RIDGWAY, S. H., 1972. Mammals of the Sea. Charles C. Thomas, Springfield, Illinois, U.S.A.
RIND, H., 1955. Aerztliche Forshung, 9 (1): p. 483.
SLIJPER, E. J., 1962. Whales. Hutchinson, London and Basic Books, New York.
SOBEL, A. E., 1952. Vitamins and Hormones, 10: p. 47.
STEFFANS and KARST, 1972. Arch. Tierernäh, 22 (6): pp. 439-444.
WHITE, J. R., 1970. J. Am. Vet. Med. Ass., 157 (5): p. 559.

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## REMARKS ON THE COMPOSITION OF WATER FOR DOLPHINS IN INLAND DOLPHINARIUMS

*by Dr. W. H. Dudok van Heel, Curator Dolfinarium Harderwijk, Netherlands.*

*Summary*

In the Dolfinarium Harderwijk the original imported dolphins have been alive for nearly ten years. However, evidence has accumulated that artificial seawater with sodium chloride as the only salt present is insufficient for maintaining dolphins over a long period of time. A number of minerals and trace elements have been added and the results after 6 months are distinctly positive. It may also be more favourable for marine fungi, but this drawback has to be accepted.

*Introduction*

For years we have realized that in feeding deep frozen fish, even of the best quality, losses in quality occur and ought to be corrected. Therefore we add vit. $B_1$ to counteract thiaminase developing in dead fish. Other vitamins which feature in diets nowadays are in particular Vit. A, E, C and K.
The vitamin tablets usually contain minerals and sometimes trace elements. Interviewing colleagues about this matter I learned that they did not give much attention to this matter. Generally speaking it is assumed that the animals get enough minerals and trace elements from the fish supplemented from the daily tablets.

Over the years Dolphinaria or Oceanaria gather a lot of background information part of which is found in bloodvalues and postmortems. Evertytime one has a casualty, in particular if it is fatal, it is good practice to go through the records and see whether it is possible to learn from the addition of new data. These persusals lead us to believe that extra attention to minerals was badly needed. In our case even more so because the water in our systems is not oceanwater, but an artificial mixture.

*Minerals and trace elements*

To a certain extent minerals and trace elements could be considered as the inorganic counterpart of the vitamins and hormones. They are the basic elements of living tissue. In daily practice minerals are composed of elements that occur in relatively large quantities, whilst trace elements occur in very small quantities. Both are as vital as vitamins and hormones but cannot be made by living organisms. Many minerals and especially trace elements are essential components of enzymes.

If we consider the periodic system and the elements present in living tissue, we can see that some elements are essential, a large number do not occur and a fair number is toxic. Trace elements which occur in large numbers in tissure are usually not toxic. A shortage of trace elements leads to deficiencies as is the case with the minerals, but an overdose of trace elements is toxic. Toxicity of trace elements varies greatly from species to species. For example, the trace element Cu is needed in fair quantity in pigs. If their manure is spread over a meadow on which sheep are grazing the latter may even die because of Cu poisoning.

Let us consider the periodic system once more in relation to the occurrence of elements in living organisms. It is interesting to note that living organisms are composed of for 99% of the first 20 elements of the stable 92. It is logical to assume (Ciba Revue 1974) that when life first evolved it used elements which were largely available, like C, H, O, N, S, P, Cl with Na, K, Ca, Si and Mg. We find these in large quantities in the sea and in organisms and what is more significant in the same relative concentrations. The remaining one percent of their constitution consists of the elements 21-42, existing in much smaller quantities in seawater and, therefore, only in traces in living organisms. During evolution Cu and Fe were probably the first to be incorporated, as they are vital in oxidative systems. When organisms grew more and more complex specialized functions evolved and consequently special enzymes became necessary. To differentiate them nature used Zn, Mn, Cr, Co. These elements are excreted via the intestinal tract, usually as cations, and probably came into use before the kidney developed, that is before early vertebrates developed. Mo and I are exceptions. They are excreted as anions via the kidney.

Our knowledge of the part minerals and trace elements play in animal metabolism is far from complete. A very intricate pattern emerges form their study. Not only are these elements essential for certain enzyme systems, but they also demonstrate an influence on each other. Of the 9 essential trace elements, deficiencies have been observed for all except Mo and Cr. A few examples well suffice. Se is essential for the uptake or metabolism of Vit. E. When Vit. E is needed Se must be added and vice versa. Mn absorption is suppressed by calcium phosphate and Zn by fytine acid. Raising the level of Mo suppresses the retention of Cu. The same happens to Cu when the Zn concentration is raised. The latter is a reversible reaction.

*Considerations with respect to dolphins*

The Dolfinarium Harderwijk acquired dolphins (*Tursiops truncatus*, Mont. 1821) from Florida in 1965, 1968, 1969, 1970 and 1971 (DUDOK VAN HEEL, 1972). We lost one animal from the 1969 group, two from the 1970 and two from the 1971 group, i.e. 5 out of 21 animals. With respect to the age of those that died, one of them was an adult female, one was adolescent and three were juveniles. Although the direct cause in four cases out of five was some kind of infection, the indirect cause had been assumed to be pollution (DUDOK VAN HEEL, 1972). At the time of writing, February 1975, all other animals are alive.

The following facts and questions turned up:

1. Over the years the skin of the healthy dolphins slowly lost its dark grey colour. One of the males of the 1965 group became almost white.
2. Irregular patches, especially on the sides appeared. At first they came and went but in recent years became persistent, showing a tendency to increase in number and size. No microorganisms could ever be cultured from them. Some of these patches look similar to these described by GREENWOOD in a lecture during the Symposium of the EAAM at Kolmården, Sweden, in September 1974.
3. In sick animals low K figures occurred regularly.
4. Why did we loose four young, and only one adult animal?
5. Bacterial infections were noted as the primary cause of death except in one case. This particular case was a classic example of a heart attack victim, which was strange to find in a young animal that was definitely not overworked. More strange was that alle the post-mortem reports of the young animals mentioned heart lesions.
6. Baby no. 5 unexpectedly died seven days after birth. The baby had been born in a large tank and was in good condition, fed well and had no pneumonia, which was the cause of death of the three other live babies. The only irregularity in the post-mortem picture of how a healthy mammal should look internally was a heart which was somewhat abnormal. Not sufficient according to two different pathologists (one DVM, one MD) to be the cause of death but perhaps a sign?
7. Cu is absent in mammalian milk. Feeding piglets on a pure milk diet leads to serious deficiencies of Cu and even death in about 100 days. Heart and arteries are affected. Could a Cu deficiency be the cause of the death of baby nr. 5?

Mr. D. de Bruyn, the bio-chemist of Salem Hospital, Ermelo, with whom we cooperate closely and the author propose the following hypothesis for discussion. Healthy dolphins brought into an artificial system of water and NaCl only, may be able to withstand the osmotic problems they meet by the food uptake as is generally accepted. However, they may acquire a certain amount of deficiency over a period of 8 - 10 years. The problem becomes more critical in the case of sick animals, babies or juveniles. In the two latter categories the young animals are far more sensitive to deficiencies of trace elements than adult animals. In sick animals the membranes between body fluid and surrounding environment are

weakened, so that the possible leakage of minerals and trace elements from the body fluid into the artificial seawater can not be discounted. Therefore it might not be such a wild idea to assume that dolphins suffering to a certain extent from pollution also youngsters, feel the lack of minerals and trace elements in their environment, notwithstanding the fact they are properly fed and receive a daily addition of vitamins, minerals and trace elements. It should be noted that all the phenomena we observed, i.e. deterioration of liver, heart failure, patches on sides and around blowhole, could be explained as being caused by a deficiency of certain minerals and trace elements, as well as the result of infection, pollution etc.

We have discussed this problem thoroughly in a day long meeting at Harderwijk, expecially arranged for this purpose with two specialists on minerals and trace elements. The consideration of the dutch agronomist Dr. S. C. Redlich, director of the Laboratoire Agronomique at Gargenville, France, and his french colleague Dr. M. Lefevre, DVM, have added largely to the thoughts of Mr. de Bruyn and the author. In the first place we compared the analysis made of various water samples. Table I shows the composition of Oceanwater, taken from the surface at

TABLE 1: Values of essential elements and trace elements in oceanwater, well-water and poolwater in the Dolfinarium Harderwijk, determined bij atomic absorption sprectroscopy.

| | | Ocean: | Well: | Pool: | Pool after addition: |
|---|---|---|---|---|---|
| Na | mg/L | 10842 | 6,8 | 6642 | 9815 |
| Cl | mg/L | — | — | — | 15400 |
| K | mg/L | 389 | 0,2 | 19,8 | 195 |
| Ca | mg/L | 318 | 39 | 53 | 232 |
| Mg | mg/L | 1281 | 2,1 | 3,4 | 620 |
| Zn | µg/L | 50 | 24 | 4 | 2 |
| Cu | µg/L | 3 | 4 | 3 | 4 |
| Mn | µg/L | < 10 | 130 | < 10 | < 10 |

St. Kilda, West coast Hebrides, in 58°-09 N., 9°-05 W., at our request, the composition of the water of our well points and that of the water in our pools. The samples were analysed by the same method in the same institute. What worried the specialists most was not only the lack of certain essential elements but rather more, the reversed balance between K+ and Ca++ Mg++ in our pool water with respect to ocean water. Dr. Redlich was able to report on a French experiment using a radioactive trace method (at normal levels) to determine the uptake of Cu. The experiment showed that over 95% of the Cu is taken up by the mucosa of the mouth but hardly any by the intestinal tract. Rinsing of the mouth with water for about 30 seconds, containing traces of Cu, is enough to provide the body with sufficient Cu. He also pointed out that the large dark patch around the blowhole of Lara, similar to those found in two of the juvenile animals that died, looked very much like those seen around the nostrils of cows, a symptom indicating a Zn deficiency.

Table 1 also shows that our well water contains enough Mn but it appears to be filtered out quickly, being oxidized by the chlorine to $MnO_2$ and colouring the sand in the filter a dark brown. Also Cu and Zn are partly lost in the filter probably due to the use of Na aluminate as a flocculant. We planned an experiment to add K (KCl), Ca ($CaCl_2$) and Mg ($MgSO_4$) to our well water at 50% of normal ocean water values, which is above the values of each of these elements in the body fluid and Mn ($MnCl_2$), Cu $CuSO_4$), Zn ($ZnSO_4$), Se ($Na_2SeO_4$) at the average levels recorded for ocean water. Na was added to reach a total of 2,5%. The balance K+ versus Ca++ and Mg++ would be as it is in normal ocean water. Once a week 5% of the total volume would be changed and the necessary elements added.

*Results*

Within a month of introducing the extra minerals the first effects were clearly noticeable. Commencing from the top of the head, the normal dark coloration on the dorsal side of the animals returned, and within 3 - 4 months the original colour was regained. More slowly but distinctly, the patches have been disappearing and this process is continuing (February 1975).
Although it is difficult to asses these results properly, we think that in all our Dolfinaria (Harderwijk, Netherlands; Brugge, Belgium; and Munster, Germany) the appetite of the animals has improved. After a few weeks the dark raw patch around Lara's head started to heal. The patch became smaller and the skin over it became normal. In late autumn we stopped adding the trace elements Cu, Zn and Mn to Lara's pool. The patch rapidly became raw again and increased in size. When these elements were again added the skin rehealed, although the dark colour is still visible. We assume that Zn is the element involved, and the weekly addition seems to be enough to insure healing. There is additional evidence of a negative nature that our new approach to water quality may be correct. In the summer of 1974 we discovered two cases of Lobo disease (POELMA c.s., 1974) one animal being infected by the other. Reconstructing the case of the original victim it is obvious that the fungus was present but only started to develop and infect a secound case after the introduction of the minerals. Part of the successful treatment has been to return the originally infected animal to a pool containing NaCl only.

*Conclusion*

To us there is no doubt that adding minerals and trace elements to the pool water is beneficial to the animals. It seems logical to assume that if the new formula is more adequate for our animals it also is for bacteria and fungi, but that this should be accepted. We intend to carry on with these additions of minerals and trace elements notwithstanding the quite considerable rise in operating costs.
It is still too early to tell wheter these additions also benefit the husbandry of baby dolphins. Theoretically it should, but more cannot be said about this at this moment.

*References*

CIBA Revue 1974: Sporenelementen vandaag.

DUDOK VAN HEEL, Dr. W. H., 1972. Raised levels of mercury and chlorinated hydrocarbons in newly captured *Tursiops truncatus*, Mont. from Florida waters. J. Aq. Ma. 1 (2): pp. 24-36.

POELMA, F. G. DVM, G. A. DE VRIES, E. A. R. BLYTHE—RUSSELL and M. H. F. LUYKX, 1974. Lobomycosis in an Atlantic bottle-nosed dolphin in the Dolfinarium Harderwijk. J. Aq. Ma. 2 (3): pp. 11-15.

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# AN OVERWIEW OF WORLD WIDE CULTURED FISH PRODUCTION

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*Summary*

Fish farming in salt water is usually referred to as mariculture; fish farming in fresh or brackish water is known as aquaculture. This paper presents basic information on both types of fish farming, specifically, (1) total world fish supplies including mariculture and aquaculture and, (2) mariculture and aquaculture in selected countries, i.e. — Japan and the United States. The presentation pertains mostly to finfish. The interest in production of finfish through mariculture and aquaculture is at a high level. In certain countries such as Japan production is increasing rapidly. In the United States we have not yet achieved a breakthrough in mariculture. In aquaculture the past five years has seen rapidly increased production of rainbow trout and channel catfish, a trend which will probably continue.

*Some basic information*

More than 70 precent of the solar energy reaching the earth falls on the surface of the oceans. Sea water is a dilute broth, holding in solution all the chemical nutrients necessary for the growth of plants. The bounties of the sea might seem endless as shown by great schools of herring in the north Atlantic, endless numbers of tuna in the central Pacific, and hordes of salmon surging up Alaskan spawning streams. Yet in the face of these theories and observations the sea produces only two to three percent of mankind's calories. Like so many of the land's riches, the plant nutrients of the sea are very unevenly distributed. The range of productivity in the sea is at least as wide as the range on land. Fish farming may be compared to intensive agriculture practices such as greenhouses,