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The Polarium at Munich Zoo

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The Polarium at Munich Zoo is a large complex containing three sets of enclosures specifically designed for the display of Arctic species. Completed in 1974, and fully operational in 1975, the 60×100 m complex spreads across a shady slope in the southeastern area of the park. Designed by the architect Peter Lanz, it is essentially an isolated concrete construction divided in the centre by a wide public pathway; on one side is an exhibit containing various species of seal and on the other are two adjacent but separate exhibits in which penguins and Polar bears *Thalarctos maritimus* are maintained (Plate 1).

PENGUIN EXHIBIT

The penguin area comprises two separate glass-fronted indoor display sections lying on either side of a smaller off-exhibit section which is open to the air from above (Fig. 1). The two indoor enclosures cover an area of 74 m^2 and 77 m^2, respectively, and are 2·4 m high. A service area lies behind the centrally placed off-exhibit section which measures 38 m^2. The smaller of the indoor displays contains ten King *Aptenodytes patagonica* and six Gentoo penguins *Pygoscelis papua*, the other holds 32 Humboldt *Spheniscus humboldti* and six Rockhopper penguins *Eudyptes crestatus*; only the two last species have access to the outdoor enclosure. There are no night-time quarters.

All three displays contain a pool at the front and an area of land extending out from the back wall. The water in the pool rises 1·2 m from just below ground level,

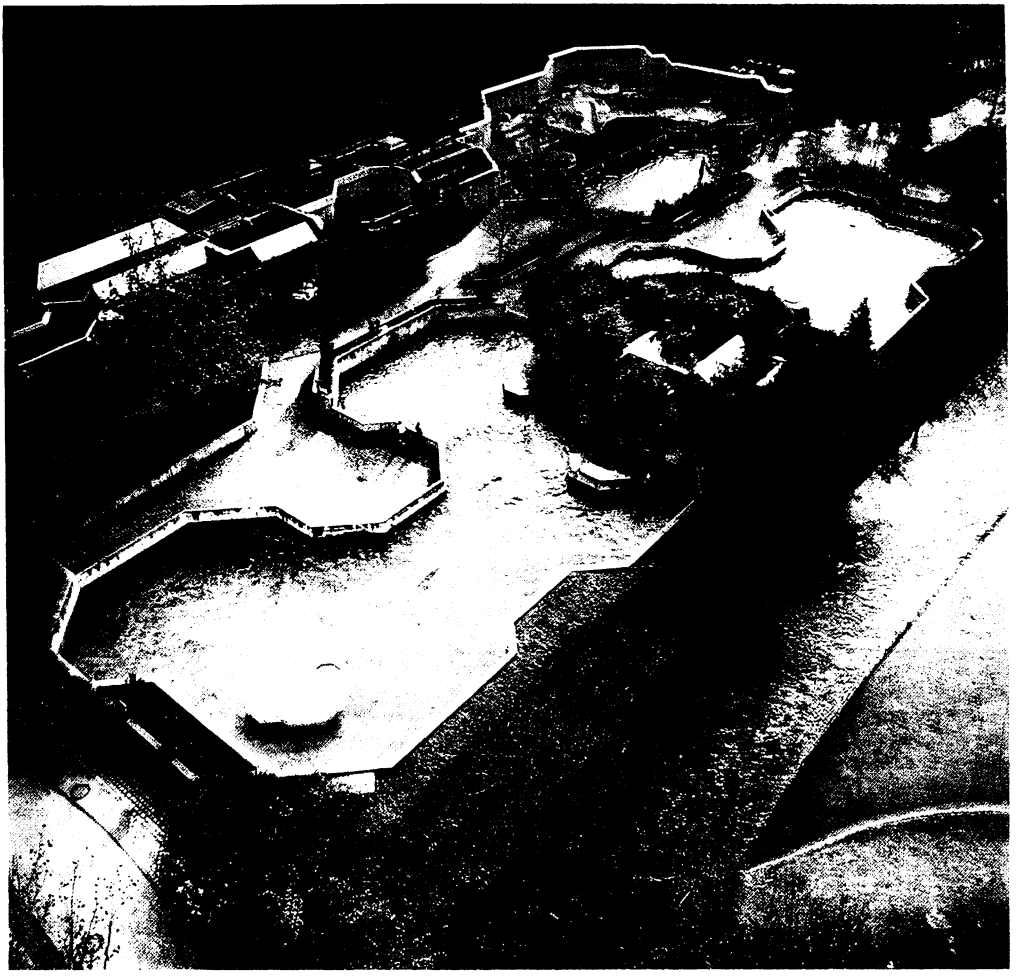

Plate 1. General view of the Polarium at Munich Zoo showing the seal exhibit with its pools, the Polar bear *Thalarctos maritimus* enclosure (top right) and penguin enclosures (top left).

occupying the space between the land and the viewing window which forms the front wall of each exhibit. The window, which is made of double-sided safety glass 3·8 cm thick, extends almost to the ground in order to give visitors the opportunity to watch the penguins swimming under water. The land area is *c.*1 m above ground level, being just a few centimetres above the edge of the water. Visitors are thus given a clear view of the birds' activities at all times. In order to cut down on reflections, and to provide the viewing window with some protection from wind and rain, a large slab of concrete (which is a continuation of the roof in the case of the two indoor enclosures) juts out over the visitor area to give shade. This has the added benefit of preventing direct sunlight from heating the glass and raising the temperature inside.

Most of the land area in the two indoor enclosures is covered with 2×2 cm tiles, laid in order to prevent the occurrence of bumblefoot (with almost complete success). There is also a 5 m^2 gravel bed, 10–30 mm deep with drainage

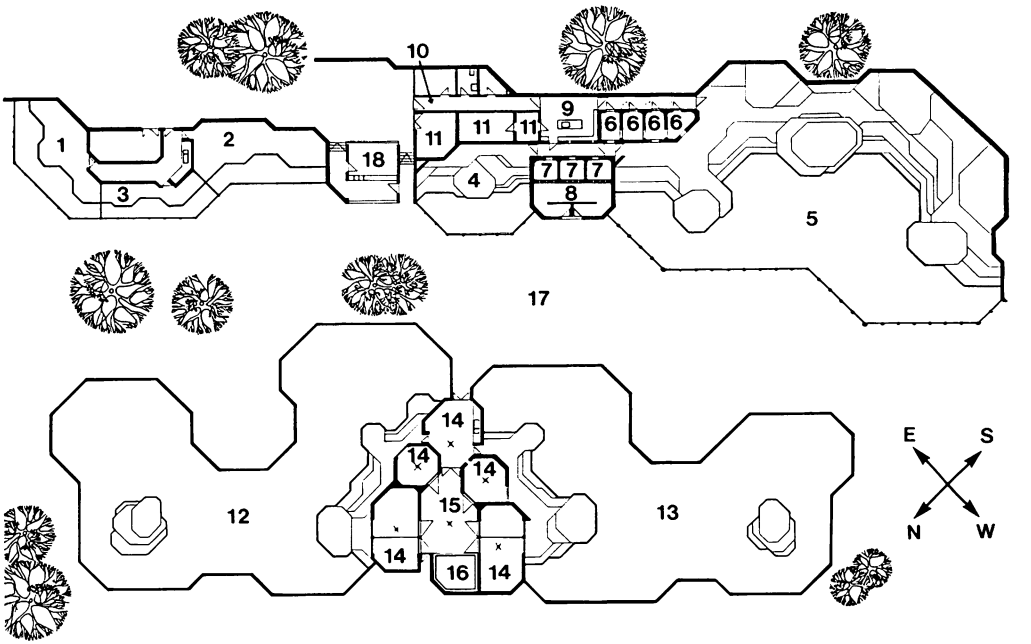

Fig. 1. Plan of the Polarium at Munich Zoo. 1. indoor enclosure for King *Aptenodytes patagonica* **and Gentoo penguins** *Pygoscelis papua;* **2. indoor enclosure for Humboldt** *Spheniscus humboldti* **and Rockhopper penguins** *Eudyptes crestatus;* **3. outdoor enclosure for Humboldt and Rockhopper penguins; 4. small outdoor enclosure, with a pool at the front, for Polar bears** *Thalarctos maritimus* **(mainly intended for mothers with young); 5. main Polar bear enclosure with pool; 6. stall; 7. birthing room; 8. visitors' observation room; 9. keepers' work room; 10. service corridor; 11. freezers (capacity: 40 tonnes frozen fish); 12. outdoor enclosure for Southern sealions** *Otaria byronia;* **13. outdoor enclosure for Californian sealions** *Zalophus californianus* **and South American fur seals** *Arctocephalus australis;* **14. stall; 15. central service yard; 16. water basin; 17. public path; 18. cafeteria.**

underneath, for use during the moult and at the start of the breeding season when pair bonding begins and nesting material is required. Small caves $40 \times 30 \times 30$ cm high have been set into the back wall for use as nests. The land area in the King and Gentoo penguin enclosure has proved to be too narrow for young chicks to negotiate with safety, so during the breeding season a fence is erected along the outside edge to prevent the young from drowning (Plate 2).

Natural light enters the indoor exhibits through frosted glass skylights in the ceiling as well as through the front window. When necessary artificial light is provided by 65W incandescent neon tubes (44 for the King penguins and 42 for the Humboldt penguins) and underwater spotlights. A one-year experiment involving the development of a computerised lighting schedule similar to the natural photoperiod showed no apparent effect on breeding success.

The indoor displays are served by air-conditioning, the temperature usually varying from 4–12°C depending on the season; if the temperature outside is 35°C, the maximum inside will be 12°C and if the temperature outside is −15°C the minimum inside will be 4°C. In the breeding season, however, (February to April for the Humboldt penguins and April to June for the King and Gentoo penguins) the temperature is kept at a constant 15°C. The air is changed 1·5 times per 24 hours, the main filtration occurring through a dust filter containing glass wool. If necessary fresh air can be sterilised using ultraviolet light beams

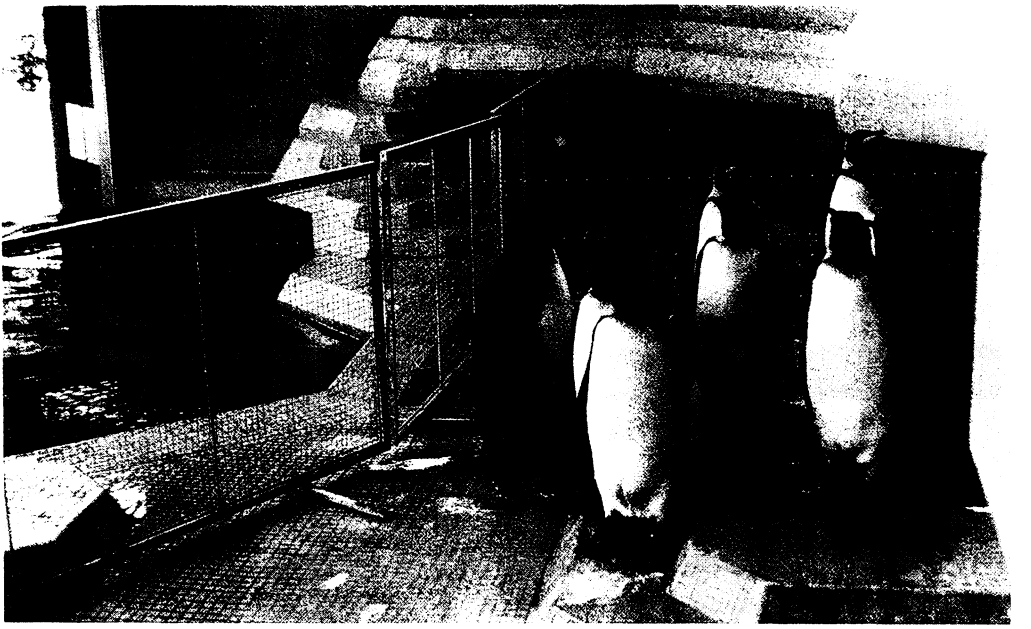

Plate 2. King penguins *Aptenodytes patagonica* in their enclosure showing the gravel bed, tiled land area and fence erected during the breeding season to prevent the young from falling into the pool and drowning.

within a two-way channel. Relative humidity is kept at 80%.

Water for the pools is obtained from a local spring, owned by the zoo, and is recycled constantly through quartz-sand filters, changed at a rate of 10%/24 h and renewed completely every 14 days. In an emergency, water can be taken from the main supply. The water volume is 43 m^3 and 30 m^3 in the smaller and larger indoor enclosures, respectively, while that in the outdoor pool is 25 m^3. No chemicals are added.

Neither the King nor the Gentoo penguins are normally allowed outside; during winter, however, the King penguins are released into the park for a 15-minute walk twice a day. Access to the outdoor enclosure is given to the Humboldt and Rockhopper penguins via an 80 × 80 cm underwater channel which is usually blocked by a sliding door which can be opened manually. When the door is left open the birds can choose whether or not to go outside. The outdoor pool remains filled even if the exhibit is not in use. As mentioned earlier the enclosure is glass fronted, with a concrete overhang to provide shade and protection, but has no roof.

POLAR BEAR EXHIBIT

The Polar bear complex lies adjacent to the penguin exhibit and comprises two outdoor areas, each with a pool, and a number of indoor facilities including three small rooms used for ♀♀ giving birth, four stalls for the short-term maintenance of individuals, a visitors' observation room and various service areas (Fig. 1).

One of the outdoor areas is considerably larger than the other (Fig. 1), having a land area of 760 m^2 and an unpainted concrete pool containing 675 m^3 of water, measuring 40 × 8·5 × 2·0 m deep. It is here that the 1.4 Polar bears currently on exhibit spend most of their time. As in the penguin enclosures, the pool lies between the public pathway and the remainder of the exhibit although in this case the edge of

the pool is at ground level with the water's surface being 10 cm below the edge. Visitors view the area from the pathway through a 3·8 m high barrier made of safety glass held in place with steel bars buried in concrete. The barrier forms one side of the exhibit, the other three sides being made of concrete 3·8–4·8 m high. The top section of the back wall is inclined slightly. The land area runs out from the back and side walls, consisting of concrete slabs piled onto one another in various formations to make an uneven surface which varies in height from 0·5–5 m, being highest at the back wall. Part of the surface hangs over the pool.

The smaller outdoor enclosure is intended for use mainly by ♀♀ and their offspring although it is also used for the temporary isolation of one or more individuals when a change in group structure is required or if the larger area is being cleaned. The land section, set at various heights, covers an area of 92 m^2 and the pool, which is $10 \times 3{\cdot}6 \times 1{\cdot}8$ m deep, contains 64 m^3 of water. The water in both pools has no added chemicals, is changed at a rate of 10%/24 h and renewed totally every 14 days. The constant flow of water in and out of the pools prevents them from freezing over in winter.

Lying between the two outdoor enclosures is a visitors' observation room, entered from the pathway, at the back of which are the three small birthing rooms $2{\cdot}5 \times 2 \times 1{\cdot}8$ m high (Fig. 1). When required the rooms are heated to *c.*15°C from under the floor, and lit with a red bulb. Unfortunately the observation area is not currently in use since the sound proofing between it and the birthing rooms is too poor.

A corridor behind the birthing rooms links the two outdoor enclosures and also leads into the centrally placed work room (Fig. 1) where all food preparation takes place. Three freezer rooms (for deep-freezing, shock-freezing and defrosting), as well as facilities for the keepers, lie next to the work room on one side while on the other side at the back is a corridor leading to the four stalls and to the main outdoor enclosure. The stalls, which measure $2{\cdot}9 \times 2$ m, $2{\cdot}9 \times 2{\cdot}5$ m and are 2·1 m high, are not used for the isolation of sick animals because it is impossible to keep the rooms warm enough to prevent an individual from developing pneumonia after a short time. Since there is no underfloor heating the floors remain extremely cold even in summer. Instead the rooms are of value for animal movement. All four are interconnected via sliding doors and three exit directly into the large enclosure as well as into the back service corridor. The stall nearest the work room (Fig. 1) exits into the front corridor to allow an animal to be moved into a birthing room or into the small outdoor enclosure. This stall contains a squeeze-cage but, following the development of successful immobilisation techniques for the treatment of sick animals, this is no longer in use. All sliding doors can be operated from the work room or the hallway by a system of pulleys when necessary. The location of the work room means that all enclosures can be serviced easily. The doors to the indoor areas are always left open at night so that the Polar bears have the opportunity to sleep there if they wish; most of them do.

Fresh air is pumped into the indoor complex through pipes set into cavities in the walls and air leaves through vents in the ceiling. A skylight in the roof provides the work room with some natural light but in all other service areas and in the holding rooms the lighting is artificial.

SEAL EXHIBIT

The seal exhibit is situated on the other side of the public pathway, forming a separate unit. It consists of two 35×20 m unpainted concrete pools with an indoor complex of stalls and service areas lying between them (Fig. 1). The northeastern enclosure contains 1.5 Southern sealions *Otaria byronia* and covers a total area of

668 m^2, only 80 m^2 of which consists of land. The pool contains a water volume of 1300 m^3 and is 1·8 m deep except for a single 'diving pit' which is 2·8 m deep. Most of the outer edge of the pool is surrounded by a 90 cm barrier of safety glass mounted on a 60 cm concrete wall. One portion, however, has no glass barrier but instead forms a thick wall 80 cm high over which visitors can lean and look into the water.

An island lies in one corner of the pool, the remainder of the land area being located on the side leading into the stalls and service area. The roof of the building is roughly tiered, the various levels having been planted with small shrubs and other greenery. Part of the roof hangs over the land area to give a cave-like atmosphere. Two outcrops of land are suspended over the water and between them is a 'bay' where the land becomes submerged in a series of steps. The diving pit is located under one of the overhangs. When required in the breeding season the pool is divided by a fence which is installed from the bay to the outer wall of the pool (Plate 3). The land area can also be

Plate 3. View of the seal exhibit showing the two display pools and central indoor complex; part of one of the pools has been fenced off to allow a mother and her young to remain separate from the other members of the group while maintaining some contact with them.

divided, allowing a mother and cub to be protected while remaining in contact with the group.

At one time the water level in the pool was varied to simulate low and high tides, the water at 'high tide' being 1·8 m deep so that the whole of the island plus 60% of the land area was under water. It was intended that the procedure would force the seals to exercise more, but this did not happen and the water is now permanently at the high tide level.

The second seal exhibit is similar to the first but contains 2.5 Californian sea-lions *Zalophus californianus* and 1.2 South American fur seals *Arctocephalus australis*. It covers a total area of 639 m^2, of which 61 m^2 is land, and has a water volume of 1200 m^3; the pool is of the same depth as that in the other enclosure.

No chemicals are added to the water of either pool which is renewed at a rate of 10%/24 h and changed completely every 14 days or as needed. At this time the pools are cleaned and algae and other aquatic plants are removed with a high-pressure water jet. Drainage points are located at the lowest point of each diving pit.

Inside the central building are five stalls and a salt-water basin positioned in a circle around a central service yard (Fig. 1). One of the stalls can be accessed from either of the outdoor areas, the remainder can be entered from only one enclosure or the other. The stall dimensions are 4 × 3·8 m, 5 × 3·5 m, 6 × 5·9 m, 7·8 × 3·8 m and 7·2 × 4·0 m. The first two are 2·0 m high, the remainder are 2·5 m high, and the two largest can be divided in half if necessary. All open into the central yard 7 × 5·2 × 2·5 m and are intended for the maintenance of one animal at a time although more can be kept together if they are compatible. Each stall is heated electrically from under the floor, which is also provided with drainage, and a skylight in the roof provides natural light. The yard is used for food preparation and acts as a station through which animals can be moved from one place to another with relative ease. In addition, it is valuable as an isolation area for the treatment of individuals. The salt-water basin is used for the treatment of 'blue eyes', a condition probably caused by the animals' being kept in fresh rather than salt water. Heating in the service area is provided by gas, and lighting is mainly artificial. The doors between the exhibit and the two largest stalls (Fig. 1) are left open at night.

ANIMAL HISTORY

Stock movements, births and deaths of all the species maintained in the Polarium from 1975 to the present day are given in

SPECIES	STOCK 31 Dec 1975	REC'D	OF WHICH DIED	SOLD	BORN	REARED	STOCK 30 Oct 1986
King penguin *Aptenodytes patagonica*		10	1.1		2	2	10
Gentoo penguin *Pygoscelis papua*	10		3.2		4	1	6
Rockhopper penguin *Eudyptes crestatus*	12		6.0				6
Humboldt penguin *Spheniscus humboldti*	20		7.3	5	34	27	32
Polar bear *Thalarctos maritimus*	2.5	2.4	0.2	3.2	1.1.1		1.4
Californian sealion *Zalophus californianus*	1.3	1.1	0.2		6.2.1	2.1	2.5
South American fur seal *Arctocephalus australis*	2.1	1.2	1.1	1.0	0.1		1.2
Grey seal *Halichoerus grypus*		1.2	0.1	1.1			
Southern sealion *Otaria byronia*	1.5	1.2	1.2		3.2.5		1.5
Southern elephant seal *Mirounga leonina*	0.1		0.1				

Table 1. Stock movements, births and deaths of all species maintained in the Polarium at Munich Zoo from 1975 to October 1986.

SPECIES	NO. & SEX	DATE ARRIVED	DATE DIED	AGE (years)	POST-MORTEM FINDINGS
King penguin	1.0	Aug 1976	Apr 1979		gout
	0.1	Aug 1976	Jun 1984		renal tumour
Gentoo penguin	0.1	Dec 1975	Jul 1976		trauma
	0.1	Dec 1975	Jun 1977		nephrosis
	1.0	Dec 1975	Apr 1982		foreign object
	1.0	Dec 1975	Mar 1983		degeneration of heart muscle
	0.1	Dec 1975	Feb 1985		aspergillosis
	0.1	Dec 1975	Mar 1985		poisoning
Rockhopper penguin	1.0	Dec 1975	Dec 1978		nephritis
	1.0	Dec 1975	Oct 1978		unknown
	1.0	Dec 1975	Apr 1979		trauma
	1.0	Dec 1975	Aug 1981		aspergillosis
	1.0	Dec 1975	Mar 1983		unknown
	1.0	Dec 1975	Jun 1983		nephritis
Humboldt penguin	0.1	Jun 1979	Jan 1981	1.5	foreign objects (two 5 × 5 cm pieces of wood)
	1.0	Aug 1980	Aug 1981	1	aspergillosis
	0.1	Dec 1975	Aug 1983		trauma
	1.0	Dec 1975	Aug 1985		*Pseudomonas* infection
	1.0	Jul 1983	Sep 1985	2	foreign object (plastic)
	4.1	1983–1984	1983–1984	90–180 days	aspergillosis
Polar bear	0.1	Oct 1977	Sep 1978	3	encephalitis
	0.1	Sep 1957	Jan 1981	30	acanthosis nigricans
Californian sealion	1.0	Aug 1975	May 1981	11	nephrosis
	1.0	May 1983	Apr 1984	1	foreign object (coin)
South American fur seal	1.0	Dec 1975	May 1981	7	trauma
	0.1	Dec 1975	Feb 1984		foreign object (woollen cap)
Grey seal	0.1	Mar 1976	Jun 1977	4	struggle injuries
Southern sealion	0.1	Nov 1974	Nov 1980		pasteurellosis
	0.1	Dec 1975	Nov 1980		laryngopharyngitis
	1.0	Aug 1975	Jul 1984	14	heart failure
Southern elephant seal	0.1	Aug 1975	May 1982	9	virus pneumonia

Table 2. Perinatal mortalities and post-mortem results for all species maintained in the Polarium from 1975, when animals were first introduced into the exhibit, to the end of 1985.

Table 1. The species kept in each section remain the same as those first housed, although in the northeastern pool of the seal exhibit a Southern elephant seal *Mirounga leonina* and a few Grey seals *Halichoerus grypus* have been added to the Southern sealion group on occasion. The elephant seal died after seven years and the Grey seals were removed after about a year because they proved to be incompatible with the Southern sealions; one Grey seal died as a result of injuries caused by a ♂ sealion.

A summary of all perinatal deaths which have occurred in the Polarium, including post-mortem results, is presented in Table 2. Foreign objects which have been swallowed can be regarded as the main cause of death in mammals as well as in birds. Aspergillosis is another serious problem in the birds, especially the Humboldt penguins. Neonatal mortality within one to 11 days (including abortions in the mammals) has been recorded for 1.1.1 Polar bears, 5.2 Californian sealions, 1.0 South American fur seal, 4.4 Southern sealions, one King penguin, three Gentoo penguins and seven Humboldt penguins. Three Californian sealion pups have survived to

maturity although they had to be hand-reared because their mothers suffered from agalactia.

The Polarium at Munich is an attractive exhibit which provides interesting and unhampered views of Arctic animals in comparatively naturalistic surroundings. During its 12 years of operation it has proved increasingly popular with our visitors from at home and abroad.

Manuscript submitted 29 December 1986; revised February 1987

APPENDIX 1

TAXONOMIC AUTHORITIES CONSULTED IN THE YEARBOOK

As in previous years, scientific and common names used in the Yearbook have been standardised and brought up to date in accordance with the latest available works of reference. The following is a list of major taxonomic authorities consulted. Attention is drawn in particular to the rearrangement and reclassification of the birds to follow Morony *et al.* (1975), and the majority of mammals to follow Corbet (1978) and Corbet & Hill (1980).

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author index to volumes 22–26

A cumulative index to senior authors in Volume 1–17 of the *Yearbook* is contained in Volume 17. The author index for Volumes 17–21, published in Volume 21, additionally includes a cross-reference from co-authors, as does the present index.

cumulative index to volumes 22–26

Previous cumulative indexes are contained in Volume 11 (Volumes 1–11), Volume 16 (Volumes 12–16) and Volume 21 (Volumes 17–21). In the present index figures in bold indicate the volume number. Plates are indicated by (Pl) after the relevant page number(s). Where the name of a town is indexed this refers to the zoo, aquarium or other institution in that town. Animal species covered at any length in the text are cross-referenced from the vernacular to the scientific name and the main reference to the species appears under the scientific name and/or the name of the institution concerned.

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M