleton becomes gradually greater, probably mainly on account of the development of haematopoietic tissue in the vertebral column, where there occurs a gradual displacement of the cartilage by the bone tissue. In the embryos the main part of the bone marrow is localized in the bones of the skull (about 60%). Half as much of the bone marrow is contained in the bones of the vertebral column. On average, 8% of the bone marrow is contained in the ribs; in the sternum, represented by a cartilaginous plate with a few centres of ossification, in which there is also found haematopoietic tissue, is located 0.4% of the total bone marrow. In the skeleton of the girdle and free fore limbs of the embryos there is concentrated about 8% of the bone marrow, while in the pelvic bones there is found about 0.2% of its total weight.

In generalizing the materials on the weight of the skeleton and of the bone marrow in the various bones of the dolphins there are manifested several common patterns. During the process of the intra-uterine development of the embryo
the cartilaginous skeleton is replaced by the bony skeleton. The process of the replacement of the cartilage by the bone occurs especially intensively in the second half of the intrauterine development. While during the first phase of development the skull occupies the largest part of the skeleton of the embryo, during the following stages it is the bones of the vertebral column which become dominant. The bones of the skull are almost definitively formed towards the time of birth. Thus, the weight of the skull of the embryos and adults of the white-sided dolphin is the same (approximately 28% of the weight of the skeleton). In the vertebral column the cartilage is almost completely displaced only in the sexually mature individuals. With the development of the embryo the amount of bone marrow increases in both absolute and relative terms, and at the same time its relative amount decreases in the skull, while it increases in the vertebral column. According to the data of Z. I. Brodovskaya (1964), in dolphins during the embryonic period there is found an intensive haematogenesis in the sternum and the bones of the flippers, which continues on also in the adult animals. According to our data, during the process of the development of the embryos there does not occur any marked increase in the relative weight of the bone marrow in the flippers and sternum (see Tables 6, 8 and 9), although in the adult animals the amount of bone marrow in these sections of the skeleton is somewhat increased (see Tables 3 and 4). The fluctuations which are present in the weight of the bone marrow of these structures in the sexually mature individuals probably, in the main, reflect individual variability.
The haematopoietic capabilities of newly born dolphins may be judged only by indirect data. Thus, in the adult common porpoise the amount of bone marrow comprises 2.0%, while in the 6 - 8 month old embryo this is higher - 2.7% of the body weight. In the adults of the common dolphin the weight of the bone marrow comprises 1.9%, while in their 9 - 10 month old embryos (almost just prior to birth) the bone marrow comprises 3.0% of the body weight. Proceeding from these data it may be concluded that in the newly born dolphins the amount of bone marrow is one and a half to two times greater than in the adult individuals. Between the weight of the skeleton of the newly born and adult dolphins there is found this same relationship. The study of the skeleton and bone marrow of terrestrial mammals showed that the relative weight of the skeleton and bone marrow of the newly born individuals is also approximately twice as great as the corresponding values of the adult animals (P. A. Korzhuev, 1964; A. M. Evstratova, 1965, and others).

During the period of intra-uterine development the embryo finds itself in conditions of a relative physiological hypoxia, the reaction to which is an intensification of haematogenesis on account of the increase in the mass of the bone marrow and also of its productivity. In the aquatic mammals during the embryonic period the intensification of haematogenesis obviously proceeds to a greater degree along the path of an increase in the productivity of the bone marrow, while in the terrestrial mammals this occurs along the path of an increase in its mass.
A basic feature of the adult Black Sea dolphins, as compared to non-diving mammals that lead an active way of life, is the smaller weight of their skeleton and bone marrow. Thus, while the weight of the skeleton of the dolphins is as much as 6.5% and the weight of the bone marrow - 2% of the body weight, in the dog (P. A. Korzhuev et al., 1968) these values are correspondingly equal to 10.5 and 3.3%, and in the reindeer, according to the data of P. A. Korzhuev and I. S. Nikol'skaya (1960), correspondingly 10.9 and 4.8% of the body weight.

In spite of the decreased weight of the skeleton and bone marrow of the Black Sea dolphins, their haematopoietic productivity is fairly high, which may be judged by the supply of haemoglobin to the organism. The haemoglobin supply of the common dolphin (13 g haemoglobin per 1 kg body weight) is almost twice as great as the haemoglobin supply to the organism of the guinea pig (*Cavia porcellus*), which, according to our data, has a bone marrow weight equalling the weight of the bone marrow of the common dolphin, and a little greater than the haemoglobin supply to the organism of the dog (11.9 g per 1 kg body weight).

The noted features of the quantitative characteristics of the main haematopoietic organ of the Black Sea dolphins are related to the shutting-off of the breathing for some period or other during diving, and also to the life in a high density medium, in which, in contrast to the terrestrial environment, the load on the body is evenly distributed.
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The specific characteristics of the way of life of the cetaceans and those data which we possess, concerning the unusually wide frequency spectrum utilized by these animals for echo-location and communication purposes, makes the study of their organs of hearing a very pressing question.

Up to the present time many experimental studies have been conducted on the capabilities of the cetaceans for perceiving sounds, but insufficient attention has been paid to the fine morphological structure of their organs of hearing. For the elucidation of the functional possibilities of the organ of hearing of the cetaceans, the detailed examination of the morphology and histology of this organ presents considerable interest.

The organ of hearing of the terrestrial mammals has been studied in detail by both Soviet as well as foreign investigators (Vinnikov and Titova, 1961). Some data are available on the anatomy and histology of the outer, middle and inner ear of cetaceans. However the histological structure of Corti's organ has not been studied in detail.
MATERIALS AND METHODS

The investigations were carried out on 5 white-sided dolphins and 5 bottlenose dolphins.

The external and internal ear was studied histologically and anatomically. The material was fixed in 10% formalin and embedded in celloidin according to the usual method. The bullae tympani were collected immediately after the death of the animal and were fixed in Vitmaak's fixative for 3 weeks, they were then decalcified and embedded in celloidin. Section thickness 15μ. Staining with haematoxylin-eosin.

EXTERNAL AUDITORY MEATUS

It is known that many investigators (Hunter, 1787; Purie, 1873; Zille, 1915; Jamada, 1953; Fraser and Purves, 1960; Reysenbach de Haan, 1957; Purves, 1955; Purves and Utrecht, 1964), concerned themselves with the study of the structure of the external auditory meatus in both the Mystacoceti (Balaenoptera acutorostrata, B. musculus, B. physalus, Megaptera nodosa) as well as in the Odontoceti (Hlobicephalus melas, Physeter catodon, Phocaena phocaena, Tursiops truncatus). We have not found any studies in the Russian literature on the structure of the external auditory meatus in the white-sided dolphin and the bottlenose dolphin.

The external auditory meatus in the cetaceans starts with a very small opening behind the eyes. Further on it is represented by a winding duct. Its inner end, which abuts onto the middle ear, is tightly closed by the tympanic membrane-ligament, which separates the outer ear from the middle ear.
The whole of the external auditory meatus was divided into 5 sequential sectors (from the periphery to the center), the preparations of which were serially prepared.

In sector 1 (Figure 1) the external auditory meatus in the white-sided dolphin and the bottlenose dolphin is represented in the form of a very narrow slit. In sector 2 the dimensions and form of the external auditory meatus change markedly. The thickness of the wall increases considerably, and at the same time the auditory meatus itself is completely obliterated. The lumen of the auditory meatus appears at the very end of this sector (Figures 2 and 3). In sector 3 the lumen of the external auditory meatus acquires an oval form with protrusions (Figure 4). The wall of the auditory duct,
Figure 2. Sector II of the external auditory meatus.

2a - connective-tissue obliteration of the proximal part of the auditory duct,
2b - dense unformed connective tissue,
2v - muscle bundles.

in comparison with the preceding sector, becomes thinner. In sector 4 the auditory meatus has an oval form with a considerably enlarged lumen, in comparison with the preceding sector (Figure 5). The thickness of the walls of the auditory duct becomes uniform. And, finally, in sector 5 the external auditory meatus differs but little in its form from the preceding sector, though its dimensions are enlarged (Figure 6).
Figure 3. Terminal portion of sector II of the external auditory meatus.

3a - appearance of lumen in auditory meatus, 3b - secretory glands, surrounding auditory duct.

In the preparations of sector I the external auditory meatus is surrounded by numerous dermal papillae, between which, within the epidermal cells, melanin is located in the form of grains and granules.

In sectors 2, 3, 4 and 5 the inner wall of the auditory meatus is surrounded in an annular manner by a layer of dense connective tissue. In sectors 2 and 3 between the bundles of connective tissue are situated protein glands and individual fat cells.
Figure 4. Sector III of the external auditory meatus.
4a - oval form of auditory duct with finger-like protrusions,
4b - secretory glands.

In the dense connective tissue there are found almost undifferentiated cells: fibroblasts and histiocytes. States of mitosis and amitosis of the cells were found. Lying adjacent to the layer of dense connective tissue are muscle bundles (m. zygomatico auricularis and occipiti auricularis), which extend along the auditory duct and have a varying thickness. Between the individual muscle bundles and also between the cartilage and the inner wall of the auditory duct is situated loose connective tissue, including bundles of collagen fibres and separate elastic fibres.
Figure 5. Sector IV of the external auditory meatus.

5a - oval form of the auditory meatus,
5b - fat cells.

Directly around the auditory duct there are situated many blood vessels and blood lacunae, filled with blood.

Commencing from sector 3, cartilage adjoins the external auditory meatus. Initially it appears on one side of the auditory duct. Then it lies adjacent to the two narrower sides of the auditory duct, in the form of two caps. Further on there is traced the fusion of the two separate cartilages of the preceding section, and already in sector 5 the cartilage acquires a horseshoe-shaped form, surrounding the auditory duct on 3 sides. The cartilage forms a tube which joins up
Figure 6. Sector of external auditory meatus.

6a - blood vessel,
6b - blood lacuna,
6v - dense unformed connective tissue,
6g - elastic cartilage.

into the bulla tympani. By comparing the dimensions of the external auditory ducts of the two species of dolphins under consideration, by individual sectors, it can be ascertained that these vary only insignificantly.

Thus, the external auditory meatus runs like a pigmented tube surrounded by fibrous tissue. After passing through the fat layer the auditory duct enters a cone-shaped mass of fibrous tissue, which is considered as being connected with
the auricular muscles and the distal end of the auricular cartilage (Purves and Utrecht, 1964).

INNER EAR

On investigating the inner ear of the dolphins it was noted that, macromorphologically, the cochlea of the dolphins was distinguishable from that of terrestrial mammals (for example, of the guinea pig).

The cochlea of the dolphins is flat and completes 1.5 spiral turns, while in the guinea pig it is pyramidal and completes 4.5 turns (Figure 7).

As in the terrestrial mammals (Ya. A. Vinnikov and L. K. Titova, 1961), the cochlear canal is divided by Reissner's membrane into the two scalae, the upper one of which passes to the apex of the cochlea, while the lower scala, running from the apex, terminates at the round window.

The upper scala is divided by Reissner's membrane into two unequal cavities, the smaller of which is the scala media. Within the scala media on the vestibular surface of the basilar membrane is located the organ of Corti. From the inside closely abutting to the organ of Corti is the spiral lip, which passes into the internal spiral notch. The spiral lip is formed of flat epithelium, which in the dolphins, as in terrestrial mammals, is arranged in parallel rows. The cells of the epithelium are large, with large nuclei, and are disposed along the radius of the cochlea.

The cells of the spiral notch pass into the supporting elements for the inner hair cells. At the point of termination of the internal spiral notch are disposed the border cells, which form two rows.
Figure 7. External appearance of the cochlea of the white-sided dolphin.

The receptor elements of the organ of Corti are the outer (NVK) (Figure 8) and inner hair cells (VVK) (Figure 9). These cells differ in their structure. The inner hair cells are arranged in a single row and have a jug-shaped form. The large nucleus is situated at the base of the cell. They are situated alongside the apices of the outer pillar cells.

In contrast to these, the outer hair cells are arranged in three rows and have a cylindrical form. At their base is located the round nucleus, which has a granular structure. The cytoplasm is granulated.
Figure 8. The organ of Corti. Outer hair cells (haematoxylin - eosin, 90 x 7).

The supporting cells are represented by the outer and inner pillar cells of the organ of Corti, which are located on the basilar membrane. Between the supporting pillar cells is located the tunnel and space of Nuel.

There can be clearly traced the inner border cells, beyond which follows one row of the inner phalangeal cells, which are situated between two inner hair cells, separating one from another. Between the inner pillar cells and the border cells, in the cavity, are arranged the inner hair cells. Lying adjacent to the inner pillar cells are the cells of Deiters. With their bases they lie on the basilar membrane and have a polygonal form with a large nucleus, situated in the basal part of the cell.
Next follow the cells of Hensen, which lie very closely adjacent to the cells of Deiters. The cells of Hensen are situated with their basal ends on the basilar membrane. The apices of the cells are directed towards the outer hair cells. They are large, with large nuclei. Beyond the cells of Hensen are situated the cells of Claudius, which are represented by short polygonal cells with very distinct intercellular borders. Their cytoplasm contains a nucleus with nucleoli. The basilar membrane, on which lie the elements of the organ of Corti, is clearly traceable. Distinctly evident are the parallelly arranged fibres, which are located at a uniform distance from one another.
Thus, the analysis of these data makes it possible to assume that, in contrast to the clearly observed macro-morphological differences, there were not found any notable histological differences in the structure of the cochlea in the dolphins, in comparison with terrestrial mammals (guinea pig).

CONCLUSIONS

In the study of the external auditory meatus we attempted to elucidate the question of its obliteration in a particular sector. Some investigators consider that, along its entire length, the auditory duct in the toothed whales runs in the form of an open tube (Fraser and Purves, 1960; Reysenbach de Haan, 1957), while the studies of other authors indicate that the external auditory meatus is a tube with a lumen that is obliterated in some sector (Jamada, 1953).

Our data confirm the data of Jamada. The results of the anatomical and histological studies showed that in the white-sided dolphin and the bottlenose dolphin at a distance of two centimeters from the surface of the skin there occurs an obliteration of the auditory duct with connective tissue, and this comprises approximately one twentieth of its length (see Figure 2).

The obliteration of the auditory duct is of important significance in the treatment of the mechanism of sound conduction. The complete obliteration in the dolphins cannot worsen the conduction of the signals to the middle ear in the water medium and serves, mainly, to prevent water entering the ear.
The funnel-shaped auditory duct of the dolphins, which is completely isolated from the medium, confirms the position that they make use of another (as compared to the terrestrial mammals) pathway for conducting the acoustic signals to the middle ear.

On account of the "acoustic transparency" of the fat layer of the hypodermis, the signals from the water penetrate, with minimal losses, through the integument and, reaching the cavity of the auditory duct, they move along this to the middle ear.

As to the studies of the inner ear, there are all grounds for assuming that in its anatomical structure the cochlea of dolphins is well adapted for the perception of ultra-sounds. This is indicated by the presence of the lower loop of the cochlea, since, according to the existing electrophysiological studies conducted on terrestrial mammals (Altukhov, 1949; Andreev, 1940; Bekesy, 1954; Davis, 1957, and others), the shorter fibres lying at the base of the cochlea perceive the high frequencies, while the longer fibres located in the apex of the cochlea perceive the low frequencies.

ЛИТЕРАТУРА

2 Андреев Л. А. О некоторых новых данных, характеризующих деятельность звукового анализатора. 7-е совещание по пробл. высш. нерв. деятель. нов. наук. Полн. Тезисы докладов. М.-Л., 1940.
REFERENCES

1. Altukhov, G. V. Conditioned reflex activity of the dog with experimental injury to the peripheral section of the auditory analyzer. "Problemy fiziologicheskoj akustiki" (Problems of physiological acoustics), vol. 1, 1949.


The study of the pinnipeds in the Tatar Strait was initiated by S. V. Dorofeev (1935), who established that the harbour seal, ringed seal, bearded seal and ribbon seal are encountered here in the spring. The predominant species in the Strait is the harbour seal and it comprises about 80% of the catch of the hunting of the coastal inhabitants. The remaining species are not very numerous. The approximate periods of whelping of the harbour seal, ringed seal and bearded seal, and the period of moulting in the harbour seal were established.

Later, P. G. Nikulin (1935) and E. A. Tikhomirov (1956) placed the Tatar Strait in the category of unpromising regions for commercial hunting.

These conclusions were made at a time when the seals were caught for the sake of obtaining the fat. Now, however, considerable attention is given to procuring fur skins. Therefore our attitude to the Tatar Strait as a commercially exploitable region should be re-examined. In an aero-visual survey of seals, which was conducted by the Pacific Ocean Research Institute of Fisheries and Oceanography (TINRO) in 1968 (Fedoseev and others, 1968), a fairly large accumulation of harbour seals was noted in the Tatar Strait. The study of the harbour seal population that is living here, which has not been affected by ship-based sealing operations, is of both purely scientific as well as applied interest.
From March 14 until April 7 of 1969 co-workers of the TINRO on the sealing ship "Sanzar" carried out field studies in the Tatar Strait. Included in the purpose of the cruise was the study of the distribution and biology of the seals, and also the elucidation of the feasibility of commercial exploitation of the animals. The exploratory transects covered the region of the strait from 48 to 50° lat. N. The collected materials were treated by the methods accepted at the TINRO (Smirnov, 1934; Rokitskii, 1961; Chapskii 1963, 1967; Yablokov, 1963, 1966; Tikhomirov and Kleveza1', 1964; Sokolov et al., 1966). Some of the materials on the harbour seal of the Sea of Okhotsk were passed on by us to A. V. Yablokov. In addition to the authors, A. I. Gorshkova participated in the collection and analysis of the materials.

Many authors have devoted studies to the description of the harbour seal, and yet the overall morphological characterization of this seal is far from being complete. What has been said applies to the same degree also to the harbour seal population, living in the Tatar Strait.

Coloration of the hair coat. Earlier (Kosygin and Tikhomirov, 1969) in describing the harbour seal or mottled seal (Phoca largha) its coloration was grouped into 4 types: light-coloured, slight mottling, very large mottling and typical.

In the 64 harbour seals that were examined from the Tatar Strait, the typical coloration predominated (60%); standing in second place was the slight mottling (33%); 6 animals had the very large mottling, and 1 was lightly coloured. The colouration of the harbour seals is similar to that described
by S. P. Naumov and N. A. Smirnov (1935), S. I. Ognev (1935) and K. K. Chapskii (1963, 1966) on the basis of individuals from other parts of the species range. Among all of the whitecoats of the harbour seal that were found in the Tatar Strait only two pups were encountered that had the smoky coloration, characteristic of the young of this species of seal from the Bay of Peter the Great.

**Length and weight of body.** The average length of the body \( (Z_c) \) of the harbour seal, living in the Sea of Okhotsk, is 165.3 cm in the males and 151.6 cm in the females (Pikharev, 1941). There are available measurements of \( Z_c \) on the harbour seal from the Tatar Strait on individual animals (Gagichko and Surzhin, 1935) from an autumn catch, which have not been included with our data, because of the small numbers. According to our data, the seals of this species from the Tatar Strait are larger than those from the Sea of Okhotsk: the body length \( (Z_c) \) of the males and of the females was, correspondingly, 169.0 and 167.7 cm. On the basis of this feature they differ little from the harbour seal of the Bay of Peter the Great (Sea of Japan) and are significantly larger than the females of the Bering Sea, Kuril and Sea of Okhotsk populations (Table 1). There are also significant differences between the males. The average length of the body of the whitecoats is 101 - 103 cm. On the basis of the total weight of the body (Table 2) and the weight of the carcass without the skin and the fat (sculp) the sexually mature harbour seals from the Tatar Strait are smaller than the individuals from the Bay of Peter the Great. The weight of the whitecoats is the same
as in the Bering Sea. The weight of the sculp of the harbour seals of the Tatar Strait ranges from 24 to 43 kg, averaging 36.5 kg, in the adult males, and from 22 - 56 kg, with an average of 35.1 kg, in the females. The relative weight of the sculp comprised 31.40%* (averaging 37%) in the males and 29-49% (averaging 39.6%) in the females. In the harbour seals from the Bay of Peter the Great during the whelping period this equalled 43.3% in the males and 43.2% in the females.

Meristic features. Many authors (Yablokov, 1963; Yablokov and Klevezal', 1964; Yablokov, 1966; Chapskii, 1967; Sokolov et al., 1968; Kosygin and Tikhomirov, 1969) employ the number of vibrissae, of tracheal rings and of ribs as a morphological feature.

The labial vibrissae of the harbour seal of the Tatar Strait are seated in 7 - 8 rows. The same number of these were counted in the harbour seal from the Sea of Okhotsk (Yablokov, in litt.). The number of vibrissae in the males ranges from 37 to 46, with an average of 43.2 ± 0.43; in the females - from 37 to 50, with an average of 42.7 ± 0.44. In comparison with the harbour seal of the Bay of Peter the Great, no great differences were found in their total numbers; on average, there were somewhat fewer vibrissae in both the males (t = 0.88) as well as the females (t = 0.36) of the former population.

In two females (a whitecoat and a sexually mature animal) there was found a null row, in which there were from 1 to 4 vibrissae on each side of the snout. Such an occurrence has

*Translator's note. Sic. Presumably this should be 31 - 40%.
Table 1.

The body length of sexually mature individuals (Zcv) and of whitecoats (Zc) of the harbour seal from different regions.

<table>
<thead>
<tr>
<th>Region</th>
<th>Sex</th>
<th>n</th>
<th>L (cm)</th>
<th>M ± t</th>
<th>σ</th>
<th>n</th>
<th>L (cm)</th>
<th>M ± t</th>
<th>σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tatar Strait</td>
<td>самец</td>
<td>8</td>
<td>94-111</td>
<td>101,2±1,91</td>
<td>5,65</td>
<td>-0,38</td>
<td>16</td>
<td>146-173</td>
<td>158,0±1,68</td>
</tr>
<tr>
<td></td>
<td>самка</td>
<td>7</td>
<td>87-114</td>
<td>102,7±3,41</td>
<td>9,25</td>
<td>35</td>
<td>145-179</td>
<td>157,7±13,2</td>
<td>7,81</td>
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<tr>
<td>Bay of Peter</td>
<td>самец</td>
<td>7</td>
<td>84-112</td>
<td>95,8±2,37</td>
<td>7,11</td>
<td>-0,03</td>
<td>3</td>
<td>152-168</td>
<td>159,3</td>
</tr>
<tr>
<td>the Great</td>
<td>самка</td>
<td>9</td>
<td>89-102</td>
<td>96,0±1,61</td>
<td>4,21</td>
<td>10</td>
<td>144-173</td>
<td>156,5±2,78</td>
<td>8,80</td>
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<tr>
<td>Bering Sea</td>
<td>самец</td>
<td>60</td>
<td>80-108</td>
<td>95,9±1,03</td>
<td>7,99</td>
<td>+0,18</td>
<td>12</td>
<td>128-170</td>
<td>148,5±4,14</td>
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<tr>
<td></td>
<td>самка</td>
<td>47</td>
<td>78-109</td>
<td>94,1±0,93</td>
<td>6,43</td>
<td>13</td>
<td>123-156</td>
<td>141,2±2,62</td>
<td>9,09</td>
</tr>
<tr>
<td>Kuril Islands*</td>
<td>самец</td>
<td>4</td>
<td>92-108</td>
<td>103,0</td>
<td>-</td>
<td>-</td>
<td>14</td>
<td>134-163</td>
<td>150,0±2,58</td>
</tr>
<tr>
<td></td>
<td>самка</td>
<td>4</td>
<td>83-110</td>
<td>103,7</td>
<td>-</td>
<td>6</td>
<td>135-154</td>
<td>145,5±0,89</td>
<td>2,19</td>
</tr>
<tr>
<td>Sea of Okhotsk**</td>
<td>самец</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>19</td>
<td>135-171</td>
<td>153,3±2,18</td>
</tr>
<tr>
<td></td>
<td>самка</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>16</td>
<td>134-155</td>
<td>142,1±1,52</td>
<td>6,07</td>
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</table>

** Males **

<table>
<thead>
<tr>
<th>Sex</th>
<th>f1 = 0,39</th>
<th>f1 = +5,81</th>
<th>f1 = +7,67</th>
</tr>
</thead>
</table>

** Females **

<table>
<thead>
<tr>
<th>Sex</th>
<th>f1 = 2,50</th>
<th>f1 = +1,70</th>
<th>f1 = +7,76</th>
</tr>
</thead>
</table>

m - male  
f - female
Table 2.

**Total body weight of the sexually mature individuals and whitecoats of the harbour seal, caught during the period of whelping in different regions, kg.**

<table>
<thead>
<tr>
<th>Region</th>
<th>Whitecoats*</th>
<th>Adults</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>11m</td>
<td>M±m</td>
<td>s</td>
</tr>
<tr>
<td>Tatar Strait</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samciy</td>
<td>8</td>
<td>13—30</td>
<td>19.4±1.78</td>
<td>5.04</td>
</tr>
<tr>
<td>Samka</td>
<td>7</td>
<td>11—31</td>
<td>22.6±2.70</td>
<td>7.34</td>
</tr>
<tr>
<td>Zaliz Petra</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samciy</td>
<td>9</td>
<td>8.0—27.0</td>
<td>12.9±1.96</td>
<td>5.89</td>
</tr>
<tr>
<td>Samka</td>
<td>7</td>
<td>9.4—23.0</td>
<td>14.7±2.19</td>
<td>5.80</td>
</tr>
<tr>
<td>Kuril Islands</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samciy</td>
<td>4</td>
<td>15.6—29.5</td>
<td>23.0</td>
<td>—</td>
</tr>
<tr>
<td>Samka</td>
<td>4</td>
<td>17.0—32.0</td>
<td>27.0</td>
<td>—</td>
</tr>
<tr>
<td>Bering Sea</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samciy</td>
<td>36</td>
<td>5.8—33.8</td>
<td>21.9±1.25</td>
<td>7.53</td>
</tr>
<tr>
<td>Samka</td>
<td>34</td>
<td>7.3—34.7</td>
<td>22.2±1.12</td>
<td>6.51</td>
</tr>
</tbody>
</table>

* Принадлежность возрастной группы (от рождения до одного месяца).  
* Young from birth to an age of about one month.

m - males  
f - females
not previously been noted in the harbour seal, either in the Bering Sea (Chapskii, 1967) or in the Bay of Peter the Great (Kosygin and Tikhomirov, 1969). Moreover, vibrissae were found in one sexually mature female on the lower jaw. They were distributed as in the bearded seal (Kosygin, 1968).

In the harbour seals of both the Tatar Strait and the Bay of Peter the Great there are 1 - 2 nasal vibrissae and 3 - 6 ocular vibrissae.

Between the males of the harbour seal from the Tatar Strait and from the Bay of Peter the Great, in the average numbers of labial vibrissae, there is found a significant difference in the first row \( t = 2.5 \) and a highly significant difference \( t = 3.33 \) in the fourth row. In the remaining cases no significant differences were noted, either in the total number of vibrissae or in the number of these in the different groups in the populations examined.

The trachea of the harbour seal from the Tatar Strait has no significant differences in its structure from that which has already been described by A. S. Sokolov et al. (1968). In 6 out of 28 individuals (21.4%) the rings situated around the bifurcation had a left overlap. In the harbour seals caught in the bay of Peter the Great (26 head), tracheae of a similar structure were present in 31% of the examined individuals.

59 - 76 rings were counted in the tracheae: in the males the average was \( 67.5 \pm 1.17 \), while in the females this was \( 63.7 \pm 1.07 \) rings (Table 3). The differences between these were significant \( t = 2.48 \). As is evident from Table 3,
Table 3.

Total number of tracheal rings in males and females of the harbour seal from different regions.

<table>
<thead>
<tr>
<th>Region</th>
<th>Males</th>
<th>Females</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tatar Strait</td>
<td>n 62-76</td>
<td>n 66-71</td>
<td>63.7±1.01</td>
</tr>
<tr>
<td>Bay of Peter the Great</td>
<td>n 61-71</td>
<td>n 61-70</td>
<td>64.1±0.64</td>
</tr>
<tr>
<td>Sea of Okhotsk (according to Yablokov, 1966 in litt, 1969)</td>
<td>n 64-76</td>
<td>n 60-75</td>
<td>68.0±0.84</td>
</tr>
<tr>
<td>Kuril Islands</td>
<td>n 61-75</td>
<td>n 66-75</td>
<td>71.2±0.83</td>
</tr>
<tr>
<td>Bering Sea</td>
<td>n 65-73</td>
<td>n 66-77</td>
<td>72.7±1.42</td>
</tr>
</tbody>
</table>

The degree of the differences in this feature between the harbour seal of the Tatar Strait and the other populations of this species is not uniform: differences were not found between the males, though, apparently, they are real between the females from the Kuril Islands, the Bering Sea and the Sea of Okhotsk.

A. V. Yablokov (in litt) made a count of the sternal and asternal ribs in 16 males and females of the harbour seal from the Sea of Okhotsk and found a variation in their number.

In the 23 harbour seals from the Tatar Strait that we examined no deviations were noted in the number of ribs: each had 10 sternal and 5 asternal ribs.

Some data on other internal organs. The investigation of the internal organs of this species is a
continuation of similar studies, which were started on pinnipeds in 1960 (Scheffer, 1960; Kleinenberg et al., 1965; Sokolov et al., 1966; Kosygin et al., 1969; Sokolov et al., 1969).

In a description of the superficial structure of the lungs of the harbour seal from the Bering Sea, attention was drawn to the fact that in addition to the so-called typical form (a not very deep, clearly evident notch on the acute edge) there are also found variations, in particular: among the 27 individuals examined in one individual the lungs had a lobed structure (Sokolov et al., 1966).

A similar phenomenon has also been noted in other populations. Thus, among 31 specimens which were caught by us in 1968 in the Bay of Peter the Great, in 8 the lungs had an atypical form: in one animal there were deep notches and grooves on the lungs, while in the other 7 there were no notches of any kind at all.

Of the 80 examined harbour seals from the Tatar Strait, 24 individuals had atypical lungs: 8 were entire and 16 with deep notches. Some of the lungs had two notches with deep grooves running from these, dividing the lungs into almost independent lobes (Figure 1).

Either both of the lungs or one of them were atypical. Both the right and left lungs, to an approximately equal degree, were noted as having a superficially different configuration.

Gagichko and Surzhina (1935) had data on the weight of the internal organs of the harbour seal from the Tatar Strait.
Figure 1. The frequency of occurrence of the different forms of lungs in harbour seal populations from:
A - Bering Sea;  B - Bay of Peter the Great;  V - Tatar Straight.

Form of lungs:
a - typical;  b - atypical lobular;  c - atypical entire.

but, because of the fragmentary nature of these data, the occasional lack of information on the sex of the animal and also because this catch was made during the autumn period, these data, unfortunately, could not be utilized. Our materials indicate that in the adult males, as compared to the females, the average weights of the heart, liver, spleen and diaphragm are somewhat greater and equal, correspondingly, for the former $0.56 \pm 0.04$, $2.63 \pm 0.21$, $0.28 \pm 0.02$, $0.54 \pm 0.23$ kg, while for the latter the values are $0.52 \pm 0.006$, $1.79 \pm 0.07$, $0.24 \pm 0.02$, $0.48 \pm 0.02$ kg. In this case the differences in the weight of the liver are at a highly significant level ($t = 3.81$). The index of this organ is also greater in the males (Figure 2). In the females there is found a comparatively
Figure 2. The weight of the internal organs of the harbour seals (%), caught in different regions.

Legend:
1 - Tatar Strait; 2 - Bering Sea; 3 - Bay of Peter the Great; 4 - Kuril Islands.
A - intestine; B - liver; V - lungs; G - stomach; D - heart; E - spleen; Zh - diaphragm; Z - kidney; I - pancreas.

high relative weight of the lungs (22.6%). Differences between males and females in the cardiac and diaphragmal indices were negligible (in the males and females these were correspondingly equal to 8.5 and 8.6%, and 8.0 and 7.9%).

The fact should be emphasized that the relative weight of the lungs and heart of the animals from the Tatar Strait is somewhat lower than of those from the Bering Sea. Thus, in the Bering Sea females the index of the lungs equals 24.8%, of the heart - 11.1%, of the diaphragm - 8.0%. In general, the relative weight of most organs of the females exceeds that of the males.
The noted characteristics of the internal organs of the harbour seal depend on the living conditions, which are specific to each region (Sokolov et al., 1969).

Craniometric characteristics are presented in Table 4. The index of the greatest length of the skull, calculated from the body length ($Z_{CV}$), comprises 13.7 and 13.6%, respectively, in the males and females. Thus, the sex differences in the length of the skull are insignificant. In this feature the skull of females of the harbour seal from the Tatar Strait is, on average, somewhat longer than in those from the Bay of Peter the Great ($t = +0.80$), the Kuril Islands ($t = +0.73$) and the Bering Sea - 207.8 mm (according to the latest data of Chapskii, 1967).

Notable differences between males and females are present only in the rostral width and in the length of the nasal bones. The absolute length of the nasal bones and the right upper row of molar teeth in the females from the Tatar Strait is a little greater than in the females from the Bay of Peter the Great.

In the skull of the females from the former region the value of the zygomatic (greatest) width is somewhat smaller ($t = -2.26$). This same difference is also noted in the relative dimensions. Thus the index of this feature, calculated from the greatest length, on average is equal to 58.0% for the individuals from the Tatar Strait and 61.4% - for the Bay of Peter the Great.

The dimensions of the longitudinal diameter of the alveoli of the right upper canine show differences that are close to significant ($t = -2.57$).
For a more complete characterization of the harbour seal of the Tatar Strait it would be desirable to compare its craniometric data with those of the neighbouring population, from the Okhotsk Sea. Unfortunately, we do not have any of our own skull materials on the Okhotsk Sea harbour seal, while in the published studies these are either too scarce (Allen, 1902; Ognev, 1935) or have been presented without subdivision according to sex and region of catch (Naumov and Smirnov, 1935).

Thus, the analysis of this material shows that, on the basis of the morphological features presented, there are features of similarity and noticeable differences in the harbour seal which lives in the Tatar Strait, in comparison with individuals from other parts of the species range.

Food objects. Out of 76 harbour seals, aged 1 to 41 years, that were caught, food remains were contained in the stomachs of 27 animals. 20 of these animals were caught on the ice and 7 afloat. In most of the seals the food was strongly digested; in some stomachs there were retained only parts of the skeletons and otoliths of fishes, and beaks of cephalopod molluscs.

The food base of the harbour seal in the Tatar Strait during March-April consisted of fishes, mainly the Korean cod. These were found in 25 stomachs (93%). These data confirm the conclusions of previous authors (Ognev, 1935; Chapskii, 1963; Kenyon, 1965, and others), that fishes play an important role in the food of this seal.

In second place were cephalopod molluscs, found in 10 stomachs (37%), and last were crustaceans, in 3 stomachs*.

* The species affinity of the food objects was determined by L. I. Semenenko.
<table>
<thead>
<tr>
<th>Feature</th>
<th>Головной профиль</th>
<th>Сибирское море</th>
<th>Bay of Peter the Great</th>
<th>Sex</th>
<th>Длина</th>
<th>Среднее</th>
<th>Стандартное отклонение</th>
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</table>

* м — male
* ж — female
The cephalopod molluscs most frequently found in the stomach contents were octopuses. It is characteristic that molluscs predominated in the stomachs of sexually mature animals. This characteristic of the feeding of the harbour seal has also been observed in the Bering Sea (Gol'tsev, 1969).

Sand and small stones were found only in those stomachs in which there were contained some benthic animals, which had been the objects of feeding. It was obvious that these had been ingested by the harbour seal while hunting for its prey, as is the case among other species of pinnipeds (Ggnev, 1935; Kind, 1964; Köhr, 1963 and others).

The maximal weight of food found in the stomach (3.27 kg) was discovered in a seven-year old female, containing the remains of 19 specimens of Korean cod. A weight of food similar to that found in this seal is not a frequent phenomenon. S. P. Naumov (1933) reported the finding of 80 specimens of navaga (saffron cod) in the stomach of a harbour seal caught on the Shantarskiye Islands. Unfortunately, their weight was not given.

Distribution. In that part of the Tatar Strait which was investigated by us, the harbour seal predominated in encounters of pinnipeds. Females, which had whelped, with their young were mainly concentrated 20 - 30 miles from the continental coast off Sovetskaya Gavan' (Figure 3), and here there could sometimes be seen up to 77 whitecoats per day from on board the ship.

Large patches of sexually immature harbour seals were found in the northernmost part of the region of the studies,
not far from the Sakhalin coast. The harbour seals were found on both flat as well as on hummocky ice.

During the period of observation it was noted that individual harbour seals which were participating in the reproduction were, for the most part, situated close to the sea edge of the ice, while the sexually immature and maturing animals kept themselves deep in the ice fields, at times at a considerable distance from the edge.

Some representation of the age structure of the population of harbour seals in the Tatar Strait may be obtained from an analysis of the small series of our samples (76 specimens). Since the hunting was conducted primarily on the whelping patches, in the catch there was a predominance of adult animals and young of the previous year. There were few sexually immature animals, aged 1 - 4 years, and therefore the age structure of our catch may to some extent characterize only the part of the herd of bearing age.

The main part of the catch consisted of seals 5 - 14 years old (81%). The remaining 19% comprised animals aged from 15 to 41 years. The average age of this part of the herd was 11.8 years. We will note that among the 64 harbour seals that were caught in 1962 in the Bering Sea, no animals older than 23 years were found (Tikhomirov, 1969). In the Okhotsk Sea and Bering Sea populations of harbour seals the average age is, correspondingly, 11.5 and 9.9 years. The relatively high average age of the harbour seal population of the Tatar Strait indicates that it, like the two former populations, has been little affected by commercial hunting.
Figure 3. The frequency of occurrence of seals in the Tatar Strait in the period from March 20th to April 6th 1969.

Legend: A - harbour seal; B - bearded seal; V - Steller's sea-lion; G - ribbon seal.

In the numerator - seals encountered, in the denominator - whitecoats included in above number. Figures, illustrated by a continuous line - encounters from March 20 to 26; interrupted line - from March 27 to April 8; interrupted line with dots - from April 3 to 6.
In the habitats of the harbour seal in the Tatar Strait there also live other species of pinnipeds. For example, Steller's sea-lion is encountered here (Naumov, 1933; Ognev, 1935). The former author considered the encounters with the Steller's sea-lions to be fortuitous.

We have noted considerable accumulations of Steller's sea-lion. In groups of up to 15 head and singly, these seals were found near the edge of the ice close to the Sakhalin coast. Bulls and young animals predominated in these encounters. In all, we registered 160 Steller's sea-lions. In addition to these, there were encountered individual specimens of the bearded seal and the ribbon seal (see Figure 3).

Among the factors determining the concentration of the harbour seal in particular sections of the Strait, the main ones, apparently, are the ice conditions and the feeding conditions. According to an oral communication from G. A. Fedoseev, A. V. Evzerov and G. P. Kovalev, co-workers from the TINRO, who carried out an aerial survey of the seals, on April 1st 1969 in the Tatar Strait the white hummocky ice, suitable for the whelping and resting of the harbour seal, was distributed northwards from the region of our studies for a distance of 60 miles, to the latitude of the settlement of Aleksandovsk, further on up to the narrowest part of the strait there was slush, and no seals were registered on this. According to our observations, the southern border of the ice extended not far from the settlement of Uglegorsk. Here was noted the southernmost point of encounters with the pinnipeds.
Under the action of the currents and winds the ice fields gradually were displaced and extensive stretches of open water were formed, at times near the continental coast and at times near the island of Sakhalin. In accordance with this, the animals were encountered on the edge of the ice either close to the continent or near the island.

According to V. L. Andreev (1965), in February - April in the Tatar Strait there occur spawning aggregations of the Korean cod. These aggregations of the fish shift from place to place. Probably, following these the harbour seals also move from one part of the gulf to another.

**Periods of whelping and moulting.** During the period from March 20 to April 2 among the encountered pups there were whitecoats aged 3 - 5 - 10 days. Consequently the whelping commenced in the second third of March, which once again confirms the conclusions made previously by S. V. Dorofeev (1935) and G. P. Nikulin (1935).

With the aim of elucidating the conditions under which the whelping of the harbour seals occurs, we conducted observations on the temperature of the air and of the surface layer of the water. In the Tatar Strait the temperature of the air ranges from -2 to -9°C, while that of the water ranges from -1 to 2°C. It was found that during the period of the whelping of the harbour seal in various parts of its range (Tatar Strait, Bay of Peter the Great, Bering Sea) there are no great differences between the air and water temperatures.

In many of the harbour seals that were caught in the first third of April the ovaries already had mature follicles,
which indicates that the animals are ready for ovulation and the next pregnancy.

At the end of March - beginning of April the hair coat of the spotted seals was robust. Among the sexually immature animals there were found individuals with loosened hair, and rarely - with portions of bare skin. The first moulting individuals of the young harbour seals (ragged-jackets) were encountered on April 1st.

Recommendations for the commercial exploitation. It is known that at the present time the sealing flotilla of the UMRZF is paying considerable attention to the procurement of fur pelts of seals. Thus, in the Sea of Okhotsk in recent years the vessels of the UMRZF have been catching about 6000 harbour seals, among other species of seals. Because of the severe ice conditions during the period of the whelping of the seals the whitecoats are caught in small numbers.

The volume of the procurement of fur pelts may be increased by catches of harbour seals in the Tatar Strait. According to the data from the aerial survey, which was conducted by the TINRO, about 9000 harbour seals were registered here. In the past in the Tatar Strait, in the Bay of Tyk there were caught about 800 head of this species in a year (Gagichko, 1931; Gagichko ans Surzhin, 1935).

On the basis of the results of the aerial survey, of the literature sources and the materials obtained during the cruise of the sealing ship "Sanzar", we recommend the opening up of a new region for commercial sealing: the Tatar Strait.

*Translator's note. I was unable to find the meaning of this abbreviation.*
Until further information is obtained on the harbour seal, we propose to establish the quota for its catch for the first year of the sealing operations at 1000 head.

As has been shown by the experience of the work on the sealing ship "Sanzar", in years with favourable ice conditions during the period of whelping, in the Tatar Strait it may be possible to conduct the sealing operations for the harbour seal both directly from the ship as well as from its boats. Consequently, whitecoats and beaters may form a considerable portion of the catch. It would obviously be advisable to commence the sealing at the beginning of March.

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* Translator's note. "ostrovnoi tyulen" - literally "island seal", probably refers to the Kuril seal (Phoca stejnegeri)


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38. Mohr E. *Phoca vitulina largha* Pallas, 1811, and seals that are white at birth.
The three-year-old males of the fur seal, as compared to other age groups, possess the most valuable fur and comprise the main group that is exploited for commercial purposes. Therefore, the study of the seasonal variation in the density of the fur in the hair bundles of this particular age group of fur seals is of considerable importance for determining the optimal periods of the kill.

Studies which were carried out on the Pribilof Islands showed that in all of the fur seal males (including also the three-year-old males) the density of the fur in the bundles remains almost unchanged during the course of the winter, spring and summer (i.e. for the greater part of the annual cycle of their life) and only in the autumn, when the new hairs grow more rapidly, does the total number of the underfur hairs in the bundle increase (Scheffer and Johnson, 1963).

Similar studies have not been conducted on the fur seal population which reproduces on Robben Island. In connection with this, the present study is intended to elucidate the characteristics of the variation in the density of the underfur hairs in the bundles on the body of the three-year-olds in relation to the periods of their kill, on the basis of which refinements may be made in the optimal periods for the sealing operations on the fur seals on Robben Island.
The materials for the study of the seasonal variation in the density of the fur in the bundles of the three-year-olds were collected on Robben Island from June to November during 1959-1961. There were collected 120 samples of pelt from 24 tagged bachelors of the local population of fur seals. The samples, which were 2 - 3 sq. cm in size, were taken from the mane, back, lumbar region, sides and belly (Figure 1), and were fixed in a 10% solution of formalin. Histological preparations were prepared from each sample specimen in the form of series of sections crosswise to the root part of the hair bundle. The sections were prepared on a freezing microtome, stained with haematoxylin and eosin, stuck onto a microscope slide, embedded in gelatine-glycerin and covered with a coverslip, according to the methods given in the textbook by G. I. Roskin and L. B. Levinson (1957). The thickness of these sections was 15 - 30 µ. The evaluation of the density of the fur was carried out under the microscope (with a magnification of a X7 ocular and X8 objective) in the root portion of the hair bundle at a depth of 1.0 - 1.5 mm (Figure 2). For each sample there was determined the density of the fur in 25 homogeneous hair bundles. The hairs in each bundle were counted three times and the average was taken as the "datum" for setting up the variational series. In grouping these "data", the class interval (i) equalled 5. The arithmetic mean (x), the standard deviation (σₓ), the standard error of the mean (mₓ), the confidence limits of the mean (x ± t₃mₓ) and the confidence limits of the series in question (x ± t₁σₓ) were calculated, to one decimal place, by the methods recommended by N. A. Plokhinskii (1961).
Рис. 1. Схематичное изображение туши холостика со спины. (Точками указаны участки взятия проб)

Figure 1. Schematic illustration of the body of a bachelor from the dorsal side. (The dots indicate the sections where samples were taken)

The results of the determinations of the density of the fur in the bundles of the three-year-old bachelors are presented in Tables 1 - 5, from which it can be seen that the density of the fur varied in each month and on all parts of the body of the bachelors. The amount of fur on the central portions of the skin (mane, back sides) proved to be greater than on the peripheral portions (belly, lumbar region). It can also be noted that three-year-olds with the least amount
Figure 2. General appearance of a hair bundle in cross section at a depth of 1.0 - 1.5 mm from the surface of the skin.

of fur in the bundles were most frequently found in August - September. Furthermore, it was established that neither in October nor in November were there animals among the examined three-year-olds, in which the numerical values of the modal classes of the density of the fur in the bundles would exceed the corresponding indices in June - July.

Even in a comparison of the relative indices of the density of the fur in the bundles on different parts of the body, only in one case was it noted that, in the fur on the
Количество пуховых волос в пучке на гриве трехлетних холостяков морского котика

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<th>Date of kill</th>
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<td>21,0—36,2</td>
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<tr>
<td></td>
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<td>22</td>
<td>28—32</td>
<td>43</td>
<td>32,4±1,27</td>
<td>19,0—45,8</td>
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</tr>
<tr>
<td></td>
<td>11 » »</td>
<td>20</td>
<td>28—32</td>
<td>38</td>
<td>30,2±0,96</td>
<td>20,1—40,3</td>
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<tr>
<td>September</td>
<td>4 сентября 1958 г.</td>
<td>18</td>
<td>23—27</td>
<td>33</td>
<td>25,2±0,77</td>
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<tr>
<td></td>
<td>8 » »</td>
<td>21</td>
<td>23—27</td>
<td>37</td>
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<td>19,6—34,4</td>
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<tr>
<td></td>
<td>18 » »</td>
<td>26</td>
<td>33—37</td>
<td>42</td>
<td>33,2±0,79</td>
<td>24,9—41,5</td>
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<tr>
<td>September</td>
<td>22 сентября 1959 г.</td>
<td>24</td>
<td>28—32</td>
<td>41</td>
<td>32,4±0,94</td>
<td>22,5—42,3</td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>21 октября 1959 г.</td>
<td>27</td>
<td>35—42</td>
<td>47</td>
<td>37,9±0,99</td>
<td>27,4—48,4</td>
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</tr>
<tr>
<td></td>
<td>23 » »</td>
<td>25</td>
<td>35—37</td>
<td>39</td>
<td>32,4±0,80</td>
<td>24,0—40,8</td>
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<tr>
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<td>28—32</td>
<td>42</td>
<td>33,0±1,09</td>
<td>21,6—44,4</td>
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</tr>
<tr>
<td></td>
<td>26 » »</td>
<td>24</td>
<td>33—37</td>
<td>47</td>
<td>36,2±0,90</td>
<td>26,8—45,6</td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>8 ноября 1959 г.</td>
<td>16</td>
<td>33—37</td>
<td>44</td>
<td>35,4±1,29</td>
<td>21,8—49,9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 » »</td>
<td>28</td>
<td>38—42</td>
<td>48</td>
<td>36,2±1,10</td>
<td>24,7—47,7</td>
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<td>28,6±0,80</td>
<td>20,2—37,0</td>
<td></td>
</tr>
</tbody>
</table>

Table 1.
The numbers of fur hairs in a bundle on the mane of three-year-old bachelors of the fur seal.
Table 2.

The numbers of fur hairs in a bundle on the back of three-year-old bachelors of the fur seal.

<table>
<thead>
<tr>
<th>Date of kill of animal</th>
<th>Minimum class</th>
<th>Mode class</th>
<th>Maximum class</th>
<th>Mean</th>
<th>Confidence limits</th>
</tr>
</thead>
<tbody>
<tr>
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<td>27</td>
<td>33–37</td>
<td>45</td>
<td>35.8±0.88</td>
<td>26.6–45.0</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>38–42</td>
<td>47</td>
<td>37.4±1.10</td>
<td>25.8–49.0</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>38–42</td>
<td>47</td>
<td>40.0±0.85</td>
<td>31.1–48.9</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>33–37</td>
<td>42</td>
<td>35.8±0.71</td>
<td>25.4–43.2</td>
</tr>
<tr>
<td>July 2 July 1959</td>
<td>32</td>
<td>38–42</td>
<td>47</td>
<td>40.8±0.84</td>
<td>32.0–49.6</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>33–37</td>
<td>45</td>
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</tr>
<tr>
<td>July 24 July 1960</td>
<td>32</td>
<td>38–42</td>
<td>46</td>
<td>36.8±0.93</td>
<td>27.1–46.5</td>
</tr>
<tr>
<td>Aug. 10 August 1959</td>
<td>24</td>
<td>28–32</td>
<td>46</td>
<td>33.8±0.91</td>
<td>24.4–43.2</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>33–37</td>
<td>43</td>
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</tr>
<tr>
<td></td>
<td>11</td>
<td>33–37</td>
<td>42</td>
<td>35.2±0.66</td>
<td>28.3–42.1</td>
</tr>
<tr>
<td>Sept. 4 September 1958</td>
<td>20</td>
<td>28–32</td>
<td>38</td>
<td>29.2±0.88</td>
<td>20.0–38.4</td>
</tr>
<tr>
<td>8</td>
<td>23</td>
<td>28–32</td>
<td>38</td>
<td>30.2±0.87</td>
<td>21.1–39.3</td>
</tr>
<tr>
<td>18</td>
<td>25</td>
<td>28–32</td>
<td>41</td>
<td>31.6±0.84</td>
<td>22.8–40.4</td>
</tr>
<tr>
<td>Sept. 22 September 1959</td>
<td>20</td>
<td>28–32</td>
<td>39</td>
<td>31.0±1.06</td>
<td>19.9–42.1</td>
</tr>
<tr>
<td>Oct. 21 October 1959</td>
<td>24</td>
<td>33–37</td>
<td>45</td>
<td>35.6±1.14</td>
<td>24.6–46.4</td>
</tr>
<tr>
<td>23</td>
<td>26</td>
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</tr>
<tr>
<td>23</td>
<td>20</td>
<td>33–37</td>
<td>42</td>
<td>34.4±0.95</td>
<td>24.4–44.4</td>
</tr>
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<td>26</td>
<td>29</td>
<td>38–42</td>
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<tr>
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<td>14</td>
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<td>19.0–53.4</td>
</tr>
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<td>33–37</td>
<td>43</td>
<td>32.6±1.20</td>
<td>20.0–43.2</td>
</tr>
<tr>
<td>10</td>
<td>19</td>
<td>38–42</td>
<td>45</td>
<td>36.6±1.16</td>
<td>24.4–48.8</td>
</tr>
<tr>
<td>10</td>
<td>25</td>
<td>28–32</td>
<td>36</td>
<td>31.2±0.56</td>
<td>24.3–38.1</td>
</tr>
</tbody>
</table>
Table 3.

The numbers of fur hairs in a bundle on the lumbar region of three-year-old bachelors of the fur seal.
### Table 4.

The numbers of fur hairs in a bundle on the sides of three-year-old bachelors of the fur seal.

<table>
<thead>
<tr>
<th>Date of kill</th>
<th>Minimum</th>
<th>Modal class</th>
<th>Maximum</th>
<th>Mean</th>
<th>Confidence limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 24 1960</td>
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<td>46</td>
<td>36.0±0.66</td>
<td>24.9–47.1</td>
<td></td>
</tr>
<tr>
<td>24 &gt;</td>
<td>23 33–37</td>
<td>44</td>
<td>34.0±0.88</td>
<td>23.7–44.3</td>
<td></td>
</tr>
<tr>
<td>29 &gt;</td>
<td>25 36–42</td>
<td>47</td>
<td>37.6±1.10</td>
<td>26.1–49.1</td>
<td></td>
</tr>
<tr>
<td>29 &gt;</td>
<td>27 33–37</td>
<td>41</td>
<td>34.0±0.92</td>
<td>24.6–43.8</td>
<td></td>
</tr>
<tr>
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<td>43</td>
<td>37.2±0.75</td>
<td>29.3–45.1</td>
<td></td>
</tr>
<tr>
<td>10 &gt;</td>
<td>28 38–42</td>
<td>44</td>
<td>38.8±0.82</td>
<td>30.2–47.4</td>
<td></td>
</tr>
<tr>
<td>July 24 1960</td>
<td>26 38–42</td>
<td>45</td>
<td>36.8±1.09</td>
<td>25.3–48.3</td>
<td></td>
</tr>
<tr>
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<tr>
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<td>15.5–37.3</td>
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</tr>
<tr>
<td>11 &gt;</td>
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<td>28.2–42.6</td>
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</tr>
<tr>
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<td>20.3–41.7</td>
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</tr>
<tr>
<td>11 &gt;</td>
<td>21 28–32</td>
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<td>29.1±0.86</td>
<td>20.1–38.1</td>
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</tr>
<tr>
<td>Sept. 4 1958</td>
<td>24 26–32</td>
<td>42</td>
<td>30.4±0.93</td>
<td>20.7–40.1</td>
<td></td>
</tr>
<tr>
<td>8 &gt;</td>
<td>23 28–32</td>
<td>38</td>
<td>30.8±0.84</td>
<td>22.0–39.6</td>
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</tr>
<tr>
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</tr>
<tr>
<td>Sept. 22 1959</td>
<td>23 28–32</td>
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<td>20.1–43.1</td>
<td></td>
</tr>
<tr>
<td>Oct. 21 1959</td>
<td>26 33–37</td>
<td>39</td>
<td>33.2±0.96</td>
<td>23.2–43.2</td>
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<tr>
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</tr>
<tr>
<td>23 &gt;</td>
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<td>26 &gt;</td>
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<td>47</td>
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<td>28.4–48.0</td>
<td></td>
</tr>
<tr>
<td>Nov. 8 1959</td>
<td>31 43–47</td>
<td>53</td>
<td>42.0±1.06</td>
<td>30.8–53.2</td>
<td></td>
</tr>
<tr>
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<td>5 33–37</td>
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<td>23.1–38.9</td>
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</tr>
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</table>
Table 5.

The numbers of fur hairs in a bundle on the belly of three-year-old bachelors of the fur seal.
Figure 3. Weighted mean ($\bar{x} \pm t_{\alpha/2} s$) of the seasonal variation in density of the fur in the bundles on the body of 3-year old bachelors.

side of an animal, caught on the 8th of November 1959, the value of the mode was found to be higher than in animals that were killed in June - July. The analysis of the individual mean values and confidence limits of the variation in the density of the fur in the bundles of the three-year-olds also indicates the small probability of finding in October - November animals on the body of which there would be found bundles containing more fur hairs than in June - July.
The above described characteristics of the change in the density of the fur in the bundles of three-year-olds is manifested even more obviously in a comparison of the weighted mean values of this feature (Figure 3). From the figure presented it can be seen that over the entire body of the bachelors the numbers of hairs in August - September are lower than in the other periods (this difference is found to be statistically significant), while in the comparison of these same indices in the animals that were killed in June - July with the animals killed in October - November only a small difference was detected between these, and moreover this was not statistically significant.

On the basis of the data obtained, it is not possible to agree with that interpretation of the seasonal variation, of the density of the fur in the bundles in bachelors, which was given by Scheffer and Johnson (1963). The scheme that was indicated by them is, apparently, atypical. In our opinion, it is more reasonable to propose that the seasonal changes in the density of the fur in the bundles proceed according to the following scheme: as a result of the massive falling out of the fur hairs of the previous year's generation their numbers in the bundles on the body of the bachelors decreases markedly in August - September. Then, during October - November, as the fur hairs of the new generation grow up, the density of the fur in the hair bundles again increases, but on the average it does not exceed that amount which is found on the bachelors at the beginning of their appearance on the hauling grounds in June - July. Taking into account
the fact that at the moment of the departure of the bachelors from the hauling grounds the majority of them have not completely moulted, the possibility cannot be excluded that the growth of some portion of the new fur hairs will continue during the marine period of their life, as a consequence of which the total number of fur hairs in a bundle will build up during the winter.

Thus, from the data presented above, it may be concluded that in August - September the quantity of fur hairs in the bundles on the body of the three-year-olds is, as a rule, lower than during other periods of the annual cycle of their life. However, the violent falling out of the fur from the bundles in August - September, in its turn, leads to the situation that the total density of the fur hairs on the skin of the three-year-olds at this time also decreases. Consequently, under all conditions August - September cannot be recommended for the sealing operations on fur seals on Robben Island.

ЛИТЕРАТУРА

REFERENCES
In 1963 on the Komandorskiye Islands there were set up the first tests on the use of the curare-like preparations, ditiiline and diplacin, in the slaughtering of fur seals. Ditiiline was found to be the most suitable for these purposes. The effect of the preparation commences after 30-40 seconds. At the moment that the fur seals became completely immobile they were exsanguinated with a knife.

This method of slaughtering, in comparison with that existing at the present time (killing with a club), has several advantages. It is more humane and permits selective slaughtering to be carried out. The meat and meat products are suitable for food. It is more economical, since it eliminates bruisings on the pelts. In a slaughter of 10,000 fur seals the profit may comprise 45-50 thousand rubels. All of this permits this method of slaughtering to be recommended for introduction.

In the selection of methods for the pre-slaughter stunning of the animals, an important criterion is the possibility of retaining the cardiac activity in the animals, which is necessary for a better exsanguination. The latter is also important in the sealing operations on the fur seals, and therefore we set ourselves the aim of determining the effect of ditiiline on the organism of the fur seals.
From the literature sources it is known that during the narcotization of animals with non-lethal doses of ditiline there are not noted any drastically expressed changes in the blood circulation and respiration (Zhulenko, 1963; Zhulenko and Korneva, 1965).

Similar studies were carried out by us with fur seals. As a result of this work there were determined the mean effective, optimal and lethal doses of ditiline. The effect of the preparation on the cardiovascular and respiratory systems and on the body temperature was studied, and at the same time the consequences of the effect of ditiline on these animals were revealed.

METHODS OF STUDY

The investigations on the immobilization of the fur seals with the muscle relaxant were carried out on animals which were kept in cages. The animals were first weighed, after which 5% and 10% solutions of ditiline in various doses were administered intramuscularly. In the experimental animals electrocardiograms were taken, the respiration was measured and the body temperature was measured every five minutes. The electrocardiogram was recorded from 3 standard points of contact at a current voltage of 1 mv. The changes in the bio-electrical potentials of the heart under the influence of ditiline were registered from the fore and hind flippers on photographic film with the aid of a portable EKP-60 electrocardiograph (Figure 1). The respiration was measured only in animals which were not held down. The body temperature was measured rectally.
DESCRIPTION AND RESULTS OF EXPERIMENTS

For the purpose of determining the mean effectiveness, the optimal and lethal doses for the fur seals, there were tested the following amounts of the preparation: 0.25; 0.5; 0.75; 1.0; 1.25; 1.5; 1.75 and 2.0 mg per 1 kg weight of the animal. Each dose was tested on 6 male fur seals, aged 2 - 4 years.

The results of the tests indicate that 0.25 mg/kg shows no effect. A weakly expressed narcotization sets in at doses of 0.5 and 0.75 mg/kg, within which range was found the mean effective dose. The optimal immobilizing dose, which brought about a clearly expressed immobilization of the animal in all
of the tests without having a lethal outcome, is found to be between 1.0 and 1.25 mg/kg. A dose of 1.5 mg/kg causes a stoppage of breathing (apnea) in individual animals. Death always ensued after the administration of 2.0 mg/kg. This is the absolute lethal dose (Table 1).

Table 1.
The effect of the muscle relaxant ditiline on the organism of fur seals.

<table>
<thead>
<tr>
<th>Dose mg/kg</th>
<th>0.25</th>
<th>0.50</th>
<th>0.75</th>
<th>1.00</th>
<th>1.25</th>
<th>1.50</th>
<th>1.75</th>
<th>2.00</th>
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</thead>
<tbody>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
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<td>0</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Did not ensue</td>
<td>Ensued</td>
<td>Lethal outcome</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Change in the pulse of fur seals depending on the size of the dose of ditiline.
With the aid of the electrocardiograms it was shown that in optimal doses the preparation slows down the cardiac activity, which later returns to the original level (Figure 2). The duration of the intervals in the cardiac cycle is directly dependent on the dose (Figure 3). The initial part of the ventricular complex (GPS) is subject to the least changes. On emergence of the experimental animal from the state of adynamia, the duration of the intervals in the cardiac cycle returns to the initial state.

The pulmonary respiration in the narcotized animals is changed to a greater degree, the greater the amount of the muscle relaxant reaching the blood. With the administration of mean effective doses there is an insignificant depression of respiration, while optimal doses impair gaseous exchange and may even evoke short-term arrest of respiration (Figure 4).

The mean effective dose caused an increase in the body temperature of the fur seals of 0.6°C; the optimal dose evoked a temperature increase of 1.0 - 1.5°C, while the absolute lethal dose evoked a temperature increase of 3 - 4°C (Figure 5). With the restoration of the capacity for movement, the body temperature gradually attains the initial level.

Our investigations showed that the muscle relaxant affects the fur seals for 15 - 30 minutes, after which the animals recover their locomotory function. With the aim of elucidating the influence of the preparation on the fur seals on the days following the injection, observations were carried out on the animals for 1 - 4 days in a cage, after which they were released onto the rookery. Before release, the fur seals
Figure 3. The change in the duration of the intervals in the cardiac cycle depending on the quantity of the dose of ditiline.

* State of animal

--- Normal

--- Incomplete immobilization

--- Complete immobilization

Figure 4. The change in the respiration of fur seals under the influence of ditiline.
Figure 5. The effect of ditiline on the body temperature of fur seals.

were tagged by clipping the guard hairs on the head and front flippers. The clipped areas varied in their form and position on the body of the fur seals. During the course of the entire daylight period constant observations were conducted on the fur seals. 14 out of 23 experimental animals (60.8%) were again found on the hauling out grounds. They came out onto the shore and were caught in some of the sealing drives. In their behaviour these fur seals did not differ in any way from the remaining animals. Those tagged fur seals that were not found were apparently in the sea or in such places in the rookery where it was extremely difficult to catch sight of them, since the percentage of encounters with control animals, to which no ditiline was administered, was about the same.

From this we conclude that, when administered in optimal doses, the muscle relaxant ditiline does not produce harmful consequences to the organism of fur seals.
CONCLUSIONS

The mean effective dose of dilitine for fur seals aged 2 - 4 years lies between 0.5 and 0.75 mg/kg; the optimal dose - between 1.0 and 1.25 mg/kg, while the absolute lethal dose is 2.0 mg/kg.

The mean effective and optimal doses, at the start of the action of the preparation, slow down the cardiac activity in the fur seals, which later returns to the initial level.

The more dilitine is administered, the more marked is the depression of the pulmonary respiration in the narcotized animals.

In the fur seals the dilitine gave rise to a short-term increase in body temperature.

No harmful consequences of the effect of dilitine on the fur seals were observed after the administration of mean effective and optimal doses of this muscle relaxant to these animals.
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In recent times questions concerning the rational exploitation of the stocks of marine mammals have acquired a particularly important significance, since these stocks in different basins have either been undermined or are found in a stressed state.

The Ministry of Fisheries of the USSR is paying considerable attention to the rational utilization of the stocks of marine animals and considerable efforts are being undertaken, especially in recent years, in this direction.

THE FAR-EASTERN BASIN

The hunting of the sea-otter has been banned everywhere, which has had a very favourable influence on the re-establishment of its stocks. The numbers of this species at the present time in the waters of the Soviet Union comprise 5.5 - 6 thousand head. In recent years measures have been undertaken to strengthen the conservation of the sea-otter; throughout the course of the whole summer period vessels of the Sakhalin Fisheries Service and the Kamchatka Fisheries Service patrol the region off the Kuril Islands and Mednyy Island; in 1967 there were organized two permanent posts for the conservation of sea-otters on the Kuril Islands, on the islands of Paramushir and Urup, while in 1968 a third post was set up on the island of Iturup.
For the further increase in the population of this very valuable marine animal the ban on its hunting should be maintained. It is necessary to intensify the work on the acclimatization of the sea-otter on Bering Island and in other regions, which used to be its habitats.

Recently commercial organizations are proposing the introduction of a prophylactic culling of the sea-otters. In the opinion of Far Eastern scientists, a commercial culling operation of a so-called "selective" cull afloat is premature. At the present time it is sensible to restrict ourselves to collecting the pelts of sea-otters which have died as a result of the natural mortality and to carry out further tests on culling.

Sealing operations on the fur seals are being conducted on the Komandorskiye Islands and Robben Island.

The measures for the conservation and regulation of the sealing operations on the fur seals on the on-shore rookeries favour the growth in their population numbers.

After the signing in 1957 of the Provisional Convention on the conservation of fur seals in the northern part of the Pacific Ocean, the numbers of these in the Far East increased by almost 2.5 times and attained a level of 400 - 420 thousand head (Komandorskiye Islands - 200; Robben Island - 180 - 200 thousand head).

The dynamics of the catches from 1961 appear as follows: in 1961 there were killed 12 thousand head, in 1962 - 13.5 thousand, in 1963 - 14.7 thousand, in 1964 - 18.9 thousand, in 1965 - about 20 thousand, in 1966 - 18.9 thousand, in 1967 -
17.7 thousand, in 1968 - 15.0 thousand and in 1969 - 15.6 thousand head. It should be noted that from 1966 the fur seal kill began to be reduced in connection with the decrease in the numbers of the commercially exploited bachelors. The causes of this decrease still remain unclear, in spite of the deliberations of a special conference and the organization in 1969 of a trip of a commission to the Kuril Islands.

It may be supposed that one of the causes of the decrease in the numbers of bachelors in the rookeries was the overestimate of the catch limits, which were established in previous years, and also the prolongation of the sealing operations after August 1st and the frequent driving-off of these animals from the bachelor hauling grounds.

In recent years several measures have been undertaken for the further strengthening of the conservation of the fur seals: a 30-mile prohibited zone has been established around the Kuril Islands and Robben Island. It has been resolved to kill bachelor males that are no younger than 3-4 years and of a size not less than 108 and no more than 150 cm. Drives of fur seals are authorized only from bachelor hauling grounds with not fewer than 100 head of the commercially exploitable animals present on the hauling ground.

The population numbers of Steller’s sea-lion have attained a level of 40-60 thousand head, but these are virtually not being commercially exploited. Thus, "Dal’ryba"* has caught the following numbers of Steller’s sea-lion in different years: in 1964 - 329, in 1965, - 146, in 1966 - 40, in 1967 - 74, in 1968 - 420 head, while about 3000 head could be caught each year.

* "Dal’ryba" - Far East Trust of Fishing Industry Enterprises.
In connection with the reduction in the stocks of the true seals in the Far East, a limitation of their catches was initiated from 1967:

In 1967 limits were established for the ringed seal (45.0 thousand head) in the Sea of Okhotsk; the ribbon seal (5.0 thousand head) in the Bering Sea;

in 1968 for the ringed seal (32.0 thousand head), the ribbon seal (5.0 thousand head), the harbour seal (11.7 thousand head), the bearded seal - ban in the Sea of Okhotsk; in the Bering Sea: for the ringed seal (1.0 thousand head), the ribbon seal (5.0 thousand head), the harbour seal (3.0 thousand head), the bearded seal (1.0 thousand head);

in 1969 for the ringed seal (32.0 thousand head), the ribbon seal (5.0 thousand head), the harbour seal (11.7 thousand head), the bearded seal - ban in the Sea of Okhotsk; in the Bering Sea: for the ringed seal (26.0 thousand head), the ribbon seal (5.0 thousand head), the harbour seal (5.2 thousand head) and the bearded seal (2.0 thousand head).

From 1970 the sealing has been subdivided into coastal (sovkhoz*), state shipborne and for the needs of the local native population.

We consider it advisable to switch the hunting operations for the seals from the spring to the autumn, since during the autumn sealing all of the seal pelts may be utilized as high-quality fur raw material. It is necessary that scientific organizations, within a short period of time, give their proposals on the localities and periods for the sealing operations and on the rational exploitation of the pinniped stocks.

* sovkhoz - state farm.
In connection with the small numbers of the "antur" of which there are 4.0 thousand head on the Komandorskiye Islands and about 2.0 thousand head on the Kuril Islands, there has been a ban on its hunting from 1970.

With the aim of conserving and re-establishing the stock of the Pacific Ocean walrus, the numbers of which are estimated at 53 thousand head, the catch limit will be maintained at 1.0 thousand head for the needs of the native population of Chukotka with a complete ban on shipborne hunting.

In addition, there have been introduced several measures to strengthen the conservation of the walrus on the hauling grounds. Every year during the hauling out period of the walruses an inspector will be present on Wrangel Island.

Commercial whaling for the beluga is not developed in the waters of the Far East. The numbers of the beluga are not known. From 1970 the catch of older individuals has been authorized, with the exception of belugas with suckling young.

Scientists should devote their attention to the study of this animal and should recommend methods of organizing its exploitation to the industry.

THE NORTHERN COMMERCIAL BASIN

The main regions of the commercial operations are the White and Barents Seas. From 1965 shipborne sealing for the harp seal in the White Sea was banned for five years, the catch of whitecoats did not exceed 20 thousand head.

In 1969 the period of the ban expired but the re-establishment of the stocks is proceeding extremely slowly and therefore the limit for 1970 was set at 23 thousand head with a complete ban on killing the females.
In 1969 for the first time there were carried out observations on the Norwegian sealing operations in the Barents Sea. No infringements were found on the part of the Norwegians.

From 1970, in connection with the unsatisfactory state of the stocks, bans were established against sealing for the bearded seal in the White Sea and the grey seal in the White and Barents Seas.

At the present time sealing operations for the ringed seal are not restricted. The SevPINRO (Northern PINRO) and PINRO (The M. Knipovich Polar Research Institute of Marine Fisheries and Oceanography) should, in the very near future, study the state of the stocks of marine mammals in the White, Barents and Kara Seas, and provide conclusions on their rational exploitation.

In recent years the Jan Mayen and Newfoundland stocks of the harp seal have not been exploited by the Soviet sealing industry.

CASPIAN BASIN

In recent years the hunting for the adult Caspian seal has been banned, with the exception of the hunting for unmoulted whitecoats and greycoats during the period from January 25th to March 15th on the ice in the Northern Caspian within the limits of the quota. For 1970 the catch limit was set at 60 thousand head.
THE BAIKAL BASIN

The numbers of the Baikal sea at the present time comprise 33 thousand head, which permits a yearly catch of 2.5 thousand head. The catch of moulted individuals up to 1 year of age ("serka", "kumatkana"*) is authorized during the period from April 25th to the termination of the sledge sealing by means of rifles of 5.6 mm caliber with fortified cartridges and by means of fixed capron** nets under the ice, in the region to the north of the line which joins the Ol’khanskie Vorota to Cape Tonkii, except for the three kilometer zone around the Ushkan’iye Islands.

In recent years measures have been undertaken to intensify the conservation of the Baikal seal, the staff of inspectors has been increased and additional transportation has been allotted.

THE BALTIC AND LADOGA BASINS

In the Baltic Sea a limit of 2.5 thousand head has been set for sealing operations.

In Lake Ladoga a catch of the Ladoga seal in the amount of 500 head has been authorized.

In accordance with the recommendations of the 3rd All-Union Conference on Marine Mammals, the "Glavrybvod" (The Main Directorate for Fish-breeding and Protection of Fishes) devised

Translator’s notes.

* "serka", "kumatkana" - names of older stages of the seal pups. For the harp seal, "serka" would be translated by "beater".

** "capron" - a synthetic fibre
the "Provisional regulations for the conservation and exploitation of marine animals for Soviet ships, organizations and citizens", which were confirmed by the Ministry of Fisheries of the USSR and came into force from January 1st 1970. After these have been in force for 1 - 2 years it will become clear as to how good they are and then the question will be decided on the promulgation of permanent regulations.
The study of the way of life, behaviour and many other questions of the biology of marine mammals is made difficult by the lack of opportunity for systematic prolonged observations on individual animals. The keeping of these animals in an aquarium or oceanarium permits such observations to be made and, in addition, provides an opportunity for studying such questions as the dynamics of the growth, the change in weight and other aspects during particular periods of the year and in step with the increase in the age of the animal. However, it should be borne in mind that life in captivity naturally to some extent changes the instincts and habits of the animals.

In Japan and certain other countries there has already been accumulated a fairly considerable experience on the keeping in captivity of certain species of pinnipeds, including also the fur seals. In the Soviet Union such work has not been carried out, with the exception of individual short-term experiments on the purposeful keeping of fur seals in enclosures and the more prolonged keeping of Caspian seals (Badamshin, 1959). The opportunity for organizing and conducting such studies in our country has emerged with the bringing into operation of the marine aquarium in Batumi.

In October of 1966 there were brought by airplane to the Batumi aquarium three Caspian seals, which had been caught
on Zhemchuzhno Island in the Caspian Sea, but which died in November of 1967. Immediately (in this same month) there were again brought to the aquarium five Caspian seals, that had been caught on the same island (Table 1). The animals were transported by airplane, where they had been placed in wooden crates without water.

Fur seals were delivered to the Batumi aquarium on three occasions (Table 2). From Robben Island, located in the southern part of the Sea of Okhotsk, in August of 1967 there were brought, in the same way as the Caspian seals, by airplane in wooden crates six fur seals, including one pup that had been born this same year. The next batch, amounting to four fur seals, was brought in September of 1968 also from Robben Island. Finally, in August of 1969 from Bering Island (the Komandorskiye Islands in the Bering Sea) there was brought one adult female, that was presumably pregnant.

One of the fur seals was an unweaned pup and the attempts to artificially feed it were not successful. The simultaneous death of the three Caspian seals and four fur seals in 1967 occurred from food poisoning. Up to December 1969 three Caspian seals had survived in the aquarium for 2 years, one fur seal for more than two years, 3 fur seals for one year and one female was delivered in August of 1969.

In the northern part of the Pacific Ocean the fur seals accomplish regular seasonal migrations. Spending the winter months in the open sea, in the spring, as the waters become warmer, they move to the north and spend the summer months on the on-shore rookeries, located on Robben Island and the Kuril, Komandorskiye and Pribilof Islands. The water temperature in
### Table 1.

**Information on the delivery of Caspian seals**

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age</th>
<th>Date of delivery</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Самец — male</td>
<td>2 года</td>
<td>Октябрь 1966 г.</td>
<td>Погиб 8 ноября, 1966 г.</td>
</tr>
<tr>
<td>Самка — female</td>
<td>2 года</td>
<td>Октябрь 1966 г.</td>
<td>Погибла 8 ноября, 1966 г.</td>
</tr>
<tr>
<td>Самка</td>
<td>1 год</td>
<td>Октябрь 1966 г.</td>
<td>Погибла 8 ноября, 1967 г.</td>
</tr>
<tr>
<td>Самка</td>
<td>2 года</td>
<td>24 ноября 1967 г.</td>
<td>Погибла 7 мая 1969 г. Bay</td>
</tr>
</tbody>
</table>

### Table 2.

**Information on the delivery of fur seals**

<table>
<thead>
<tr>
<th>Sex</th>
<th>Возраст Age</th>
<th>Вес kg</th>
<th>Дата прихода delivery</th>
<th>Время в пути transit</th>
<th>Примечания Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Самец — male</td>
<td>2 года</td>
<td>25</td>
<td>23 августа 1967 г.</td>
<td>52 часа</td>
<td>To же</td>
</tr>
<tr>
<td>Самец — male</td>
<td>2 года</td>
<td>23</td>
<td>23 августа 1967 г.</td>
<td>52 часа</td>
<td>To же</td>
</tr>
<tr>
<td>Самка — female</td>
<td>2 года</td>
<td>21</td>
<td>23 августа 1967 г.</td>
<td>52 часа</td>
<td>To же</td>
</tr>
<tr>
<td>Самка — female</td>
<td>1 год</td>
<td>19</td>
<td>23 августа 1967 г.</td>
<td>52 часа</td>
<td>Погибла 31 июля, 1967 г. Sept</td>
</tr>
<tr>
<td>Самка — Pup</td>
<td>Детеныш</td>
<td>12</td>
<td>23 августа 1967 г.</td>
<td>52 часа</td>
<td></td>
</tr>
<tr>
<td>Самка — female</td>
<td>3 года</td>
<td>26</td>
<td>9 сентября 1968 г.</td>
<td>131 час.</td>
<td>Погибла 21 апреля, 1969 г. April</td>
</tr>
<tr>
<td>Самка — female</td>
<td>2 года</td>
<td>14</td>
<td>9 сентября 1968 г.</td>
<td>131 час.</td>
<td></td>
</tr>
<tr>
<td>Самка — female</td>
<td>1 год</td>
<td>19,5</td>
<td>9 сентября 1968 г.</td>
<td>131 час.</td>
<td></td>
</tr>
<tr>
<td>Самец — male</td>
<td>1 год</td>
<td>18,5</td>
<td>9 сентября 1968 г.</td>
<td>131 час.</td>
<td></td>
</tr>
<tr>
<td>Самка — female</td>
<td>7 лет</td>
<td>42</td>
<td>4 августа 1969 г.</td>
<td>53 часа</td>
<td></td>
</tr>
</tbody>
</table>
Figure 1. Fur seals in the aquarium.

The regions of the winter habitats of the fur seals keep within the limits of 1-2 to 9-10°C, occasionally dropping to 0°C. The air temperature in these regions rarely exceeds 12-13°C. With the warming of the water above 14-15°C the fur seals leave the wintering regions and move to the north (Panin and Panina, 1968; Arsen'ev, 1964).

The regions of the on-shore rookeries are characterized by having cloudy weather with drizzling rains and an air temperature ranging from 10 to 15°C. On occasional sunny days this may increase to 20°C and more, and then the fur seals tend to spend the greater part of the day in the sea, where the temperature of the water generally does not exceed 10-12°C.

In the Batumi aquarium the fur seals encountered completely different conditions (Figure 1). The water temperature in the aquarium varied from 6.5 to 25.4°C, while the air temperature varied from 2.5 to 30°C. The differences in the
Table 3.

Comparative data on the water and air temperatures, °C.

<table>
<thead>
<tr>
<th>Year and month</th>
<th>A. - Water temperature</th>
<th>B. - Air temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>c Average</td>
<td>d Ranges</td>
</tr>
<tr>
<td>1968</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>Batumi</td>
<td>Komandorskiye Islands</td>
</tr>
<tr>
<td></td>
<td>21.2</td>
<td>6.8</td>
</tr>
<tr>
<td>July</td>
<td>23.0</td>
<td>8.2</td>
</tr>
<tr>
<td>Aug.</td>
<td>21.3</td>
<td>10.8</td>
</tr>
<tr>
<td>Sept.</td>
<td>24.2</td>
<td>11.5</td>
</tr>
<tr>
<td>1969</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>21.5</td>
<td>7.8</td>
</tr>
<tr>
<td>July</td>
<td>24.0</td>
<td>9.3</td>
</tr>
</tbody>
</table>

A. - Water temperature  
B. - Air temperature  
c - Average  
d - Ranges  
e - Batumi  
f - Komandorskiye Islands  

temperature conditions in the aquarium and in the region of the Komandorskiye Islands are shown in Table 3.

As can be seen from the table, the hydrometeorological conditions of the habitats of the fur seals in the region of the Komandorskiye Islands and in the Batumi aquarium differ considerably. So abrupt and rapid a change in the conditions of the habitat may lead to certain changes in the organism of the animals, but the investigation of these questions is a task for further studies.

All that has been said also applies, to a somewhat lesser degree, to the Caspian seals.
With their placement in the aquarium, there also occurred a considerable change in the food objects of the animals. In the northern part of the Pacific Ocean within the stomachs of the fur seals there have been found the remains of 45 species of fishes and 8 species of squids. The main food objects in different regions are the Korean cod, the sand lance, greenlings, lanternfishes, herring and certain squids (Panina, 1964). Under natural conditions the Caspian seals feed on gobies, "kilka", herring, silversides and gammarids (Badamshin, 1948, 1959). In the aquarium both the fur seals and the Caspian seals were fed on the Black Sea scad, and more rarely on the picarel and the Black Sea anchovy. Predominantly defrosted fish was provided, more rarely live fish (Figure 2).

Under natural conditions in both the fur seals and the Caspian seals the weight of the food consumed per day ranged from 5 to 15% of the weight of the animal itself, though in this case the regularity of the feeding could not be observed (Boitsov, 1934; Dorofeev, 1964), since at times the animals cannot obtain food for themselves over the course of relatively long periods, while at other times the food is plentiful.

In the aquarium the animals were provided a regular feeding twice a day, and in this case, as our investigations showed, the amount of food consumed ranged within the limits of 10 - 15% of the body weight. In individual cases over the course of two to three days the amount of food consumed was as much as 20-26% of the weight of the animal, but then the demand for food dropped markedly. It is possible that with the higher caloric value food, obtained by the animals in the aquarium, the feeding rate decreased somewhat.
Figure 2. Feeding the fur seals.

Table 4.
Change in weight of the animals.

<table>
<thead>
<tr>
<th>Date of delivery</th>
<th>Sex</th>
<th>A.</th>
<th>12 October 1968</th>
<th>3 March 1969</th>
<th>12 August 1969</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fur seals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 August 1967</td>
<td>Aug.</td>
<td>25.0</td>
<td>30.0</td>
<td>28.0</td>
<td>31.5</td>
</tr>
<tr>
<td>9 September 1968</td>
<td>Sept.</td>
<td>20.0</td>
<td>25.0</td>
<td>25.0</td>
<td>31.5</td>
</tr>
<tr>
<td>9 September 1968</td>
<td></td>
<td>18.5</td>
<td>18.0</td>
<td>17.0</td>
<td>21.5</td>
</tr>
<tr>
<td>4 August 1968</td>
<td>Aug.</td>
<td>19.5</td>
<td>19.0</td>
<td>18.5</td>
<td>23.5</td>
</tr>
<tr>
<td>4 August 1968</td>
<td></td>
<td>42.0</td>
<td></td>
<td></td>
<td>42.0</td>
</tr>
<tr>
<td>Caspian seals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 November 1967</td>
<td>Nov.</td>
<td>20.0</td>
<td>23.0</td>
<td>22.0</td>
<td>29.0</td>
</tr>
<tr>
<td>24 November 1967</td>
<td></td>
<td>16.0</td>
<td>19.0</td>
<td>19.5</td>
<td>25.5</td>
</tr>
<tr>
<td>24 November 1967</td>
<td></td>
<td>15.0</td>
<td>15.0</td>
<td>18.5</td>
<td>24.5</td>
</tr>
</tbody>
</table>

* Note. During the period from December 1968 to March 1969 the animals in the aquarium were not provided with an adequate amount of food.

A. - Weight at delivery, kg
B. - Weight in aquarium, kg
m - male
f - female
In Table 4 is shown the change in weight of the fur seals and Caspian seals during the period of their stay in the aquarium.

A task for further studies is the detailed investigation of the feeding of the animals under the holding conditions in the aquarium and the influence of this factor on the growth and development of the organism.

In the Batumi aquarium constant observations are conducted on the behaviour of the animals which are being kept, and some preliminary results of these observations may be reported.

The fur seals easily and rapidly become accustomed to people, especially to those who constantly attend them. They quickly begin to recognize those who feed them and quietly submit themselves to these people. Fur seal No. 1, an aborigine of the Batumi aquarium (the only survivor of the first batch, who is now already 4 years old) and the adult female do not resist when their mouth is opened to examine the state of the teeth.

The Caspian seals have also become accustomed to people, they calmly take food from the hand but do not allow themselves to be touched.

Observations show that the marked change in the living conditions, and apparently primarily of the temperature regime, has exerted a considerable influence on the periods of moulting. Thus, in fur seal No. 1 in 1969 the moult commenced on May 28th, approximately one month or even earlier than is usual under the natural conditions. The so-called third stage of the moult
was noted at the beginning of July, while on the islands this stage is generally observed in the first half of August (Nes-
terov, 1968; Bychkov, 1964). In the Caspian seals also the moult commenced at an earlier period than in the Caspian Sea.

Of great interest is the elucidation of the question as to the influence of the life under the aquarium conditions on the quality of the fur pelt of the animals, especially of the fur seals.

The work with the pinnipeds, which are being kept in the Batumi aquarium, is only beginning. Included among future tasks are comprehensive studies on the effect of the stay in artificial conditions on the vital activity, growth and development of the organism.

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The study of the feeding of the seal under natural conditions presents certain difficulties. In connection with the fact that the animals feed mainly during the crepuscular periods, while, as a rule, they are caught during the day, the stomachs of the animals are found to be empty. However in the large (rectal) portion of the intestine there is always contained a greater or lesser amount of otoliths, which are very convenient to use for determining the species composition of the fishes. Moreover, in the sorting of the otolith samples, removed from the intestine of the seals, a striking feature was that the otoliths that belong to one and the same fish species differ markedly from one another in their dimensions. This suggested to us the idea that the fishes consumed varied in age, size and weight. From this, naturally, it seemed possible to establish the data on these fishes on the basis of their otoliths. However for this there had to be answered other, no less complex questions: could the otoliths be digested, how long were they retained and what was the degree of their state of preservation during their passage through the gastro-intestinal tract of the seal. All of these points, as well as a whole series of other questions, could be resolved only in an experiment.
With these aims, during the period from September - November 1967 to April - June 1968 there were held in large tanks (1.2 m$^3$; 2.3 m$^3$; 7.4 m$^3$) three Baikal seals: Ushkan (aged 1.5 years), Vega (of the same age) and an adult female Manyunya (more than 10 years old). In the 7.4 m$^3$ tank there was constant running water, while in the two other tanks the water was completely changed once a day. The water temperature in the tanks was close to the mean annual temperature of the surface waters of Lake Baikal, about 5$^\circ$C.

The animals were fed with fishes, which commonly occur in their food: the Baikal oil-fish, and pelagic and benthic gobies. However, while the Baikal oil-fish predominates in the natural rations, in the conditions of the experiment the seals were fed primarily on pelagic gobies. Mainly fresh, recently caught fish were provided.

For determining the periods of retention of the undigested remains in the digestive tract, marked food was manufactured. Coloured tags of three different types were employed: plastic platelets (25 x 6 x 1 mm); finely cut up pieces of this same plastic (2 x 2 x 1 mm), which are close in their dimensions to the otoliths of fishes, and pieces (30 x 10 mm) of thin rubber (Table 1).

The plastic platelets were retained for a particularly extended period of time. The rubber tags emerged three times as rapidly as the former. The small pieces of plastic appeared in the tanks, on average, 1.5 times more rapidly than the rubber tags. Evidently, as a result of the working of the stomach and the peristalsis of the intestine, small undigested particles are expelled more rapidly from the digestive system of animals.


Translator's notes.

* sic. Should be J. C. Lilly.

** This is a direct transliteration of the Russian phonetic transliteration. Probably K. Ray.
TRANSPORTATION OF LIVE DOLPHINS

The transportation of live dolphins is one of the important questions in the overall problem of the maintenance of these animals in captivity. Dependant on the quality of the transportation are the health of the animals and the duration of their life in captivity, and consequently also the opportunity for conducting various studies and experiments. Within a single experimental station the animals are moved from the summer sea pens to the winter pools with warmed water. During the course of the cleaning of the pools and in the preparation of various experiments it is necessary to move the dolphins from one from one building to another. A mastering of the technique of transportation of dolphins permits one to transport experimental animals from one specialized station to another, to employ trained dolphins in spectacle shows and to solve problems of an applied character (searches for underwater objects and securing diving work).

In connection with the expansion of experimental studies it seems useful to provide a generalization of our experience concerning the transportation of dolphins, which has been accumulated in conjunction with F. A. Leontovich, V. A. Kalganov, V. V. Kanukhov, V. V. Belyaev and others.

Commencing this work in 1965 and having available very limited information on achievements abroad, we were forced to make and test devices that we had constructed ourselves and
to try out various methods of transportation. Notwithstanding
the diversity of the means of transportation which have been
utilized for this purpose (motor boats, launches, medium Black
Sea seiners, dry-freight transporters, special and passenger
ships, several types of motor vehicles, helicopters etc.),
at the present time we may single out only three basic methods:
towing in the sea, placing in a limited volume of water and
transportation without water.

Particularly unfavourable to the dolphins are the condi-
tions of transportation "without water". Under natural con-
ditions these animals are found in a state that is close to
equilibrium and analogous to weightlessness. The force of
buoyancy, evenly applied to the whole body of the dolphin,
neutralizes the force of the weight, and at the same time only
the hydrostatic pressure acts on the internal organs. During
deep dives under the influence of the hydrostatic pressure,
as a consequence of the great motility of the thorax, the vo-
lume of the lungs in the dolphin may decrease tenfold for a
short period (V. V. Babenko and D. A. Morozov, 1968). During
transportation without water the lungs and other internal or-
gans are compressed for an extended period under the action
of the weight of the animal. Dolphins are unaccustomed to the
drastic limitation of space and mobility, and to the isolation
of animals from one another.

During transportation the following undesirable effects
and traumas may arise:

1. Compression of the internal organs, which makes
breathing and the work of the heart more difficult.
2. Injury to developing embryos and premature births.
3. Dislocation or spraining of the joints of the pectoral flippers.
4. Mechanical injuries by the transporting apparatus: cuts, bruises, scratches, abrasions and tears to the edges of the flippers, leading to considerable losses of blood.
5. Temporary loss of motility of the locomotory musculature.
6. Drying of the eyes and portions of the skin, heat and sun burns.
7. Overheating of the organism and heat stroke.
8. Entry of water into the blowhole during inhalation.
9. The impossibility of raising the dolphin to the surface of the water for the normal exchange of air in the lungs, as a result of entanglement in nets or the dolphin being under other animals.
10. Stress with a lethal result.

The main inconvenience in the transportation of the Azov dolphins (common porpoises) is caused by their habit of being constantly in motion. The active movement of the tail makes every stage of the transportation of these animals more difficult. They are inconvenient to carry by hand or in a stretcher, they frequently push one another down under the water, they acquire traumas and, consequently, suffer more from loss of blood. The specific difficulties in the transportation of the bottlenose dolphins arise as a result of the great weight of the adult animals, which in some cases may be as high as 300 kg.
We will pass on to a description of the procedures and contrivances which assist in averting the enumerated troubles. Entanglement of the dolphin in the net may occur during the catching, when the purse seine is hauled in. This is most likely to occur in those places where the net gathers into folds or is pushed-in by the current into an overhanging wall. Much more rarely the dolphins will ram perpendicularly hanging nets. Having gotten caught in the mesh by its beak and attempting to raise itself to the surface of the water by the shortest path, the dolphin takes up a vertical position in the water and in doing this it tangles its jaws still more deeply in the net. Sometimes at a depth of only one or two meters from the surface of the sea there arises a threat of suffocation and drowning of the dolphin. Therefore, several of those who are participating in the transportation get dressed beforehand in their diving suits, fins and masks, and, in case of necessity, jump into the water. It is generally possible to free the animal from the net without an aqualung on the diver, but at the same time watching the divers from the ship are one or two aqualung divers, who are ready to quickly come to assist.

* In working with nets the prototype model "Ukrainy-3" proved itself in an excellent manner; this is a new aqualung by the designer A. I. Gnann. Special arches (bulges) prevent nets from hooking onto this aqualung. The AVM-1-I aqualung often hooks onto a net with its charging nozzle, minimal pressure indicator, manometer and shut-off valve. Moreover, the minimal pressure indicator and other metallic components on the left shoulder strap may injure the delicate skin of the dolphins. For working in nets one may remove from the AVM-1-I aqualung the charging nozzle and all of its fittings. A charging point end-cap covers the opening of the high pressure nozzle near the shut-off valve. A supplementary arch prevents the nets from hooking onto the valve.
One of the procedures for protecting the bottlenose dolphin from injury by the net is the placement of a diver between the dolphin and the net. The head of the animal is placed on the shoulder of the man, the net is kept away from the tail by using one's legs, while the hands protect the pectoral flippers from getting tangled in the mesh of the net. The water suits "Sadko" and "Super-Calypso" without the weighted belts have a positive buoyancy and this permits one to lie on the surface of the water without effort. The animals are calmed by careful stroking. We did not have a single case of a dolphin biting while it was being caught, although fairly frequently it was necessary to grasp them by the jaws with one's hands and even to remove the net from the teeth. The ideal procedure for protecting the dolphins in a partially
hauled in purse seine would be to position divers beside each dolphin, although under the conditions of mass capture this is generally not possible (Figure 1).

The ship which transports the dolphins does not approach right up to the purse seine net, and the animals are towed to it in special cages. The frame of the cage is welded of duralumin tubing, in such a way that water cannot get into the internal cavities of the tubes. To increase its buoyancy and stability, there may be attached to the cage additional foam-plastic floats. Over the frame of the cage is stretched fine-mesh capron material, if possible - made of thick threads.

The dolphin is moved out of the purse seine through the open end side of the net (Figure 2). After one or two dolphins are placed in the cage, it is towed by a row-boat or small motor boat to the transporting vessel. The position of the animals in the cage during the towing is controlled by swimmers (Figure 3). Particularly restless dolphins are placed in the cage with a man, whose job it is to support the head of the animal during the towing, to avoid entanglement in the net.

The raising of the animal from the water onto the deck of the transporting ship is the most difficult and dangerous, to the animals, operation. Norris (1966) warned against attempts to raise the dolphins from the water by the tail, since in this case the blowhole is under the water, the breathing is impeded and the animals often drown. Pulling out the animals by hand into the small boat generally leads to traumatization of the animals against the hard fixtures on the side of the boat, the ribs and other parts of the boat. The

* Translator’s note. sic. However the actual Figure 3 is not found in the paper.
best method up to the present time remains the method of raising the dolphins from the water on a stretcher, using a derrick. On special ships the cage with the animal may be pulled up a slip or through an open ramp.

In Figure 4* is illustrated the most successful design for a transporting cage, in which the end walls fold down on hinges for the entry of the dolphin into the cage. Other designs, which do not have the folding-down walls, have to be sunk down on one side in order to, as it were, scoop up the animal, but in the confinement of the partly hauled in net this is very inconvenient. The latter design permits one to take up the dolphin without bringing the cage into the net but placing only the folded-down wall over the top line. The second folding wall permits one to bring the dolphin out of the cage head first. The convexly arched side wall struts and the upper connecting tubes have a form which decreases the probability of the animal being injured by them. The skids

*Translator's note. *sic. Description, however, refers to Figure 3.
Figure 3. A transporting cage of a new design.

Figure 4. Transporting a dolphin on a hydroplaning frame.

protect the cage from being damaged when it is pulled up on shore or up a slip onto the deck and raise up, above the slipway or ground, the bottom of the cage on which the dolphin is lying. It is best to make the bottom of rubberized capron.
It should have small openings for the drainage of water, so that when the cage is lifted the excess water is not lifted with it. The most convenient variant has a removable bottom. In this case the bottom has a separate framework with 4 - 6 ring bolts for the attachment of the slings of the derrick. The size of the bottom of the cage, 3.5 x 0.8 m, permits loading of three-meter Black Sea bottlenose dolphins. The correspondence of the dimensions of the removable bottom of the cage with the dimensions of the tubs used for transportation permits one to place the dolphin into the tub on this same bottom, avoiding superfluous transfers. A reserve supply of interchangeable bottoms considerably expedites the work of loading and unloading. A cage of this design may be employed for the temporary isolation of dolphins in a pen or pool.

For the towing of dolphins there can be proposed a hydroplaning frame design (Figure 5) which was elaborated by us. The outside dimensions of the frame (3.5 x 0.8 m) permit it to be placed into a transporting tub. While the removable bottom of the cage should have a negative buoyancy, the front and side tubes of this frame should hold it on the surface, while supporting a dolphin. After the securement of the animal with straps to the canvas panel the posterior edge of the frame sinks down. This is achieved by the fact that the posterior tube fills up with water through its openings and does not serve as a float. Additional trim at the stern may be obtained by installing foam-plastic floats in the front part of the frame. On account of the trim there is created the initial angle of attack (see Figure 2), and, at the start

Translator's notes. * and **. sic. * - Figure 4. ** - second figure in Figure 4.
of the towing, the frame emerges to hydroplane along the surface. This considerably decreases the towing force required. A distinguishing feature of the towing on the hydroplaning frame is the securement of the dolphin with straps and the hydrodynamic lifting of the blowhole above the water. In securing the dolphin particular attention should be paid to tightly fastening down the caudal flukes to the canvas panel, this prevents the possibility of the animal rolling over onto its side. The trimming of the frame at the stern helps to lift the blowhole of the dolphin out of the water even when the frame is not moving, which is of particular value when it is installed in the transporting tub. For the greater comfort of the animal openings are cut in the canvas of the frame for the pectoral flippers.

The frame may be utilized as a cradle for ensuring the immobility of a dolphin during the course of a medical examination of the animal or for experimental purposes.

The described ways of towing may be used in bringing the dolphins from the purse seine to the transporting ship, from the transporting ship to the pen (through a special passage in the wall of the pen), in moving the animals from one section of a holding pen to another or in moving the dolphins along channels, connecting several pools.

The second method of transporting dolphins, conveyance in a limited amount of water, was introduced into practice in the USSR by F. A. Leontovich*. Aqualung divers were first used

* This information was published by F. A. Leontovich in the report "A test of underwater filming of dolphins" at the 3rd plenary session of the Section of Underwater Studies of the oceanographic Commission of the USSR Academy of Sciences in January of 1966.
for removing dolphins from a purse seine on the 9th of July 1965. They held the dolphin and brought up under it in the water a special stretcher, on which the animals were raised from the water, transferred and suspended in containers with water. Used as the containers were the canvas deck tubs on a metallic frame, of the type that is found aboard the Black Sea refrigerator ships and seiners. F. A. Leontovich noted that dolphins suffer considerably from all reloadings and transfers, and recommended that a large number of stretchers be employed, so that each animal is only once placed onto and once removed from the stretcher during the entire journey. This principle of "straight from the sea onto the suspension device and to the place of holding without transfers" was set at the basis of the further improvement of the procedures for the transportation of dolphins.

F. A. Leontovich's observations showed that the dolphins which were placed in an individual canvas tub, 2.0 x 0.5 x 0.6 m in size, began to struggle and manifested nervous behaviour, while in a transparent aquarium of perspex of the same size they behaved much more calmly. This was taken into consideration in the design of the special tubs for the transportation of the dolphins. Before these tubs were made there were used canvas brine tubs, stretched out on ropes in the hold of the ship or in the back of a GAZ-69 A truck, and canvas tubs on wooden end-panel frames. There were also used plywood boxes, lined with porolon*, within which was inserted an inner lining of polyvinyl chloride film. Besides these, there have also been utilized rectangular steel boxes, welded of thin sheet metal, inflatable rubber boats etc.

* Translator's note. "porolon" - a foam plastic.
John Lilly (1962) prepared boxes according to the dimensions of the animals and attempted to decrease the volume of water in these to a minimum. The tubs were shaped out of thin plexiglass in the form of the body of a dolphin, while the strength and rigidity of the design was ensured by plywood ribs. In order to lessen the spillage of water en route, the box was covered with a lid, with a large slot for the dorsal fin. In this case there was utilized the principle of simultaneous loading of the tub together with the animal and water, though such a tub was suitable only for a dolphin of a particular size.

Our tubs were designed for the transportation of various species of dolphins. They had a rectangular form, which permitted, depending on the size of the animals, the transportation in one tub of one or two bottlenose dolphins, or up to five white sided dolphins, or up to nine Azov common porpoises simultaneously. The most suitable type proved to be welded tubs of duralumin, which were much lighter than steel tubs, more durable than plywood tubs, and did not produce such scratches and abrasions to the delicate skin of the dolphins as did the canvas tubs. The internal dimensions of the transporting tubs should be no less than $3.5 \times 0.8 \times 0.8$ m. In the anterior part of the tub are mounted three rectangular windows of plexiglass.

In the preparation of the tubs particular attention should be paid to the method of securing the windows. In the first design the six-sided heads of the bolts which projected inside the tub and the edges of the tub at the window were the cause, in several cases, of traumas to the dolphins that were
being transported. The second design eliminated this defect by the placement of the bolts on the outside and by the selection of the bevelling on the plexiglass. We note that from the outside the plexiglass should be clamped down with nuts through a steel strip which borders the window along its perimeter. This ensures a more even distribution of the load on the fastenings. The hydraulic impacts which arose during rolling and pitching caused cracks in the windows and loss of water, if ordinary washers were placed under the nuts instead of such a strip.

Edging the upper edges of the tub with 7cm diameter tubing considerably decreases the probability of traumas during the loading of the dolphin into the tub. The bottom of the tub was provided with skids as a convenience for moving it, while on the lower part of the sides of the tub there were fixed handrails, which could be used for carrying the empty tub by hand or for raising it mechanically. The presence of drainage plugs considerably facilitates keeping the tub clean and allows for the possibility of changing the water level in it. It should be borne in mind that painting the tub with red lead and the subsequent transportation of an animal in standing water in such a tub may lead to the poisoning and death of the animal.

Aboard ship the presence of running water in the tubs is provided for by making use of sea water from the fire mains. On motor vehicles, loss of water from the tubs occurs on starting, during turns and on braking, and also when moving over an uneven road. Strips of porolon, placed on the surface of
the water, decrease the splashing. En route, fresh water may be added: the movement of dolphins into rivers, sometimes for hundreds of kilometers upstream from the mouth of the river, indicates that brief sojourns in fresh water do not harm them. The suspension of the dolphin in the tub on a stretcher prevents injury of the animal against the walls. In this manner, in 1968 and 1969, there were transported by motor vehicle four bottlenose dolphins and four white-sided dolphins over a distance of 250 km. Without a stretcher it is fairly difficult to restrain an animal on an uneven road, though enthusiasts were able to deliver dolphins without injury, at the cost of a five-hour stay in the water together with the animal. The main thing in this situation is the timely raising of the dolphin by the jaw, so that its blowhole is above the water.

Thanks to the experiments of A. G. Tomilin (1951) it became known that the loss of heat from the organism of the dolphin to the surrounding medium occurs through the flippers*. If the flippers are not moistened with water for a prolonged period, then, because of the smaller heat capacity of air, there may occur overheating of the organism and death of the dolphin from heat shock. Drying of the eyes may cause blindness. Some authors recommend wrapping the dolphins in wet woolen blankets or in sheets. This method has its disadvantages: The fabric does not adhere closely to all parts of the skin and it hides dried-out portions from the observer. Such coverings, however, protect the skin from burns by the direct rays of the sun.

* Translator’s note. The Russian word "plavniki" refers not only to the flippers but also to the dorsal fin and tail flukes.
Spending a prolonged time without movement during transportation may cause a temporary numbness of the locomotory musculature in dolphins. Therefore, when it is let out into the pen or pool the dolphin sometimes may not be able to raise itself to the surface to exchange the air in its lungs. At such times it is desirable to have an aqualung diver in attendance.

Further studies of the physiology and characteristics of behaviour of dolphins under experimental conditions will permit improvements to be made in the methods of transporting these animals.

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Already in a paper published ten years ago (Chapskii, 1961) the author argued his views on the subfamily structure of the phocids, the main criterion for the systematic subdivision of which was taken to be the incisor formula. On this basis was confirmed the classical suprageneric structure of the seals in the form of the three subfamilies: the Phocinae, Monachinae and Cystophorinae, which had been accepted three years previously by Scheffer (1958) in his review of the seals of the world. It may be recalled that it was namely this systematics of the phocids which were adhered to by the predominant majority of mammalogists, commencing with those who laid the foundations of the systematics of the pinnipeds: Gray, Gill and others. Many other prominent zoologists of our time have gone even further and have found it possible to divide the phocids into four subfamilies (Kellogg, 1922; Hay, 1930; Simpson, 1945; Frechkop, 1955; Ellerman and Morrison-Scott, 1957, and others).

However the arguments presented for such a division were, in large part, very limited and inaccurate.

This "fragmentation" of the family began in the last quarter of the last century and, apparently, pertains to Gray (1874), who, after including the 8-incisor seals in a single subfamily or tribe for many years, decided to divide these,
separating from the monk seals the southern 8-incisor seals and including these in the tribe (essentially, from the taxonomic aspect, equated to a subfamily) Stenorhynchina, equivalent to the Lobodontinae. In the final analysis, even though this did not improve the systematics as a whole (since in the process of the rearrangement of the genera the monk seal was placed together with the 10-incisor seals), it focused the attention of mammalogists on the taxonomic heterogeneity of the 8-incisor seals and, in particular, on the specific characteristics of their Antarctic representatives.

THE INCONSISTENCY IN THE TAXONOMIC INTERPRETATION OF THE 8-INCISOR SEALS

The differing views on the systematic position of the seals that have in common a single incisor formula are, undoubtedly, conditioned by the insufficient clarification of the elements of similarity and difference (primarily of the craniological features) between the subtropical and Antarctic components of this group of phocids.

Even in contemporary reviews it is difficult to find indications of any distinct osteological differences between the seals of the genus Monachus, on the one hand, and the whole aggregate of the 8-incisor seals from the Southern hemisphere, on the other. This situation may be illustrated by several specific examples.

Almost fifty years after the systematics of the phocids were enriched, following Gray's initiative, by the new name of a distinct subfamily of the southern 8-incisor seals,
Kellog (1922) was forced to state that it was difficult to find any precise differences between the Antarctic seals (Lobodoniae) and the monk seal. Scheffer (ibid.) also agreed with this, adding that, in the presence of the already existing subfamily of 8-incisor seals of the Southern hemisphere, the separation of a distinct subfamily for the seals of the genus *Lonachus* seems to be unsubstantiated.

Not without interest in this connection is the statement by King (1966) that the intergeneric skull differences in the seals were in general so great that it was difficult to find any features that were common to the group. It is impossible not to agree with this statement. Unfortunately, however, from this King arrived at extremely different conclusions in another direction.

**THE NEWEST ATTEMPT AT A RADICAL RECONSTRUCTION OF THE SUBFAMILY STRUCTURE OF THE PHOCIDS**

In King's opinion, which was expressed in the previously mentioned paper, the mammalogists who created and perfected the systematics of the phocids had, as it were, "gone along the line of least resistance" in making use of the number of incisors as a criterion of the subfamily for precisely the reason that this is a very convenient feature, although, from her point of view, this is by no means sufficiently reliable. In her own studies, directed towards elucidating the genetic relationships between the various groups of phocids and, consequently, to the creation of a more rational systematics of
the latter, she completely abandoned the incisor criterion, considering it as being too variable.

She preferred to place completely new features at the basis of her reconstituted systematic scheme:

1. The size of the posterior lacerate foramen (foramen lacerum).

2. The partially visible, from above, mastoid (os mastoideum).

3. The ventral part of the petrous bone (os petrosum) which projects from the lacerate foramen.

It is already known what followed from this. The reconstructed systematic scheme was found to be reduced to two subfamilies, which were quite sufficient, as it seemed to King, to include all of the seals. In one of these, the subfamily of the northern phocids (Phocinae), she included the 10-incisor seals and the hooded seal, in the other (Monachinae) - all of the seals of the Southern hemisphere, including also the elephant seal. King admits that in these subdivisions it is difficult to clearly place: firstly, the bearded seal (genus Erignathus), in which the posterior lacerate foramen is abbreviated, and secondly, the monk seal itself (genus Monachus), since in this two of the basic features (the visibility of the edge of the mastoid in dorsal view and the distinctly projecting petrous bone in the lacerate foramen) do not correspond to the requirements of affinity to the subfamily Monachinae in its new interpretation. Acknowledging these deviations, King found a way out of a difficult situation by considering that both of these genera of seals were transitional forms,
linking the subfamilies of the northern and the southern seals. Strictly speaking, there are no grounds for disputing this thesis in general, even if only for the reason that the Antarctic 8-incisor seals undoubtedly belong to one and the same genetic line with the monk seal, from the ancestral form of which they also originated. Likewise, there is also no doubt that the contemporary monk seal (from the ancestor of which there commenced the divergence which led to the appearance of the whole group of genera of 8-incisor seals of the Southern hemisphere) is itself a derivative of the more primitive 10-incisor seals.

Probably there is nobody who doubts also the fact of the relatively more primary and primitive character of the numerous morphological features that are characteristic of the seals of the genus Erignathus, which aspect has already been discussed by Winge (1924, 1941), Naumov and Smirnov (1936), and Chapskii (1955). Nevertheless, it by no means follows from this that the seals of the Southern hemisphere could have originated directly from the predecessor of the contemporary bearded seal.

The term "transitional form" is a concept from the phylogenetic arsenal, and by itself is essentially not connected with systematics. Whatever this form is, the components which it embraces are taxonomic categories, and these should have a fully defined position, for which arguments have been presented in the proper manner. However, in the system which has been constructed by King on the new morphological criteria the position of both the monk seal and of the
bearded seal is fairly precarious. This is a postulated position, rather than one which corresponds to the formal requirements of systematics. In actual fact, the motives for including the first of the named species in the subfamily Monachiinae (against which, of course, there can be no objections) clearly will not pass criticism from the formal aspect, since out of the three criteria of the subfamily, proposed by King, two do not fit. At the same time the only and, obviously, in these circumstances, the decisive feature, the specific character of the lacerate foramen, cannot play a similar role in the second case, in establishing the systematic status of the bearded seal.

What else can explain these facts, if not the weak aspects of the systematic scheme itself and the unreliability of the arguments on which it is based? No references to the transitional character of the species can rectify the situation here.

The transitional position of any particular species, genus, subfamily etc. may manifest itself only in those features of the structure which do not belong to the diagnosis. To rephrase this postulate, it may be formulated in another way: the features which are distinguished by an inconstancy of their manifestation cannot serve as diagnostic features.

Observance of these requirements is obligatory for all of the links of the systematic scheme, particularly for categories of so high a rank as the subfamily. Deviations may be encountered, but only in the form of extremely rare exceptions to the rule in individual cases. In the system proposed by
King, however, the infringement of those few structural features to which an exclusively diagnostic significance is ascribed seems to be the rule rather than the exception! What then, under these conditions, is the advantage of the new systematic scheme and why should it be given preference?

SOME CRITICAL REMARKS CONCERNING THE DIVISION OF THE PHOCIDS INTO TWO SUBFAMILIES

All that has been said above (the inadequate diagnostic value of the new features which were erected by King to the position of the primary craniological criteria of the subfamilies, and, as a consequence of this, the presence of the mentioned "transitional forms") already by itself very much weakens King's position, which so decisively broke with the classical systematics of this family of pinnipeds.

There are, however, also other serious grounds for not agreeing with the new taxonomic structure.

In the first place, there calls attention to itself the undervaluation of the dental criteria (the incisor formula), the negative attitude towards which was not argued out in a proper manner.

The main objections, however, arise from the results of a special craniological study, undertaken by the author with the aim of re-examining the taxonomic problem that has arisen. Having checked the mentioned new criteria of the subfamilial integration and, at the same time, having reviewed the craniological material on the phocids that is available in the osteological depository of the Zoological Institute of
the USSR Academy of Sciences with the aim of revealing more completely, as far as was possible, the similarities and differences between the various groups which were being compared, the author reached a firm conviction as to the stability of the previous classical systematic scheme for the phocids (Chapskii, 1969, in litt.). Without repeating here all of his arguments, the author nevertheless considers that it would be useful to present in a very brief form the main motives, on the basis of which he disputes such radical changes, introduced by King into the systematics of the phocids.

The objections may be reduced, basically, to the following points.

1. The significance of the craniological elements of similarity, which are in fact present in the hooded seal and the 10-incisor seals, were exaggerated in King's study; at the same time the cranial differences between these seals were revealed by her very incompletely and were underrated. Meanwhile, in fact the number of similar features in these seals is only about half of the number of the features of difference: there are about fifteen of the former and at least twenty five of the latter. In this situation, the categorical judgement of King on the inadequate diagnostic value of the incisor criterion does not appear to be very convincing. If however one takes into consideration certain additional diagnostic features, namely: a) the narrowed spindle-shaped bulge of the mastoid part of the temporal complex (precisely that portion which is visible beyond the lateral mastoid process from dorsal view and which in cross section does not exceed
half of the length of the tympanicum); b) the direction of
the axis of this bulge, which is inclined markedly downwards
behind the mastoid process; v) the marked swelling of the
maxillary bones immediately in front of the orbits; g) the
well developed anterior palatine foramina, situated in groove-
like depressions, - then, together with the incisor formula,
the subfamily of the ten-incisor seals acquires a fairly good
craniological basis.

2. Speaking convincingly against the systematic bring-
ing together of the elephant seal and the 8-incisor (in parti-
cular, the Antarctic) seals is the marked predominance of fea-
tures of difference between these over the features of simila-
ritv. Strictly speaking, these seals are linked only by the
abbreviated lacerate foramen; while on the basis of almost all
of the remaining elements of the craniology they are differen-
tiated. If, however, there are scrupulously counted all of
the features by which the compared seals are in any way simi-
lar and these are set beside those features which differentiate
them, then, with such an approach, it is found that there are
almost three times as many features of difference as there are
features of similarity. In these conditions it is difficult
to speak of closer genetic ties between the seals which are
being compared.

3. On the other hand, the similarity between the
elephant seal and the hooded seal is far from being exhausted
by those few and, in King's opinion, unimportant features which
she mentions. In actuality, the similarity between them is
much greater. With an attentive examination of the skulls,
it turns out that there are twice as many elements which bring these two genera of seals together as there are elements by which they are differentiated, although there are fairly many (about 20) of the latter, since these are different genera. Thus, if the dental formula is accepted as the criterion for the systematic grouping of the genera Cystophora and Mirounga, i.e. in this case the presence of six incisors \( (i = 2/1) \), then in the seals which are united by this characteristic there are found to be about 40 similar features, and only about 20 dissimilar features. If however, on the contrary, one is guided not by the incisor formula but by the relatively little extended lacerate foramen, and, consequently, one unites the elephant seal with the southern 8-incisor seals, then the total number of similar elements of the cranial structure in these will be no greater than five, while at least a dozen features of difference can be compiled.

With such numerical ratios, one would think that it would be difficult to insist on uniting the elephant seal in one subfamily with the 8-incisor seals. Similarly, it is unnatural to combine in the second subfamily the hooded seal with the 10-incisor seals and, as a result, to liquidate the third subfamily of the 6-incisor seals, the Cystophorinae.

To sum up, the truth in the taxonomic structure of the phocids is found to be on the side of the classical systematics, and as the leading criterion of this, at any rate for the contemporary members of the family, we may consider the dental formula*.

* (This footnote is given on the next page of the translation.)
CRANILOGICAL SPECIFIC CHARACTERISTICS OF THE 8-INCISOR SEALS

Accepting the incisor formula as being sufficiently weighty, from the taxonomic aspect, and giving preference to this classical criterion in subdividing the phocids into subfamilies, it is impossible not to see also how difficult it is to find any other craniological features which would in the same way unite all of the 8-incisor seals and would be specific only to these. This most important, if not the only, diagnostic element could be expanded by taking into account certain additional features, namely:

1. The low positioning of the anterio-inferior edge of the cheekbones (Figure 1).

2. The markedly more developed, than in other seals, and further backwardly directed zygomatic process of the maxillary bones (Figure 2).

3. The narrowed anterior angle, which is markedly smaller than a right angle, of the lumen of the orbit in the horizontal plane (Figure 2).

However all of these additional craniological characteristics are not very expressive, are subject to considerable variability, are not free of exceptions and may sometimes be found also in other seals.

Still less diagnostic are several other structural features, which, though characteristic of all of the members of

* (From previous page).

The author is forced to make the stipulation with respect to the contemporary phocids at the present time on the grounds that in the upper Tertiary ancestors of the monk seals (genus *Lono-therium*) there were allegedly present not 2 but 3 incisors in each half of the upper jaw (Kellogg, 1922; Boettger, 1951).
Figure 1. The contours of the left zygomatic bone (profile) of the monk seal (upper figure) and the Weddel seal (lower figure).

Legend: a - suborbital foramen, b - body of zygomatic bone, v - anterio-superior process of bone, g - its anterio-inferior edge.

this subfamily without exception, are at the same time inherent also to the representatives of the subfamily of the six-incisor seals. Among these belong: the wide but not markedly protruding bulge of the mastoid, which is not directed downwards behind the mastoid process; the concave outlines of the projection of the lateral contours of the pre-orbital part onto a horizontal plane; the disappearing anterior palatine foramina; developed pre-orbital processes; a wide inter-ocular space; abbreviated lacerate foramina.
Figure 2. Schematic depiction of parts of the skull from above:

- **a** - the contours of the skull of the harbour seal (a representative of the 10-incisor seals);
- **b** - fragment of right side of skull of the monk seal;
- **v** - orbital part of right side of skull of the Weddell seal;
- **g** - the same, of the Ross seal

The interrupted lines indicate the length (along the longitudinal axis of the skull) of the zygomatic process of the maxillary bone.
CRANIOLOGICAL GROUNDS FOR THE TAXONOMIC DIFFERENTIATION
OF THE SUBFAMILY OF THE 8-INCISOR SEALS

The inadequacy of the available characteristics of the tribes, of their diagnostic features, makes it urgently necessary to have a proper revision and more precise definition of the craniological basis of the established taxonomic subdivisions of the 8-incisor phocids, the Monachinae.

Gray (1874) was probably the first to present certain definite and fairly accurately grasped specific characteristics of the bones of the skull (in particular, the fusion and elongation of the nasals), which permitted one to more or less reliably identify the 8-incisor seals of the Southern hemisphere. Subsequently to these was added one other feature, the elongated zygomatic processes of the maxillary bones.

As a result of the most recent examination of these diagnostic features and all measurements of the craniological difference of the 8-incisor seals of the Southern hemisphere (Lobodonini) from the subtropical representatives of the Monachinae, there were found, on the one hand, certain weak aspects of Gray's diagnosis, while on the other hand there were revealed several new and more precise elements of difference*.

It was found, in particular, that even such a characteristic feature of the southern Monachinae as the fusion of the nasal bones is not completely reliable, since divided nasal bones are not infrequent in Weddell seals (and not only in the

* This work was carried out mainly on the same craniological material in the osteological section of the Zoological Institute of the USSR Academy of Sciences.
young); it is encountered in the crabeater seal, and a tendency to this is also noted in the leopard seal.

In all of the subtropical monk seals the nasal bones, of course, are always divided. The second feature, the elongated frontal part ("apex") of the nasal bones, also sometimes does not give the typical picture in the southern seals, and at times manifests the opposite development also in the monk seal. Reference has also been made to the variability in the length of the zygomatic processes.

Thus, in spite of the characteristic nature of the craniological features, which one cannot avoid taking into account, they nevertheless cannot have a primary diagnostic significance.

Taking into consideration all that has been said, the craniological part of the expanded diagnoses of both tribes of seals of the subfamily Monachinae may be represented in the following form.

TRIBE MONACHINI

Zygomatic bone and profile with a fairly clearly outlined anterio-inferior edge, permitting the length of its body to be measured (without the anterior articular process). The inferior edge, from the same position, along its whole length has the form of an arch, which is elevated to the greatest degree in the middle part of the body of the bone (Figure 1).

The end of the anterio-superior process of the zygomatic bone extends far anteriorly and terminates almost over the interior edge of the suborbital foramen. The latter is
Figure 3. Schematic diagram of part of the right side of the skull from the front. There is shown the relationship between the position of the pre-orbital foramen (the level of which is marked by the double interrupted line) and the position of the zygomatic bone (the trough of its upper edge).

Legend: M - monk seal, N - leopard seal.

situated no higher than the level of the greatest deflection downwards of the upper edge of the body of the zygomatic bone (Figures 1 and 3).

The nasal bones are not grown together with one another; the frontal portion of these is generally not longer than the remaining (anterior) portion (Figures 2b and 4).

The fontanelles in the region of the presphenoid are huge and round.

The tribe includes the three species of monk seals of the genus *Monachus* Flem.
Figure 4. The form of the fused nasal bones of the seals of the Southern hemisphere: the Ross seal (A) and the leopard seal (B).

The arrows and interrupted lines indicate the length of the frontal portion ("apex") of the nasal bones.

Legend: fr - frontal bone, m - maxillary bone, n - nasal bones.

TRIBE LOBODONINI *

Profile of the zygomatic bone without any angular border between the maxillary process and the body of the bone.

* The 8-incisor seals of the Southern hemisphere were first grouped in a separate tribe, as far as may be judged now on the basis of the available literature sources, by Gray (1871, 1874), though the author made use of a preoccupied name, Stenorrhynchina, which was subsequently replaced by another. Since the presently accepted name for this tribe is derived from the genus Lobodon (not Lobodont), then from this it seems that the more correct derivative is namely Lobodini, by which name the tribe is here designated.
its inferior edge is either completely without an arch-shaped curvature, or with a barely expressed, shallow arch only in the posterior half of the bone. The antero-superior end of the zygomatic bone reaches far short of the suborbital foramen, terminating at the level of the latter or below this. The zygomatic bones in general are set considerably lower and the greatest bend downwards of their upper edge is situated below the suborbital foramen (Figures 1 and 3).

The nasal bones, as a rule, are grown together, while their frontal portion is considerably longer than the remaining part (Figure 4).

The paired fontanelles in the region of the presphenoid are in the form of narrow slits, and if they are wider then nevertheless they have a distinct tapering in front and behind.

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QUANTITATIVE CHANGES IN THE VERTEBRAE IN THE VERTEBRAL COLUMN OF PINNIPEDS

In considerations of the post-cranial skeleton of mammals it is customary to determine the overall vertebral formula. To an equal degree this applies also to the representatives of the order of the pinnipeds. Thus, Flower (1885) and Turner (1912), on the basis of an examination of about 46 individuals of various species of the true and eared seals, derived similar formulas for the whole order of the pinnipeds, namely: C 7, Th 15, L 5, S 2-4, Cd 8-15*. An exception was presented by the walrus, in which these authors noted 14 vertebrae in the thoracic section and 6 in the lumbar section. Many years later this was still accepted as the vertebral formula and this conclusion was confirmed by King (1956). Two years later Scheffer (1958) introduced certain corrections, as a result of which the formula took on the form: C 7, Th 15, L 5, S 3-4, Cd 10-12, with no exceptions being made. Still later King (1964) corrected this once again: C 7, Th 15, L 5, S 3, Cs 10-12, an exception to which still remains the walrus with its 14 thoracic and 6 lumbar vertebrae.

This small review of the literature shows that there is no agreement in the opinions on the numerical values of the

* C - cervical section (pars cervicalis), Th - thoracic section (pars thoracicalis), L - lumbar section (pars lumbaris), S - sacral section (pars sacralis), Cd - caudal section (pars caudalis).
vertebral formula. In the present paper an attempt is made
to investigate the causes of this and, as far as possible, to
clarify the actual situation concerning the vertebral formula
in the pinniped order. With this aim the author again ana-
lyzed the fairly extensive material which is kept in the col-
lections of the Zoological Institute of the USSR Academy of
Sciences. There were examined two hundred vertebral columns
of almost all of the species of this group of animals, of
various sex and age.

The results are presented in the table, from which
it is evident that, on the basis of the character of the ver-
tebral formulae, there may be established at least seven groups
for the pinnipeds. The first group, which embraces the largest
number of cases (66.5% of all of the examined individuals), is
characterized by the formula: C 7, Th 15, L 5, S 4, Cd 8-16.
In this group are included representatives of all three fami-
lies. In the second, less numerous group (19% of the examined
individuals), the vertebral formula is: C 7, Th 15, L 5, S 3,
Cd 8-15. In this group the walrus family is completely lacking,
but for the rest the composition is identical to that of the
preceding group. In the third group (6%), with a vertebral
formula of C 7, Th 14, L 6, S 4, Cd 11-12, there are included
in all only two* Odobenus rosmarus and Erignathus barbatus.
The fourth group, which is just as small (5%), includes Histrio-
phoca fasciata, Phoca hispida ladogensis and Eumetopias jubatus.
Its vertebral formula is C 7, Th 16, L 4, S 4, Cd 8-16. The

* Translator's note. Sic. Presumably - "... two species ..."
The number of vertebrae in different sections of the vertebral column in representatives of the pinniped order.

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Table
remaining vertebral formulae are scarcely characteristic of the pinnipeds and each of them is represented by two specimens of some different species, which comprises 1% of the total number of examined vertebral columns. Thus in a Weddell seal (Leptonychotes weddelli) the vertebral formula had the form: C 7, Th 15, L 5, S 2, Cd 11. In a fur seal (Callorhinus ursinus) there was found a somewhat different formula: C 7, Th 16, L 4, S 3, Cd 9-10. Finally, the formula C 7, Th 14, L 6, S 3, Cd 12-14 is characteristic of the leopard seal (Hydrurga leptonyx).

In all of the vertebral columns of pinnipeds which were examined by us and also by other investigators (Allen, 1880; Flower, 1885; King, 1956, 1964, 1969; Scheffer, 1958) the cervical section was invariably represented by 7 vertebrae. In the thoracic and lumbar sections there are counted, in total, 20 trunk vertebrae, which is characteristic also of the representatives of the order of carnivores. Only in two cases: in one ringed seal (Phoca hispida) and one ribbon seal (Histriophoca fasciata) were there 21 trunk vertebrae. Such cases may be considered as atypical deviations from the norm.

In the thoracic section 15 vertebrae were found in 87% of the examined vertebral columns. This number, evidently, should be considered as being the most typical for the pinnipeds. However, as can be seen from the summary table, there are encountered individuals with 14 and 16 thoracic vertebrae (6.5% in each case). A thoracic section with 14 vertebrae, as has already been mentioned above, is typical of the walrus. The second species in which there are 14 thoracic vertebrae
is the bearded seal (*Erignathus barbatus*) and moreover this species was also characterized by having 15 and even 16 thoracic vertebrae. Such a variation of the vertebrae under consideration possibly conforms, to some extent, with the concepts of certain authors (Winge, 1941; Chapskii, 1955) on this species as being little specialized and primitive. It is interesting to note that in the Ladoga ringed seal (*Phoca hispida ladogensis*) the thoracic section is formed exclusively of 16 vertebrae. This feature distinguishes this seal not only from the species *Phoca hispida* but also from the whole of the genus *Pusa* and, possibly, may prove to be a taxonomic feature. Perhaps the same applies also, though this is less convincing because of the very small number of individuals examined, to one other species of true seal - the leopard seal, the thoracic section of which is composed of 14 vertebrae.

In the eared seals a variation in the number of thoracic vertebrae, from 15 to 16, is observed only in the fur seal (*Callorhinus ursinus*) and Steller's sea lion (*Eumetopias jubatus*).

The lumbar section in the pinnipeds characteristically has 5 vertebrae, though more rarely there may be encountered 4 or 6. Since, as has been mentioned above, the number of the trunk vertebrae in the pinnipeds is constant, the frequency of occurrence of such cases is precisely the same as the number of encounters of 14 and 16 thoracic vertebrae. In view of the fact that these values are correlated, all of the arguments presented above on the variability in the number of the thoracic vertebrae will be valid also for the lumbar vertebrae.
As is evident from the literature references, each author considers that for the pinnipeds that number of sacral vertebrae is characteristic, which seems to be in accordance with the results of his own analysis of the vertebral formula. In summing up, the authors agree that for the true and eared seals the typical sacrum is composed of both 4 and 3 vertebrae. If, however, one again turns to the summary table, then it can be noted that all of the enumerated investigators were to some degree right, for in the sacrum there are found four, three and even two vertebrae. Most often (79%) the sacrum is composed of four fused vertebrae, which, apparently, may be considered as being typical of all of the eared and true seals of the Northern hemisphere. Sometimes, however, in these seals there may be found a sacral bone which is formed of three fused vertebrae. With a more detailed examination of such cases it turns out that the sacrum, even if only morphologically, is nevertheless formed of four vertebrae. Two facts lead one to this conclusion. Firstly, the caudal epiphysis of the third sacral vertebra and the cranial epiphysis, in this case, of the first caudal vertebra are considerably flattened, their edges have lost the rounded outlines (Figure 1), in contrast to all of the epiphyses of the bodies of the vertebrae in the other sections (Figure 2). Secondly, the transverse processes (processus transversus) of the sacral vertebrae, which here form longitudinal ridges (pars laterales), in the normal four-vertebral sacrum gradually become narrower and thinner from the first vertebra to the fourth, merging completely with the body of the fourth and last vertebra in
Figure 1. Caudal portion of three-vertebral sacrum of a harbour seal and first caudal vertebra (view from ventral side, the numerals indicate the ordinal number of the vertebrae in the sacrum).

Figure 2. Four-vertebral "normal" sacrum of a harbour seal (view from ventral side).

its caudal portion (see Figure 1*). In the case, however, of the three-vertebral sacrum these ridges, on the contrary, become slightly wider and thicker on the body of the third vertebra, which is clearly not "ended", and only on the first caudal vertebra do they become thinner and merge with its body (see Figure 2*). Such a "morphological incompleteness"
of some of the three-vertebral sacra considerably reduces, if it does not practically stop, the freedom of movement of the last sacral and first caudal vertebrae relative to one another (such cases are marked in the table by the + sign). Consequently, the thought arises that such sacra function like the four-vertebral sacra. Thus, the number of individuals for which a sacrum composed of four vertebrae is typical becomes even greater. There are also encountered cases of a clearly normal sacrum that is formed out of three or even two vertebrae, representing a morphologically single sacral bone. Such a sacrum is basically characteristic of all of the Antarctic seals, in which there is observed a tendency towards a reduction in the number of the constituent elements of the sacrum. In the examined series there were also noted two cases, in one individual of the Caspian seal (*Phoca caspica*) and one harbour seal (*Phoca vitulina largha*), in which the sacrum was composed of five fused vertebrae. This phenomenon represents a clear deviation from the norm and may be considered as a teratism: in both cases the first sacral vertebra was separated from all of the others, while the junctions of the last sacral vertebra with the first caudal vertebra bear traces of a distinct ankylosis.

In the caudal section it is generally impossible to establish any regular pattern of the variation in the number of vertebrae. In one and the same species the number of vertebrae may vary from 8 to 12-16. Therefore it is scarcely possible to utilize the number of vertebrae in this section as a taxonomic feature of the species, subspecies or population rank, at least within the order of the pinnipeds (Yablokov,
The only feature which may be noted is the abbreviated nature of the tail of the eared seals: the tail in these is formed of a smaller number of vertebrae (from 8 to 14) than in the true seals, in which the caudal section is composed of 10 - 16 vertebrae.

Summing up all of the information presented above, the general vertebral formula of the pinnipeds may be presented in the following form: C 7, Th 14-16, L 4-6, S 2-4, Cd 8-16.

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Over the course of many years in the northern and eastern part of the Baltic the ringed seal (Pusa hispida gm*) and the grey seal (Halichoerus grypus F.) have served as objects of the marine sealing industry; these seals have been caught here at all periods of the year and without any limitations. Furthermore, in Sweden and Finland a bounty is paid for catching the seals (Curry-Lindahl, 1965).

Every year there are caught by these countries in the coastal waters about 15-16 thousand seals (Ropelewski, 1952; Bergman, 1958).

It is natural that such destructive sealing has affected the stocks of the seals.

In the territorial waters of the Soviet Union (in the Gulf of Riga and the Gulf of Finland) the sealing is carried out by sealers from fishery kolkhozs in Estonia and Latvia, the annual catch of which does not exceed 1200 - 1500 head (according to official data from the Estrybakkolkhozsoyu** in which each 100 kg of production from sealing operations is considered as equivalent to 3 seals).

From 1970 a limit has been placed on the catch of Baltic seals in the USSR.

Translator's notes. * Sic. Schreber is the species author. ** Acronym for Estonian fishery collectives union.
Up to the present time the representations of the numbers of seals in the Baltic remain very indefinite. Moreover, there has been noted a marked reduction in their population numbers.

Thus, according to Bergman (1958), "the stocks of the ringed seal in the coastal waters of Finland have decreased considerably from the twenties and thirties up to the late fifties of this century. In the southern part of the Gulf of Bothnia they are particularly small, in the middle part of the Gulf of Finland and in the central portion of the Gulf of Bothnia (Salkameri and Melenkuru) they are rather small, in the shallow waters off the islands of Valgrund and Bergö they are not more than average, and in the eastern part of the Gulf of Finland they are average, at the level of the 1920s and 1930s. In comparison with the 30s, even in the northern part of the Gulf of Bothnia the population numbers of the grey seal have decreased considerably. In the western part of the Gulf of Finland there were considerably fewer grey seals in 1940-1950 than there were in 1920; there were a few more of these in the eastern part of the Gulf of Finland. The total number of grey seals within their territorial waters was, on average, considerably smaller than the number of ringed seals. Their ratio, according to Gotberg's data, comprises 1:3".

According to the tentative estimate of Sundström (1962), the Baltic population of the grey seal at the end of the fifties was about 10 thousand head. A marked lowering of its population numbers was pointed out in the middle sixties already by Curry-Lindahl (1965). According to Smith (1966), the stock of grey seals in the Baltic comprises 5 thousand head.
The only approximate indication of the population numbers of the Baltic ringed seal was found by us in a Finnish fishermen's journal ("Kalamichnen Viesti", no. 1, 1966), where it was stated that each year after the sealing operations in Finnish waters there remain about 20 thousand ringed seals. There are very few operational data of any kind, on the basis of which judgements can be made on the population numbers of the two species of seals in the Gulf of Finland and the Gulf of Riga.

It is even more difficult to judge the population numbers of the Ladoga ringed seal, of which about 500 head are caught each year by hunters and fishermen.

K. K. Chapskii (1932) assumed the possibility that about 20 thousand seals could be living in Lake Ladoga; in the opinion of S. M. Sokorin (1958) the population numbers of the Ladoga seal were nor high, while A. I. Zubov (1965), referring to data from the State Research Institute of Lake Fisheries (GOSNIORH), estimates the stocks of the Ladoga seal at 5 - 10 thousand head.

In connection with the growing demand of the sealing industry there has come to a head the necessity for reorganizing this on a scientific basis. A most important condition for the rational utilization of its resources should be the knowledge of the population numbers and other questions related to this.

From 1969 the AtlantNIRO (Atlantic Research Institute of Marine Fisheries and Oceanography) has been conducting work on the study of the seals in the eastern coastal region of the
Baltic Sea and Lake Ladoga, and therefore in March-April of 1970 there was made the first attempt at an aerial survey of these seals by workers of the AtlantNIRO.

MATERIALS AND METHODS

As far back as the forties Dorofeev (1940) wrote about the advisability of employing aviation for surveying marine mammals.

In recent years Tikhomirov (1966), Fedoseev (1966), Shustov (1969) and other investigators have conducted aerial surveys and aero-visual counts of seals in the Far East.

In the Gulf of Riga and Gulf of Finland and on Lake Ladoga no special aerial surveys of seals were conducted up to this time.

Conducting an aerial survey of the ringed seal and the grey seal in these regions was accompanied by considerable difficulties. Up to the present time there has been no methodology worked out for the counting of these seals in the zone of the landfast ice, although we know of the attempt by Sviridov (1954) and by the far-eastern investigators, who conducted aero-visual counts of the ringed seal and other seals on broken drift ice. At the same time, it is known that the ringed seal, as a rule, does not form concentrated whelping and moulting patches, similar to the patches of the harp seal, and therefore we did not employ continuous aerial photography.

In elaborating the methodology for the aerial survey, we made use of information obtained by questioning local sealers and the experience acquired in counting seals by the far-eastern investigators and other authors.
Table 1.

Some indices of the periods of retention of tags in the digestive tract of the experimental animals, hours.

<table>
<thead>
<tr>
<th>Material</th>
<th>$M \pm m$</th>
<th>$\sigma$</th>
<th>С. V.</th>
<th>$n$</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic tags</td>
<td>73.5±16.4</td>
<td>73.5</td>
<td>100</td>
<td>20</td>
<td>$t_{AB} = 3.1$</td>
</tr>
<tr>
<td>Pieces of rubber</td>
<td>22.6±2.7</td>
<td>13.4</td>
<td>50.0</td>
<td>25</td>
<td>$t_{AB} = 3.5$</td>
</tr>
<tr>
<td>Small pieces of plastic</td>
<td>14.9±0.8</td>
<td>3.1</td>
<td>22.7</td>
<td>20</td>
<td>$t_{BB} = 2.7$</td>
</tr>
</tbody>
</table>

*Note. In view of the fact that significant differences were not found in the retention times of tags of the same type between the animals, generalized data are presented in the table.

The retention of the tags and, probably, of the undigested remains of the food also depends on the amount of food consumed by the animals and on the characteristics of the working of the digestive organs. Thus, the plastic platelets that were given to Ushkan before a prolonged fast were found after 55 days, while with Vega (in a similar case) they were found after 20 days. In contrast, when Vega was fed abundantly during the first third of February (the daily ration exceeded 4 kg) the tags often appeared in the tank 4 - 5 hours after the ingestion of the food.

However it should be noted that the small pieces of plastic, just like the otoliths, did not pass through the gastro-intestinal tract simultaneously: on the average, about
80% of these appeared after 10 hours, about 15% approximately after one day, and 5% - two days after being given to the animals. If the working of the digestive system of the animals under the natural conditions does not differ substantially from that in the test conditions, it may be assumed that the otoliths, collected from the intestines of caught animals, must belong to fishes that were caught by the seals within a period of 2 - 3 days, although the main mass of the consumed fishes had been digested less than half a day previously.

In spite of the fact that the animals were held in small tanks, i.e. in almost immobile conditions, the assimilation rate of the food was found to be very high. The faeces, which are composed to a considerable degree of undigested or poorly digested remains of fishes (bones, otoliths, crystalline lenses of the eyes etc.), under a moderate feeding regime (March - May) on the average had a weight of about 4 - 5% of the value of the daily ration*. There were found differences among the animals in the weights of the faeces, expressed as percentages of the daily ration, though statistically (with $P = 0.05$) these were insignificant.

Because of an insufficiency of food, the animals did not always obtain the necessary amount of fish. Moreover, from October 10th 1967 till January 9th 1968 Vega did not feed at all, while Ushkan did not feed at all from January 13th until March 3rd 1968. During 60 days of fasting Vega's weight fell by 10.6 kg (from 38.8 to 28.2 kg), by 29.7% of the initial weight. Over 50 days of an enforced fast the weight of Ushkan dropped from 40 to 29.45 kg or by 26.4%, i.e. he lost 10.55 kg. The mean daily weight losses comprised: 177 g for Vega and 211 g for Ushkan.

* Urinary wastes were not taken into account.
The two month fast of the seals in the described conditions should not be considered as the limiting value.

Over 222 days (including the period of fasting) Ushkan consumed 301.4 kg of fish, i.e. on the average he ate 1358 g per day. From the initial (39 kg) to the last weighing he lost 3.6 kg or 9.8% of his initial weight. Over 154 days (also including the period of fasting) Vega consumed 191.5 kg of fish, i.e. on the average 1244 g per day. Her weight dropped by 7.95 kg (from 38.8 to 30.85 kg), i.e. by 20.5%.

Manyunya obtained food in some amount or other over the course of almost the whole of the holding period. Nevertheless, the lack of food during the winter period also affected her. While initially her weight was 65.8 kg, after 184 days this was equal to 61.9 kg, i.e. she lost 3.9 kg or 6.3% of the initial weight.

The animals reacted very sensitively to changes in the size of the ration by changes in their own weight (Figure 1). With a low daily norm over several days, the weight of the animals began to fall, while with an increase in the norm the weight began to increase. At the same time, in the changes of the body weight with respect to the amount of food consumed there was observed a certain asynchrony, a semi-antiphase relationship of the maxima and minima. It is quite possible that this time lag in the changes in weight in relation to the size of the ration was caused by a differing assimilability of the food.

In the conditions of the experiment, i.e. with the markedly restricted movements of the animals, it was found to be possible to approach the question of estimating the daily
Figure 1. The change in body weight of the seals in relation to the size of the daily ration.
I - body weight (kg); II - daily ration (kg);
a - Vega, b - Manyunya, v - Ushkan.

ration which, in energetic respects, is close to the value of the standard (basal) metabolism. With this aim, in March - May 1968, when the animals were provided with food to an adequate degree, we attempted to select for each animal just such a daily ration, i.e. to establish such a moderate feeding regime in which the weight of the seals would remain more or less stable (Table 2).

The animals were primarily fed with the yellowfin Baikal sculpin*. Both species of Baikal oil-fish**, the longfin Baikal sculpin*** and also the benthic gobies were given in the form of a small supplement. Even under such conditions,

Translator's notes.
* Cottocomephorus cocomhoridae or C. growingki
** the "big golomanka" - Cophorpus baicalensis and the "little golomanka" - C. dybowskii.
*** Cottocomephorus inermis
Table 2.

Some indices of the daily ration with a stabilized weight of the experimental animals.

Некоторые показатели суточного рациона при стабилизированном весе подопытных животных.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ushkan (N=25)</td>
<td>Vega (N=25)</td>
<td>Manyunya (N=25)</td>
</tr>
<tr>
<td>Weight of daily ration, g</td>
<td>2097±49.1</td>
<td>1872±84.2</td>
<td>2559±54.9</td>
</tr>
<tr>
<td>M±m</td>
<td>1900—2500</td>
<td>150—3000</td>
<td>1000—4500</td>
</tr>
<tr>
<td>σ</td>
<td>282</td>
<td>533</td>
<td>429</td>
</tr>
<tr>
<td>C. V.</td>
<td>13.4</td>
<td>28.4</td>
<td>16.7</td>
</tr>
<tr>
<td>n</td>
<td>36</td>
<td>41</td>
<td>63</td>
</tr>
</tbody>
</table>

when the energy losses for all possible movements were reduced to a minimum, the animals required a fairly large quantity of food. In percentages of the body weight the rations comprised:

for Manyunya - 4.2%, for Vega - 5.6% and for Ushkan - 6.1%.

There is no doubt that under natural conditions the ration is at least 1.5 times greater than in the conditions of the test.

Just like with other mammals, on a per unit body weight basis the young animals required a supply of energy accumulated in the food than did the adults.

The food coefficient changes with the age of the animals. While for a body weight gain of 1 kg Vega required 23 kg of yellowfin Baikal sculpin, and Ushkan required 26 kg, the adult female had to consume twice as much of this same fish or 54 kg.
The maximal uptake of food at one time comprised 2 kg. Generally, however, the animals consumed not more than 1 kg in one meal (within 1 - 5 minutes). When fed "ad libitum" Kanyunya consumed not more than 5.6 kg of pelagic gobies in a day, Ushkan - 5.3 kg, and Vega - 4.5 kg.

In spite of the fact that the food was usually given during the day (once every 24 hours), the main mass of the food was consumed in the evening (crepuscular) period.

In March - April, during the period of the optimal feeding regime of the animals, there were set up experiments on the digestibility of the otoliths of the big and little golomankas and also of the yellowfin Baikal sculpin, i.e. the otoliths of those fishes which comprise the basis of the feeding of the seal under natural conditions. The otoliths were removed from freshly caught fish, measured under a binocular along their long and short axes with a precision of to 0.05 mm, fed to the animals, and later these same otoliths were picked out of the faeces of the seals and again measured. Subsequent comparison showed that the average values of the dimensions of the otoliths of the control and experimental series differed from one another at a high level of statistical significance (Table 3). On average, for the three seals, the length of the otoliths of the big golomanka decreased by 5% after passage through the gastro-intestinal tract, of the little golomanka - by 3.4% and of the yellowfin Baikal sculpin - by 4.3%; the widths decreased, respectively, by 6.9, 4.2 and 5.7% from the initial dimensions.
Table 3.

Changes in the dimensions of the otoliths of fishes with their passage through the gastro-intestinal tract of the experimental animals, mm.

<table>
<thead>
<tr>
<th>Otoliths</th>
<th>Parameters of the distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M \pm m$</td>
</tr>
<tr>
<td><strong>Big golomanka</strong></td>
<td></td>
</tr>
<tr>
<td>Длина</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td>Ширина</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>B</td>
</tr>
</tbody>
</table>

| **Little golomanka** | | | | | |
| Длина | A | 1,672±0,0036 | 0,161 | 9,6 | 2020 | 9,1 |
|       | B | 1,520±0,0052 | 0,179 | 11,5 | 1237 | 10,1 |
| Ширина | A | 1,272±0,0031 | 0,140 | 10,9 | 2220 | 10,1 |
|       | B | 1,224±0,0015 | 0,154 | 12,6 | 1237 | 10,1 |

| **Yellowfin baikal sculpin** | | | | | |
| Длина | A | 1,893±0,0053 | 0,145 | 7,7 | 746 | 11,7 |
|       | B | 1,820±0,0044 | 0,177 | 9,8 | 1599 | 11,7 |
| Ширина | A | 1,062±0,0025 | 0,069 | 6,3 | 784 | 11,5 |
|       | B | 1,034±0,0048 | 0,194 | 18,8 | 1599 | 11,5 |

* A — before experiment, B — after experiment.

$L$ — length

$W$ — width

The degree of digestion of the otoliths was found not to be uniform in each of the three seals. The otoliths were found to be somewhat more strongly digested in Manyunya, more weakly in Vega. It may be assumed that the intensity of the digestion of the otoliths is under the control of several factors, being dependent on the time spent in the gastro-intestinal tract, on the age of the animals, their nutritional state, motility etc. It is a curious fact that in each of the animals the otoliths of the big golomanka were most strongly digested.
less so - of the yellowfin Baikal sculpin, and still less -
of the little golomanka. In this, one cannot but perceive a
species specificity of the otoliths themselves. It is also
interesting that the otoliths decreased in size somewhat more
markedly along their short axis than along the long axis.
Apparently, the digestion of the otoliths depends, among other
factors, also on the surface that comes into contact with the
gastric juice.

The digestibility of the otoliths, which on the whole
is very similar in the golomankas and in the yellowfin Baikal
sculpin, should nevertheless be evaluated as being insignifi-
cant. The otoliths which have been in the digestive system
of the seals do not differ superficially in any way from those
which were removed from the fishes. By visual evaluation there
are also no differences in their optical structure: the annual
rings are distinguishable with the same degree of definition
as in the original otoliths.

Thus, it may be stated that the study of the feeding
of the seal on the basis of the otoliths is well-founded.
Lending itself to reconstruction by this method is not only
the species spectrum of the food but also the size, weight
and age of the fishes consumed by the seals. This last circum-
stance is of considerable significance for acquiring an under-
standing of the inter-relationships which are established
between the representatives of the two final trophic levels
in the pelagial of Lake Baikal: the golomankas and goby fishes
and the seals.
QUESTIONS RELATING TO THE CATCHING AND LONG-TERM HOLDING
OF DOLPHINS IN CAPTIVITY

The representatives of the suborder of the toothed cetaceans, the dolphins, attract investigators of the most diverse specialities. This is connected with the study of the profound adaptive changes, brought about by the habitat, and several biological characteristics which are of considerable interest. Among these, primarily, belong: the methods of orientation and navigation in the ocean; the characteristics of the hydrodynamics; the diving to great depths and for prolonged periods; the characteristics of the behaviour and higher nervous activity.

The necessity for conducting experimental studies to resolve these problems has forced us to seek ways of transforming dolphins into experimental animals.

In this paper an attempt is made to generalize the information available to us on the catching, transportation and medical servicing of experimental dolphins abroad, and there are presented some of our own studies from the period 1965 - 1969.

THE CATCH

There are no special scientific reports devoted to the methods and procedure for catching and transporting live dolphins. The details of the methods employed are professional
secrets of the firms which are engaged in providing the animals for aquaria and oceanaria (Morris, 1966). However, the scattered fragmentary data in scientific publications of recent years and our own experience permit us to present a general picture. Catching the dolphins may be subdivided into the catching of individual animals and the catching of groups of animals.

Individual catching permits one to select the required specimen from a school and decreases the mortality. A pioneer of this method was M. Santini, who supplied dolphins to the Florida "Marineland". In addition to him, such catching is practiced by F. Brokato, the captain of the ship "Geronimo", who supplies animals to this same oceanarium, and by Jacques Ives Cousteau.

Generally the catchers on fast-moving vessels follow the school until they are able to isolate and catch the marked out dolphin by means of a throw net or a special catching device. M. Santini jumps onto the dolphin in the water and holds it until the launch approaches.

The catching of groups of dolphins is carried out, as a rule, with the help of nets. In addition, with this method there are employed vessels or motor boats as beaters, aerial reconnaissance for finding accumulations of the animals and also means of transportation for moving the captured dolphins to their destination. Such methods of catching were utilized by K. Rei (1963) for capturing belugas, and by D. Gascin (1966) for catching bottlenose dolphins.
R. Busnel (1966) worked out a special method for catching dolphins with the aid of a powerful acoustic signal which temporarily stuns the animal.

The existing method for catching dolphins in the Black Sea was designed for catching groups of animals (Figure 1). In spite of the fact that it is considered as a commercial method, the sweep net catch is acknowledged as being the most effective method up to the present time. The details and technique of the commercial fishing have been described in detail in our literature by Tatarinov, Eremeev, Marti, Freiman, Kleinenberg, Gubenko and others (according to Kleinenberg S. E. et al., 1964), and therefore we will not stop to consider this in detail here.

When we commenced the experimental work with the dolphins, utilizing accumulated experience, we somewhat modified
the commercial purse seine fishing method, which turned out to be fully justified. Thus, out of the recently caught dolphins (white-sided and bottlenose dolphins) only 24% of the animals died at the time of the catch. Protective measures were employed during the catching operations: care was taken that the current would not furl the purse seine, while during the hauling in of the net by the boats and the SChS** the net was kept stretched; during the approach of the transport vessel to the side of the SChS for the trans-shipping of the animals between these there were set up spacing struts.

The captured animals were pulled out of the water with the aid of stretchers, inflatable rubber mattresses, by suspension with a soft sling by the tail or simply by hand, depending on the species and weight of the animal. The main factor in this operation is speed. The more rapidly the animals are brought onto deck from the drawn up seine net, the lesser will be the traumas and the less likely they are to get entangled in the nets and to choke.

With the contemporary methods of catching groups of small dolphins (the common dolphin and the common porpoise) the best results are obtained by the use of a fine-mesh kapron** purse seine net (of the scad purse seine type), since with this the losses of the animals are reduced.

The best method for trans-shipping is the use of a stretcher with a soft covering and an opening for the pectoral fins. The trans-shipping of the small species of dolphins

Translator's notes.
* SChS - Medium Black Sea seiner
** kapron - a synthetic fibre.
may be successfully carried out by hand; in transferring large specimens, as an extreme measure, suspension by the tail in a soft sling may be tolerated.

TRANSPORTATION

The transportation of dolphins at the present time is accomplished by various methods: by ships, airplanes and motor vehicles.

Transportation of dolphins by sea was first accomplished in the seventies of the last century, when two belugas were brought to the Brighton Aquarium in England from Labrador and Newfoundland in the hold of a ship. Both animals died (Slijper, 1962). In 1907 the New York Aquarium contained in its pools a group of bottlenose dolphins, while in 1912 in transporting a new batch of dolphins to this aquarium Taylor first employed soft litters for their transportation. In recent years the technique of transporting dolphins by sea has been considerably improved, which permits them to be transported over fairly great distances. However, the most successful transportation is accomplished to those aquaria which are located on the coast and may receive the dolphins 1 - 2 hours after they are caught.

Successful transportations by sea in recent years have been accomplished by: Bel’kovich (1964), Kritzler (1949), Ray (1963), Andersen and Dziedzic (1964) and Gascin (1966).

The curator of the Napier oceanarium in New Zealand considers that the transportation of dolphins by airplane, in particular of the bottlenose dolphin, over considerable distances
in air without water over the course of a period of more than two days apparently does not cause them any harm (Gascin, 1966).

In 1960 D. Lilly transported two bottlenose dolphins by airplane. The dolphins were placed in a special box of perspex and plywood, 2.8 x 0.6 m in size. Within the box, at a distance of 17.5 cm from one another, there were installed plywood partition-frames, strengthened with perspex. From the town of St. Augustine (Florida) to the island of St. Thomas the animals were conveyed aboard a cargo plane, the flight of which was at an altitude of 2000 m and lasted 7 hours. During the course of the flight the respiratory rhythm of the animals was measured. The altitude does not have any effect on the frequency of the respiration, if the dolphins are in water "in a suspended state". K. Rei (1963) transported three belugas from the south-western coast of Alaska to the New York oceanarium. The animals made the 5900 km journey on stretchers, boats, a fishing vessel and then on a special B-17 airplane. The animals were placed in wooden boxes, partially filled with water, the walls and bottom of which were covered with a soft plastic lining. All three belugas withstood well the 24-hour non-stop flight. However, immediately after landing at New York airport one of the belugas died.

Dudok van Heel (1966) successfully transported by airplane four bottlenose dolphins from the USA to Holland. He indicated that for the successful transportation by air the airplane should fly at an altitude of 1500 m. To protect them from contusions, the animals were suspended in hammocks. The flight lasted 16 hours and ended successfully.
In 1969 there was carried out a successful transportation of two male common porpoises aboard an IL-14 airplane from the Crimea to Moscow; the animals were delivered in a satisfactory state (Sokolov et al., 1969).

Transportation by motor vehicle is employed mainly over short distances: from the shore to the oceanarium or from the oceanarium to the airport. The transportation is accomplished in open vehicles, employing soft linings and maintaining protective measures to prevent the action of the direct rays of the sun on the integument of the animals.

It is difficult to say who first employed a truck for the transportation of dolphins, but as early as 1948 Kritzler transported two young male pilot whales (Globicephalus macrocephalus), which had been stranded ashore in Florida to Marineland.

D. Lilly (1960) delivered by truck, from Marineland to the airport in St. Augustine, two bottlenose dolphins over a distance of approximately 30 km. W. Kellog (1966) conveyed an adult female bottlenose dolphin to his laboratory in an open truck. Among other investigators, who have used the method of conveying dolphins to the laboratory by motor vehicles, should be mentioned Schievill and Lawrence (1956), M. Caldwell and D. Caldwell (1963), Ray (1963), Andersen and Dziedzic (1964), Heel (1966) and Sokolov (1969).

For the transportation of captured animals we utilized a refrigerator ship (TKhS), and moreover we employed several variants, which may conventionally be divided into two methods: "semi-aquatic" and "aquatic".
The basic factor, necessary for the successful transportation of dolphins, is the establishment of optimal conditions for thermoregulation. A prolonged sojourn of the dolphins in air, especially under the action of the direct rays of the sun, leads to a fairly rapid death of the animals. This is explained not only by the low thermal conductivity of the air, which causes overheating and heat stroke during the summer period in literally a few hours, but also by a disturbance in the activity of the cardio-vascular and respiratory systems. The latter occurs as a consequence of the infringement of the "practical weightlessness" on dry land and the compression of the thorax by the weight of the animal, and also from the marked shrivelling of the skin, wrinkling and flaking-off of the epidermis.

Thus, the transportation of dolphins out of water brings to the forefront several requirements, on the correct fulfilment of which depends the success of the entire transportation. The animals must be protected from the action of the direct rays of the sun, care being taken that the skin is kept moist all of the time; in addition, to avoid the formation of bed sores, the dolphins should be placed on thick, fairly soft linings, which may to some extent compensate the temporary loss of the state of "suspension" by increasing the area of support of the body. For this on the deck, shaded by awnings from the rays of the sun, there is set up a soft bedding: of inflatable rubber mattresses, boats or thick porolon*. On these the animals are placed individually. A sufficiently thick and soft bedding will somewhat decrease the normal loads in the region of the thorax and abdomen.

* Translator's note. "Porolon" - presumably an aerated plastic of the styrofoam type.
The second method of transportation is the "aquatic" method. For this there is utilized a tub aboard the transporting vessel, with running water, or special containers, in which the dolphins are secured in hammocks (Figure 2). The securing is absolutely necessary, even when there is only a slight rolling and pitching, in order to minimize the traumatism in general. In addition to this, the individual securement prevents the possibility of the occurrence of a panic among the dolphins, during which they fight, ripping the skin and inflicting serious injury to one another with their powerful tails. The securement also prevents, and this is probably the most important factor, the entry of water into the blowhole.

In one standard shipboard tub, 180 x 250 cm in size, there are accommodated, depending on their length, 1 - 3 bottlenose dolphins or 5 - 6 white-sided dolphins. The containers are for individuals.
The elaborated method for transporting the animals on the special soft bedding and in the shipboard tubs on the refrigerator ships (TKhS) were found to be suitable for maintaining the health of the dolphins for 54 hours and for their subsequent prolonged holding in captivity.

MEDICAL SERVICING

The problem of the medical servicing of dolphins, kept in captivity, has attracted the attention of many investigators (Brown, 1962; Brown and Norris, 1956; Brown and McInture, 1960; Ridgway, 1965; Ridgway and McCormick, 1967; Nagel et al., 1964, and others).

Dolphins that are kept in captivity most frequently suffer from skin diseases, which cause real distress and lead, as a rule, to a lethal outcome (Russel, 1966). In addition there have been found in them: erysipelatous inflammations, stomach ulcers, jaundice, insults and infarcts of the myocardium, diabetes, scurvy, inflammation of the lungs, and numerous external and cavitary parasites (Ridgeway, 1955). One of the most serious problems is the swallowing by the dolphins of extraneous objects that fall into the pools (balls, gloves, toys). In recent years (Ridgeway, 1955, 1967; Nagel et al., 1964) there have been elaborated methods for the catherization and venous puncture of dolphins, of anaesthesia for serious surgical operations, and standards for the application of antibiotics, tranquilizers, drugs and vitamins. In the Tobo Aquarium (Japan) there has been established a special hospital for diseased fishes and dolphins, where they undergo a course
of treatment (Russel, 1966). It has been established that the medicines which help people also help dolphins, in particular tablets that aid the digestion of food and vitamins, as a supplement to the food ration.

In the work with the dolphins we carry out a medico-biological control on the state of their health (Figure 3). The importance of this work is dictated among other factors by the fact that commercial hunting of dolphins in the USSR is banned and every catch of experimental animals is turned into a complex problem, and therefore we consider that it is more important to preserve the animals than to catch new ones.

Serving as objective symptoms that are indicative of the state of health of the animals are: the rate of swimming and diving; intercourse with other animals; degree of activity at feeding; character of respiration. A slowing in the rate of swimming, long periods spent on the surface of the water and a reduction in activity at feeding are all pathological symptoms, and in the presence of these the animal should be examined.

The most important disease symptoms of the animal are: A disturbance in the rhythm and intensity of the respiratory act - a prolonged respiratory act with a sluggish exhalation-inhalation and the appearance of foaming from the blowhole at the moment of exhalation; assistance given to any animal on the part of the others; a yellow or grey colour of the faecal masses; a categorical refusal of food. In such cases it is necessary to immediately examine the dolphin.

Fucilagenous discharges from the blowhole (of the sputum type) and a putrescent odour of the expired air are
Figure 3. Routine medical examination. Obtaining a cardio-
gram from a white-sided dolphin.

indicative of a flooding of the respiratory tracts with water
and the presence of inflammatory processes in the lungs. In
this case it is necessary to isolate the diseased animal from
the general group, placing it in a laboratory aquarium for 4-
5 days and treating it with antibiotics (penicillin or bicillin
* in the usual doses per 1 kg weight).

Liquid faeces of a yellow or grey colour are indicative
of diseases of the gastro-intestinal tract. In this case it
is necessary that the animal be fed only fresh fish, with which
there may be administered tablets of laevomycetin. Besides
this, use is made of antibiotics (biomycin, synthomycin**
) and vitamins of the "B" group (in the usual doses per 1 kg body
weight). When there is a lack of appetite and deterioration
of the state, it is advisable to isolate the dolphin for a pro-
longed period from the remaining stock, to avoid the spread of

Translator's notes.
* bitsillin or bicillin - benzathine penicillin G.
** synthomycin - synthetic streptomycin
the infection among the remaining animals, and to carry out
an intensive penicillin therapy.

In the case of the presence on some part of the body
or other of fungal diseases, ulcerations, bedsores and other
skin diseases, there were employed intramuscular injections
of antibiotics and administrations of polyvitamins in the food.
Simultaneously with this there was carried out a treatment of
the infected portions of skin with antiseptic solutions (iodine,
alcohol, potassium permanganate), with a subsequent drying in
air and smearing of the affected sites with special dermato-
logical ointments. A depressive state of the animals may be
revealed only with systematic observations. The superficial
symptoms are: aggressiveness, swimming separately from the
group, loss of appetite and increased caution. All of these
may be evoked by a depressive state, if it proves on examina-
tion that other diseases are absent. In these cases aminazine
was employed.

The methods of medical control which were used in our
work proved themselves to be fully justified. For illustration
we present two examples when the treatment was effective and
operative.

On the 24th of June 1969 a young female bottlenose dol-
phin, which was living its second year in captivity, refused
its food. On the following two days she continued to ignore
the food, swam apart from the group on the surface of the
water, and did not react at all to man and the dolphins. She
was given intramuscular injections of bicillin, 600 thousand
units, and a complex of the vitamins $B_1$, $B_6$ and $B_{12}$, in 2ml
After 3-4 hours she began to move more actively about the pool but continued to refuse the food. Over the course of the next few days she made attempts to eat fish, but without success. On June 30th a thorough medical examination was made, since the suspicion arose that the dolphin had swallowed a small rubber ball. In 6 days the animal had grown considerably thinner, the back was sunk in, the mucosa of the mouth cavity was inflamed and a distinct putrescent odour emanated from this. A strut was placed into the mouth and an attempt was made to introduce some machine lubricating oil into the stomach through a rubber tube. This was not successful. However an inclination to vomiting was noted. The cavity of the mouth was treated with penicillin and a solution of potassium permanganate. Intramuscular injections were made of bicillin - 1 million 800 thousand units, and a complex of vitamins ($B_1$ and $B_{12}$) in 4 ml aliquots. Already on the following day there were noted attempts, though it is true that these were still fairly sluggish, by the dolphin to play with a black rubber ring and with the other dolphins.

On July 3rd repeated injections were made of bicillin (1 million 200 thousand units) and a complex of vitamins ($B_1$ and $B_{12}$) in 4 ml aliquots, while during the examination the mouth cavity was again irrigated, although the state of the mucosa was already satisfactory. Towards the evening of this day the bottlenose dolphin fairly readily and energetically played with a ball and with rubber rings. Her movements became more confident, energetic and pronounced. She readily began to eat fish. She began to swim in a pair with a young
bottlenose dolphin, reacting in a lively fashion to the appearance of a man and making contact with him. During the course of the following week she was given polyvitamins and oxytetracycline. This animal soon recovered completely.

In a white-sided dolphin, which had been caught in May of 1969, during a routine change on July 16th there was noted typical loss of coordination of movement, which was expressed by a rolling over onto the side and bumping into the walls of the pen. After several convulsive movements of the head she suddenly sank. We were able to quickly raise her from the bottom, but she could not maintain herself afloat. It was necessary to transfer her into a laboratory aquarium and to secure her on a hammock, so that she would not choke. She was given an intramuscular injection of bicillin (1 million 200 thousand units) and mellipromin (2ml), after which the water in the aquarium was disinfected with a solution of potassium permanganate, while the skin was treated with alcohol and iodine solutions. The respiration of the animal had a rate of 31 times in 5 minutes, the heart-beat frequency was 110 beats per minute. On July 19th we repeated the injection of bicillin (600 thousand units) and of the vitamins B6 and B12 (4 ml of each). The frequency of respiration decreased considerably, to 12 times in 5 minutes. The pulse - to 90 beats. The irrigation was repeated with the disinfectant solutions and the infected portions of the skin were smeared with undecine ointment.

On July 20th, after she had been kept in the laboratory aquarium for 87 hours without food (refusing the food), she
was let out into the pool. Here she began to swim actively, and after 5 minutes to take scad greedily from the hand. Over the course of a week we continued to give oxytetracycline and polyvitamins with the food. This white-sided dolphin is still alive at the present time.

The catching, transportation and relocations, and the medical servicing during the course of long-term holding in captivity are important constituent parts, on each of which is dependent the overall success of the work with the dolphins.

The tested methods for carrying out the catch and transportation, taking into account the available practical possibilities under the conditions in the Black Sea basin, have shown that they may be successfully utilized in future work.

The transportation of the captured animals on a refrigerator ship in containers with running sea water, with the animals being secured in hammocks, was found to be the most favourable form of transportation of dolphins by sea. However, the extension of work with dolphins sets investigators the task of elaborating and employing method of transportation on dry land, which is a more complex problem.

The application of therapeutic measures, utilized by man, deserves by all means to be maintained and to be introduced even more boldly into the practice of the routine work with dolphins. However, in spite of the assistance rendered, the mortality among dolphins during long-term holding in captivity remains high. Therefore there are needed further thorough studies on the causes of the mortality of the animals and on the elimination of these.
Our work does not pretend to provide a complete elucidation of the problems that have been raised. One of its aims was to prepare the soil for the further development of the above listed problems, connected with the long-term holding of dolphins in captivity.

REFERENCES


The fairly constant maintenance of the holes by the ringed seals (Chapskii, 1940) suggested to us the possibility of counting the number of seals and of their holes as these were encountered; therefore, in conducting the aerial survey, we recorded encounters with both seals and their holes, situated both in direct proximity to a lying animal and also with no animal present.

It is still difficult to make a completely definitive judgement as to the number of holes that are made and maintained by different individuals of the ringed seal, though in the opinion of Greve (1896) each ringed seal in the Baltic Sea has from 5 to 8 breathing holes (according to Ropelewski, 1952).

With respect to the holes of the grey seal Holm (1921) writes: "There occur cases, when in severe freezing weather the exit holes of the seals not infrequently freeze over and many animals are forced to leave these and accumulate at one hole in numbers of 10 - 15 individuals".

As a result of the studies, conducted on the landfast ice in the Gulf of Finland in March of 1970, by one of the authors there was thoroughly investigated the region between Kalyi and Bol'shoi Tyuters Islands. In the investigated area there were found 17 seals and 17 holes of various diameter (from 34 to 40 cm), visible from above. The ratio of their upper diameter (on the outer surface of the ice) to the lower diameter (the edge of the ice that is under the water) comprised from 0.57 to 0.63. It is possible that the size of the hole is directly dependent on the size of the animal. The holes were situated at a distance of from 1 - 1.5 to 3 km from one another.
Besides the 17 separately situated holes, there were found by us in one place three holes of various sizes situated next to one another (Figure 1).

Taking into consideration the smaller diameter of two of these on their upper edge (16 x 15 and 20 x 17 cm), in comparison with the large hole which was found beside these (37 x 40 cm), the thickness of the ice in the place where these holes were located (about 30 cm) and the tracks of small sized flippers around them (around the large hole there were tracks of an adult seal), we assume that these two holes were used by a young animal (possibly born in this same or in the previous year). Such groupings of holes, of 2, 3 or even 4 together, were observed by us on more than one occasion also from the airplane.

Further studies of the characteristic features of the distribution of the seals, and of the disposition and arrangement of their holes will allow us to explain this phenomenon more specifically.

According to the observations of V. A. Zhelgov every ringed seal on the landfast ice makes a hole for coming out onto the surface in the freezing over patches and cracks ("smorozi") between the ice floes that have been drifting from the middle of the winter. Later the thickness of the ice on these "smorozi" increases but it always is less than the thickness of the main frozen together ice floes. In the Gulf of Finland this difference comprised from 10 to 20 cm. The holes which are maintained by the ringed seal in the snow drifts amidst the ice hummocks are also located on "smorozi". As the thickness of the ice on the "smorozi" increases, the ringed
Figure 1. The disposition of holes of various size in one location. March, Gulf of Finland. Photograph by A. G. Esipenko and V. A. Zheglov.

Seal constantly maintains the hole, for which even in the middle of March it must break through, once or twice a day, the crust of ice which forms on it (up to 2 cm in a night).

In the course of the investigations on the ice it was noted that a ringed seal which had been frightened away did not appear at its hole until the next day. Observations in the regions closest to the hole (in a radius of 3 - 4 km) showed that the ringed seal did not appear within this distance on the surface of the ice, even though the weather conditions for its emergence onto the ice were favourable (clear, light wind, daytime temperature of +1 to -2°C).

It is possible that during this period it either made use of its hiding places (in the hummocks and snow drifts
with an access hole from the water) or it moved away from this hole to a distance greater than 3 - 4 km.

In the basis of the information presented we assume that on the landfast ice each ringed seal, up to a certain time (until the holes are broken up during the break-up of the ice or due to other factors), makes use of one hole for emerging onto the surface of the ice and several hiding places with an access to the water, situated in the ice hummocks, where the ringed seal lies during bad weather, utilizes these for replenishing its air reserves during feeding and gives birth to its young. The hole which the ringed seal uses for emergence onto the surface of the ice is clearly visible from an airplane. The holes that are located in the hiding places cannot be counted from an airplane.

During the aerial survey we noted that the break-up of the ice occurs mainly along the sites of the "smorozi" and hummocking. This has also been noted by hydrometeorologists (Methodological instructions, 1959). In such cases, both the holes which are concealed in the hiding places as well as the open holes, used by the ringed seal for emergence onto the surface of the ice during its break-up, in our opinion, are destroyed in approximately the same ratio. The ringed seals, whose holes have been destroyed, are apparently forced to make use of the open patches of water or the holes of their "neighbours".

Taking into consideration the approximate periods of whelping and moulting of the ringed seal and of the grey seal, the count of the seals in the Gulfs of Finland and Riga and
on Lake Ladoga was conducted in two stages: first - on March 9 - 11, and second - on April 3 - 7. On the basis of information obtained from questioning the local sealers and our own assumptions on the possible distribution of the seals in the regions under study, the transects for the observation flight in March were set up ahead of time, while in April these were set up on the basis of the observations made during the first flights and the direct observations made on the ice in March.

On detection of a region with a more concentrated distribution of the seals there were "set up" counting areas (see the schematic maps of the aerial survey). The region was intersected by several counting lines. This permitted us to estimate more reliably the density of the hauling-out of the seals in the given region and to determine the borders of their hauling-out patches.

The flights were made on LI-2 and IL-14 airplanes at an altitude of from 100 to 150 m, at an average speed of 200 km per hour, from 9-10 a.m. to 3-6 p.m.

The observations were carried out from the right and left side from the blisters (transparent hemispheres, which were mounted in place of the portholes in the navigator's compartment), which permitted the observer to see not only to the side but also to the front and underneath the airplane.

The data on the state of the ice cover was periodically recorded in the log-book using the generally accepted method for charting ice maps in accordance with the methodological instructions for aerial observations on ice conditions at sea.
Special attention was paid to determining the degree of hummocking, the snow cover and the closeness of the ice. Generally on the state of these factors depended the distribution and concentration of the seals and their holes, the numbers of which and the characteristics of their disposition were carefully recorded in the flight logs according to the time of encounter.

According to our observations, it is best to make the simultaneous count of the seals and the holes from one side, over a counting strip not more than 150 m in width, although the seals may be discerned also from the side at a distance of 300 - 350 m from the airplane. At a greater distance from the airplane the holes are poorly discernable and it is possible to miss them. It is necessary to mention also the particularly cautious behaviour of the animals themselves in the Baltic. In the Gulfs of Finland and Riga the ringed seals escape into their holes 100 - 150 m ahead of the approach of an IL-2 airplane to it and 200 - 250 m ahead of an IL-14 airplane, which forced the observer to look ahead, along the flight path of the airplane, from time to time.

The Ladoga seal behaves more calmly in the presence of the IL-14 airplane, and escapes from it into the water at a distance of 75-100 m.

It is possible that such differences in the behaviour of the Ladoga seal and the ringed seal of the Baltic during the spring period depend on their physiological state or on some other factors connected with living in bodies of water with different hydrological characteristics.
Figure 2. Landfast ice, formed of ice which has drifted in. April, Gulf of Riga. (The arrows indicate holes of the ringed seal. Beside one of these lies a seal). Aerial photograph by A. K. Shlyundin.

a - hole of seal  
b - ringed seal and hole

From the air the ringed seal is similar in form to a comma (Redoseev, 1966). The holes of the seals in the Baltic are very even dark circles situated beside hummocks. From a height of 100 - 150 m around the holes there can be clearly seen the snow that has been crushed down by the seals. The edges of the holes are not frozen over, as in the holes of the harp seals (Figure 2).

It is almost impossible to determine the size of animals lying singly from an airplane. In April, when groups of animals were found lying in direct proximity to one another, we observed both small as well as large seals. It is fairly difficult to discern a whitecoat from an airplane. We noted these only against ice of a background colour darker than them.
The whitecoats are distinguishable from the adult animals by their colour and smaller dimensions (about half the length of the body beside a lying adult animal).

In March and April in the Gulfs of the Baltic Sea we noted 2 and 3 whitecoats.

The grey seal was visible as a dark-grey comma against the background of the white and grey-white ice. It has a much lighter colour and is larger than the ringed seal, and lies more frequently beside cracks. It scarcely reacts at all to the airplane, and if it does escape into the water, which occurred only in two cases, it does this only right under the airplane.

The tentative count of the numbers of the ringed seal and the grey seal in the regions under investigation was conducted according to the following scheme:

1. Drawing the counting transect on a large-scale map on the basis of the times and orientation points.

2. Transferring from the flight log onto the schematic map of the transect the information on the sites of finding of the seals and their holes, and, as changes occurred, the ice conditions.

3. Outlining the contours of uniform ice conditions (according to the types of ice formation), in which we utilized our own observations and the data from the ice survey by the hydro-meteorological service, which conducted its work simultaneously to us.

4. Calculating the areas of similar ice conditions.

5. Calculating the area of the counting strips for each type of ice formation (the width of the total counting
strip from both sides of the airplane was 300 m), determining the density of the distribution of the seals and their holes on the counting strips and in the areas with more concentrated hauling-out patches (see the schematic maps of the surveys and the counting areas on these) for each sq. km. for each category of ice formation.

6. Calculating the approximate numbers of seals and holes over the area for each type of ice formation (separately for each Gulf and for Lake Ladoga) by the method of extrapolation of the obtained densities and their distribution.

RESULTS OF SURVEY

As a result of the data obtained by us from the aero-visual observations, the ice types accepted by other investigators - white, grey-white, grey etc. (Popov, 1966; Shustov, 1969, and other authors), did not permit us to characterize the conditions and characteristics of the distribution of the ringed seal and the grey seal in the Gulfs of the Baltic Sea and on Lake Ladoga.

For the characterization of the habitat conditions and the distribution of the seals and their holes we distinguished several types of ice formations, which were characterized by a particular density of the distribution. Under the concept of "density" we imply the average number of seals and of their holes per one square kilometer.

1. Landfast ice of local origin is characterized by a thick ice cover with a thickness of the ice of more than 30 - 40 cm (from our ice observations), with a
weak hummocking (up to strength 1), formed by a certain shifting of the ice during the winter; its snow cover in the middle of the winter has an index of up to 3. The grey seal was not found by us in this type of ice formation; the ringed seal and its holes are occasionally encountered in hummocks or beside these.

No seals or their holes were found at all either from the airplane or during the observations on the ice in the Gulfs of the Baltic Sea on landfast ice of local origin which overlies depths of up to 10 - 15 m (see schematic maps of aerial survey). At present it is difficult to explain this. It is possible that this was due to the absence of the basic food objects of the seals at small depths during the winter period or by the small number of hummocks, which are needed by the seals for the construction of their hiding places. Therefore we did not take these areas into consideration in calculating the areas of landfast ice of local origin.

2. Landfast ice, formed by the freezing together of white ice that has drifted in, with a degree of hummocking of strength 2 - 4, in our opinion, is the most favourable for the construction of the hiding places and for the maintenance of the holes by the ringed seal (Figure 3).

At the beginning of January - February, during the hummocking and freezing together of the ice which is drifting in the gulfs, the ringed seal, in all probability, is distributed along the open patches of water among the ice floes. Subsequently, when these freeze together and ice is formed on the open patches, the seal here makes and maintains its holes, and in the hummocks - its hiding places.
3. **Breaking-up landfast ice of frozen together drift ice** is formed mainly with the onset of warm weather.

In the Gulf of Riga in 1970 this landfast ice began to be formed from the beginning of March; in the Gulf of Finland and on Lake Ladoga - from the beginning of April (the closeness of the ice had an index of 8 - 10).

In March in the Gulf of Riga, the density of the distribution of the seals on the broken up landfast ice (with an 8 - 9 index of closeness of the ice) attained a level of 0.43 head and the holes had a density of 0.41; in April these values were only 0.01 head and 0.02 holes. This is probably connected with the breaking up of the holes and the distribution of the animals along the cracks and on ice formations of other types.

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**Figure 3.** Typical site for the construction of holes by the ringed seal on landfast ice derived from drift ice. March, Gulf of Finland. (In the foreground is a hole of the ringed seal).

*Photograph by V. A. Zhelgov*
In the Gulf of Finland on the broken up landfast ice (closeness of the ice with an index of about 10) in April the density of the seals was 0.15 head, while the density of the holes was 0.37.

The smaller density of the holes in the Gulf of Riga, in comparison with the Gulf of Finland, was obviously related to the greater break-up of the ice, and therefore of the holes, in this Gulf.

In the Gulf of Finland the opening up of the landfast ice and its subsequent break-up occurs later than in the Gulf of Riga, by 10 - 15 days (Atlas of ice conditions in the Baltic Sea, 1960).

4. Ice fields of white and grey-white ice are formed of frozen together drifting ice floes in the central and western part of the Gulf of Finland at the end of January - beginning of February, and in the middle of the Gulf of Riga in the middle to the end of February (Atlas of ice conditions in the Baltic Sea, 1960).

It was noted by us that in April the ringed seal and its holes were encountered more frequently (density up to 0.17 head and 0.17 holes) on the ice formations of this type in the Gulf of Finland than on the landfast ice of local origin.

We consider that the more broken up ice of this type in the Gulf of Riga also explains the smaller density of the seals and of their holes on this ice (correspondingly 0.02 and 0.13).

In March - April, as the ice fields break up, there occurs a translocation of the seals onto firmer ice, where they
distribute themselves along the cracks and open patches of water, and sometimes also utilize the holes of the "old residents". Thus, according to our aerial observations, neither seals nor holes were found in April on the broken white and grey-white ice in the Gulf of Finland and the Gulf of Riga.

At the same time on the ice fields and broken up landfast ice beside one hole or crack there lay 2 - 5 seals, which was noted by us on more than one occasion in April in the Gulfs of Riga and Finland.

This is indicative of their concentration at the beginning of April on the firmer ice. In the Gulf of Riga the fragmentation of the ice occurs in the direction of from south to north of the gulf, while in the Gulf of Finland this occurs from the west towards the north and east (Atlas of ice conditions in the Baltic Sea, 1960). In step with the fragmentation of the ice the redistribution of the seals apparently occurs in the same direction.

5. Broken-up white and grey-white ice, in our opinion, is unfavourable, in March and in April, for the hauling out of the ringed seal and the grey seal. The areas with this type of ice in the Gulfs of the Baltic Sea are small (see schematic maps of aerial survey).

In March on ice formations of this type in the region of the Irbenskii Strait we noted a relatively high density of ringed seals, 0.33 head. We explain this as a result of the drifting of the breaking-up ice fields through the Irbenskii Strait into the open sea, where the ringed seal does not pass with the ice, but as the broken up ice drifts out to the west the seals concentrate in the Irbenskii Strait.
Figure 4. Schematic map of the aerial survey transect and ice conditions in the Gulf of Finland (March, 1970).

A. - Counting area.

In April, when the edge of the broken-up landfast ice and of the ice fields moves to the north, and the more broken-up grey-white ice is carried out into the open sea, the ringed seal is no longer encountered here.

6. **Light and very light floe grey ice** (area of floes from 40 to 200 sq. m) is formed at the edge of the ice fields and as it were girdles them with a 5-10 km belt: in the Gulf of Riga from the south, and in the Gulf of Finland from the south-west (see schematic map of aerial survey). The areas of this are small, and in the spring it is rapidly broken up. The seals clearly avoid such ice and were not found by us here.
Legend to Figures 4 - 8.

1. Landfast ice of local origin.
2. Landfast ice of drifted-in frozen together ice.
3. Broken-up landfast ice of frozen together drift ice.
4. Ice fields of white and grey-white ice.
5. Broken-up white and grey-white ice.
6. Light and very light floe grey ice.
7. Water.
8. Borders of the types of ice formations and counting areas.
10. Ringed seal encountered along transect.
11. Grey seal encountered along transect.
12. Hole encountered along transect.

On ice formations of other types (ice rind, pancake ice) the seals were also not found. This is connected with the fragility and remoteness of such ice from the ice fields.

The distributions of the listed ice formations, the encounters with seals and holes along the transects, and the regions of their concentrations (counting areas) in the
investigated bodies of water are presented in the schematic maps of the aerial survey (Figures 4 - 8).

DYNAMICS OF THE FREQUENCY OF OCCURRENCE OF THE SEALS AND OF THEIR HOLES IN THE GULF OF FINLAND

In comparing the data on the density of the distribution of the encountered seals and their holes on the various types of ice formations, we found:

In March the maximal density of hauling out of the ringed seal occurred on the landfast ice of drifted-in ice (up to 0.62 head). A smaller density occurred on the ice fields of white ice, 0.17 head. The densities of the distribution of the holes were correspondingly expressed as 0.4 and
In summing up, from the calculations, in March there were about 5000 seals and 4500 holes.

During the course of the period between the surveys profound changes occurred over the whole ice area in the Gulf.

In April there was a decrease in the size of the areas of continuous landfast ice of frozen together ice; these were replaced by broken-up landfast ice and partially broken-up
ice fields. The average density of hauling-out of the ringed seals on the broken-up landfast ice of frozen together drift ice in April was 0.15 head, while the density of the holes was 0.37. The ringed seal was not found on the ice fields (the size of the floes here had decreased to 0.3 - 0.7 sq. km.), where there were still occasionally found traces, i.e. the holes, of their prior habitation.
The absence of seals on this type of ice formation is explained, apparently, by their migration to other regions. According to our calculations, in April in the Gulf of Finland there were present on the ice about 900 ringed seals and about 3000 holes.

It is generally known that the ringed seal does not carry out distant migrations, with the exception of slight seasonal migrations, related to shifts in the edge of the ice (Bergman, 1958; Chapskii, 1963), and therefore we consider that the number of ringed seals calculated on the basis of the encounters in April does not reflect their actual numbers.

The decrease in the frequency of encounters with the ringed seals on all of the types of ice formations in April is explained by us as being due to their redistribution onto the edges of the broken up landfast ice, where they form denser moulting patches, for the detection of which a large counting area is necessary. Three such patches of ringed seals were found by us in April in the region of the Islands of Pykh'ya-Ukhti, Vigrund and Mayak. The seals lay here in groups of 2 - 5 individuals beside one hole or beside an open patch of water in direct proximity to one another. Groups of ringed seals were situated at a distance of 0.5 - 1.5 km from one another.

The decrease in the total number of holes encountered in April (according to our calculations there were up to 3000 of these) is related, in our opinion, to the widening of the "smorozi" and the fragmentation of the hummocked sections on the ice fields and broken-up landfast ice.
The data obtained on the distribution of the seals, on the basis of the calculations for the entire area covered by ice in the Gulf of Finland, permitted us to make a tentative estimate of their approximate numbers and to determine the regions of their spring concentration. It was found that the main part of the population of the ringed seal in the Gulf of Finland at this time is concentrated in the eastern part of the Gulf between the Islands of Vaindlo and Seyskari.
The approximate number of the ringed seals, present on the ice, is reckoned by us, on the basis of the encounters in March, at about 5000 head, with about 4500 holes. The encounter with one grey seal in April was a natural occurrence, since the area investigated at this time was 1.6 times larger than in March, and these seals are very rarely encountered on the ice during this period.

We consider that the number of ringed seals and of their holes which was calculated by us on the basis of the density is underestimated. In our case, during the survey all of the record entries were made by the individual conducting the count, who had to interrupt his observations to do this. It has been established experimentally by American investigators that the error in counting from an airplane, even in the case of ungulates on tundra, leads to an underestimate of the results by up to 20% on average. It is therefore recommended that those making the count should transmit their observations, without interrupting these, to a co-worker who makes all of the record entries (Chervonnyi, 1969).

Taking into consideration a similar miscalculation in our work and the approximate percentage of occurrence of the seals in the water (about 30%) during the daytime in March, it may be assumed that in the Gulf of Finland during this period there were present about 8 thousand head of the ringed seal. The calculated number of holes, on the basis of the findings in March (with a correction for omissions of 20%), is about 5.3 thousand.
THE GULF OF RIGA

The overall character of the distribution of the seals and their holes according to the types of ice formation is similar to their distribution in the Gulf of Finland (see Figure 7).

The number of ringed seals calculated by us on the basis of the frequency of their encounters in April is also smaller (in March - 3.1 thousand head, and in April only 0.12 thousand head). It is probable that the ringed seal in the Gulf of Riga in April also quits the moving ice and concentrates on the edges of the firmer ice (the stationary and broken-up landfast ice).

In April, in connection with the breaking-up of the "smorozi" and hummocks, the number of holes decreased considerably (according to the calculations there were 3.9 thousand of these in March, while in April there were only 1.5 thousand holes).

The number of ringed seals obtained on the basis of its encounters in April undoubtedly does not reflect the actual stocks (as is the case in the Gulf of Finland), and therefore we calculate the tentative population numbers of the ringed seal on the basis of its encounters in March.

In March and April on the breaking-up landfast ice in the Gulf of Riga there were encountered individual grey seals. In April at the edge of the ice fields of white and grey-white ice (with a closeness index of 7-8, and a degree of hummocking of 2-3) there was found by us a hauling-out patch of grey seals, where a counting area was set up. The seals here were diffusely
distributed, with 1 - 2 beside one hole or edge of an open patch of water, at a distance of 0.3 - 1.5 km from one another.

According to our calculations (density 0.89 head), in this area there were lying about 200 - 250 seals. Besides this, individual grey seals were also encountered on the breaking-up landfast ice.

The finding of a single hauling-out patch of grey seals in April evidently cannot serve for evaluating their population numbers in the Gulf. According to the data of Sundström (1962), adult grey seals are attached to their own regions and migrate only in the summer. Therefore we assume the possible presence of such hauling-out patches in other regions of the Gulf.

On the basis of the results of the aerial survey, which was carried out by us in March - April, there were reckoned to be about 3 thousand ringed seals on the ice in the Gulf of Riga. Taking into consideration that at the moment of the count a part of the animals were in the water and another part was omitted while making the record entries, and introducing the appropriate corrections (tentatively 30% - in the water, and 20% - for omissions), the approximate numbers of ringed seals in the Gulf of Riga were estimated at about 4.5 thousand head.

The calculated number of holes on the basis of the encounters in March was 3.9 thousand; with the correction (20%) for omissions the numbers of these come to 4.68 thousand holes.
LAKE LADOVA

A tentative picture concerning the places of the distribution of the Ladoga seal (on the basis of findings of holes) over the expanse of the lake was provided by the first test flight over this in March. Holes of the ringed seals were occasionally found from 5 to 30 km from the eastern and western shores of the lake.

At the beginning of April up to 20% of the surface of the lake remained covered with stationary ice, 60% of its remaining area was covered with breaking-up landfast ice (Figure 8). The snow cover on the breaking-up landfast ice had an index ranging from 1 to 2.

At this time on the ice there were found not only holes, but also ringed seals beside the holes or open patches of water. The Ladoga seal, like the ringed seal of the Baltic, prefers landfast ice derived from drifted-in frozen-together ice. In the northern part of the lake, up to the line of the Valaam archipelago, on the landfast ice with very sparse cracks and hummocks the density of the hauling-out of the ringed seals in April was 0.028 head, while the density of the holes was 0.084. The density of the hauling-out of the seals on the breaking-up landfast ice derived from drifted-in ice was 0.19 head, while the density of the holes was 0.36.

The main part of the population of the Ladoga seal during the spring period was dispersed around the central part of the lake, which part is the last to freeze up (in mild winters - in February, and in severe winters - in January). It is interesting that, according to the data of Kalesnik (1968), these places are the basic regions for catching fish.
The number of seals calculated on the basis of their encounters (2200 head), in our opinion, does not reflect the actual stocks, since the average yearly catch of these seals of about 0.5 thousand head has been maintained for several years without changing. Moreover, the small number of encounters with these seals during the survey in April may be explained by the fact that at this time there was cloudy and rainy weather over Lake Ladoga.

The number of holes of the seals on Lake Ladoga, with the correction for the inherent error (20%), is about 5.1 thousand. The partial breaking-up of the landfast ice undoubtedly influenced the numbers of these, but at the present time we cannot estimate any correction factor for this. It can only be assumed that the numbers of ringed seals in this case should be greater than the calculated number of holes.

In the analysis of the data obtained in March and April on the distribution of seals beside the holes and open patches of water some interesting data were obtained.

In the Gulf of Finland in March 85% of the seals were found beside the holes, while in April - only 44%. In the Gulf of Riga the corresponding value was 48% in March, while in April the ringed seals were encountered only beside open patches of water.

In Lake Ladoga in April 79% of the ringed seals were found beside the holes and 21% beside open patches of water. On more than one occasion, while conducting the aerial survey, we noted that on the approach of the airplane the ringed seal escapes into the water not by way of the polynya but through its hole, which is sometimes situated fairly close to the
polynya (up to 3 m). On this basis we judge that there is a considerable attachment of the seal to its hole. The differing percentage of the finding of the animals beside the holes or beside the open patches of water in March and in April may be explained by the availability of the holes, the number of which decreases as the ice breaks up, or by a differing physiological state of the animals, which compels the seals to make greater use of open patches of water and cracks.

CONCLUSIONS

The comparison of the results of the aerial survey in March and April showed that:

1. The ringed seal in March and April prefers landfast ice derived from drift ice and ice fields.

   In April it is concentrated on the edges of the breaking-up landfast ice, where it forms scattered hauling-out patches (possibly, moulting patches). The number of holes decreases on the gradually breaking-up ice.

2. On the basis of the presence of whitecoats of the ringed seal in the Gulfs of Riga and Finland at the beginning of March and in April there may be assumed to exist a certain protraction in the periods of its reproduction.

3. The grey seal (in hauled-out groups and singly) is found only on broken-up white ice.

4. Taking into consideration that this was the first attempt to survey the ringed seal and grey seal on the landfast ice in the conditions of the severe winter of 1969-1970, the data obtained on the distribution and the numbers of the seals
should be considered as tentative. It is possible that the spring concentrations and numbers of seals in the Gulfs of the Baltic are not constant and depend on the climatic conditions each year. In the future, after a thorough study has been conducted on the ice on the ecology and character of the distribution of the seals, it would be useful to conduct a repeated aerial survey of these seals.

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RESEARCH ON MARINE MAMMALS

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Editor É. S. Mil'chenko
Technical editor T. M. Andreeva
Artistic editor G. P. Burov
Proof-reader E. I. Arenko


Atlantic Research Institute of Fisheries and Oceanography.

Printing-house of the "Kaliningradskaya pravda" publishers.
Kaliningrad obl., ul. Karla Marks, 18.