Fig. 1

SOME EXPERIENCES WITH GAS CHLORINATION

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Summary

The Zoological Society of London has long been aware of the gap in its collection by the omission of a representative of the family Cetacea. It was, therefore, logical to open at Whipsnade Park a small unit as the beginning of a more complex exhibition showing members of this family. This was done in May 1972. At the present time we have 1 male and 3 female bottle-nosed dolphins (*Tursiops truncatus*) in the pools and are giving four or five public feeds a day to demonstrate to visitors the range of activities and capabilities found in this species. Following a description of the establishment the experiences with gaschlorination are rendered as these seem to deepen our insight in water purification in enclosed marine mammal water systems.

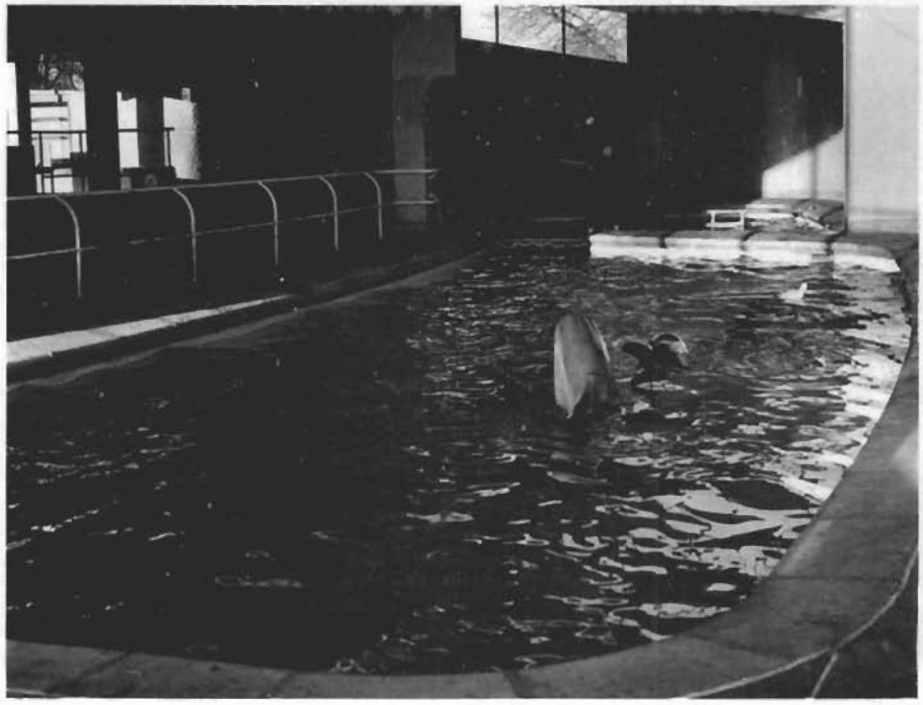


Fig. 2

Design

The house does not extend over the whole pool so that there is a facility for indoor and outdoor displays. The total water content is 130,550 gallons (593,247 litres) and is devided up as follows:

Outside pool	73,350 gallons	(333,218 litres)
Indoor pool	44,000 gallons	(200,022 litres)
Isolation pool	13,200 gallons	(60,007 litres)

The outside pool (Fig. 1) measures 62 ft (19 metres) in length and is over 16 ft 9 ins (5 metres) in width. The depth averages 11 ft (3,4 metres).

The main indoor pool (Fig. 2) measures 42 ft (13 metres) in length and has the same width and maximum depth as the outside pool.

The isolation pool is 20 ft (6 metres) in length, 15 ft 9 ins (5 metres) in width and is 8 ft (2,5 metres) in depth over half its length. The rest of the pool comprises a stranding shelf some 7 ft (2 metres) in depth extending for the whole width of the pool but itself only having 1 metre depth of water.

Three underwater viewing windows at the side of pool 2, measuring 2 metres by 1,25 metres, are glazed with 1½ inch (3,58 cm.) thick plate glass to give good vision of the animals to the public.

The circulation time for the water to pass and re-pass the high speed sand filters is three hours for the main indoor and the outdoor pools; the isolation pool has an increased circulation time of one hour. The intention of this set-up is to maintain a closed system with artificial salt water and for this purpose common salt (sodium chloride) is added to give an approximate concentration of 2,5% (specific gravity 1.014 to 1.016). Two large oil fired boilers each of 577,000 Btu's per hour output are used alternatively to maintain a pool temperature of 18°C or thereabouts, and to heat the air in the indoor pools to approximately 19/20°C. After filtration of the water, the sand filters require backwashing about every 7 to 10 days and for this purpose a sedimentation tank holding nearly 2,000 gallons (9,091 litres) allows solid matter to settle to the bottom so that most of the water can then be re-used in the system. Under this situation less than 1,5% of the water is sent to waste each week. Stand-by generators are available so that in the event of power failure, the circulating and heating systems can be kept operating.

A small quantity of so-called "kibbled alum" and which is actually the single salt, aluminium sulphate, is added to the water occasionally to increase flocculation of particulate matter. This is seldom added in excess of 1 Kg. a month. All pools are fitted with skimmer boxes which suck floating debris from the surface of the pools over a non-return flap valve.

Chlorination

The management of the pool was designed to work on breakpoint chlorination using gaseous chlorine for the purpose.

The chlorine is supplied in 33 Kg. cylinders attached to an automatic changeover unit. This ensures that as soon as one bottle is empty, a flow is maintained from the second; the unit also has a safety valve which cuts off the supply of chlorine should a break in the pipe occur. This is achieved by using a negative pressure system so that the pressure in the pipes from the gas cylinders is less than atmospheric. The gas is drawn under negative pressure to a pumping system whereby it is mixed with a sodium carbonate solution and pumped under pressure into the water leaving the sand filters. Three such pumps and three tanks for sodium carbonate, together with three gas stop cocks and attached flow meters, make it possible to vary the flow of gas to each of the three pools and also to increase or decrease the amount of sodium carbonate added to maintain a pH of 7.5 to 7.6.

When the first animals arrived in May 1972 the pumping system was incomplete and chlorination had to be commenced by using sodium hypochlorite. Fig. 3 shows that despite constant addition of hypochlorite, the amount of combined chlorine (present as mono-, di- and trichloramines) in the system continued to increase. Since these substances are toxic to mammals, it is important for the levels to be kept as low as possible.
Fig. 4 shows the immediate effect of switching on a supply of chlorine gas; the amount of combined chlorine in the system rapidly dropped. I should interpolate here that the levels of free, combined and total chlorine are made using a Lovibond Comparator and Palintest DPD tablets. Originally, pH was measured using the same comparator and phenol red tablets. This method is unreliable in the presence of chlorine and we have now purchased a small pH meter to give us more accurate estimations.

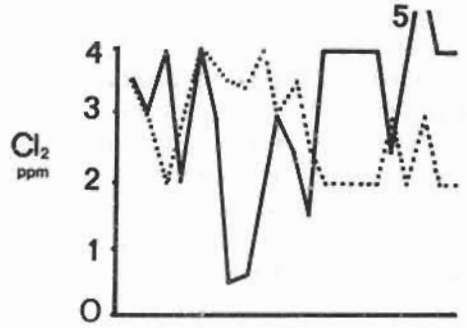


Fig. 3 — = free chlorine
... = combined chlorine

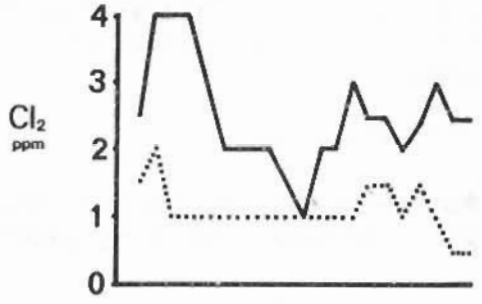


Fig. 4

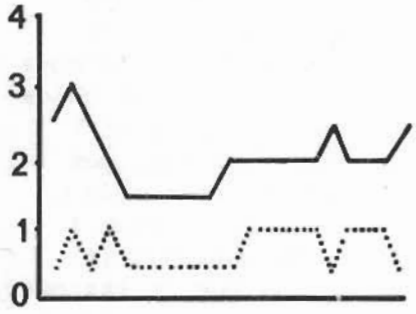


Fig. 5

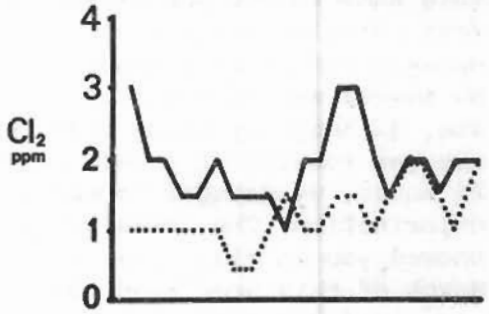
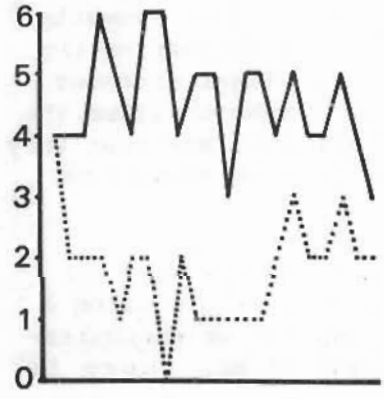


Fig. 6

Fig. 5 shows the levels of chlorine taken in late October last year when the whole system had settled down. On 20th October we restricted the movement of the dolphins to the inside pools only and at the same time introduced two extra female animals. Fig. 6 shows the effect which this had on the chlorine levels. Indeed, we found it very difficult to control free and combined chlorine in the reduced amount of water, which was only about 286 tons. On the basic rule of 100 tons or 20.000 gallons (90.920 litres) of water per animal, this was barely sufficient for three animals, let alone four, and our experiences showed that it was extremely difficult to control the level of chlorine with this ratio of water to animals; even by increasing the flow of chlorine to a rate of 20 lbs (9.1 Kg.) per 24 hours and until the free level reached 6 parts per million, we were unable to reduce the combined chlorine to less than 1 part per million, (Fig. 7). This was the situation early in December 1972.

Fig. 7



Normally each of the three pools has its own separate pumping circulation and filtration system. However, in an attempt to reduce the amount of combined chlorine present, the circulation was varied so that the filters to the outside and main indoor pools were used in series in either direction and also in parallel. This meant that the

whole system, namely 117,000 gallons (531,877 litres) of water in these pools, could be drawn through the area in which the dolphins were confined and by reversing the flow this same volume was given a longer period in which the free chlorine could react with the by-products from the animals before it reached the filters. Despite all attempts no succes was achieved in reducing the total level of chlorine, although by using high levels of free chlorine with the gas running at a rate of up to 20 lbs. (9,1 Kg.) per 24 hours, we managed to maintain a system of break point chlorination. The satisfactory level of chlorine which I showed you in Fig. 5 was very rapidly re-established in March of this year when the outside pool was put on its own circulation system and the dolphins allowed out there during the day.

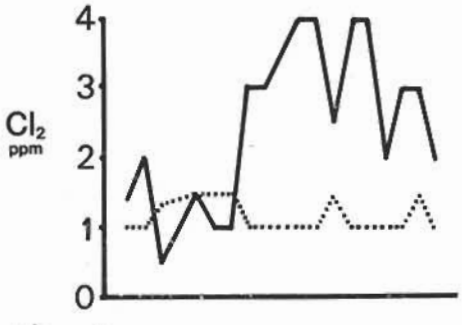


Fig. 8

The amount of chlorine used in this system has obviously varied from day to day and even from hour to hour. Generally speaking, though, both the outdoor and indoor pools are using chlorine at the rate of 10 lbs.(4,5 Kg.) per 24 hours for the period of maximum activity during the day but these are reduced to between 3(1,4 Kg.) and 5 lbs. (2,3 Kg.) per 24 hours during inactive periods.

In August this year the system apparently broke down and no chlorine was being delivered to the water. Originally we thought this was due to vandalism but after close investigation we discovered that the plastic piping delivering the gas from the cylinders was corroded and a slight movement had caused a fracture. Fig. 8 shows the situation after the chlorine had been off for 1½ days and you will see that very rapidly an effective level was restored, which shows the efficiency of this system.

I mentioned earlier that we had now given up the use of phenol red tablets to measure pH levels and we are using a pH meter. Fig. 9 shows the discrepancies that we encountered which you see vary at different levels of pH. There is

Phenol red	pH Meter
6.9	6.72
7.4	7.2
7.5	7.7
8.4	8.6

Fig. 9

Cl_2	pH meter	pH tablet	pH meter	pH tablet
22	7.60	7.85	7.85	7.85
17	7.70	7.90	7.90	7.85
10	7.70	7.80	7.80	7.80
4.5	7.55	7.60	7.65	7.70

Fig. 10

some indication that the variation between the two levels, as indicated by tablets and meter, depends upon the amount of combined chlorine present in the system. Closer analysis reveals that the phenol red tablets contain sodium thiosulphate, which reacts with the chlorine in the solution, thereby increasing the pH. Fig. 10 illustrates a test carried out by Tintometer Limited, the manufacturers of DPD and phenol red tablets, which shows that the addition of sodium thiosulphate to water at different chlorinated levels affects the pH.

In conclusion, I would like to state that we feel ourselves extremely lucky to be in the happy situation of achieving breakpoint chlorination without fully realising the reasons for it, but we have learnt exactly what happens in our system and how levels can be maintained.

AQUATIC EXHIBITS AT WEST BERLIN ZOO

by Prof.Dr. Heinz-Georg Klös, Direktor Aktien-Verein des Zoologischen Gartens zu Berlin.

Summary

The enclosures for pinnipeds at the West Berlin Zoo are among the few animal enclosures that survived the Second World War. They were designed in 1930 by Prof. Ludwig Heck and have always been among our most successful exhibits. Rockwork forms one of their most important features; this