

Caring for Asian small-clawed, Cape clawless, Nearctic, and spotted-necked otters

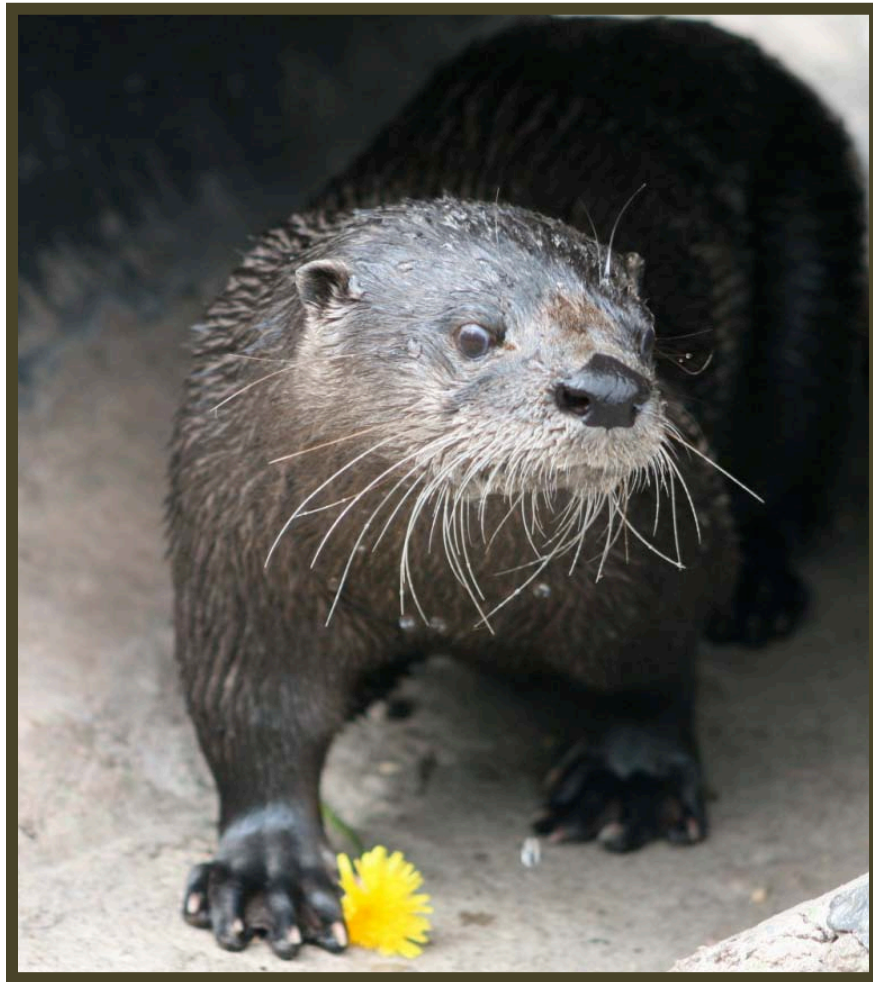


Photo credit: Jennifer Potter, Calgary Zoo

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Acknowledgments

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Photo Credits: Our thanks go out to the photographers who allowed us to incorporate their work: Jason Theuman – N.A. river otter female and pups (this page); Jennifer Brink – Asian small-clawed otter family (page 7); Unknown – Cape clawless otter (page 8); Doug Kjos – N.A. otter group (page 9); Jenna Kocourek- spotted-necked otter (page 9); Jennifer Potter – N.A. otter (page 15).

Manual use and objectives

This otter care guide is a compilation of professional experience to provide guidance to all professionals working with these species in a captive setting. Recommendations set out in this manual are just that, recommendations. Individual institutions should establish their own policies to fit their particular needs. It is important to remember that every situation is different, every animal is different. None of the authors or organizations consulted for the creation of this document supports the keeping of otters as pets. Otters can be dangerous, inflict serious bites, and require specialized care and knowledge to properly provide for their needs.



Photo: Jason Theuman, Buttonwood Park Zoo, N. A. river otter female and pups.

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Taxonomy

This manual covers only four species, listed below in bold, for information on the care of other otter species consult the Otter Specialist Group's (OSG) Otters in Captivity Task Force link: (<http://www.otterspecialistgroup.org/>)

Table 1: Taxonomic classification for Lutrinae

Classification	Taxonomy	Additional information
Kingdom	Animalia	
Phylum	Chordata	
Class	Mammalia	
Order	Carnivora	
Suborder	Caniformia	
Family	Mustelidae	
Sub Family	Lutrinae	Some species names are still being debated

Table 2: Genus, species, and status information for Lutrinae managed by author facilities (bold type).

Genus	Species	Common Name	IUCN Status	Managed by AZA, EAZA [^] , ARAZPA+
Aonyx(Amblonyx)	cinereus(cinerea)*	Asian small-clawed otter	Vulnerable	SSP,PMP1a+
Lutra (Hydriectis)	maculicollis	Spotted-necked otter	Least Concern	SSP
Pteronura	brasiliensis	Giant otter	Endangered	SSP, EEP [^]
Lontra(Lutra)	canadensis	North American river otter	Least Concern	PMP
<i>Lutra</i>	<i>lutra</i>	Eurasian otter	Near Threatened	EEP [^]
Aonyx	capensis	Cape clawless otter	Least Concern	AZA Not managed
<i>Lontra</i>	<i>longicaudis</i>	Neotropical otter	Data Deficient	Not managed*
<i>Lontra</i>	<i>felina</i>	Marine otter	Endangered	Not managed*
<i>Lontra</i>	<i>provocax</i>	Southern River otter	Endangered	Not managed*
<i>Lutrogale</i>	<i>perspicillata</i>	Smooth-coated otter	Vulnerable	Not managed*
<i>Lutra</i>	<i>sumatrana</i>	Hairy-nosed otter	Endangered	Not managed*
<i>Lutra</i>	<i>congicus</i>	Congo clawless otter	Least Concern	Not managed*
<i>Enhydra</i>	<i>lutris</i>	Sea otter	Endangered	Managed by other groups

[^] European Association of Zoos and Aquaria – European Endangered Species Program (EEP)

+ Australasian Regional Association of Zoological Parks and Aquaria

* Some recent resources are still using *Aonyx cinerea* (Wilson & Reeder 2005) however, the IUCN/SSC Otter Specialist Group and ITIS have switched to *Aonyx cinereus* based on input from Koepfli & Wayne (1998, 2003) and advise that the appropriate Latin gender declination is *cinereus* and not *cinerea*; we are using the OSG as our citing source (<http://www.otterspecialistgroup.org/>).

Introduction

Quality care of otters is a goal we all strive for. This manual should be viewed as a living document and in the future we hope to expand its coverage to all otter species held in wildlife facilities. The authors invite all professionals working with otters to contribute their expertise to this document; to do so please contact lontracat@live.com. Additional information on the care of otters is available in the following husbandry manuals:

- Asian Small-clawed Husbandry Manual (Lombardi et al. 1998); dusty.lombardi@columbuszoo.org
- International Giant Otter Studbook Husbandry and Management Information and Guidelines 2005, 2nd Edition (Sykes-Gatz 2005); sheilasykes@hotmail.com
- AZA Small Carnivore TAG 2009. Otter (Lutrinae) Care Manual. Association of Zoos and Aquariums, Silver Spring, MD. p.160.
- North American River Otter Notebook, 3rd Edition (Reed-Smith 2008). lontracat@live.com; <http://www.otterspecialistgroup.org/Library/TaskForces/OCT.html>
- The following documents also are available at: <http://www.otterspecialistgroup.org/Library/TaskForces/OCT.html>
 - o Summary of Husbandry Guidelines for African Spotted-necked Otters in Captivity (Benza et al. 2009) Otters In Captivity Task Force document
 - o Summary of Husbandry Guidelines for Asian small-clawed otters (Heap et al. 2009). Also available in Vietnamese. Otters in Captivity Task Force document
 - o Summary of Husbandry Guidelines for North American (aka Nearctic) River Otters (*Lontra canadensis*) in Captivity (Owens et al. 2009). Otters in Captivity Task Force document
 - o Basics of Otter Training (K. McKay) Otters in Captivity Task Force document
 - o Husbandry Guidelines: Eurasian Otter (*Lutra lutra*) (A. Melissen 2000)
 - o Minimum Husbandry Guidelines for Smooth-coated Otters in Captivity (Wright 2008)
 - o Minimum Husbandry Guidelines for Asian small-clawed Otter (Wright 2008)
 - o Additionally, there are several other very useful reprints.

Natural History/Description

Asian small-clawed otter (*Aonyx cinereus*) (Photo credit: Jennifer Brink, Zoo Atlanta) This is one of five otter species found in Asia. It is one of the smallest of the world's otters, rarely weighing more than 5kg. A gregarious species, it is often seen in large groups of up to 15 animals, and captive studies suggest that these groups are composed of an alpha breeding pair and their offspring from successive litters. Asian small-clawed otters have unusual hand-like front paws with increased tactile sensitivity and reduced webbing, which they use to forage for their prey of crustaceans, mollusks, and small fish.

Asian small-clawed otters are found from Palawan (Philippines) through Indonesia, Southeast Asia, southern China, and westwards throughout the Himalayan foothills of Bangladesh, Bhutan, and Nepal. A disjunctive population occurs in southern India (Foster-Turley et al. 1990). Listed on CITES as Appendix II (www.cites.org) and as Vulnerable by IUCN/SSC the population is considered to be decreasing.



African (Cape) clawless otter (*Aonyx capensis*):

The African clawless otter is one of four species of otters found in Africa. It is the third largest species of otter. Only the giant otter and sea otter are larger. Adults range in size from 1.15-1.5m (3.8-5ft), and weigh from 16-20kg (35.3-44.1lbs) (Foster-Turley et al. 1990). The African clawless otter has been reported as living in family groups including the male, female, and pups (Rowe-Rowe 1978), family groups consisting of the female and pups, or singly (Chanin 1985). The prevalent social grouping may vary with the habitat, which also likely influences the size and degree of overlap of home ranges. African clawless otters use their sensitive, non-webbed fingers to forage food, which consists primarily of fresh-water crabs, crayfish, and some fish. In some areas, this species is reported to occasionally raid near-by farms for young maize and cabbages (J.Reed-Smith, personal communication).



This species is distributed from Ethiopia in the east to Senegal in the west and south to South Africa, with a distributional gap in the rain forest area of the Congo basin, where the Congo clawless otter is found (Rowe-Rowe 1991). The African clawless otter is found in both fresh water streams and rivers, and along marine coastlines in South Africa.

Due to the infrequency of the holding and exhibition of the African clawless otter in captivity, many of the standards set for this species are extrapolated from those set by the N.A. river otter and Asian small-clawed otter husbandry manuals. Listed on CITES as Appendix II (www.cites.org).

North American river otter (*Lontra canadensis*) (Photo credit: Doug Kjos, friend of Roosevelt Park Zoo)

The North American river otter is one of the four new world river otter species. There are at least seven subspecies of *L. canadensis*. Adults range in size from 1-1.53m (3.3-5ft) and weigh from 4.5->16kg (9.9-35.2lbs) (Ben-David et al. 2001a,b; Reed-Smith 2001).

Although frequently solitary, except for female with pups, the North American river otter shows a great deal of social plasticity (particularly males), often forming groups of 8-15 or more animals in environments offering abundant resources (Blundell et al. 2002a,b). All male groups of up to 15 individuals have been maintained successfully in captivity (Ben-David et al. 2000). In the wild, males do not participate in pup rearing; in captivity males can be reintroduced to the family group once the pups are swimming well and in general interact and play with the pups. Both sexes occupy linear shaped home ranges due to their affinity for the land/water interface. Activity centers (e.g., latrines), located within home ranges, are important for both sexes. During a latrine activity study in Pennsylvania, Stevens & Serfass (2008) documented that visiting otters spent 72.7% of their time there smelling and investigating, 10.9% marking, 10.6% traveling, 4.6% rolling and rubbing, and <1% either sliding or autogrooming when visiting alone. When visiting as groups of two or more, they spent 43.6% of the time smelling and investigating, 30.7% wrestling, 7.4% traveling, 5.92% marking, 5.5% engaged in miscellaneous play behavior, 2.76% autogrooming, 2.3% sliding, 1.5% rolling and rubbing, and 0.3% allogrooming. They also found a seasonal difference in latrine visitation patterns with a visit peak occurring in spring (winter according to the Gregorian calendar) which corresponds to just before, and during breeding season (Stevens & Serfass 2008). The least number of latrine visits were recorded in summer which may reflect the tendency of females with pups defecating in the water which has been recorded in captivity.



N.A. river otters primarily feed on fish and crayfish.

This semi-aquatic species is found throughout the United States and Canada in a wide range of fresh water and marine ecosystems. Listed on CITES as Appendix II (www.cites.org).

Spotted-necked otter (*Lutra maculicollis*) Photo credit: Jenna Kocourek, Little Rock Zoo) This species was known as *Hydriactis maculicollis*. The spotted-necked otter is smaller than the often-sympatric African clawless otter. Their size ranges from roughly 4-6.5kg (8.8-14.3lbs) (Chanin 1985) to a maximum of ~9kg (19.8lbs) (Harris 1968), with a total length of 0.95-1.07m (3.1-3.5ft) (Chanin 1985). The spotted-necked otter has been reported to live in family groups, possibly groups of more than one family (Procter 1963), and single sex groups (IUCN 1992). During a recent study (Reed-Smith in prep.) male/female family groups were not observed. Instead the most frequent groupings observed were female(s) with young, all male groups, adolescent groups (sex undetermined), single animals, and breeding pairs. They generally forage for fish within 10m of the shore (Kruuk & Goudswaard 1990), but do forage further from shore (Kruuk & Goudswaard 1990; J.Reed-Smith, personal observation). The spotted-necked diet consists primarily of fish, supplemented at times by fresh-water crab and crayfish.



This species is found in all countries south of the Sahara, from Senegal to Ethiopia to the African Province of South Africa. It is absent only from desert areas as it lives primarily around the larger lakes (Foster-Turley 1990; IUCN 1992). Listed on CITES as Appendix II (www.cites.org) and as a species of Least Concern by IUCN/SSC (2009). However data is scarce and populations are known to be decreasing in portions of their range.

Adult males are known as “dogs” but typically referred to as males; females are typically referred to as females. Young otters are referred to as pups (North America), cubs (Europe, Asia, Latin America), and in some publications as kits. The words “spraint” or “scat” are used to refer to feces and “latrine, sprainting zone, or camp site” denotes areas where otters deposit scat and urine. Otters deposit secretions from their anal gland known as “jelly” or “slime”.

CHAPTER 1 Ambient Environment

Temperature and Humidity

Air temperature

All otter species should be provided with shelter from the sun and inclement weather. Indoor exhibits should offer an ambient temperature gradient within the exhibit providing the animals the opportunity to select for their comfort. Overheating can be a concern for all otter species.

A. cinereus: The ideal air temperature is between 22.2-24.4°C (72-76°F). If Asian small-clawed otter have access to radiant heat, or a heated indoor facility, they can handle temperatures down to 10-15°C (50°F). The recommended water temperature is between 18.3-29.4°C (65-85°F). It is recommended that warm water (29.4°C/85°F - Lombardi 2004) be provided for swimming, since these tropical animals will spend more time in the water if it is warm (Petrini 1998), and this may have beneficial health effects.

A. capensis and *L. canadensis*: These species can tolerate a wide temperature range as long as they are offered protection from the sun and inclement weather in outdoor exhibits. Indoor exhibits should offer a thermal gradient allowing animals the selection of a comfortable temperature (10-24°C or 50-75°F) (Reed-Smith 2004a). A temperature below 21-24°C (70-75°F) is recommended for indoor holding/night facilities (Wallach & Boever 1983). Animals should always be provided with shelter from the sun in outdoor exhibits.

L. maculicollis: This species has been housed successfully at floor temperatures ranging from 14.4-25.5°C (58-78°F) (Schollhamer 1987). Their temperature tolerance is likely to be similar to that of *A. cinereus* and *A. capensis*, however, at this time there is insufficient information and experience to make informed recommendations. Animals should be monitored for signs of overheating and hypothermia at temperatures above 25.5°C (78°F) and below 14.4°C (58°F), respectively.

Water temperature

More detailed research is required into optimal water temperature levels for the tropical otter species; however, experience indicates that warmer water may stimulate otters to spend more time actively engaged in the water:

A. cinereus: The water temperature for *A. cinereus* should be maintained between 18.3-29.4°C (65-85°F), preferably at the warmer end of this scale (Petrini 1998).

A. capensis, L. canadensis: The water temperature for *A. capensis* and *L. canadensis* does not appear to be critical.

L. maculicollis: Water temperature in successful *L. maculicollis* exhibits has ranged from 8.9-15.6°C (48-60°F). Temperatures in the 15.6-21.1°C (60-70°F) range may encourage this species to spend more time in the water, however, this has not been objectively demonstrated at this time.

Humidity

Since otters always should have water features available to them, humidity appears to only be a factor if it is excessive. Excessive humidity and an inability to adequately dry off create problems for all otter species, and these conditions should be avoided. The relative humidity of indoor exhibits should range between 30-70%. Nest boxes and den sites should be provided with good ventilation and placed in locations that are not chronically humid. Sufficient dry land and the provision of natural substrates as well as dry bedding material are very important to aid otters in proper coat maintenance, and allow for adequate drying of their pelts and feet. This is a point that will be stressed throughout this document.

Facilities that rely on climate control or mechanically run air systems should have emergency backup systems or plans in place. Maintenance of these systems should be documented and regular records maintained.

Light

If otters are held in holding areas for any length of time, some natural light is recommended. Fluorescent, metal halide and mercury vapor, as well as natural light have all been used in exhibit areas. Currently there is no hard data on the impact of light intensity on otter health or reproduction; this should be investigated in the future. However, it is strongly suspected that otters held indoors should be provided a seasonally appropriate light cycle to promote breeding and general animal health (Bateman et al. 2009). There are no available data on possible deleterious effects of less than full spectrum light on a long-term basis.

A. cinereus: If housed indoors, these species should be kept on a 12-hour light cycle (Wilson, Tropea & Calle, unpublished data).

L. canadensis, *A. capensis*, *L. maculicollis*: The light cycle for indoor exhibits/holding should be set to mimic the natural photoperiod for the species range of origin in Equatorial Africa, for *A. capensis* and *L. maculicollis*, or the local photoperiod for N.A institutions housing *L. canadensis* (Reed-Smith 2001, Bateman et al. 2009).

Water and Air Quality

Air changes

The number of air changes per hour of non-re-circulated air needed to control odors and maintain a healthy condition for the animals and public will vary according to the number of animals in the enclosure and the size/volume of the enclosure. The initial design should be for the maximum number of animals that could be housed in that particular enclosure. Standardized rates of change for various human-occupied enclosures suggest that pet shops require a rate of air exchange of non-recirculated air equal to 1 cubic foot of air/minute/ft² of floor space, in order to keep odors down to a level acceptable by the public (Anon. 1981). Pupping dens may well need higher rates of air exchange in order to maintain air quality and/or low humidity. It should be noted, however, that no work has been done specifically targeting air change rates for otter exhibits or dens.

As a general rule, indoor exhibits should have a negative air pressure of 5-8 air changes per hour of non-recirculated air. Glass barriers and separate ventilation systems between indoor exhibits and visitor areas (Moore 1997) will help reduce the potential of disease transmission from the public as well as complaints due to odor.

Water quality

See Appendix H for information on designing a life support system for otter exhibits, glossary of terms, and additional details on water treatment provided by J. Sabalones (2009), life-support systems advisor to the IUCN Otter Specialist Group's Otters in Captivity Task Force.

Otters are semi-aquatic mammals, using bodies of water for foraging, transportation corridors, mating (typically), cleaning, and "play-type" behavior. It is recommended to monitor nutrients and perform pool water changes as needed. There are no standards yet established for pools provided to semi-aquatic otters, however, it is suggested that coliform levels be maintained at 400 per ml water or lower, which is the standard set for seal rehabilitation pools. A level of 100 per ml is considered safe for humans. All chemical additives should be monitored daily and recorded.

It is recommended that filtration be used in closed otter pools. Sand filters, pool pumps, charcoal filters, and ozone pressure sand filters have all been used effectively. Ultraviolet sterilization has proven helpful in inhibiting algae build-up, particularly when combined with regular cleaning of pool-sides. Drain outlets, filters, and skimmers should be covered or designed to prevent furnishings from blocking them, or otters from becoming stuck in them. Daily use of long-handled skimmers will help remove floating debris and keep skimmers open and flowing. Natural flow-through systems also work well in otter exhibits, as long as the water is determined to be clean and free of heavy pollutants. In general, otters should be kept in fresh water systems; however, Ben-David et al. (2000, 2001a and b) successfully kept a group of 15 males in sea water that was changed daily. In this case, fresh water

was provided in tubs for the animals to bathe in. Regardless of water treatment method used, an additional source of fresh, potable drinking water should be available at all times.

Water quality should be maintained at a level sufficient to control bacterial counts and organic load, and to allow clear underwater visibility of animals for health inspections. Clarity and color maintained to provide a perceived color of clear and/or blue water is preferred by most facilities. This water clarity is an aesthetic requirement only, as long as the water quality is maintained, and the presence of floating algae or other material is not harmful to the otters.

Otters can be messy eaters and will track a lot of particulate debris into their pools. All food remains should be removed from pools daily to prevent consumption of spoiled items. The filtration system needs an effective means of skimming (from top to bottom) particulate matter. Turn over rate using rapid sand filtration is suggested to be once/hour; meaning that the total exhibit water volume should be turned over at least one time per hour when using rapid sand filtration. When using rapid sand filtration couple with Ozone; the turnover rate can be extended to once every 1.5 hours.

Ozone applied through a contact chamber in conjunction with a low dosage of chlorine is an effective treatment for freshwater systems. A large surface area biological filter bed should be incorporated if possible. This will allow a natural nutrient removal system to establish itself, which will provide system stability. It also will help reduce organic loading as well as reduce colonization of undesirable bacteria species. The tank effluent should be pre-filtered before it is sent to the sand filters and foam fractionators.

At least bi-weekly water quality tests are recommended for bacterial counts and daily tests of chemical additive levels. Records should be maintained and available for APHIS inspection (in the U.S.) and reference if problems arise. All appropriate regulatory agencies should be consulted in other countries.

Coliform bacteria: Coliform bacterial counts are used to monitor filtration system efficiency and keep track of potentially harmful bacteria. Coliform counts should be done at least every other week and more often if there are multiple animals using the pool (a policy regarding coliform testing should be set by the institution). Often a MPN (Most Probable Number) per 100ml is given as an acceptable limit. However, a more accurate measure is the total or fecal coliform count (NOAA 2006). There are no standards yet established for fresh-water otter pools. At this time, it is suggested that coliform levels be maintained at or lower than levels established for rescued pinnipeds by NOAA. These are:

- Total coliform counts should not exceed 500 per ml, or a MPN of 1000 coliform bacteria per 100ml water.
- Fecal coliform count should not exceed 400 per ml water.

If animal caretakers are routinely exposed to pool water, an institution may establish a higher standard of 100 per ml, which is the level considered safe for humans; this should be based on institutional policy.

Chlorine: Many municipalities add chlorine to their water, and readings from tap water of 1ppm or higher are possible. While otters generally show no adverse effects from these levels, it is not known what the overall impact is to their health and the water repellency of their coats. For this reason, the AZA Otter SSP recommends that otters should not be exposed to chlorine levels higher than 0.5ppm for prolonged periods, and ideally chlorine should be kept at a non-detectable level. The addition of sodium thiosulfate will neutralize any residual chlorine (see below and Appendix H).

Algae control: Algae control is a continuing problem in otter pools, particularly those exposed to significant sunlight. There are several techniques that have been used with varying success (see Appendix H).

- *Liquid copper sulfate:* Liquid copper sulfate can be added directly to the pool water without harm to the animals. While this does not get rid of algae, it will inhibit algal growth.
- *UV sterilization:* Ultra violet sterilization has proven helpful in inhibiting algae build-up, particularly when combined with regular cleaning of pool sides.

- *Chlorine*: Chlorine can be used, if necessary, when the otters are not present. In this case, sodium thiosulfate can be added and run through the system for an hour before the otters are allowed access again. A 5% concentration of sodium thiosulfate added has been successful. To obtain the amount needed for a particular system, multiply 0.53 by the volume of the pool in gallons; this provides the amount of sodium thiosulfate required in millimeters (C. Harshaw, personal communication).
- *Barley straw*: Hanging a bag of barley straw in the water stream assists in filtering out algae. This should be hung where the otters cannot get to it (e.g., at the top of a waterfall, etc.). Reports of its efficacy varies and may be dependent on design and location of pool.

All of these techniques should be accompanied with routine scrubbing of the pool sides to inhibit algae growth, and discussed with life-support professionals.

Drinking water

Clean drinking water should be available at all times. Drinking water should be provided in bowls small enough that the otters do not swim in them, or via lixits (a drinking fixture that an animal pushes/licks to release water) or similar devices. Animals should be introduced to the use of lixits (or other drinking fixtures) and monitored by staff until they are certain they are proficient in their use. (Lixit™, P.O. Box 2580, Napa, CA 94558 U.S.A. 011-800-358-8254)

Further research is needed into the impact, if any, of pH on otters. The deleterious effects of chlorine on otters specifically is anecdotal, e.g. stripping of water repellency; presumed, e.g. potential carcinogenic by-products of chlorine break-down; and, unknown, e.g. impact on overall health. While research is desirable it is not recommended on these wildlife species and instead caution should be exercised when using chlorine in otter pools.

Sound

While there is no evidence that low level background noise is disruptive to otters, loud noises can be frightening to them, and high-pitched, long-term noise should be avoided. Parturient females should not be subjected to loud or unusual noises; this is particularly true with primiparous females. Females about to give birth and with very young pups should not be subjected to close proximity of the public, loud or unfamiliar voices, construction noise, sudden loud noises such as sirens, unfamiliar ambient noises, or vibrations to which they are not already accustomed. All precautions should be taken to eliminate these during the last two weeks prior to birth (time margin is estimated based on difficulty of predicting parturition dates in these species) and during roughly the first month after parturition for primiparous females.

Otters' hearing is considered to be good but nothing is known definitively about their hearing acuity or frequency ranges heard. Both of these are areas needing further research.

CHAPTER 2. Physical Environment

Space and Complexity

Important factors to consider when creating successful otter exhibits include: exhibit land area size, design and complexity; pool size-design and complexity (including shoreline length and complexity); substrate materials and depths; water quality; climbing surfaces; digging areas; and denning sites (location and construction). See Appendix A for photos of enclosures.

Land/water ratio

Suggested optimal land/water ratios will change as an exhibit size increases or decreases. The ratios offered here are for the recommended minimum exhibit size. Smaller exhibits will require a higher land area proportion within the ratio. Larger exhibits may have a somewhat lower land to water ratio and still be successful.

L. canadensis, *L. maculicollis*, and *A. capensis*: The recommended land/water ratio for *L. canadensis*, *L. maculicollis*, and *A. capensis* is 3:1 to 4:1 (3:1 is the absolute minimum land area proportion and considered adequate only if the exhibit is large, vertically complex, and offers hard-surface features within the pool, such as logs, islands, etc.) (Duplaix-Hall 1975; Reed-Smith 2001 2004a).

A. cinereus: For *A. cinereus*, the recommended ratio is 5:1 or 6:1 (Duplaix-Hall 1975; Lombardi et al. 1998).

Exhibit complexity – terrestrial

Otters are land mammals that swim; they are semi-aquatic or amphibious, not aquatic animals. Behaviorally healthy otters kept in appropriate enclosure conditions spend more of their daytime hours on land than in the water. As instinctively avid diggers (*A. capensis* and *L. canadensis* in particular) and groomers (all species), otters dig and groom extensively in soft loose natural substrates. They groom when wet or dry by rubbing, scratching, and digging into soft loose dry substrates, often covering their body fur with the freed particles. (See photo-N.A. river otter, Jennifer Potter, Calgary Zoo) These behaviors are among the most favored and frequently performed terrestrial activities in captivity, and otters will use the entire expanse of their land area to carry them out. Together with foraging, exercising, and frequent play bouts on land, these terrestrial behaviors constitute a significant proportion of otters' natural, daily goal-oriented activities. These behaviors are considered essential to maintaining the otters' physical and behavioral health, as well as to the promotion of successful pup-rearing practices (Reed-Smith 2001). Additionally, the ability to carry out all of these behaviors is considered important for an otter's healthy adjustment to new or unusual situations.



It is strongly recommended that exhibits should be constructed of a variety of natural substrates to accommodate these activities. If artificial surfaces like concrete are used, these should be kept to a minimum. Digging pits and grooming areas with soft, loose substrates should always be included in otter exhibits. Adequate land area and substrates on which otters can groom are considered key to the captive care of otters. In order to maintain healthy thermal properties of their coats, otters have to frequently groom their fur, replacing the air layer trapped within the under-fur (Dunstone 1998, Weisel et al. 2005).

A variety of live plants can be used in exhibits, as well as log piles, large tree stumps or root systems, hollow logs, hills, etc., all of which can provide visual complexity to the exhibit and offer otters excellent foraging, playing, and shelter opportunities. All of these features can be placed to allow for visitor viewing. However, accommodation giving very shy animals the ability to hide should be made.

As with any species, otter exhibits should be "redecorated" periodically. However, it is advisable that preferred denning or hiding spots not all be changed simultaneously. All exhibits should be constructed with a means of accomplishing re-fitting of exhibit furniture, including the introduction of large deadfall. Self-dug dens, particularly those of *A. capensis*, *L. canadensis*, or *L. maculicollis* should be allowed to remain as long as they are deemed safe.

The minimum exhibit size (including land and water surface area) suggested for otters is as follows:

- *A. capensis* and *L. canadensis*: 150m² (1615ft²) for two animals. An extra 25m² (269ft²) of useable land surface and 10m² (108ft²) water surface should be provided for each additional animal (Duplaix-Hall 1975; Reed-Smith 2004a).
- *A. cinereus*: 60m² (646ft²) for 2-4 animals (Duplaix-Hall 1975); 93m² (1,000ft²) for more than 4 animals.
- *L. maculicollis*: 100m² (1076.5ft²) land and water surface for two animals. An extra 20m² (215.3ft²) of useable land and 5m² (54ft²) water surface should be provided for each additional animal.

Recommended minimums are based on the species natural history, observations of captive otters, and authors experience with otters in captivity.

Exhibit complexity – aquatic

The water portion of an otter exhibit should include areas of varying depths, and some portion of shoreline that allows for easy access to and from the shore for both old and young animals. Shorelines also should be complex and designed to allow for the periodic change of features (e.g., logs, rock piles, pebble pockets, etc.). Streambeds or shallow wading pools with rocky bottoms offer good enrichment and foraging opportunities, but can cause footpad abrasions if otters are forced to walk on them too often without access to natural substrates for drying their feet. To aid in minimizing the transference of debris into pool water, the shoreline can be constructed of raised flat/sloping rocks or logs positioned to hold natural substrates; Sykes-Gatz (2005) recommends a ~10cm (4-inch) curb. Furnishings should allow otters, especially pups, females carrying pups, and geriatric otters easy and safe ingress and egress to/from pools. Pools should be designed with several skimmers that can capture large particle debris before it reaches the filtration system. All pool openings such as skimmers, drains, filters, etc. to which the otters have access should be securely covered with sturdy wire fencing to prevent curious otters from getting their heads/feet stuck. Ample, extensive dry land areas should be provided to allow all otter species to dry off completely.

Exhibit pools should have varying depths, offering opportunities for animals to forage in the shallow water and swim/dive in deeper water. Shorelines should be complex and curving, as opposed to straight lines and uninterrupted. Additionally, the shore should be periodically interrupted with shade structures (e.g., bushes, trees, etc.), and climbing or laying-out structures, such as logs, boulders, log jams, etc. Otters should not be forced to swim continuously next to public viewing windows as this frequently leads to stereotypic activities such as flip-swimming, tail-sucking, and back-flips (J. Reed-Smith, unpublished data). Instead, exhibit pools should offer swimming alternatives that allow the animals to access deep and shallow areas that are not next to the public viewing areas. See Appendix H for additional information regarding designing and maintaining pools in otter enclosures.

Exhibit design and species-appropriate behaviors

In addition to a pool, all otter enclosures should be enhanced with a variety of furnishings. The quality of space for these animals is just as important as exhibit size. Logs, trees, tree roots, stumps, grasses, boulders, dens, caves, climbing structures, bushes, deadfall (positioned so animals cannot use them to climb out of the enclosure), waterfalls, floating log piles, rafts, islands, varied exhibit levels, and a variety of substrates are all important elements of a complex and successful otter exhibit (for all species). On-exhibit sleeping and hiding places should be provided; these sites should be of varying sizes to allow the group to sleep together or to allow for individual seclusion. Animals should be allowed to dig, roll, climb, and slide within their exhibit. Enclosure designers should take all of these activities into consideration when designing the land/water interface, public viewing, substrates, and pool filtration systems. Pools should be designed so that the animals are not always forced to swim in close proximity to the public. Public viewing should be provided from various angles while maintaining one side without

public access as a secure zone for the animals. Sykes-Gatz (2005) and Hancocks (1980) are two of the many resources available with information on naturalizing older exhibits.

All pool shorelines should be provided with lounging logs, shaded rest areas, and sandy banks to be used as latrine sites. Large flat/sloping rocks and logs can be used along the shoreline to hold back the substrate as well as provide good sunning areas.

A variety of substrates should be incorporated into otter exhibits. These substrates include: grass, mulch, sand, clay, soil, rocks, boulders, pebbles, leaves, bark, concrete, and gunite (the latter two are not recommended and should be limited to small areas, or should be covered with soft pebble-free sand or tree bark mulch when their use is unavoidable). Exhibits with artificial substrates should offer areas of grass, dirt, sand, pebbles, etc. for exploration and adequate grooming. Hard-pack soils, abrasive sands, and sharp rocks should not be used in otter exhibits. Recent research into the structure of sea otter (*E. lutris*) and river otter (*L. canadensis*) hair structure shows guard hairs can suffer damage (Weisel et al. 2005). While unclear at this time, it is possible that extensive damage to guard hairs can impact the insulative ability of the otter's coat. Problems with chronically wet surface areas or overexposure to hard surfaces should be addressed immediately to prevent injuries to the animals (e.g., foot pad abrasions) or health issues (e.g., fungal infections) from developing.

All exhibits should offer bedding material; products used successfully include: grasses, leaves, hay, straw, wood wool, sedges, pine needles, towels, burlap bags, indoor/outdoor carpeting, natural fiber mats, and wood shavings (Reed-Smith 2001). Some facilities have successfully used fleece and blankets (Ben-David et al. 2000, 2001a,b; J. Reed-Smith, personal experience). However, as with all bedding, these should be monitored to ensure the otters are not chewing on, or eating them. If animals are chewing on these items, they should be removed immediately. Some wood shavings (from conifers) contain residues that can strip the water proofing from the coat of semi-aquatic species, and/or may cause sneezing. Cedar contains aromatic phenols that are irritating to the skin and respiratory system. Several studies indicated that close, chronic contact with cedar shavings contributed to infant mortality (Burkhart & Robinson 1978), respiratory disease (Ayars et al. 1989), and liver damage (Vesell 1967) in rodents. The impact of these products on otters is unknown; if used, caution should be exercised.

Some facilities use paper products such as shredded paper, cardboard boxes, paper bags, and cardboard rolls. These products should be monitored carefully to ensure the animals are not ingesting them or taking them in the water where they could become plastered over an animal's mouth and nose, or become impacted in their teeth. In most cases using these products with otters is not advised.

Indoor/outdoor carpeting and natural fiber mats also have been used for the animals to roll and groom themselves on in concrete holding areas. All materials used for bedding should be monitored in case an animal consumes them excessively, or in the case of towels, etc., shreds or eats them. 'Wood wool' sticks to fish or other moist foods, and so should not be used near feeding areas to prevent its ingestion. When it is used in nest boxes, caution should be exercised if any females become pregnant as pups can become entangled in it.

L. canadensis: Typically *L. canadensis* shed their under-fur between May and August (This "...under-fur produces a dense, matted, felt-like layer, which forms an efficient insulating layer by trapping air next to the skin..."[Dunstone 1998]), and replace their guard hair between August and November (northern latitudes, there may be some variation in timing at southern latitudes) (Ben-David et al. 2000; J.Reed-Smith, personal observation). Animals' health requires ample grooming opportunities and surfaces on which they can rub to prevent matting, and aid in this annual coat replacement process. Grooming and drying opportunities also are important for the maintenance of healthy foot condition, with damp or excessively humid conditions leading to footpad abrasions.

Sensory barriers

Visual barriers are important to allow animals to avoid one another, when necessary. All individuals, particularly paired otters, will go through times when they exhibit a tendency to stay by themselves. Vegetation, exhibit topography, denning sites, and deadfall should be strategically placed to allow for this. While there is no evidence that low level background noise is disruptive to otters, loud noises can be frightening to them, and high-pitched, long-term noise should be avoided.

Otters can be odiferous; facilities with indoor exhibits may want to provide olfactory barriers for the comfort of the viewing public. If exhibiting more than one breeding otter group, or permanently separating animals from a group and housing them within the same institution, it may be very important to have visual,

olfactory, and audio separation to avoid intra-specific aggression or abnormally elevated levels of stress and/or frustration. In these cases, it is advisable to plan for this in advance rather than trying to accommodate it if a problem arises.

L. canadensis: Parturient females generally become very aggressive towards the male several days before giving birth and while the pups are quite young. Pairs housed in large naturalistic exhibits can be maintained together if sufficient visual barriers are provided to allow the male to remain out of the female's line of sight. In all other cases, it is important that the pair is separated. The pair can be left at the exhibit if one animal is held in the holding dens/off-exhibit area while the other is on exhibit. In these instances, the animals should not have to pass in view of one another to shift into alternate areas for cleaning or feeding.

Enclosure cleaning

Otters are scent-oriented animals; therefore, their entire exhibit or holding area should not be cleaned at the same time. Enclosures should be raked and spot cleaned daily, with appropriate disinfecting as necessary. Indoor or hard surface floors should be cleaned with detergent daily. Due to their natural scent marking behavior, exhibit furniture should not be cleaned as frequently. It may actually be stressful to some otters if their territory is totally cleared of their markings. All detergents should be thoroughly rinsed, as any residue left on the floor, mats, or furnishings can strip their coats of its natural oils (Schollhamer 1987).

Food and water containers should be cleaned and disinfected daily. All food remains should be removed before it can become spoiled; in some climates this may require removal more than once a day. A safe and effective control program for insects, ectoparasites, and bird and mammal pests also should be maintained.

A holding area connected to the exhibit is recommended; ideally this should include a pool with clean water available at all times, proper lighting, appropriate lighting cycle, a sleeping or den box, enough floor space for grooming and drying areas, an outdoor play area (if extended stays are routine), and at least one nest box that is heavily bedded to allow excess moisture to be removed from the animals' coats (Lombardi et al. 1998; Reed-Smith 2001). Each holding den should be large enough to at a minimum allow the animal to turn around (when used only for holding during cleaning) but at least 122cm (4 ft.) by 122cm (4 ft.) if an otter is to be held over-night. Best practices would include larger night dens than this minimum. Holding pens should have non-climbable sides, access one to another (allowing animals to have more room during extended stays), and multiple ingress and egress to the exhibit. Maternity dens should be isolated so exhibit mates do not have to pass in front of this den to enter or exit the exhibit. If chain-link barriers are present, the sides should be covered with lexan or similar material to prevent animals from climbing too high and falling.

Quarantine facilities should offer the maximum space available. They should be furnished with natural items to include logs, stumps, and outdoor carpeting that can be periodically disinfected/changed as well as sand/mulch/straw/soil boxes that can be changed when they become soiled or saturated.

Safety and Containment

Otters can climb (see Appendix A for photo), and will take advantage of anything provided. Trees, bushes, etc., should be placed away from exhibit perimeters. Walls should be non-climbable, and fences should be strong and inhibit climbing. The containment walls/fence should be at least 1.52m (5ft) high for *A. cinereus* and at least 1.83m (6ft) high for *L. canadensis*, *L. maculicollis*, and *A. capensis*. While these heights should contain most otters, Ben-David (personal communication) reported a *L. canadensis* scaling a 3m (9.8ft) fence. Animals that are known to be climbers may require additional containment height or features. It has been shown that *Lutra lutra* can clear 1.3m (4.27ft) when leaping from the ground to a platform, 1.6m (5.25ft) when jumping from one platform to another, and 0.92m (3ft) when jumping from the water onto a platform, if they are able to push off from the pool bottom (Reuther 1991). If containment barriers are mesh, they should be topped with an un-climbable, inward-facing overhang of 80cm (2.7ft) (Duplaix-Hall 1975; Foster-Turley 1990). Hot wire can be used, but should not be accessible to an animal in the water, and should be placed at a height that will not cause injury to an animal if they fall as a result of touching the wire.

Otters also dig proficiently (particularly *A. capensis* and *L. canadensis*). When designing exhibits, perimeter walls and fences should be buried or mesh linked. Sinking perimeter fences/walls at least 80cm (2.6ft) is

advisable for most species. Holes along perimeter containment should be promptly refilled. To provide additional safety, secondary containment areas should be constructed at all enclosure entrances.

CHAPTER 3: Transport

Preparations

The transport of wild animals is regulated by the International Air Transport Association (IATA). The standards of care provided within this chapter are based on IATA regulations (e.g., IATA 2007), best practice recommendations from the AZA Otter SSP, and professional experience. All otter transports should be well thought out and planned in advance. When possible experienced personnel should accompany the animal; at a minimum contingency plans should be put in place in case travel delays are encountered. Otters are highly susceptible to over-heating; shipments are not recommended during extremely warm seasons.

Pre-shipment exams

All otters should receive a thorough pre-shipment physical examination (for more information see Chapter 6). Ideally, a copy of the pre-shipment physical exam findings and laboratory work should be sent to the veterinarian at the receiving institution before the animal is transferred. If an otter has a current medical condition requiring ongoing treatment, the case should be discussed between the veterinarians at the shipping and receiving institutions before the animal is moved. All animal shipments should be accompanied by a hard copy of the medical record, as well as a health certificate and the USDA acquisition, disposition, or transport form (APHIS form #7020) as well as any other paperwork required by IATA, carrier, or regulatory agency. Institutions using MedARKS should provide the receiving institution with electronic copies of the medical records. Dietary, enrichment, and training records should be sent prior to shipping the animal

Crate requirements

All possible relevant regulatory agencies always should be checked for shipping, health, and permit requirements before transporting animals (USFW, state regulations, CITES, etc.). The International Air Transport Association (IATA) publishes specific guidelines for transport containers used for animal shipments. These guidelines are available from the Publication Assistant, IATA, 2000 Peel Street, Montreal, Quebec, Canada, H3A 2R4 (Ott Joslin & Collins 1999). An alternate address for IATA is International Air Transport Association, 800 Place Victoria, P.O. Box 113, Montreal, Quebec, Canada, H4Z 1M1. The Live Animals Regulations document is available in print or CD ROM format, and can be ordered from sales@iata.org. IATA regulations change periodically, and so the most recent publication or website should be consulted. It is very important to adhere closely to these requirements as airlines may refuse to fly animals in containers that do not conform to the guidelines. In general, IATA regulations require the following:

All shipping crates must allow for adequate ventilation. Ventilation apertures should be small enough to prevent the escape of the animal and small enough that the animal cannot get any part of its body through the opening.

Generally, a Vari Kennel[®] may be used for *A. capensis*, *A. cinereus*, *L. canadensis*, and *L. maculicollis*, with the following modifications. The grill door must be covered with securely fixed weld mesh and all ventilation openings covered with wire mesh. The door must have secure fasteners at the top and the bottom. A curtain that can be raised and lowered and does not block ventilation should be fixed over the door to reduce light inside the container. A dropping tray must be fixed to the floor and filled with absorbent material. There must be ventilation openings on the rear of the container; extra ventilation openings may have to be added in order that the total ventilation area is at least 20% of the four sides. The container must be correctly labeled. If the container has wheels, they must be removed or rendered inoperable. Airlines also may require a wire mesh cage be fitted to the inside of the Vari Kennel[®].

Shipping crate doors should be secured with additional fasteners; *A. cinereus* has been known to pull doors inwards when they could not push them out and escape from containers that were not fastened securely. This proviso applies to all otter species.

Otters should be transported separately. *A. cinereus* have been transported successfully in groups when the animals are less than six months of age. Crates should be large enough to allow the animal to stand up and turn around.

Transportation Protocols

Transport protocols should be well defined and clear to all animal care staff.

Food and water

IATA requires that the crate allows for feeding and watering of the animal if needed. The food and water ports should be clearly marked on the outside of the crate. In case of delay on long flights, provisions should be made for feeding in transit (this may necessitate shipping food with the animal).

Otters do not normally require additional food and water during transport for periods up to 24 hours. If unforeseen delays occur, canned dog food or cat food may be offered. Adequate moisture is present in these foods to take care of water needs during short periods. A metal bowl may be attached to the corner of the crate; this should be accessible from the outside. Always check for any specific IATA or shipping carrier regulations or requirements.

Bedding and substrate

Bedding such as straw or shavings should be placed in the transport container for the animal's comfort and absorption of feces and urine. Types of bedding material allowed should be checked with the airline. In order to separate urine and feces from the animal, IATA requires a drop tray be fixed to the floor of the crate and filled with absorbent material.

Temperature

Temperatures of 7.2-26.7°C (45-80°F) that are permitted by the airlines for transport are not appropriate at the high end for otter species. Otters should not be exposed to 21.1°C (70°F) temperatures for periods longer than 15 minutes when contained in a shipping crate. These animals can easily overheat at elevated temperatures (21.1°C or 70°F and higher), especially when stressed and/or contained in a shipping crate. While this is a more restrictive temperature range than previously recommended, past experience has shown that otters quickly overheat and succumb to hyperthermia. Animals in unheated vehicles should not be exposed to temperatures less than 7.2°C (45°F).

A. cinereus: *A. cinereus* should not be exposed to drafty 7.2°C (45°F) temperatures for extended periods. This also may be true for *L. maculicollis*, but it is not known at this time and requires further research.

L. canadensis: *L. canadensis* exhibit a low heat tolerance, and should not be shipped when temperatures are forecasted to exceed 21.1°C (70°F) at transfer locations.

Light and sound

As far as possible, noise should be kept to a minimum (including sudden loud noises, constant high-pitch noises, or anything considered uncomfortable to people), and the animal kept in low light conditions. Mesh doors or side windows (i.e., as in air kennels) should be covered with a breathable, opaque material to allow for ventilation and privacy for the animal (Ott Joslin & Collins 1999). These basic noise reduction precautions will help reduce stress from sudden, frightening sounds, and low light will provide a minimal sense of security for species that hide in small, dark spaces (e.g., dens) when frightened.

Animal monitoring

Otters should not be maintained in shipping containers for longer than 24 hours without food and water. Directions on what should be done in the case of an emergency that necessitates animal treatment should accompany all animal shipments. If access to an animal is required due to illness or extended shipment delays, the shipping/receiving institutions should be notified, and the crate should be transferred to the nearest zoo or veterinary clinic prepared to handle the animal.

Emergencies

In case of emergencies contact information for the shipping and recipient zoos should be included on the paper work and the crate. If an otter escapes the animals should be closed into a confined space (if possible) and

both institutions notified as quickly as possible. At a minimum visual contact, from a distance, should be maintained until one or both institutions have been contacted and professional arrived.

Post-transport release

Upon arrival at their destination, shipping crates should be placed inside the quarantine holding pen, the door opened, and the animal left to exit at will. All holding pens should be provided with food, water, alternate hiding places, appropriate bedding, and enrichment structures.

CHAPTER 5: Social Environment

Group Structure and Size

Careful consideration should be given to ensure that animal group structures and sizes meet the social, physical, and psychological well-being of those animals and facilitate species-appropriate behaviors.

A. cinereus: In captivity, Asian small-clawed otters are monogamous, with both members of the pair helping to raise the offspring. Unlike *L. canadensis*, the otter parents and offspring should be housed together. Older siblings help raise the younger ones, and a family group or breeding pair can produce two litters a year, with up to seven pups in each litter. Similar sized groups are sometimes found in the wild (Foster-Turley 1990). It is recommended that these otters be held in adult pairs, adult pairs with offspring, or single sex groups. The size of the group will depend on the size of the exhibit and the compatibility of the individual animals (Lombardi et al. 1998). The formation of single sex groups should be accomplished at a very young age to avoid aggression.

A. capensis: *A. capensis* have been observed in multiple social situations. In fresh water inland systems, the male stays with the female and offspring (Rowe-Rowe 1978). Clans up to 10-15 individuals have been observed. In marine ecosystems, it has been noted that the male does not stay with the family group (Estes 1989). Females with pups are the typical family group (Chanin 1985), but this species is often seen alone (Chanin 1985). In captivity, pairs have been separated during parturition and early pup rearing. This species has been held in pairs and in groups of 1.2 in captivity (Reed-Smith & Polechla 2002).

L. canadensis: *L. canadensis* are believed to be more social than most other mustelids (but not as social as some of the other otters), based on the findings of a number of researchers (Beckel 1982; Rock et al. 1994; Testa et al. 1994; Johnson & Berkley 1999; Blundell et al. 2002a,b; Gorman et al. 2006, M. Ben-David, personal communication; S. Shannon, personal communication). For example, Stevens & Serfass (2008) documented that out of 172 film documentations of otters using latrines, 59.3% were by single otters, 19.2% were by two otters, 17.4% were by three otters, and 4.1% were by four otters.

A variety of social groupings have been documented, but, in general, the following are most typical: female with offspring; lone male; group of males; lone female; group of males with sub-adult females; pair (during mating season only); or two females with offspring. Male groups have been reported by Blundell et al. (2002a, 2002b, 2004) and Hansen (2004); female groups were recorded by Gorman et al. (2006)

Otter associations may vary with the habitat in which the animals are found. Blundell et al. (2002a, and b) found otters living in areas rich in resources seem to show more of a tendency to socialize, particularly the males and sub-adult females. Discounting female and pup associations, the Blundell et al. (2002a, and b) telemetry study found that females were asocial in 47% of their locations, while males were asocial during only 24% of their locations. Further, they determined that among the “social” otters, males were social in 46% of their locations and 63% of that time was spent in all male groupings. “Social” females were located in social groupings only 26% of the time, and 78% of that time they were located in mixed-sex groupings (Blundell et al. 2002a and b).

Gorman et al. (2006) found in Minnesota that annual home ranges for males were 3.2 times greater than for females and annual core areas for males were 2.9 times greater than for females. Core areas frequently overlapped with interactions between overlapping resident females and males most common (51.7%) while male-male (27.6%) and female-female (20.7%) interactions were slightly less frequent. Female core areas overlapped those of other females 22.2% of the time and males 15.8% of the time; male core areas overlapped with those of other males, on average, 15.7% of the time. They concluded that river otters living in the upper Mississippi watershed, “exhibited clear evidence of space sharing, suggesting that individuals in this population were neither solitary nor territorial...[otters] appeared to socialize to some degree with any individual for which they had an encounter opportunity.”

Zoos and aquaria would qualify as “habitats rich in resources”, thus providing the opportunity to keep more social groupings of this species, as found in some portions of their range. Ben-David et al. (2000, 2001a, and b) maintained 15 unrelated males in one enclosure for 10 months with little to no problem.

There are no minimum or optimum group sizes for this species. To the contrary, this species’ behavioral plasticity allows the formation of social groups not normally associated with a typically solitary species. Preferred groupings include: multiple males, a male-female pair, one male and multiple females (1.2), multiple pairs (2.2).

The only social grouping not recommended is all female, unless they are related, or introduced at a very young age, and have been together continuously (Reed-Smith 2001). This does not mean it is impossible to introduce adult females, or house unrelated females together, just that it is very difficult and frequently unsuccessful (Reed-Smith 2001, 2004b). See Introductions/Reintroductions and Appendix I for additional information. There are some indications that pairs raised together do not breed well; in situations where breeding is desired one of these young pairs may need to be switched with an unfamiliar animal.

Multiple pair groupings should be monitored closely for signs of stress in subordinate animals. Multiple male, one female groupings are not recommended, but can be maintained if monitored closely, or separated during breeding season to prevent the males from fighting over the female, or causing harm to the female with overly attentive advances (Reed-Smith 2001).

L. maculicollis: This species is best housed as pairs or family groups. All male groups also may be a good option but not enough is known yet to determine how this natural social pattern works in a confined setting. While several field researchers have reported seeing large groups (10-20 individuals) of *L. maculicollis* (Proctor 1963; Kruuk & Moorhouse 1990; Kruuk 1995, J. Reed-Smith in prep), it is not known what role, if any, older siblings play in caring for younger pups, or how often family groups join. Proctor (1963) reported observing groups of about five otters most frequently, a size believed to be consistent with a single family. Ongoing studies in Lake Victoria cite frequent observation of groups of 6-8 animals, at times constituted of animals of varying sizes (J.Reed-Smith, personal observation).

It is considered unwise to introduce adult males, and difficult to introduce adult females. In the latter case, some females show a marked preference for certain females over others. Compatible groups of females may show aggression towards one another at times, particularly if a female is in estrus (Scollhamer 1987). In one instance, older pups have been maintained in an exhibit with the adult pair and younger pups (R.Willison, personal communication); the female kept the older pup and adult male at bay as parturition neared. However, there have been reports of adult females ostracizing female offspring requiring the young female to be moved (Benza et al. 2009). Reports from the wild that this species typically live as pairs, with both parents participating in pup rearing have come under some doubt (Reed-Smith in prep). This has not been the case in captivity, at least during the early phase of pup rearing; instead the female raises the pups alone until they are active and swimming at which time the male is again allowed into the group (R.Willison, personal communication). Recent field studies in Lake Victoria, Tanzania (Reed-Smith in prep) recorded single animals, mother with young, two or more adult females with young, male groups/pairs, and adolescent groups as the social configurations sighted.

Optimal group size will vary with the size of the exhibit and compatibility of individuals involved, as with all otter species.

Single-sexed groups

The following recommendations are provided for the formation and maintenance of single-sexed otter groups:

A. cinereus: All male (and all female) groups are not seen in the wild, but are found in captivity. Groups should be formed as early, and at as young an age as possible, and extra care should be given at feeding time. Extra dens should be provided so that every animal has its own area to be apart from the others (Lombardi et al. 1998).

While it is possible to keep single sex sibling groups, it is not a preferred grouping, and should be attempted only at the recommendation of zoo organization management groups. Generally, the group structure begins to break down beginning at sexual maturity, leading to increasing aggression toward subordinate animals. Typically, all male groups have been more successful than female groups, and hinge on introduction of non-sibling animals at a very young age.

In one case, six females housed together all of their lives began fighting at the ages of 3-5 years, when the dominant female began harassing the most submissive animal. This behavior was not apparently associated with estrus, and reduction of the aggression was originally handled through training (the animals had been conditioned to separate into two groups and station singly for brief periods) and positive reinforcement (e.g., the aggressive and subordinate animals were reinforced for looking calmly at one another – this was not successful). However, with time, the aggressive behavior focused on expelling the subordinate female spread throughout the group, and

previously friendly otters began to have problems as well. The situation eventually resulted in the need to permanently separate the dominant and subordinate animals, at first rotating them in with different group members, and then sending them out to different institutions (S.Duncan, personal communication).

A. capensis: Information on the success of single-sexed groups is unknown at this time, and further research is required.

L. canadensis: All male groups do very well together, and have been repeatedly documented in the wild, particularly in resource rich environments (Blundell et al. 2002a and b; G.Blundell, personal communication; S.Shannon, personal communication, Gorman et al. 2006). Fifteen unrelated adult males were successfully housed together for 10 months at the Alaska Sea Life Center (Ben-David et al. 2000, 2001a,b), and five males have been successfully housed together at the Virginia Aquarium (C.Harshaw, personal communication). All male groupings are suggested for non-breeding situations.

Sub-adult females (older than one year but less than two years of age, or prior to first estrus) and females without pups (this occurs less often) have been known to associate with all male groups (Blundell et al. 2004). All female groups generally do not do well, however have been reported in the wild by Forman et al. (2006). In captivity, sisters, or females introduced at an early age may be compatible for years. However, if one animal has to be separated, sisters, they may not re-establish this social equilibrium upon reintroduction (Reed-Smith 2001, see Appendix I for introduction/reintroduction protocol). In one other field study, an all female clan was identified, (S.Shannon, personal communication). All female groupings are not generally recommended.

L. maculicollis: Adult males introduced before the age of four months have been kept together successfully, as long as they are not exposed to the scent or sight of estrus females (Schollhamer 1987).

Adult females can be housed together, but their introduction may be difficult. Some females show a marked preference for certain females and a dislike of others. Females that have been previously housed together can be reintroduced after giving birth, once their pups are eating solid food at about three months of age (Schollhamer 1987). Aggression has been shown towards younger females but documented only in mixed-sex situations (Benza et al. 2009). Further research is required to determine the most compatible social groupings for this species.

Influence of Other Species and Conspecifics

Compatible otters typically do not require specific inter-individual distances. All animals should be provided with denning choices, allowing them the opportunity to sleep together or separately. Breeding pairs of *A. capensis*, *L. canadensis*, and *L. maculicollis* will require separation during the early stages of pup rearing, or an exhibit environment that allows for physical and visual separation of the male and female.

While it is not recommended to house Asian small-clawed otter groups within visual or auditory range of each other (Lombardi et al. 1998), different groups of spotted-necked otter (R.Willison, personal communication), Eurasian otter (cited in Reed-Smith 2004b), and North American otters (Reed-Smith 2004b) have been successfully housed within auditory and visual range of one another. Care always should be taken that these groups are not experiencing undue stress; all animals should be monitored for any signs of stress or agitation. When animals are separated from a group for any reason (all species) care must be taken when reintroducing them; at times all of the steps of an initial introduction should be followed (see 4.3 Introductions and Reintroductions). Some of these reintroductions, particularly with females, may not be successful so prolonged separation, particularly of Asian small-clawed otters should be avoided except in cases of medical treatment, aggression, or parturition (this last condition, separation at parturition is not applicable to Asian small-clawed).

A. cinereus: If a group of Asian small-clawed otters have to be split for some reason (e.g., aggression between two individuals), experience has shown that the non-aggressing animals should be rotated between the two groups to prevent aggression between additional animals. In these cases, the social bond between highly compatible animals appeared to break down if the animals were left separated from any particular individuals for more than about two weeks. These temporary groups were rotated between off-exhibit holding and the exhibit on

a daily basis, allowing all animals time in each location, but essentially keeping the problem animals separated visually and physically (S.Duncan, personal communication).

Mixed-species exhibits

All individuals housed in mixed-species exhibits should be routinely monitored for stress, injuries, and to ensure they are getting adequate food and water. Typically, otters are exhibited with species that focus behaviorally on other exhibit features than those used by the otters (e.g., arboreal species). Animals within mixed exhibits should be monitored for stress, and management plans should be made to accommodate older animals, special nutritional needs, impending births, etc.

A. cinereus: This species has been exhibited successfully with barbirusa, binturong, black hornbills, butterflies, peafowl, gibbons, giant hornbill, muntjac, Prevost squirrels, proboscis monkeys, slender-nose crocodiles, giant Asian squirrels, and Rodriguez fruit bats. Water monitors were tried, but were not successful.

A. capensis: Guenons were housed with *A. capensis* unsuccessfully at one facility; another facility housed them successfully with DeBrazza guenon, with occasional interspecific aggression (R.Willison, personal communication).

L. canadensis: *L. canadensis* have been successfully exhibited with beaver. There are unsubstantiated reports of exhibiting them with deer, fox, and possibly porcupine in large naturalistic exhibits, but these have not been confirmed. Any attempt at mixed species exhibits with the North American river otter should take into account their natural inquisitiveness, their semi-aquatic nature, their inclination to climb and dig, and their carnivorous diet.

L. maculicollis: Spotted-necked otters were housed successfully for an extended period with Schmidt's spot-nosed guenon, Allen's swamp monkey, and François langur. While food was placed in species appropriate locations, the otters did eat some of the monkeys' food. There were some reports of intermittent interspecific aggression, generally initiated by the otters in these groupings. An unusual aggressive event by a young otter in one of these mixed-exhibits led to the death of a newborn monkey and several days later the death of the aggressing otter. In this case, the exhibit was re-evaluated and discontinued. It should be noted that the otters and monkeys had been exhibited together for several years, but the unexpected birth of the guenon infant altered an un-easy truce established between the otters and monkeys.

Introductions and Reintroductions

Introductions may take anywhere from a few hours to weeks, or months in some cases. There are some introductions that will never be successful. In general, these documented, unsuccessful cases involved multiple female *L. canadensis* and *L. maculicollis*, male-male introductions in otter species other than *L. canadensis*, and some *L. canadensis* male-female pairings. Introduction of same sex pairings, particularly females, may be difficult for all species. Introductions of these types, as with all introductions, should be closely monitored for signs of stress or aggression.

Otters are very social animals; introductions should be carried out in the standard way, beginning with auditory and olfactory introductions, and then moving onto visual and limited tactile contact. Once affiliative behavior is observed (e.g., chuckling, rubbing, grunting, "friendly" pawing, and rolling – for additional behavior descriptions see Rostain 2000; Reed-Smith 2001; Rostain et al. 2004), physical introduction can be attempted, preferably in neutral territory. New animals should be allowed to familiarize themselves with their new holding and exhibit prior to any physical introductions to other otters/future exhibit-mates. Introducing adult females to other adult females is difficult, and is generally not recommended for any of the otter species (see Appendix I for suggested protocol if female/female introductions are tried). Groups of females that are compatible may exhibit aggression towards one another during estrus, or be impossible to reintroduce after even a short separation (*L. canadensis* in particular). In cases of aggression during estrus, the females should be separated (Schollhamer 1987; J.Reed-Smith, unpublished data).

Auditory, visual, and olfactory introduction should be successfully completed before attempting physical introduction. Successful introductions have been reported as early as one day and have taken as long as several months or more. Training animals to station may be beneficial when attempting introductions, but there is limited data on its use with otters.

L. canadensis: Some introductions will never be successful with *L. canadensis*, particularly adult female to adult female introductions (Reed-Smith 2001), and some adult female to sexually immature male introductions. In general, the latter introductions should not be attempted while the female is in estrus; it is possible that immature males may be regarded as “female” by adult females leading to aggression on her part. Unsuccessful introductions never progress beyond the screaming, lunging, or fighting stage, or result in stressful stand-offs where the animals stay away from one another, scream if the other approaches, and may refuse to go on exhibit if the other animal is there. Introductions of breeding pairs should be handled as any other, but may move more quickly particularly during estrus. Introductions of all other *L. canadensis* pairings/groups should be conducted as indicated above.

Hand-reared *L. canadensis* may require some time to transfer their focus from humans to otters. The easiest way to accomplish this is to have their primary caregiver perform the introductions and stay with the animal (free contact situations), or on the other side of the caging (protected contact situations), for the initial introductions. Once the hand-reared animal is comfortable with the other otter, their attention often transfers immediately to that animal and away from the human caregiver. Hand-reared otters should be introduced to other otters as soon after weaning as possible. It is also recommended to raise more than one pup together, if possible (Reed-Smith 2004b). Fostering of pups to another nursing female was successful the one time tried (Columbus Zoo and Beardsley Zoo).

L. maculicollis: For male-female introductions - estrus female spotted-necked otters that have previously been with a male are easily introduced again to the same male, or to a different, experienced male. When introducing a sexually mature but inexperienced male and female, less aggression occurs if the pair is introduced when the female is not in estrus (Schollhamer 1987).

CHAPTER 5: Nutrition

Nutritional Requirements

The target nutritional values for otters are based on several sources. The cat is typically used to establish nutrient guidelines for carnivorous animals. The National Research Council (NRC) (1986, 2006), Association of American Feed Control Officials (AAFCO) (1994), and Waltham Center for Pet Nutrition (Earle & Smith 1993) have provided recommendations for cats. A limited amount of information is provided by the NRC publication for mink and foxes (1982), which represents the requirements of another mustelid species. The target nutrient values presented by (Maslanka & Crissey 1998) are a range of values reported from various references. As new information becomes available, these ranges will change to reflect knowledge gained. Table 1 lists dietary nutrient ranges for otters.

Table 1: Target dietary nutrient ranges for otters (dry matter basis).

Item	Target nutrient range*
Energy, kcal/g	3.6-4.0
Crude Protein, %	24-32.5
Fat, %	15-30**
Vitamin A, IU/g	3.3-10***
Vitamin D, IU/g	0.5-1.0
Vitamin E, mg/kg	30-120 ^a
Thiamin, mg/kg	1-5 ^a
Riboflavin, mg/kg	3.7-4.0
Pantothenic Acid, mg/kg	5-7.4
Niacin mg/kg	9.6-40
Pyridoxine, mg/kg	1.8-4.0
Folic acid, mg/kg	0.2-1.3
Biotin, mg/kg	0.07-0.08
Vitamin B-12, mg/kg	0.02-0.025
Choline, mg/kg	1000-3000
Calcium, %	0.6-0.8 ^b
Phosphorus %	0.6 ^b
Potassium, %	0.2-0.4
Sodium, %	0.04-0.06
Magnesium, %	0.04-0.07
Zinc, %	50-94
Copper, mg/kg	5-6.25
Manganese, mg/kg	5.0-9.0
Iron, mg/kg	80-114
Iodine, mg/kg	1.4-4.0

* Target nutrient ranges expressed on a dry matter basis derived from requirements for domestic cats (NRC 1986), AAFCO recommendations (1994), Waltham Center for Pet Nutrition recommendations (Earle & Smith 1993), and requirements for mink and foxes (NRC 1982).

** The fat content of fish commercially available in N.A. typically ranges from 5–40% (Maslanka & Crissey 1998), and N.A. river otters have been maintained on diets containing 24-30% fat (Reed-Smith 1994), thus an appropriate range for fat appears to fall between 15-30%.

*** The vitamin A requirement for cats is 10 IU/g (dry matter basis; NRC 1986), which represents the upper bound of the range. However, free-ranging N.A. otters consume a higher proportion of fish and may have a higher tolerance for vitamin A due to the high levels, which occur in their natural diet.

^a When mostly fish diets are offered, the presence of unsaturated fatty acids and thiaminases causes the breakdown of these vitamins. Thus, dietary levels of 400 IU vitamin E/kg of dry diet and 100-120mg thiamin/kg of dry diet or 25-30mg thiamine/kg fresh weight as fed basis are recommended (Engelhardt & Geraci 1978; Bernard & Allen 1997).

^b The recommended Ca:P ration is between 1:1 and 2:1

The table below contains updated information on feline nutritional requirements based on NRC recommendations published in 2006. The original target values have been retained for comparison. See Dierenfeld et al. (2002) for information on nutrient composition of whole vertebrate prey. Appendix B provides a description of the nutrients listed in these tables.

Table 2: Target nutrient ranges for carnivorous species (dry matter basis)

Nutrient	NRC 1986 Cat ¹		NRC 2006 Cat ²		Arctic fox ³	Mink ⁴	Carniv ⁵
	Maintenance	Growth	Maintenance	Gestation Lactation	Maintenance	Maintenance	All
Protein (%)	24-30	22.5	20	21.3-30	19.7-29.6	21.8-26	19.7-30
Fat (%)	9.0-10.5	9.0	9.0	15.0	--	--	9-15
Linoleic Acid (mg/kg)	0.5	0.55	0.55	0.55	--	--	0.5-0.55
Vitamin A (IU/g)	3.3-9.0	3.55	3.55	7.5	2.44	5.9	2.44-9
Vitamin D (IU/g)	0.5-0.75	0.25	0.25	0.25	--	--	0.25-0.75
Vitamin E (mg/kg)	27-30	38.0	38.0	38.0	--	27.0	27-38
Vitamin K (mg/kg)	0.1	1.0	1.0	1.0	--	--	0.1-1
Thiamin (mg/kg)	5.0	5.5	5.6	5.5	1.0	1.3	1-5.6
Riboflavin (mg/kg)	3.9-4.0	4.25	4.25	4.25	3.7	1.6	1.6-4.25
Niacin (mg/kg)	40-60	42.5	42.5	42.5	9.6	20.0	9.6-60
Pyridoxine (mg/kg)	4.0	2.5	2.5	2.5	1.8	1.6	1.6-4
Folacin (mg/kg)	0.79-0.8	0.75	0.75	0.75	0.2	0.5	0.2-0.8
Biotin (mg/kg)	0.07-0.08	0.075	0.075	0.075	--	0.12	0.07-0.12
Vitamin B ₁₂ (mg/kg)	0.02	0.022	0.022	0.022	--	0.032	0.02-0.032
Pantothenic acid (mg/kg)	5.0	6.25	6.25	6.25	7.4	8.0	5-8
Choline (mg/kg)	2400	2550	2550	2550	--	--	2400-2550
Calcium (%)	0.8-1.0	0.8	0.29	1.08	0.6	0.3-0.4	0.29-1.08
Phosphorus (%)	0.6-0.8	0.72	0.26	0.76	0.6	0.3-0.4	0.26-0.8
Magnesium (%)	0.03-0.08	0.04	0.04	0.06	--	--	0.03-0.08
Potassium (%)	0.4-0.6	0.4	0.52	0.52	--	--	0.4-0.6
Sodium (%)	0.05-0.2	0.14	0.068	0.132	--	--	0.05-0.2
Iron (mg/kg)	80.0	80.0	80.0	80.0	--	--	80
Zinc (mg/kg)	50-75	75.0	75.0	60.0	--	--	50-75
Copper (mg/kg)	5.0	8.4	5.0	8.8	--	--	5-8.8
Manganese (mg/kg)	5.0	4.8	4.8	7.2	--	--	4.8-7.2
Iodine (mg/kg)	0.35-0.42	2.2	2.2	2.2	--	--	0.35-2.2
Selenium (mg/kg)	0.1	0.4	0.4	0.4	--	--	0.1-0.4

¹ NRC (1986), Legrand-Defretin and Munday (1993), AAFCO (1994). All numbers are based on requirement set for maintenance.

² Dog and Cat NRC (2006).

³ NRC (1982). Protein is range of growth and maintenance; vitamins are for growth, and minerals for growth and maintenance.

⁴ NRC (1982). Protein is for maintenance, vitamins are for weaning to 13 weeks and minerals are a range of growing and maintenance.

⁵ Combination of cat, mink, and fox

Diet formulation should account for animal preferences, body weight, exercise, physical condition, environmental/seasonal changes, behavioral considerations, diet item availability, gastrointestinal tract morphology, and actual nutrient requirements.

Primarily piscivorous, otters have high metabolic rates, rapid digestion, and have been found to spend 41-60% of their time involved in feeding or foraging activities (Hoover & Tyler 1986; Davis et. al 1992; Kruuk 1995; J.Reed-Smith, unpublished data). Duplaix-Hall (1975) found that otters (unidentified species) in the wild rarely ate more than about 500g of food at a time, and that they consumed approximately 20% of their own body weight daily. Kruuk (1995) reviewed his and other study results indicating captive *Lutra lutra* consuming between 11.9-15% of their body weight maintained a healthy weight. Ben-David et al. (2000, 2001a and b) reported success using 10% of a captive *L. canadensis*' body weight as a guide for the basis of their maintenance diet. See section 5.2 for sample diets for the various otter species.

Changing nutrient requirements – age

An animal's diet should be developed to maintain optimal weight or weight gain and normal physical development for a young animal. Diets for young or senescent adults should take into account their activity level, dental development and/or condition.

Changing nutrient requirements – reproduction

There is an increased need for energy during lactation. Tumanov & Sorina (1997) supported the use of high-energy diets for lactating female mustelids. Fat is the most concentrated source of energy in the diet. For lactating females, fat levels in the diet may be increased to support lactation (see below for exceptions) and also to provide increased energy to minimize mobilization of body stores and metabolic stress associated with milk production. Diet increases for lactating otters should be based on past experiences with individual otters and/or observed body weight loss (mobilization of tissue to support lactation). To date, institutions have typically increased the amount of fish offered a lactating female versus simply increasing the fat content by switching the type of food offered. An increase of 10-30% is the accepted rule.

Seasonal changes in nutritional needs

An animal's weight should be monitored regularly, and diets adjusted accordingly. Some institutions report seasonal changes in appetite of some otters, but not in the majority of animals. Further research in this area is required. An animal's weight should be regularly monitored and diets adjusted accordingly. At this time, further research into seasonal nutritional requirements is required.

Weight loss

While otters should carry some body fat, and not be kept artificially thin, they are prone to gaining excessive weight in captivity. Tarasoff (1974) reported subcutaneous fat primarily deposits at the base of the tail and caudally on the rear legs with smaller deposits around the genitalia and in the axillary regions. There are several ways to approach formulating a weight loss diet for otters. Depending on the food items available, the feeding situation (fed alone or in a group), and the amount of weight loss desired, one or more of the following approaches may be appropriate.

- *Feed less total food:* By reducing the amount of total food offered, weight loss may occur. This practice is confounded by the aggression observed in most otters, and particularly *A. cinereus* groups around feeding time, and the potential for this to increase when less food is offered.
- *Add more water to the diet:* By providing a diet that contains more moisture, the total calories in the diet are diluted, and this may allow weight loss. The otter can consume the same amount of total diet, but will actually be consuming fewer calories.
- *Increase the "bulk" of the diet:* By adding indigestible or lower calorie items to the diet, the total "bulk" of the diet can be increased, effectively diluting the calories in the diet. The otter can consume the same amount of total diet, but will actually be consuming fewer calories.

- *Offer lower calorie items:* Lower calorie items can be substituted in the diet. For example, fish varies in energy content from species to species. If weight loss is desired, a leaner fish, such as pollock, could be substituted for a fattier fish, such as herring or capelin, to reduce total calories in the diet. This would be the preferred method for all otter species fed fish.

Diets

The one best diet for any of the captive otters has not been found and requires further research. Current recommendations are that a variety of fish species should be offered 3-4 times a week, preferably daily. Currently, due to the Asian small clawed otter's tendency to develop uroliths there is great variation in the diet offered by different zoo organizations. The AZA Otter SSP recommends a specific diet for *A. cinereus* (see Diet 1).

Sample diets

A. cinereus:

Diet 1 The following food items represent the recommended daily diet per animal for *A. cinereus* (AZA Otter SSP recommendation 2006). The items are given as percentage of diet fed:

- 54.5% commercial canned diet designed to meet the nutrient requirements for domestic cats and control occurrence of calcium oxalate uroliths (e.g., Hill's x/d[®], IAMS Moderate pH/O[®]).
- 2.5% commercial dry food to meet nutrient requirements for domestic cats and control occurrence of calcium oxalate uroliths (e.g., Hill's x/s[®], IAMS Moderate pH/O[®]).
- 17.4% capelin
- 24.6% lake smelt
- 1% cricket and meal worms
- 100 IU vitamin E per kg of fish offered
- 25-35mg thiamin per kg of fish offered

Diet 2 U.K. based institution. These foods should be divided by the number of daily feedings, preferably three but at least two. (Heap et al. 2009)

- Day old chicks: 2 per day (some institutions remove the yolk sac due to salmonella concerns) or a similar amount of rabbit with fur on.
- 70% to 80% of the diet can be meat - this should be of a good quality and can consist of, non-fatty beef including ox heart, chicken, horse, or venison. Tripe is an easily digested protein rich in vitamins and useful for sick or weak animals. Alternatively, dry food concentrates such as "Iams[®] cat food can be offered.
- Vitamins: about a quarter of a 5ml teaspoon of SA 37 or Vionate[®], or similar products per otter.
 - Vionate: ARC Laboratories 4280 Northeast Expressway, Atlanta, GA 30340 U.S.A., 770-454-3200, Order Desk: 800-755-7056; prets@gimborn.com
 - SA 37: Trilanco Bracewell Avenue, Poulton Business Park, Poulton-le-Fylde, Lancashire, FY6 8JF, U.K. Sale Phone: 01253 888188; <http://www.equos.co.uk/webstore/>

- Grated fruit and vegetables: carrots, celery, apple, tomatoes, blueberries, squash. Approximately 20gms per day per otter. Whole fruit and vegetables can be given as enrichment - some will be eaten but fruits such as melons and squash often are just played with and end up as pulp.
- 20 to 30% of the diet should be fish: non-oily and fresh is better when available. Oily fish should only be given at most 2 or 3 times per week. Feed the whole fish chopped into chunks including head and tail. If the otters are young score the fish skin into small squares and remove all bones to avoid choking. If only frozen fish is available, research shows a vitamin B₁ (thiamine) supplement should be offered.
- Potassium citrate: one quarter of a 5ml teaspoon (1.25ml) per otter x 2 per week (thought to help prevent kidney stones).
- Cod liver oil - optional 2.5mls per otter, three times per week.
- To improve coat condition, or in cold weather, suet, lard, butter or olive oil can be added to their meat meal or coated over a chick.; no more than one 5ml teaspoon per otter per day.

Diet 3 This diet has been used successfully over thirty years by the Chestnut Centre, located in the north of England where they experience cool summers and snowy or wet winters (Heap et al. 2009).

- **Morning feed:** chicks, rabbit, 2 crayfish or 2 to 4 herring.
- At least 2 scatter feeds between morning and afternoon feeds
- **Afternoon feed:** meat minced or cut into small pieces then mixed with grated carrot and apple, vitamins and cod liver oil; also fish prepared as previously suggested.

Feeding times should be varied somewhat to prevent habituation of the otters to specific feeding times. This habituation leads rapidly to stereotypic behavior, intra-group aggression, and begging as the otters anticipate the approach of a meal time. If this cannot be done for operational reasons e.g. the otter talk is always done at 3.30pm, then it is important to be prompt, so the otters know the food WILL come on time so reducing stress.

Scatter Feeding: these foods can be used as enrichment throughout the day. Mealworms, snails, earthworms, crickets, crayfish, molluscs, shell fish, grapes, raisins, apple, unsalted peanuts i.e. monkey nuts (no more than 3 to 4 per otter per week). Raw or soft boiled eggs can be used as a treat or a medium for medicating an otter. The food should be hidden around the enclosure under rocks, in tree trunks etc. to encourage the otters to forage and be active. This natural behaviour makes a very enjoyable spectre for the visitors. Scatter feeding should be done at least twice per day with the time varied slightly to prevent habituation. In hot conditions relative to the otters' normal climate, ice, and the above foods frozen can be offered. These items should be included in calorie counts when calculating diets to prevent over-feeding and obesity.

A. capensis:

The following food items represent a sample daily diet per animal for *A. capensis* in captive environments.

- 182g Dallas Crown Carnivore Diet
- 908g fish (herring, capelin, sardines, two choices daily)
- 1.5 dozen large crayfish a week
- 30g lamb & rice dry dog food
- 90 IU vitamin E
- 6.25mg thiamin

L. canadensis:

The amounts of food items in the sample diet below are based on achieving a target weight for otters. The diet should be fed at least three times a day, and 4-5 times if possible. These additional feedings can consist of the fish, rib bones, and enrichment/training feeds.

Diet 1

- 155g commercially prepared feline diet, 2 x day, 7 days a week
- 112g capelin, 1 x day
- 120g smelt, 1 x day
- 135g trout, 1 x day
- ½ medium carrot, 1 x day scattered
- 2 rib bones, ox tail, or similar 3 x week
- 25-35mg thiamin per kg of fish offered
- 100 IU vitamin E per kg of fish

Only good quality, mostly fresh water fish, low in thiaminase and fat should be offered (Wünnemann 1995a). The fish source(s) and/or vendor(s) should be examined closely to assess their handling practices, ensure that HACCP guidelines are being met, and that the fish is considered human grade. Historical use of a type of fish by zoos and aquariums does not ensure it is an adequate diet ingredient, and only careful inspection of handling practices and the fish itself ensures consistent safety and quality. Most diets currently include horsemeat products, or alternative beef-based products which are available in addition to nutritionally complete dry and wet cat foods.

Diet 2:

- 13.5% capelin
- 14.5% smelt
- 16.3% herring
- 18.2% carrots
- 37.5% nutritionally complete cat food or beef-based product (IAMS® cat food used for analysis)
- 2 bones, 3 per week (rib, ox/horse tail, or similar)
- 25-35mg thiamin and 100 IU vitamin E per kg of fish fed

L. maculicollis:

The following food items represent a sample daily diet per animal for *L. maculicollis*. The animals should be fed at least twice per day:

- 50g Iams® Less Active Cat Kibble
- 150g Natural Balance zoo carnivore diet
- 150g trout (3 x week)
- 120g squid (3 x week)
- Yams and carrots offered in small amounts.

For all otters:

Fish types containing high thiaminase and/or high polyunsaturated fat levels should be avoided as they can cause malnutrition, sickness, and even death (Merck 1986). Diets containing fish high in thiaminase can lead to thiamin (vitamin B₁) deficiency in the otters fed this diet (Merck 1986). The process of fish storage (freezing), thawing, and preparation, can lead to fish nutrient loss, particularly vitamins B₁ and E, and especially in fish with high fat and/or high thiaminase content (Crissey 1998; Merck 1986). Vitamin supplements, especially vitamin B₁ (thiamin), vitamin E, and a multivitamin should be added when fish is the main diet. The recommended vitamin supplementation regime for fish eating animals is as follows:

- *Thiamin*: 25-30mg/kg fish fed, fresh weight as fed basis (Bernard & Allen 1997)

- *Vitamin E*: 400 IU/kg dry weight basis (Engelhardt & Geraci 1978)

Feeding schedule

Due to their naturally nutrient dense diet, reliance on fat as a source of energy, rapid transit time of food through the intestinal tract, feeding style of frequent, small amounts, and generally high activity level – it is recommended that otters be fed at least twice a day, and preferably three or more times daily (including enrichment or training feeds). Frequent feeding prevents consumption of spoiled food, accommodates their rapid digestion (Ormseth & Ben-David 2000), and can stimulate increased activity in these generally active and curious species.

In addition to feeding smaller amounts frequently, it is recommended that a portion of the daily diet be fed as part of enrichment or husbandry training activities. At least one of the daily feedings, or part of a feeding, should be scattered to encourage foraging. Timing of foraging opportunities and items offered should be varied to prevent habituation.

Food variability

Otters should routinely be offered a variety of fish either as part of their diet or as enrichment. Reliance on multiple fish species, versus one or two, will prevent animals from developing strong preferences and help in switching them over to new sources if one fish type becomes unavailable.

Otters will sample a variety of food groups, especially if introduced to them at an early age; cat kibble, worms, crickets, vegetables, berries, mice, chicks, etc., can all be added to the diet as enrichment. Due to the possible formation of uroliths, foods high in calcium oxalates should be avoided (e.g., beans, celery, leafy greens, sweet potato, berries, peanuts, among others), particularly for *A. cinereus*. The use of these items for enrichment scatter feeds for North American river otter is acceptable on a limited basis, but the overall nutrient and caloric intake, body weight of the animal(s), and condition of the animal(s) should be taken into consideration.

All otters will benefit from receiving live fish/crayfish (from approved sources), at least as enrichment on a weekly basis. Whole fish should comprise a portion of the daily diet of all other species.

A. capensis, *L. canadensis*, *L. maculicollis*: It is recommended that fish constitute at least a portion of the daily diet offered these species. Hard dietary items should be routinely incorporated for dental health. These can include: hard kibble, crayfish, crabs, chicken necks, ox/horse tails, partially frozen fish, bony fish, day-old chicks, mice, rib bones, canine dental bones, or similar items.

Species-appropriate foraging and feeding

Live fish and crustaceans can and should be provided, if possible, on a regular basis. However, due to the risks of live fish or crayfish transmitting disease or parasites, policies regarding the feeding of live prey should be established by each facility. If these items are used, they should be obtained only from known, institutionally approved sources. Where live prey are used, provisions in the exhibit should be made to allow these prey species a place to hide from the otters, thus forcing the otters to use their hunting skills and extending the time of activity.

There also are a variety of puzzle, and other feeding devices described in the literature that can be adapted for use in river otters. Alternatively, feeding tubes can be built into exhibits that randomly release live prey or food items into the exhibit. See Chapter 8 for other enrichment items used, including non-food items.

Weight evaluation

The AZA Otter SSP is currently beginning work on a body-condition matrix that can be used to help assess proper weight and condition for otters (See Appendix J for working matrix draft). At this time there are no known tools for performing clinical nutritional evaluations of otters; this would be a useful area for future research.

CHAPTER 6: Veterinary Care

Quarantine

All animals should undergo a 30-day quarantine stay at the receiving institution before incorporation into the rest of the collection. This allows time for the development of clinical signs of disease that may have been incubating before the animal was shipped. During the quarantine period, the animal should be observed for signs that may be associated with disease, such as sneezing, coughing, vomiting, diarrhea, ocular or nasal discharge, etc. Three fecal examinations for parasites should be performed, and negative results obtained before release into their permanent enclosure. *A. cinereus* should be housed in social groupings, as far as possible, during quarantine.

Quarantine facilities

Ideally, quarantine facilities should be isolated from the risk of cross-contaminating other carnivores already in the collection. If this is not possible, different keepers should be used, or strict rules of personal hygiene should be adopted and resident animals should be cared for first, and then quarantine animals. Balancing between the necessity of keeping the quarantine pen clean and the needs of the animals can be challenging. Many of the mustelid species do better when isolated in enclosures, than when placed in hospital-type quarantine pens (Lewis 1995). If this is not practical, or possible, a privacy box, climbing furniture, substrate suitable for rubbing/drying-off, and a pool or water tub suitable for swimming should be provided. Whatever type holding facility is used, care must be taken to ensure that otters cannot escape by climbing, digging, or chewing their way out.

Quarantine exams

Two quarantine exams are recommended for otters; one performed at the beginning of the quarantine period, and one performed at the end.

- *Initial exam:* Veterinarians should visually inspect otters as soon as possible after they have arrived in quarantine. If a pre-shipment physical examination has not been done before the animal was transferred, it would be prudent to perform a complete examination during the first week of quarantine (see section 6.2).
- *Final exam:* During the last week of quarantine, a thorough examination should be conducted as outlined in section 6.2. It is extremely important to take radiographs of the animal during this time even if they were done at the previous institution. This gives the new institution its own baseline film from which to compare future radiographs. This is especially important since radiographic techniques vary from facility to facility.

Identification Methods

It is recommended that all otters be identified as soon as possible after birth with a transponder chip. The AZA Otter SSP recommends placing chips subcutaneously over the bridge of the nose/forehead area or SQ/IM in the intrascapular area at the base of the ears. Many institutions have placed them between the scapulas as an alternative. Placement in all of these areas has met with success and failure (migration, loss, unable to read them as planned). At this time, the AZA Otter SSP recommends the forehead area as the preferred area of placement (this location should make the chip easy to read when the animal comes to the front of the cage. The intrascapular area should be used as an alternative (this is the most frequently used location reported by AZA member institutions). However, transponders placed in the intrascapular area can migrate and may be broken or lost during fighting and breeding attempts. Placement location of the transponder chip should be recorded in the animal's medical record and checked during any physical examinations.

Preventive Medicine

It is important that a strong preventive medicine program is in place. These recommendations are based on advice from the AZA Otter SSP veterinary advisor. Please note cautions expressed regarding vaccines; these products typically have not been manufacturer tested for efficacy in otters. Recommendations are based on professional experience but efficacy or problems may vary with situations and animals.

Medical examinations

It is recommended that all animals have at least a biennial examination and, if possible, an annual examination, during which the following procedures are performed:

- Transponders and/or tattoos should be checked and reapplied if they are not readable.
- Baseline physiological parameters (e.g., heart rate, weight, body temperature, respiratory rate) should be obtained & recorded.
- The oral cavity and all dentition should be examined. Teeth should be cleaned and polished if necessary. Any tooth that is fractured or in need of repair should be noted in the medical record and the condition corrected as soon as possible.
- The reproductive tract should be evaluated. Care should be taken to record any changes in the external genitalia, such as vulvar swelling or discharge, testicular enlargement, and mammary gland changes. Contraceptive hormone implants also should be checked to make sure they are in place, and not causing any local irritation.
- Radiographs taken to check for any abnormalities. If renal or cystic calculi are seen, then numbers, location, and approximate sizes should be noted in the records.
- Blood collection done, and complete blood count and chemistry profile performed.
- Blood serum frozen and banked when possible.
- Animals housed outside in heartworm endemic areas should be checked for heartworm disease by performing a heartworm ELISA antigen test, and the animal routinely given heartworm preventative treatment (see 'parasite control' section).
- Urine collected whenever possible by cystocentesis for a complete urinalysis.
- An annual fecal examination should be performed to check for internal parasites, and anthelmintics administered if necessary (see 'parasite control' section).
- Vaccines updated if necessary (see 'vaccination' section).

Anesthesia/immobilizations of otters should only be performed when there is a medical indication for the procedure. Preventive immobilizations are of high risk for the animals, and should be substituted with regular visual examinations and testing of fecal samples, vaccinations etc. Administration of transponders, examination of the oral cavity, blood sampling, etc., should be completed only when immobilizations are necessary for medical reasons. Evaluation of the reproductive tract can be performed in animals that are regularly involved in a medical training program. In well-trained animals, sonography of the uterus may be possible, as well as the visual or palpable inspection of mammary gland and testicles.

Animal records

Thorough and accurate medical records are essential to learn and understand more about the medical problems of captive species. Medical records should be systematic and entries should identify the history, physical findings, procedures performed, treatments administered, differential diagnosis, assessment, and future plans for treatment. A computerized medical record system, which can help track problems and be easily transmitted from one institution to the next, is extremely beneficial. Where available, the use of standardized electronic medical record systems is encouraged.

Vaccination

The following vaccination schedule is recommended by the AZA Otter SSP Veterinary Advisor. Vaccination product recommendations are based on clinical experience (as of 2006) in most cases, and not necessarily on controlled scientific study. Use of these products is at your discretion and should be evaluated in a case by case basis.

Canine distemper: Merial's new PureVax™ Ferret Distemper Vaccine currently on the market is a univalent, lyophilized product of a recombinant canary pox vector expressing canine distemper virus antigens. The vaccine cannot cause canine distemper under any circumstances, and its safety and immunogenicity have been demonstrated by vaccination and challenge tests. Otters should initially be given 1ml of reconstituted vaccine for a total of 2-3 injections at three-week intervals, followed by a yearly booster. This vaccine should be given IM instead of SQ in exotic carnivores for increased effectiveness. More information on PureVax™ Ferret Distemper Vaccine can be found at www.us.merial.com; Merial Ltd., 3239 Satellite Blvd., Duluth, GA 30096. An alternative vaccine that is available is Galaxy D (Schering-Plough Animal Health Corporation, P.O. Box 3113, Omaha, NE 68103), a modified-live canine distemper vaccine of primate kidney tissue cell origin, Onderstepoort type. Safety and efficacy of canine distemper vaccinations in exotic species of carnivores have been problematic. Vaccine-induced distemper has occurred in a variety of mustelids using modified-live vaccine, and killed vaccines have not provided long-lived protection and are not commercially available. However, to date there have been no cases of vaccine induced distemper in otters given the Galaxy product, and excellent seroconversion following vaccination using this product has been documented in young N.A. river otters (K.Petrini, unpublished data, 1986). The use of any modified-live canine distemper vaccine in exotic species should be done with care, especially with young animals, and those that have not been vaccinated previously. The use of PureVax™ Ferret Distemper Vaccine is recommended where possible.

Parvovirus: The efficacy of feline and canine parvovirus vaccines has not been proven in otters. Otters should initially be given 1ml of vaccine IM for a total of 2-3 injections at three-week intervals followed by a yearly booster. Parvocine™ (Biocor Animal Health Inc., 2720 North 84th Street, Omaha, NE 68134) is a killed univalent parvovirus vaccine that has been used in otters. Using a univalent product such as Parvocine™ reduces the risk of vaccine allergic reactions.

Rabies: The efficacy of rabies vaccines has not been proven in *Lontra canadensis* or other exotic mustelids. Vaccinated otters that bite humans should not be considered protected from rabies. Only killed rabies products should be used in otters. One commonly used product is Imrab® 3 (Merial Ltd., 3239 Satellite Blvd., Duluth, GA 30096), which is a killed rabies vaccine that has been used extensively in small carnivores without apparent adverse effects. Otters should be given 1ml of vaccine IM once at 16 weeks of age followed by a yearly booster. PureVax™ Feline Rabies (Merial Ltd., 3239 Satellite Blvd., Duluth, GA 30096) is a live canarypox vectored, non-adjuvanted recombinant rabies vaccine that is currently being used at some institutions for small carnivores. Dose and route are the same as for Imrab® 3, but this vaccine can be given once at age 8 weeks or older, then annually.

Leptospirosis: The susceptibility of river otters to leptospirosis is debated in the literature, and the benefit of vaccination is unknown. Killed *Leptospira* bacterins are available and can be administered in areas where leptospirosis has been problematic. Initially two doses should be given at 3-4 week intervals. Vaccine efficacy and duration of immunity has not been studied in the otter and is an area where further study should be conducted.

Parasite control

Otters should have fecal examinations performed regularly (annual exams are advised). The frequency of these examinations depends on the incidence of parasitism in the geographic region, and the likelihood of exposure. Animals also should be screened for parasites before shipment and during quarantine. Fecal testing should include a direct smear examination and a fecal flotation, as well as sedimentation techniques, if possible. Baermann fecal examination techniques help identify certain parasites, such as lungworms, that are otherwise difficult to detect.

Heartworm ELISA antigen tests should be conducted annually in animals exposed to mosquitoes in heartworm endemic areas, and animals maintained on a heartworm preventative. External parasites (e.g., mites, fleas, ticks) can be detected during physical examinations.

Dr. George Kollias, Cornell University School of Veterinary Medicine, states: "*Dirofilaria immitis*, the cause of heartworm disease in dogs, cats and some other carnivores, has been found in the hearts of otters in and from Louisiana. This filarial worm has to be differentiated from *Dirofilaria lutrae*, the microfilaria of which can be found in the blood and adults in the subcutaneous tissues and coelomic cavity of river otters. *D. lutrae* generally does not cause disease. Newly acquired otters should be screened for microfilaria (via the Knott's test on blood) and for adults, via the ELISA antigen test on serum. *D. immitis* can be differentiated from *D. lutrae* by the morphological appearance of the microfilaria and by the antigen test. Thoracic radiographs should also be taken as part of routine health screening and definitely if an otter is Knott's test positive and/or antigen positive". See also Snyder et al. (1989), Neiffer et al. (2002), and Kiku et al. (2003) for reports of heartworm in otters.

In heartworm endemic areas, otters can be given ivermectin (0.1mg/kg orally once/month year around) as a preventative. Although it is still uncertain whether or not *D. immitis* causes progressive heartworm disease, as in the dog and cat, prevention is safest approach. If used at the proper dose, ivermectin has proven safe in otters. Mortality has been associated with Melarsomine dihydrochloride administration to North American river otters and a red panda for heartworm disease (Neiffer et al. 2002). In another report of otter deaths after treatment with Melarsomine, adult heartworms were found in the hearts of three out of the four animals during necropsy (G. Kollias, personal communication).

Parasite testing: Recommendations and protocols for parasite testing in otters are provided in the table on the following page:

Table 3: Otter parasite testing protocols

Parasite	Testing protocol
External parasites	Regular inspections during any physical examinations
Internal parasites	<i>Annual fecal examinations:</i> direct smear, fecal flotation, & sedimentation or Baermann techniques. <i>Pre-shipment fecal examinations:</i> direct smear and flotation <i>Quarantine fecal examination:</i> 3 negative direct smear results & 3 negative fecal flotation results before release from quarantine. <i>Heartworm ELISA antigen tests:</i> conducted annually in animals exposed to mosquitoes in heartworm endemic areas (test will not detect all male infections or infections with <3 female nematodes). If infection is suspected, positively identify the microfilaria as pathogenic before instituting treatment.

Parasite treatment: The following table (Table 4) provides a list of anthelmintic products that have been used safely in a variety of mustelids:

Table 4: Recommended anthelmintic treatments for otters

Treatment	Dose
Fenbendazole	50mg/kg orally for 3-5 days. In <i>P. brasiliensis</i> there was a complete elimination of a <i>Strongyloides spp.</i> infestation after treatment with 10-20mg/kg over 3 days
Pyrantel pamoate	10mg/kg orally
Ivermectin	0.1mg/kg orally, once monthly for heartworm prevention 0.2-0.4mg/kg subcutaneously or orally for treatment of intestinal nematodiasis (G.Kollias, personal communication)
Praziquantel	5mg/kg SC or orally

Medical management of neonates

Otter pups can develop health issues suddenly, and they must be carefully watched for any change in behavior. Some problems that have developed in young hand-reared pups are listed below with suggested first-step solutions or treatments, and neonatal examination and monitoring guidelines are also provided. See Table 5.

Table 5: Neonatal examination & monitoring guidelines (from Read & Meier 1996)

Vital signs	Temperature, include activity level Pulse, rate and character Respiration, rate and character
Organ systems	---
Weight	---
Hydration	Skin tone and turgor
Mucous membranes	Color and capillary refill
Vitality	Response to stimulation, activity levels: type, frequency, duration
Physical condition	---
Laboratory values (optional)	Complete blood count White blood cell count Serum chemistries, including blood glucose & blood urea nitrogen Urinalysis and urine specific gravity (recommended)

Urination	Frequency, amount, and character
Defecation	Frequency, amount, and character
Condition of umbilicus	---
Total fluid intake	Amount in 24 hours Parenteral fluids, amount, frequency, and type Oral fluids, amount, frequency, type, nipple
Housing temperature	---

Dehydration/emaciation: Give subcutaneous or oral (only if sucking well) electrolytes. Lactated Ringers Solution (LRS) with 2.5% dextrose or sodium chloride (0.9% NaCl) are recommended. Oral fluids are given at the dose of 5% body weight per feeding. The dose for subcutaneous fluids is determined by the level of dehydration, and should be determined by a veterinarian.

Diarrhea/constipation: Digestive upset is a common issue with hand-reared neonates, and may be associated with several factors (Meier 1985): a) inappropriate milk formula; b) feeding frequency; c) overfilling the stomach which can cause bloating; and d) rapid changes in the diet. When digestive upset occurs, characterized by diarrhea, bloating, inappetance, and/or extreme disorientation, it is recommended that one factor is analyzed and/or changed at a time. The veterinarian should be consulted immediately in the case of diarrhea, as the condition of very young animals can deteriorate rapidly.

Diarrhea related to diet changes may be treated with Kaopectate[®] with veterinary approval. It should be noted that Kaopectate[®] now contains salicylic acid (aspirin), as does Pepto-Bismol[®], and gastrointestinal bleeding may result from frequent doses. Persistent diarrhea, or loose stool accompanied with inappetance requires continuous veterinary care. Bacterial infections or parasites, such as *Coccidia* may be the cause of the problem and require specific medication. Osmann (personal communication) recommends the administration of *Lactobacillus spp.* into the formula for *P. brasiliensis* pups with diarrhea, or after antibiotic treatment, this also may be useful with other otter species.

Constipation may be treated by diluting the formula to half-strength for 24 hours, and gradually increasing back to full-strength over a period of 48 hours. The pup also can be given oral electrolyte fluids at the rate of 5% body weight in between feedings, and 1-2 times over a 24-hour period. The pup's back end can be soaked for a few minutes in warm water (make sure to dry off completely) accompanied by gentle stimulation, but care should be exercised that the anal area is not irritated.

Upper respiratory infections: Pups that have been eating normally and suddenly start chewing on the bottle or seem uninterested in the bottle may have an upper respiratory infection. They cannot nurse properly when congested. Upper respiratory infections need to be treated immediately. Newborn pups can die within 24 hours of the first symptom. Antibiotics should be started at the first sign of infection.

Antibiotics can be given orally or injected. Care should be taken with the location of injections to avoid the sciatic nerve in their rear limbs (in two cases where limb mobility was affected due to injection site, the lameness/paralysis was resolved over time). Pups on antibiotics may also develop GI problems and/or get dehydrated, and this should be treated accordingly. Antibiotics that have been used successfully for upper respiratory infections are listed below. Antibiotics should not be given without consulting a veterinarian first.

- Enrofloxacin: injectable at 5mg/kg BID IM
- Amoxicillin: 20mg/kg BID PO
- Amoxicillin (long-acting): 15mg/kg IM every 48 hours (used for *P. brasiliensis*)
- Penicillin G Procaine: 40,000-44,000 IU/kg q24 hr IM
- Chloramphenicol: administered orally at 30-50mg/kg/day (used for *P. brasiliensis*)
- Trimethoprim/sulfonamide combination: given parenteral at 15mg/kg/day (used for *P. brasiliensis* – C.Osmann, personal communication)

Bloat: Some otter pups have developed bloat. Care must be taken to ensure that there is no air in the formula or any leaks in the bottles. The amount of formula fed at each feeding should be re-evaluated as the pup may be receiving too much. Reducing the amount fed per feeding and adding another feeding should be considered. Watch for respiratory distress as respiration may become labored with severe abdominal distention. Treatment options for bloat include passing tubing to decompress, or the use of over-the-counter medication. Infant gas drops have been tried with no effect. Care should be taken with the use of certain gastric coating agents, such as bismuth subsalicylate (Pepto-Bismol®), as some ingredients may create more problems.

Fungal infections: Caretakers should look for hair loss and discoloration of skin, and should pull hair samples and culture for fungus using commercially available fungal culture media. At first appearance, fungal infections can be treated with shampoos and creams, and shaving the affected areas can also help. Severe infections may need to be treated with oral/injectable medication.

Parasites: Fecal samples should be taken regularly from otter pups (specifically hand-reared pups), even if they are negative. Pups should be dewormed as needed, and treatment started immediately to avoid any weight loss.

Bite/puncture wounds: Any bite or puncture wounds should first be cleaned and flushed with fluids, and then treated with topical antibiotic and systemic antibiotics if necessary.

Capture, Restraint, and Immobilization

It is recommended that anesthesia be given intramuscularly (IM) in the cranial thigh (quadriceps), caudal thigh (semimembranosus-tendinosus), or paralumbar muscles (Spelman 1999). Animals should be kept as quiet as possible. Generally, restraint is accomplished using a net, squeeze cage, or capture box. The AZA Otter SSP recommends training animals to receive injections to minimize stress prior to all anesthesia events. Immobilization of *P. brasiliensis* using a blowpipe has proven to be relatively easy, and minimizes stress to the animals involved. However, use of a blow pipe on the smaller otter species (*A. cinereus* and *A. maculicollis*) is not recommended and caution should be used for all other otter species as it is easy to injure the animal. A variety of agents have successfully been used in otter species for immobilization. These include Ketamine alone (not recommended), Ketamine with midazolam, Ketamine with diazepam, and Telazol®.

Otters have a large respiratory reserve, and so using gas induction chambers is often very time consuming (this can take up to 10 minutes in *A. cinereus*), but has been done successfully. Despite the method of induction, anesthesia can be maintained by intubating the animal and maintaining it on Isoflurane (Ohmeda Pharmaceutical Products Division Inc., P.O. Box 804, 110 Allen Rd., Liberty Corner, NJ 07938). Halothane (Fort Dodge, 9401 Indian Creek Parkway, Ste. 1500, Overland Park, KS 66210) is no longer recommended for use in otters as it may cause liver failure (G.Meyers, personal communication). Otters are relatively easy to intubate, and this method is preferred when it is necessary for an animal to be immobilized for a lengthy procedure (>30 minutes).

Careful monitoring of anesthetic depth and vital signs is important in any immobilization. Body temperature, respiratory rate and depth, heart rate and rhythm, and mucous membrane color and refill time should be assessed frequently. Pulse oximetry sites include the tongue, the lip at the commissure of the mouth, or in the rectum. Oxygen supplementation should be available and administered when indicated.

A. cinereus: For *A. cinereus*, ketamine hydrochloride can be used alone or in combination with midazolam hydrochloride (Versad®, Roche Labs, 340 Kingsland St., Nutley, NJ 07110-1199) or diazepam to improve muscle relaxation (Petrini 1998). Telazol® (Fort Dodge, 9401 Indian Creek Parkway, Ste. 1500, Overland Park, KS 66210) is another good immobilizing agent for this species. Generally, it provides smooth, rapid induction and recovery along with good muscle relaxation. Doses of Telazol® required for adequate immobilization vary considerably between individuals. Ranges for some injectable drug combinations are listed below:

- Telazol: 5.5-9.0mg/kg IM

- Ketamine: 12-15mg/kg & midazolam: 0.5-0.75mg/kg IM
- Ketamine: 9-12mg/kg & diazepam: 0.5-0.6mg/kg IM

Muscle rigidity is common with these injectable drug combinations at the lower end of the dosages. Initial apnea and low oxygen saturation readings, as measured by pulse oximetry, often accompany higher doses. All three combinations produce a relatively short duration of anesthesia time, approximately 15-30 minutes. Administering an additional 5mg/kg ketamine IM when needed can prolong anesthesia time. Alternatively the animal can be intubated and maintained on gas anesthesia.

Combining ketamine with medetomidine hydrochloride (Domitor[®], Pfizer Animal Health, 812 Springdale Dr., Exton, PA 19341) may provide a slightly longer duration of anesthesia and may give better myorelaxation, plus it has the added advantage of being reversible with atipamezole hydrochloride (Antisedan, Pfizer Animal Health, 812 Springdale Dr., Exton, PA 19341). Vomiting may occur during induction and initial apnea and low oxygen saturation readings are common. Supplemental oxygen should be available for administration if necessary. Dosages that have been used successfully are:

- Ketamine: 4-5.5mg/kg & medetomidine: 0.04-0.055mg/kg IM; reversed with atipamezole: 0.200-0.275mg/kg IM

L. canadensis: For short-term anesthesia (25-30 minutes) of *L. canadensis*, Spelman (1998) recommends the following:

- Ketamine: 10mg/kg & midazolam: 0.25mg/kg
- Ketamine: 2.5-3.5mg/kg, medetomidine: 0.025-0.035mg/kg & atipamezole: 0.125mg/kg (respiratory depression is more likely at higher dosages).
- Telazol[®]: 4mg/kg (Spelman 1998), 9mg/kg (Blundell et al. 1999; Bowyer et al. 2003), 8mg/kg (Petrini et al. 2001); reversed by Flumazenil: 0.08mg/kg to prevent a prolonged recovery time.
- Ketamine: 10mg/kg. Muscle rigidity and variable duration should be expected.
- Ketamine: 5-10mg/kg & diazepam: 0.5-1mg/kg. Prolonged recovery compared to ketamine with midazolam.

Management of Common Diseases, Disorders, Injuries

Little information on common diseases and disorders for *A. capensis* and *L. maculicollis* is available, and more research is required for these species. Urolithiasis is the most common illness, and renal calculi are the most frequent cause of death in *A. cinereus*. The cause and reversal of this condition is the subject of ongoing research.

Poor coat quality

Otters are amphibious mammals reliant on trapping air within their coats rather than a layer of blubber for thermal insulation (Tarasoff 1974). Studies have shown that otter fur is far denser than that of other mammal species, with an average of 26,000 hairs/cm² (foot) to 165,000 hairs/cm² (foreleg) (Weisel et al. 2005). Sea otter pelts are roughly twice as dense as the fur of a river otter, and the river otters' fur is twice as dense as that of a mink (Weisel et al. 2005).

Weisel et al. (2005) determined via the use of scanning and polarizing light microscopy that otter guard and underhairs are characterized by the presence of fins, petals, and grooves that allow adjacent hairs to fit together forming an interlocking structure. Trapped within this interlocking structure are bubbles of air forming an insulating layer between the skin and water. Air is trapped in the fur when the otter shakes upon emerging from the water, via piloerection of the hairs (including grooming and rubbing), and muscular pleating of the skin (Weisel et al. 2005). Thus, behavioral actions combined with the density and complexity of the underfur structure essentially prohibits water from touching the skin. Weisel et al. 2005 also determined that the outer and inner

hairs of an otter’s coat are, “... hydrophobic due to the presence of a thin layer of body oil from the sebaceous glands of the otter”.

This recent work documented that the long, outer hairs do guard the more fragile inner fur from damage, and that they can become damaged reducing their effectiveness. At this time it is not possible to say what damage is done to the otters’ guard hairs by gunite or other abrasive surfaces within captive exhibits; it is recommended that those surfaces be avoided in otter exhibits as far as possible.

Poor coat quality and other factors can lead to pneumonia. Poor coat quality is of concern when its water repellency is affected. If water does not form droplets and cannot be easily shaken off the guard hairs (i.e., dark brown fur), the otters’ guard hairs stick together resulting in a coat that looks slick and saturated; this is an indication of poor coat quality. Poor quality leads to water penetrating the guard hairs and exposure of the under-fur (gray/white under coat), which can then become waterlogged. An otter in this condition may not swim in an effort to remain as dry as possible. If the otter does swim, and it cannot keep dry, its body temperature will drop rapidly leading to observable shivering, even during sleep. Enteritis can develop in cases of extreme chilling. If measures are not taken, death can follow in a matter of days through pneumonia and/or gastro-intestinal complications (Duplaix-Hall 1972). Insufficient land area compared to water area, and/or inappropriate enclosure substrates causing overly damp/wet conditions, were historically most often the reason for poor coat condition and the resulting health problems in river otters (Duplaix-Hall 1972, 1975).

Common disease issues

Dr. Gwen Myers, AZA Otter SSP Veterinary Advisor conducted a review (G.Myers, personal communication) of all submitted necropsy reports for *L. canadensis*. Her findings (Table 6) indicate that the most frequent causes of *L. canadensis* deaths (excluding neonatal deaths) are:

Table 6: Common causes of deaths in *L. canadensis*

Cause of death	Causal factors
Heart disease	- Heartworm/death from heartworm treatment; Acute myocarditis; Myofiber degeneration
Renal failure	- Etiology unknown; Amyloidosis; Pyelonephritis
Hepatic lipidosis	-
Adenocarcinoma	-
Transitional cell carcinoma (bladder)	-
Peritonitis	- Secondary to intestinal perforation from foreign body; Secondary to GI perforation from ulcers
Diarrhea	- Unknown etiology; Clostridial endotoxin; <i>Helicobacter</i> (also causing vomiting, weight loss); <i>Salmonella</i>
Gastric dilatation with volvulus	-
Pneumonia	- Often without identifying underlying cause
Anesthetic death	-

Useful veterinary references:

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CHAPTER 7: Reproduction

Reproductive Physiology and Behavior

A. cinereus: These otters are non-seasonal, and thought possibly to be spontaneous ovulators (Bateman et al. 2009). The estrous cycle lasts 30-37 days, with breeding occurring year round. Some facilities report this cycle extending to every few months with older animals. Estrus lasts from 1-13 days. Behavioral signs of the onset of estrus may include increased rubbing and marking. Sexual behavior has been observed in pups as young as 6 months, with breeding behavior having been noted in animals (males and females) as young as 1½ years. Successful breeding has been reported for 2.1-year-old females and 2.8-year-old males. There do not appear to be any significant environmental cues that are involved with the onset of estrus. Breeding pairs have been introduced at various ages and have been together for varying lengths of time before successful breeding occurs. It has been reported that pups from previous litters have interfered with copulation, but their presence had no bearing in any other way (Lombardi et al. 1998).

Recent work has shed light on litter intervals; Bateman et al. (2009) report: "In one female having three consecutive pregnancies during [their] study, the interval between the first parturition and subsequent progesterone increases owing to the next pregnancy was 169.25±11.15 days. This female was observed nursing her pups from the first pregnancy for the first 122 days of this intergestational time period."

Breeding pairs must establish a bond for successful reproduction. The male pursues the female in courtship and most breeding occurs in shallow water. A single copulation can last from 5-25 minutes. Courtship behavior has been recorded from 1-3 days, at one-month intervals. Gestation is roughly 60-74 days (67-77 range, average 71.17±1.49 days reported by Bateman et al. 2009).

Pseudopregnancies do occur in this species, including in females housed in single sex groups (5 of 6 females housed together exhibited pseudopregnancy) (Bateman et al. 2009). Bateman et al. (2009) report: "...a mean duration of pseudopregnancy of 72.45±1.37 days (range: 62–84 days). The average interval length between sequential pseudopregnancies and/or pregnancies was 39.86±3.86 days (range: 17–92 days) in paired females and 134.50±48.94 days (range: 62–279 days) in the single gender group.

The sire plays a very active role in rearing the pups, and should not be removed prior to their birth. Male behaviors include nest building, carrying pups, and bringing food to the pups during weaning.

Table 7: Captive breeding parameters of *Aonyx cinereus* in North American zoological facilities 1980's and 1990's (Reed-Smith & Polechla 2002, Bateman et al. 2009)

<i>Aonyx cinereus</i>	
Estrus cycle	30-37 days. Polyestrous with breeding occurring year around
Estrus length	1-10 days
Ovulation	Likely spontaneous ovulators (Bateman et al. 2009)
Copulation frequency	Several times a day.
Copulation duration	1-30 minutes, varied.
Copulation position	Dorsal/Ventral most common, also ventro/ventral.
Copulation location	In the water and on land
Copulation initiated by	Varies amongst groups, in some it is initiated by male only, in others both initiate.
Age at 1 st breeding	Unknown
Breeding behavior	Increased rubbing, marking.
Gestation	Gestation ranges between 67 and 74 days; pseudopregnancies lasted 62 – 84 days (Bateman et al. 2009). No delayed implantation (Bateman et al. 2009)

Pair management	Most facilities started out w/ a pair when 1st litter born. Pair left together all of the time
Group management	Some reports of harassment of new pups by older pups (too much play), one reported cannibalism of pups by dam. Most leave all animals together.
Signs of parturition	Some weight gain, more time spent in nestbox.
Pupping boxes	Wooden boxes, hollows under logs & burlap bags have been used.
Contraception	MGA implants in females.

A. capensis: This species does not appear to have a specific reproductive season (Mead 1989). Breeding in the northern hemisphere (Ohio) has been observed in November, January, March, and April (R.Meyerson, personal communication), with pups born in January-March, and June-September (R.Meyerson, personal communication). Gestation length ranges from 63-80 days depending upon the source (Estes 1989; Reed-Smith & Polechla 2002; R.Meyerson, personal communication). In one captive breeding situation, receptivity by the female lasted one day (Oregon Zoo, personal communication); in another, breeding occurred for 2-3 days (R.Meyerson, personal communication). Generally, 1-2 days before a female is receptive, the male will start following her around. All captive pairs have shown an increase in the level of interactive play behavior for several days before and after breeding. All observed copulations have occurred in the water.

Table 8: Captive breeding parameters of *Aonyx capensis* in North American zoological facilities 1980's and 1990's (Reed-Smith & Polechla 2002)

<i>Aonyx capensis</i>	
Estrus cycle	Breeding occurred in Jan, Apr, Nov & Dec for 4 litters produced.
Estrus length	Peak receptivity lasted 1 day; day before & after consisted of play & close following
Copulation frequency	Several times during the 2 nd day of breeding behavior
Copulation duration	Not documented.
Copulation position	Not documented.
Copulation location	In the water.
Copulation initiated by	Male, females would only cooperate for 1 day.
Age at 1 st breeding	Males from 2 yrs.10 mos.; Females from 4 yrs. 2 mos.
Breeding behavior	Females fought when one was in heat. Signs of estrus shown by male behavior
Gestation	80, 103 days
Pair management	Breeding was opportunistic. Male kept away from pups by female or separated 1 week prior to expected parturition.
Group management	1.2 housed together on exhibit during the day; 0.2 given 2 dens at night
Signs of parturition	Females gained weight particularly in fold between foreleg and body.
Pupping boxes	Females did not want bedding in their boxes. Given only one box, no problems.
Contraception	Two males have been vasectomized due to small gene pool. Females medicated for contraception.

L. canadensis: These otters are seasonal breeders. Females mature reproductively as early as 12-15 months (rare reports of successful breeding at this age) to two years of age (typical). They are believed to be induced ovulators, and experience delayed implantation (Chanin 1985; Reed-Smith 2001, personal observation). Recent evidence suggests that this species also may be capable of spontaneous ovulation (Bateman et al. 2009).

There is evidence that breeding season varies somewhat with latitude (Reed-Smith 1994, 2001; Bateman et al. 2005, 2009), and also may be influenced by seasonal availability of food resources (Crait et al. 2006); however the authors of the one study (Crait et al. 2006) speculating on the influence of food availability acknowledge there could have been other things occurring and their sample size was small. In general, breeding occurs in late spring (March-June) at northern latitudes, and between November-February at more southern latitudes, with a gradient in between (Reed-Smith 2001). The estrus period lasts approximately 42-46 days, unless mating occurs (Chanin 1985). Bateman et al. (2009) found that "...peaks in fecal estrogen values occurred only during the defined breeding season from December to March". They also report, "...the estrus phase of their cycles [N=11] was observed just once per year with an average duration of 15.33±1.98 days (range: 6–54 days). The average duration of estrus elevation coincident with observed breeding (n=4) was 22.00±1.22 days (range: 19–24 days)." During this time, captive observations suggest peaks of maximum receptivity are roughly 3-6 days apart with intervals of only mild receptivity during which the female may completely reject the male (Liers 1951; Reed-Smith 2001). The work done by Bateman et al. calls into question the estrus duration of 42 to 46 days traditionally cited; this is an area that should be researched further. Worth noting is the slightly longer estrus (21-23 days) reported in breeding versus non-breeding females (14-17 days); also the widely varying range of estrus duration (6-54 days) reported in the Bateman et al. study.

More recently Bateman et al. (2009) have reported some additional interesting results from fecal hormone studies:

"In the observed pregnancies and pseudopregnancies (n= 12), the date of initial progesterone increase ranged from September 4 to January 14, and the timing was not correlated (r=0.53, P>0.05) with the female's geographic latitude (range: 27–41°N) at the time of the pregnancy or pseudopregnancy. However, the date of the progesterone increase was correlated (r=0.66, P<0.05) with the female's geographic latitude at the time of her own birth (range: 27–42°N)."

The finding of a possible genetic component tying the timing of progesterone elevation in pregnant and pseudopregnant females to the female's birth latitude (instead of to their geographic location) is significant and requires further study. This impacts captive management practices (transfers of animals to create breeding pairs) and the outcome of wild otter translocation/reintroduction projects (females may be giving birth too early or too late).

Males mature sexually at about two years; the production of male spermatozoa begins at this age. The male's testes begin to enlarge and spermatozoa production begins sometime in October/November, (or earlier at more southern latitudes), and remain distended until the end of the breeding season (Liers 1951; Reed-Smith 2001). Bateman et al. (2009) have shown that male testosterone levels increase seasonally to coincide "...with the increasing amount of daylight occurring after the winter solstice." Testosterone levels peaked at different times of the year corresponding with the male's latitudinal location; "As latitude increased, peak testosterone values appeared to occur later in the calendar year" (Bateman et al. 2009). They found that: "For all NARO males, testosterone levels were elevated above baseline for an average of 101.8±78.97 days with peak levels being maintained for 25.50±7.51 days."

Females may show some, all, or occasionally none, of the following signs of estrus: increased marking of their territory; vulvular swelling; a slight pinking of the vulva area; increased rubbing, rolling and allo-grooming; increased interest in the male or the male's quarters; increased interaction between the female and the male to include chasing, tumbling, mutual grooming, sleeping together (obviously will only be apparent in pairs that do not normally do this); chuckling to the male; genital sniffing by the male of the female and vice-versa; and copulation. If male and female *L. canadensis* are housed alone, the pair should be introduced for breeding after the first signs of estrus appear, or when the female shows unusual interest in the male's scent or enclosure. Absent any obvious signs introductions should begin roughly four weeks prior to typical onset of estrus at the facilities latitude. Some facilities have reported a small amount of estrus-associated bleeding from the vulva, while others have not seen this. This is an area that requires further research. Female river otters also appear to be prone to urogenital

infections, which frequently cause a milky, milky-blood-tinged, or slightly off colored discharge, which has been interpreted as a possible indicator of estrus or imminent parturition. If this kind of discharge is seen, the female should be closely observed and the condition monitored by a veterinarian.

Although copulation generally takes place in the water, it also can take place on the land. The copulatory act is vigorous, noisy, and can be lengthy with intromission lasting up to 60 minutes or more. A pair will copulate repeatedly over a period of an hour or two, then rest or forage for several hours before starting again. Copulation generally occurs several times over successive days. Copulations should be at least several minutes in duration to be successful. Short and/or infrequent copulatory bouts are generally not successful (Reed-Smith 2004b). Breeding activity may resume after a lull of 3-6 days throughout the course of a female's receptive period. During copulation, the male holds the female's scruff with his teeth, and positions the posterior part of his body around and below the female's tail (Liers 1951; Towell & Tabor 1982). If the female is not receptive, or interested, she may roll on her back and paw at the male, nip and scream at him, or bite him and then run away.

Total gestation lasts from ~317 to 370 days reported by Liers (1951) and Reed-Smith (2001) or 302-351 (average 333.3 ±15.7) days reported by Bateman et al. (2009); actual gestation is about 68-73 days (average 71.67±1.48) (Bateman et al. 2005, 2009). The parturient female may exhibit a number of different signs including: increased 'nest' building, swollen mammae, aggression towards exhibit mates or keepers, depressed appetite, frequent floating in the pool, refusal to leave the nest box, restlessness or lethargy. No pre-partum discharge has ever been noted. Parturition may occur from November through May, however, the peak time appears to be March through May in the northern latitudes (40-60°N) and late December through February at more Southern latitudes (23-30°N).

Estrus occurs soon after parturition lasting the same 42-46 days (recent hormonal work sets estrus as 15 to 22 days [Bateman et al. 2009]). Hamilton and Eadie (1964) record estrus as occurring not long after parturition. Most zoos that have observed postpartum estrus see behavioral signs 1-2 weeks after parturition.

The AZA North American River Otter PMP recommends that facilities interested in breeding should exchange one individual if the pair has been together since a young age and have not been successful at breeding. Based on previous hormone monitoring, the time of year in which each river otter's breeding season occurs is highly influenced by its geographic location/latitude (Bateman et al. 2005, 2009). Consequently, a possibility exists that some animals moved between widely varying latitudes may be physiologically out of synchrony and would require at least one breeding season to adapt physiologically to their new environmental cues, which are important for signaling the start of breeding season. This should be factored in when making transfer recommendations, but should not limit transfer options when creating new breeding pairs. The North American River Otter Husbandry Notebook (Reed-Smith 2001) provides greater detail on the breeding strategy and reproductive physiology of this species, and the AZA Otter SSP reproductive advisor (Helen Bateman, C.R.E.W., Cincinnati Zoo) is involved in on-going research (Bateman et al. 2009).

In both NARO and ASCO, additional research is needed to improve endocrine monitoring of estrogen metabolites to further address these questions about ovarian cyclicity and ovulatory mechanisms.

Table 9: Captive breeding parameters of *Lutra canadensis* in North American zoological facilities 1980's and 1990's (Reed-Smith & Polechla 2002, Bateman et al. 2009)

<i>Lutra canadensis</i>	
Estrus cycle	Monoestrus; can occur Nov-Jun based on latitude Post-partum elevations in estradiol levels occur 2 – 38 (ave. 19 ± 8.06) days after parturition (Bateman et al. 2009)
Estrus length	42-46 days unless mating occurs; "...the estrus phase of their cycles [N=11] was observed just once per year with an average duration of 15.33±1.98 days (range: 6–54 days). The average duration of estrus elevation coincident with observed breeding (n=4) was 22.00±1.22 days (range: 19–24 days)." (Bateman et al. 2009) Receptivity peaks roughly 6 days apart have been reported but not reflected in Bateman study. Unclear if they are induced ovulators (Bateman et al. 2009) but suspected;

Ovulation	may also ovulate spontaneously (Bateman et al. 2009)
Copulation frequency	Several times a day
Copulation duration	20-45 minutes, varied. One >60 min. reported
Copulation position	Dorsal/ventral most common, also ventro/ventral.
Copulation location	Most frequently in the water, also seen on land
Copulation initiated by	Both. Female advertises, cooperates only when she is ready. She may initiate with invitations to play chase.
Age at 1 st breeding	Sexually mature by 2 yrs. Several 2 yr. old males & a 1.5 yr. old female have bred successfully.
Breeding behavior	Female may rub, mark or vocalize to advertise; male/female may initiate w/ play, chase, splashing, genital sniffing, or “butterfly stroke”.
Gestation	<u>Total gestation</u> : 332-370 days, documented for 12 litters. 285-380 (Liers 1951); 302-351 (ave. 333.3 ±15.7) days (Bateman et al. 2009) <u>Actual gestation</u> : 68 – 73 (ave. 71.67±1.48) days (Bateman et al. 2009)
Pseudopregnancy	Pseudopregnancies seen with and without breeding and does not always result when breedings are unsuccessful. The period of elevated progesterone ranges from 68 to 72 days as in true pregnancies. (Bateman et al. 2009)
Pair management	Most facilities separate the male from the female, for his safety. A few leave the male in exhibit with female and she keeps him away from pups until they can swim well. One facility offered pair selection, females showed preference for certain males.
Group management	Sire can be reintroduced to female and pups after pups are swimming well. Generally done at about 3-6 months.
Signs of parturition	Females may show visible weight gain, teats may show through coat, increased nesting behavior, change in attitude to keeper &/or male. She may go off food as parturition nears.
Pupping boxes	Pupping boxes should be filled with dry bedding (straw or hay). A choice of birthing boxes should be available.
Contraception	MGA implants and PZP treatment in females. A few males have been neutered.

L. maculicollis: Schollhamer (1987) reported that females at the Brookfield Zoo came into estrus for the first time at about two years of age, but females typically do not conceive until they are three years old. Cycles vary between individuals, but average about 45 days, and estrus generally lasts 5-7 days. There is a postpartum estrus 2-3 weeks after parturition if pups are pulled or die soon after birth.

Males may attempt breeding at 1-2 years of age, but typically are not successful until they are 2-3 years old (Schollhamer 1987). Mating occurs in the water (Schollhamer 1987; R.Willison, personal communication), and involves the male neck biting the female and clasping her with his fore and hind limbs. Copulatory bouts may last up to 45 minutes, generally occur repeatedly over the course of several days (R.Willison, personal communication), and at any time during the day or night. There are no vocalizations associated with copulation in this species in captivity (R.Willison, personal communication) or in the wild (Reed-Smith in prep.). The rate of conception is increased if the male breeds the female for the entire 5-7 day cycle of a typical female; the conception rate is poor if the male only breeds the female for 2-3 days (Schollhamer 1987).

Gestation is roughly 60-63 days (R. Willison, personal communication). Captive births in North America have occurred in January/February and April (R. Willison, personal communication). Births in the wild were recorded during September, based on one year of observation in Tanzania (Proctor 1963); ongoing research in Tanzania substantiates this observation with breeding observed twice in June (2006 and 2007) which would result in late August to mid-September births. However, work by Bateman et al. (2009) and observations of half-grown animals throughout the year in Tanzania indicate that births may occur anytime with a peak during August/September. Further research is required.

Separation of sexes/conspecifics

If it is necessary to separate animals for reasons associated with reproduction (e.g., to promote or prevent it), a holding area connected to the exhibit is recommended; ideally this should include a pool with clean water available at all times, proper lighting, a sleeping or den box, enough floor space for grooming and drying areas, and at least one nest box that is heavily bedded to allow excess moisture to be removed from the animals' coats (Lombardi et al. 1998; Reed-Smith 2001). Holding pens should have non-climbable sides. If chain-link barrier are present, the sides should be covered with lexan or similar material to prevent animals from climbing too high and falling. See species-specific recommendations below.

A. cinereus: Females become very aggressive prior to parturition, and remain so post-parturition. It is not necessary to separate them from the male or older siblings. It is necessary to provide multiple nest boxes. The sire plays a very active role in rearing the pups, and should not be removed prior to their birth. Male behaviors include nest building, carrying pups, and bringing food to the pups during weaning. Access to pools and water sources should be strictly monitored to prevent newborns from drowning.

A. capensis: Pregnant females should be offered nest box choices and separated from the male to give birth (R. Meyerson, unpublished data). To date, records indicate two institutions have successfully bred this species in North America. One facility had one male with two females; both females bred and produced offspring. The other facility housed a pair. The animals were housed together 24 hours a day; females were separated to give birth at both facilities (Reed-Smith & Polechla 2002; R. Meyerson, personal communication). The male can be reintroduced to the female and pups when they are swimming well.

L. canadensis: There seems to be a mate preference for breeding with some females showing a definite preference for particular male, and lack of interest in others when they have a choice. Some successful zoos separate pairs for several months prior to the breeding season, introducing them every few days once the female's estrus begins. Others offer multiple mate selections to the females, and others have been successful keeping single pairs together year around. An extensive captive study (N=13.14 animals) attempted to determine breeding associated behaviors in captivity across the species over two years. The study's behavioral results show an increase in pair association, mutual grooming, and extended copulation in those pairs that reproduced successfully (N=3), but was inconclusive otherwise (J. Reed-Smith, data in preparation).

In the wild, males do not participate in pup rearing (Melquist & Hornocker 1983; Rock et al. 1994). In captivity, parturient females should be given privacy (particularly for primiparous females) and nest box choices supplied with plenty of dry bedding (all females). Males have been successfully left in the exhibit with parturient females in large exhibits that provide numerous visual barriers, and allow the male to stay out of the female's sight (e.g., St. Louis Zoo, Homosassa Springs, and others). In all other cases, the male and female should be separated prior to the birth to prevent injury to the male or neglect of the pups by the female. In multi-female groups, other females may also need to be separated from the parturient female. When separated, the male or non parturient female should not be required to pass the parturient female's den to enter the exhibit; if this cannot be done, the other animals should be removed entirely from the exhibit, or the female sequestered away until she deems it time for the pups to meet the male (see below). Males can be reintroduced to the female and pups once they are swimming proficiently, as early as 60-75 days or more typically by 80 to 90 days (Reed-Smith 2001).

Actual gestation is calculated at roughly 68-73 days (Bateman et al. 2009.); pair separation should occur either when the female becomes aggressive towards the male, or roughly 10-14 days prior to anticipated parturition date. Due to this species delayed implantation and total gestation time of >10 months, it is often difficult to anticipate delivery date, particularly for primiparous females. In these cases, staff should base their

management decisions on the female's behavior. If she becomes aggressive to the male or other exhibit mates, begins to show excessive nesting behavior, or spends increasing amounts of time in her nest box, the pair should be separated. It is important to remember that the female should be monitored for health issues during this time, as these behaviors also can be signs of illness.

Management changes should be scheduled so that they do not interfere with the birth and rearing of the pups. Any modifications to the exhibit should be finished several months prior to possible pupping season. Denning/nest box choices should be introduced at least one month prior to possible pupping season. Changes in management routines, e.g., closing the female in holding at night, closing her in holding alone, etc. should be introduced to the female at least a month prior to the possible parturition period to allow her time to become comfortable with the new routine. If the male will have to be removed from the exhibit entirely this should be done several weeks prior to possible parturition to allow the female a period of adjustment.

Generally, the best way to handle pair separation is setting up the female in off-exhibit holding (providing there is adequate space). Once the pups are old enough to begin swimming lessons (some females begin this instruction as early as 30 days, more typically at 40-50 days), the family group and the male can be alternated on exhibit. When the pups are swimming well, after about three months, the male can be introduced to the family group. This should be handled, as with any introduction, via olfactory, visual, and then physical introduction to the female alone first, and under controlled circumstances as far as possible (see Introduction/Reintroduction).

Nursery groups are not typical for this species. Helper otters have been reported from the wild. In these cases, a female with partially grown pups is accompanied by another adult female (Rock et al. 1994; R.Landis, personal communication). There are reports of two adults with young animals, but the relational composition of these groups is unknown (Reed-Smith 2001).

L. maculicollis: Females should be separated from the male at about gestation day 55 (gestation ranges from 60-63+ days calculating from the day of last observed breeding) (Schollhamer 1987), or when she shows signs of aggression towards the male (R.Willison, personal communication). Males should be separated from a pregnant/nursing female unless the exhibit is large enough for him to stay out of her line-of-sight. When separated, he should not be required to pass the female's den to enter the exhibit; if this cannot be done, he should be removed entirely from the exhibit, or the female sequestered away until she deems it time for the pups to meet the male. Females with pups are more of a danger to the male than typical males are to the pups. Males can be reintroduced to the female and pups once they are swimming proficiently and eating on their own, typically when the pups are roughly four months of age (R.Willison, personal communication).

Females should always be given a choice of denning sites with bedding provided for them to use if it is wanted. Schollhamer (1987) states that the Brookfield Zoo female spotted-necked otters did not use bedding of any kind. Kruuk (1995) references the presence of soft, leafy substrate or pebbles in most dens he or other researchers located. Brookfield Zoo used a nest box made from molded plastic and fiberglass measuring 68.6cm long x 51cm wide x 38.1cm high (27" x 20" x 15") with holes drilled in the bottom for drainage. The box was placed 4cm (1.5in) off the floor, and was accessed via a drop-guillotine door 25.4cm high x 20.3cm wide (10" x 8") (Schollhamer 1987). See Appendix A for a sample nest box.

Separation of mother-offspring

The timing of mother-offspring separations can have long-term effects on the development of otter pups, and on the reproductive success of adults. The following species-specific information is available:

A. cinereus: Adolescents are not forced from the group. In captivity, it is necessary to remove older offspring, as the group size can become quite large in a year leading to aggression resulting from over-crowding. Typically, the age at which older pups should be removed varies with the size of the exhibit and compatibility of the group.

A. capensis: The timing of emigration is unknown in the wild, but emigration of sub-adults at some point is presumed.

L. canadensis: Pups can be removed from the dam when weaned, if absolutely necessary. It is preferable that they be left with the family group until they are at least 8-9 months of age (Reed-Smith 2001), or six months old at a minimum. In the wild, pups will generally leave the female when they are 9 months to over one year of age (Melquist & Hornocker 1983; Melquist & Dronkert 1987).

L. maculicollis: No specific information on emigration is available, but pups should be left in the family group for at least 6-9 months, and be removed before reaching sexual maturity. Roving groups of what appear to be young animals, possibly dispersing and pups remaining with their mothers, or at least utilizing the same core area simultaneously for one year has been reported from the wild (Reed-Smith in prep).

Reproductive hormone tracking

Research utilizing techniques to identify reproductive state in these species is ongoing. At this time, it appears that ELISA protocols for testing hormonal secretions in fecal samples is successful in determining pregnancy in Asian small-clawed and North American river otters (Bateman et al. 2005, 2009). Pseudopregnancy has been reported for most otter species, and is an area that requires further research. Helen Bateman, at Cincinnati Zoo's Center for Research in Endangered Wildlife (CREW) and reproductive physiology advisor for the AZA Otter SSP should be contacted for more information: helen.bateman@cincinnati-zoo.org.

Facilities for reproduction

All expectant females should be provided with nest box choices that are located away from pools, and these should be well stocked with dry bedding. The size of these dens should allow ample room for bedding, pups, and for the female to turn around (*A. capensis*, *L. canadensis*, and *L. maculicollis*). Highly social species (*A. cinereus*) should be provided with a nest box or pupping den that allows enough room for the entire group.

A. capensis: Nest boxes 8-10cm (3-4in) wider and taller than those used for *L. canadensis* (see below) are suitable for this species. Nest box choices and plenty of bedding should be provided 2-3 weeks before expected parturition date to allow the female to become comfortable with them. At this stage, females show a weight gain in the axillary region (R.Meyerson, personal communication). Some females prefer to pup without the bedding, and will remove it from their nest box; in these cases, allow the female her choice.

L. canadensis: Due to delayed implantation (also known as embryonic diapause), it is difficult to determine when a female is near parturition; therefore, close attention should be paid to her behavior changes, appetite, and physical appearance. These may include, but are not limited to: aggression towards exhibit mates or keeper staff, refusal to leave holding or her den, increased or decreased appetite, obvious teat development, slow movements, more frequent floating in the pool, and lethargy.

Parturition boxes should be at least 50.8cm long x 45.72cm wide x 38.1cm high (20" x 18" x 15"), and be large enough for an adult animal to move around in, and for the pups. Slightly smaller boxes with entrance foyers have been used successfully. This box type allows the female to be secluded in a location near the pups but not actually with them. Females should be offered denning choices for parturition, and den choices of different sizes to allow for the growth of the pups.

Dimensions for a sample nest box are as follows: total width = 68.58cm (27in); chamber width = 48.26cm (19in); chamber depth = 45.72cm (18in); entrance foyer = 20.32cm (8in); entrance diameter = 16.5cm (6.5in), and 26.67-38cm (10.5-16in) high, with a 16.5cm (6.5in) height at the end of the ramp, and a 36.83cm (14in) height at the entrance to the ramp. The top is hinged on one side for easy lifting and cleaning. The ramp floor is made of wire mesh and the chamber floor should have drainage holes.

L. maculicollis: Spotted-necked females should be separated from exhibit mates prior to parturition at roughly day 55 of a 60-63 day pregnancy, (Schollhamer 1987), or when the female begins to show a tendency to keep the male or other group members away from her denning area (R.Willison, personal communication). Generally, females give birth to one pup, sometimes twins (Schollhamer 1987; R.Willison, personal communication).

Secured, sleeping dens (R. Willison, personal communication) or nest boxes that are 27" long x 20" wide x 15" high (68.6cm x 51cm x 38cm) have been successful (Schollhamer 1987). Typically, females do not use any nesting material, however, bedding should be offered to all females.

Females should be given rubber tubs in which to swim just prior to parturition (1-3 days), and for the first two months or so of the pup's life. The female will begin to bring the pup(s) out of the denning box when it is roughly 3-4 weeks old; at this point, she should start teaching pups to swim by placing them in the water tub for a few minutes at a time. It is important that the water level in tubs be kept high (which allows pups to hang on the lip), or that tubs/pools have a sloping ingress and egress so pups can get out of the water. While females are typically very vigilant, pups have suffered from hypothermia from being left too long in the water (Schollhamer 1987).

Several steps have been recommended to reduce stress to the reproductive pair and improve pup-rearing success in the giant otter (Sykes-Gatz 2005). With some modification, they also are applicable to all otter species:

- Build a positive keeper-animal relationship and allow only familiar staff to work with the otters prior to and after parturition.
- The provision of food and clean water should be accomplished with minimal disturbance to the otters during pup rearing.
- Cleaning should be minimal and not disruptive to the otters.
- Reduce stress as far as possible, including loud sounds, unfamiliar people, and the introduction of anything new to the exhibit.
- Prohibit visitor access to the enclosure area just prior to and following parturition. This step is particularly important for primiparous females. Nervous animals should be given privacy until the female begins to bring pups out of the den.
- Provide multiple nest box choices located in separate locations to allow female/parental choice according to their comfort level.
- Monitor the female's weight during the pregnancy; if the female becomes uncomfortable with this routine it should not be forced.
- Isolation of the natal den and limitation of all human activity in the vicinity prior to the birth and until staff determines the pair and young have bonded and the young are thriving is very important.
- Monitoring of the natal den and early pup rearing should be done from a hidden location or carried out via audio and video monitoring equipment with infrared capability.

Assisted Rearing and Fostering

Hand-rearing may be necessary for a variety of reasons: rejection by the parents, ill health of the mother, or weakness of the offspring. Careful consideration must be given as hand-rearing requires a great deal of time and commitment (Muir 2003). Before the decision to hand-rear is made, the potential for undesirable behavioral problems in a hand-reared adult should be carefully weighed (e.g., excessive aggression towards humans (rare in most otters), inappropriate species-specific behavior, etc.), and plans made to minimize deleterious effects on the development of natural behaviors as far as possible. This may require extensive time commitment on the part of staff, plans for fostering, relocation of the young to another facility, exposure to species-specific sounds, etc.

Pups that have been abandoned by their mother should be removed as soon as possible to prevent infanticide. See Chapter 6 for the AZA 'Neonatal Examination and Monitoring Protocol' which can be used as a template. Offspring that are not receiving milk will be restless, possibly calling continuously, may be hypothermic,

and scattered around the enclosure. Another indicator of trouble would be the female moving around the exhibit continuously while carrying the young; this could mean she is not comfortable with the denning provided, or there is a problem with her or the pups (Muir 2003).

If it is necessary to remove offspring because of an exceptionally large litter, it is best to remove two of the largest pups. The temptation is often to take the smallest, but they stand the best chance if raised by their mother. Hand-rearing of singletons is more likely to lead to severe imprinting on humans than if they have a conspecific to play with (Muir 2003). It is recommended that singleton pups being hand-reared be placed together, if at all possible. To date, fostering has been attempted once with otter pups and was successful. A pup was taken from a female with no milk and sent to another facility where their female was already nursing pups (Columbus Zoo and Beardsley Zoo). For additional information on this contact one of these facilities or lontracat@live.com.

Physical care protocol

Incubators provide the best source of warmth. Heat lamps are too intense and can be dehydrating. In an emergency, hot water bottles wrapped in a towel may be placed in a box with the pups nestled next to it, or they can be warmed slowly by placing them next to your body (Muir 2003). Pups may feel more secure if wrapped in layers of towels; this also aids in keeping them warm (Muir 2003). Pups should be dried after feeding/bathing to prevent hypothermia, until they are proficient at self-grooming. The normal body temperature for pups is unknown, but the animal should feel warm to the touch.

Altricial young are unable to self-regulate their body temperature during the early postnatal period, and require an external source of warmth. If an incubator is not used, it may be necessary to place a heating pad, set on low, under the housing container until the pups are able to thermoregulate. Meier (1986) and Wallach & Boever (1983) recommend 29.4-32.2°C (85-90°F) and 50-60% humidity as the desired incubator setting for neonate mustelids. The temperature should be gradually reduced to room temperature, 21.2-23.9°C (70-75°F), over the course of about three weeks (unless the neonate becomes ill). Litters of pups are less likely to need additional ambient heat since huddling together may provide an adequate amount of warmth. External temperatures must be closely monitored to prevent hyperthermia. Rapid and/or open-mouth breathing, restlessness, and hair loss are indication of an external environment that is too warm.

Pups should be stimulated to urinate and defecate at least 4-5 times each day for several weeks, generally before feeding. However, some animals may respond better to post-feeding stimulation. The genitals and anal area are rubbed gently with a finger, towel, or damp cotton to stimulate the baby to urinate and have a bowel movement. If pups do not urinate and/or defecate after two successive feedings, the formula should be reviewed and their health status evaluated immediately.

Specific environmental parameters, formula information, etc. for hand-rearing *L. canadensis* pups can be found in the North American River Otter Husbandry Notebook, 2nd Edition (Reed-Smith 2001).

Feeding amount and frequency

Initially, the animal should receive only an electrolyte solution for the first 2-3 feedings, depending on how compromised it is. This is to rehydrate the animal and clear the stomach of the maternal milk. The artificial formula should be started at a diluted concentration, generally at a 1:4 ratio (mixed formula:water) for another 2-3 feedings. It generally takes about 72 hours to get the animal on full-strength formula by gradually offering higher concentrations. Depending on the species, 4-5 feedings of each concentration level (1:2, 1:1, 2:1, full-strength) are required to allow for adaptation and to minimize the onset of digestive problems, particularly diarrhea. During the initial phase (24-36 hours), weight loss is to be expected, but the animal should quickly begin to maintain weight and then start gaining as the formula concentration increases. It is important that the pups are not given full strength formula too soon (in less than 48 hours after pulling for hand-rearing) because the likelihood of diarrhea is extremely high. Diarrhea is of particular concern with neonates less than one week of age, because they have very little or no immunity to infections.

Pups should have a normal body temperature and be properly hydrated before starting them on formula. Young mammals require a specific amount of calories per day for optimum development and growth. A nutritionally dense milk formula will allow for fewer feedings than more dilute formulas that are low in fat or protein. A method for calculating the volume of food to be offered per meal as well as total daily amount is presented below.

The Basal Metabolic Rate (BMR) or Basal Energy Requirement (BER) is the amount of energy (kcal) an animal needs for basic metabolic function at rest in a thermo-neutral zone. This represents the amount of calories it needs to stay alive, without having to use energy to maintain normal body temperatures (Grant 2004). Mustelids have a higher metabolic rate per body weight than many other placental mammals. For that reason, Iversen's equation of $84.6 \times \text{body weight (in kg)}^{0.78}$ (Iversen 1972) is used rather than Kleiber's equation of $70 \times \text{body weight (in kg)}^{0.75}$ (Kleiber 1947) typically used for other species. Therefore, for a 200g river otter, the BER would be: $84.6 \times 0.2^{0.78} = \sim 24 \text{ kcal/day}$.

Once the BER is established, the Maintenance Energy Requirement (MER) can be calculated. This measurement determines the amount of calories the animal needs to function in a normal capacity at its life stage. For adults in a maintenance life stage, the BER is multiplied by 2. For pups that have a higher metabolism and are developing and growing, the BER is multiplied by 3 or 4 (Evans 1985), depending on the species and other factors.

The stomach capacity for most placental mammals is 5-7% of the total body weight (Meehan 1994). Convert the body weight into grams to find the stomach volume in ml (cc). To calculate the stomach capacity in ounces, convert body weight into grams (30g \sim 1 oz). It is important that units are the same for body weight and stomach volume. The stomach capacity is the amount of formula an infant can comfortably consume at one feeding. Offering much more than this value may lead to overfilling, stomach distension, and bloat. It also prevents complete emptying of the stomach before the next feeding, and promotes the overgrowth of potentially pathogenic bacteria, diarrhea, and enteritis (Evans 1985).

The following calculations will determine the total volume and kcal to feed/day, as well as the amount of formula for each feeding and the total number of feedings daily.

- Calculate Maintenance Energy Requirement: $84.6 \times \text{body wt (kg)}^{0.78} \times 3$.
- Determine stomach capacity (amount that can be fed at each meal): $\text{Body weight (in grams)} \times 0.05$.
- Divide Maintenance Energy Requirement (number of calories required per day) by the number of kcal/ml in the formula to determine the volume to be consumed per day (this can be converted into ounces by dividing it by 30).
- Divide ml of formula per day by volume to be consumed at each meal (stomach capacity). This gives the number of meals to offer per day.
- Divide 24 hours by the number of feedings/day to find the time interval between feedings.
- See Table 1 next page.

Table 1: Calculations for formula volume and feeding frequency for neonate with an approximate birth weight of 135g (MER = Maintenance Energy Requirement)

Step 1: calculate MER	$84.6 \times 0.135\text{kg}^{0.78} \times 3$	$\sim 53 \text{ kcal/day}$
Step 2: determine stomach capacity	$135\text{g} \times 0.05$ (stomach capacity of 5% body weight)	$\sim 7\text{g (ml)}$ per feeding
Step 3: calculate daily volume fed	$\frac{53 \text{ kcal/day (MER)}}{1.78 \text{ kcal/ml (formula contents)}}$	$\sim 30\text{ml/day}$
Step 4: number of feedings	$\frac{30\text{ml/day (total volume fed)}}{7\text{ml/feeding (stomach capacity)}}$	4.2 feedings/day (=5)
Step 5: feeding schedule	24 hrs/5 feedings	Every 5 hours

New calculations should be performed every few days so formula volume can be adjusted to accommodate growth. The general target average daily gain for infants is 5-8% increase of body wt/day while on

formula feeding and 8-10% body wt increase/day on weaning diet (Grant 2005). Since neonates being hand-reared (less than one week of age) are typically severely compromised, they should be given smaller, more frequent feedings than calculated until roughly 2-4 weeks of age.

As a general rule, animals should have an overnight break between feedings that are no longer than twice the time period between daytime feedings (equivalent to missing one feeding). For example, if they are being fed every three hours during the day, they can go six hours at night without food. When they are eating every four hours, they can go eight hours at night. It is not advisable to go more than eight hours between feedings with species that typically nurse throughout the day when mother-raised. Intervals between feeding also will depend on how healthy or strong the infants are. Very weak neonates will probably need feedings every few hours even through the night; typically this is necessary for only a few days to a week. Initially, pups should be fed every two hours around the clock. Depending on how the animal is doing, these feedings may be stretched to every three hours after the first few weeks.

Otter pups should only be fed if the pup is hungry and suckling vigorously. Weak infants may be hypothermic, dehydrated and/or hypoglycemic. Do not offer anything by mouth until the body temperature is within the normal range for its age (i.e., warm, not hot, to the touch). Electrolytes can be offered orally if the pup is suckling, or subcutaneously if it is too weak and 2.5-5% dextrose can also be given to raise the pup's glucose level. More research is required to determine body temperature norms for young of all the otter species. This information should be collected by all facilities hand-rearing otter pups and offered to the AZA Otter SSP or other zoo/aquaria organizations tracking captive otter information. Young animals will be hungry at some feedings, less at others, but this is quite normal (Muir 2003). However, refusal of two feedings is a sign of trouble in young otters. Pups will not die from being slightly underfed, but overfeeding may result in gastrointestinal disease, which is potentially fatal.

If any animal's formula is changed abruptly, it is likely to cause diarrhea, which can dehydrate the pup quickly. Any formula changes should be made slowly, by combining the formulas and gradually changing the ratio from more of the first to more of the second. If an animal develops diarrhea or becomes constipated with no change having been made in the formula, consult the veterinarian. In general, adjusting the formula ratios should be attempted before medicating the animal. For diarrhea, increase the ratio of water to all the other ingredients. Be sure the water has been boiled or sterilized well, and the bottle is clean. Subcutaneous fluids (e.g., lactated ringers) may be needed if the infant dehydrates significantly.

Feeding techniques

To bottle feed, hold the pup in the correct nursing position; sternally recumbent (abdomen down, not on its back), with the head up. Place the hand holding the bottle in such a way that it provides a surface for the pup to push against with its front feet. If milk comes through their nose, the nipple hole may be too large or the pup may be trying to eat too quickly. Make sure there is consistency with who is feeding the pups. Note any changes in feeding immediately. Decreased appetite, chewing on the nipple instead of sucking, or gulping food down too quickly can be signs of a problem (Blum 2004).

It is important to keep in mind that neonates are obligate nose breathers and incapable of breathing through their mouths and nursing at the same time. For this reason, respiratory infections can be life threatening because they may interfere with breathing and make nursing difficult or impossible (Meier 1985). Aspirated formula is frequently a contributing factor to neonatal respiratory infections; to avoid this be sure to select the appropriate nipple. The nipple's hole needs to suit the neonate's sucking reflex. Also, if a nipple is too stiff, the pup may tire and refuse to nurse.

If an animal aspirates fluids the recommended protocol is to hold the infant with head and chest lower than the hind end. A rubber bulb syringe should be used to suck out as much fluid from the nostrils and the back of the throat as possible. If aspiration is suspected, or if fluid is heard in the lungs, contact the veterinarian immediately; do not administer drugs without the veterinarian's involvement. Monitor body temperature closely for the occurrence of a fever and a decline in the animal's appetite and general attitude. Depending on the condition and age of the animal, diagnostic procedures may include radiographs, CBC, chemistry. It is possible to start a course of antibiotics while results from the bloodwork are pending, and the attending veterinarian can prescribe an appropriate antibiotic course.

Pups will need to be stimulated to urinate and defecate for roughly the first six weeks of life, either immediately before or after feeding.

A.cinereus: Pups may be slow to learn how to suckle from a bottle, in one case taking eight days before suckling without aspirating (Webb 2008). Care should be taken to ensure that the nipple's hole is not too large and that pups are fed slowly at the beginning. For additional information see Webb 2008 (also available online at www.otterspecialistgroup.org/Library/TaskForces/OCT.html).

Hand-rearing formulas

It is important that the artificial milk formula matches the maternal milk in protein, fat, and carbohydrate composition as closely as possible. Table 2 provides information on the nutritional content of otter milk, and Table 3 provides information on the nutritional composition of selected substitute milk formulas/replacers.

Table 2: Otter (*Lutra spp.*) Milk Nutrition Composition on As Fed (AFB) and Dry Matter Basis (DMB) (Ben Shaul 1962; Jenness & Sloan 1970)

Species	Solids %	Kcal (ml)	Fat %	Protein %	Carb. %
Otter	38.0	2.6 (AFB)	24.0 (AFB) 63.2(DMB)	11.0 (AFB) 28.9(DMB)	0.1 (AFB) 0.3 (DMB)

Esbilac[®] (or Milk-Matrix[®] 33/40) is preferred as the base for milk formulas offered to otters, and provides good pup growth. The addition of Multi-Milk[®] (or Milk-Matrix[®] 30/55) increases the total fat and protein without adding substantially to the carbohydrate content of the formula. The maternal milk composition of otter milk only has a trace amount of milk sugars, so this component of the substitute formula must be kept as low as possible to prevent gastric upset and diarrhea. See Table 3 next page.

Table 3: Nutritional analysis of commercial animal milk replacers

Product	Solids %	Fat %	Protein %	Carbohydrates %	Ash %	Energy (KCAL/ML)
Esbilac						
Undiluted powder	95.00	40.00	33.00	15.80	6.00	6.20
Diluted 1:3*	15.00	6.00	4.95	2.38	0.90	0.93
Diluted 1:1.5*	30.00	12.00	9.90	4.76	1.80	1.86
Liquid product	15.00	6.00	4.95	2.38	0.90	0.93
KMR						
Undiluted powder	95.00	25.00	42.00	26.00	7.00	5.77
Diluted 1:3*	18.00	4.50	7.56	4.68	1.26	1.04
Diluted 1:1.5*	36.00	9.00	15.12	9.36	2.52	2.07
Liquid product	18.00	4.50	7.56	4.68	1.26	1.04
Multi-Milk						
Undiluted powder	97.50	53.00	34.50	0	6.63	6.85
Diluted 1:1*	22.70	12.00	7.83	0	1.51	1.55
Diluted 1.5:1*	36.00	19.59	12.75	0	2.54	2.47
Evaporated Milk						
Undiluted product	22.00	7.00	7.90	9.70	0.70	1.49
Multi-Milk:KMR+						
1:1*	22.81	8.93	8.71	3.20	1.55	1.45

3:1*	22.90	10.97	8.63	1.54	1.59	1.57
4:1*	22.90	10.90	8.27	1.17	1.50	1.51
1:3*	22.70	7.28	9.10	4.39	2.30	1.37
1:4*	22.60	6.95	9.16	4.68	1.57	1.36
Multi-Milk:KMR++						
1:1*	34.22	13.40	13.07	4.80	2.33	2.18
3:1*	34.55	16.46	13.03	2.31	2.39	2.36
4:1*	34.55	16.35	12.41	1.76	2.25	2.28
1:3*	34.05	10.92	13.65	6.59	3.45	2.06
1:4*	33.90	10.43	13.74	7.02	2.36	2.04
Multi-Milk:Esbilac+						
1:1*	22.81	10.63	7.70	1.78	1.44	1.49
3:1*	22.93	11.63	8.00	0.89	1.52	1.56
4:1*	22.90	11.60	7.86	0.71	1.49	1.55
1:3*	22.70	9.81	8.75	2.67	2.13	1.51
1:4*	22.60	9.65	7.54	2.84	1.39	1.43
Multi-Milk:Esbilac++						
1:1*	34.22	15.95	11.55	2.67	2.16	2.24
3:1*	34.40	17.45	12.00	1.34	2.28	2.33
4:1*	34.35	17.40	11.79	1.07	2.24	2.33
1:3*	34.05	14.72	13.13	4.01	3.20	2.28
1:4*	33.90	14.48	11.31	4.26	2.09	2.15

* Ratio of powder to water; + Ratio of powder-to-powder, diluted 1 part powder to 1 part water; ++ Ratio of powder-to-powder, diluted 1.5 parts powder to 1 part water (Evans 1985)

The addition of an anti-gas build-up product to the formula should be considered (milk sugars can cause the build-up of gas). Lact-aid[®] is an enzyme that has been used successfully with many species. Add two drops of Lact-aid[®] to 100ml of mixed formula. The formula then must be refrigerated for 24 hours prior to feeding for the enzyme to perform correctly (Grant 2005). *Lactobacillus* spp., in Bene-bac[®] or Probios[®], are a group of beneficial gut bacteria that also break down milk sugars in the digestive tract. Follow label instructions for these products.

Table 4: Substitute milk formulas for otters. Values taken from product composition documents available from PetAg™ (K.Grant, personal communication)

Formula	% Solids	% Fat	% Protein	% Carb	Kcal/ml
Formula #1 1 part Esbilac [®] or Milk Matrix [®] 33/40 1 part Multi-Milk [®] or Milk Matrix [®] 30/55 2 parts water	30.9	15.6	10.5	2.7	1.78
Formula #2 1 part Multi-Milk [®] or Milk Matrix 30/55 [®] 1 part water	31.3	17.8	10.4	1.1	1.91

L. Canadensis: At this time the preferred formula is canned Esbilac[®] due to palatability and good pup growth. Milk Matrix[®] based formulas also are nutritionally suitable but some facilities have had pups refuse this formula (Blum 2004), while others have had good success.

Weaning

The weaning process should be started when the pup shows interest in solid food, generally at about eight weeks of age. If the pup is not gaining enough weight on formula alone, solid food can be added at six weeks of age (this may need to be pureed or chopped). To begin, formula can be mixed with AD diet (canned cat food or similar), baby food, mashed up fish, rice cereal, or ground meat. New food can be added to the bottle; feed this mixture with a syringe, baby bottle, or offer it in a bowl. Only add one new food component to their diet every couple of days until they are eating solids well. It is best to be creative, flexible, and not to rush the weaning process. In the case of problems, try different approaches, try them multiple times, and try foods in new ways like bottles, syringes, suction bulbs, bowls, etc. Do not cut back on bottle-feeding to make the pup “hungry”. Offer new food at the beginning of the feeding and finish with the bottle (Blum 2004). Situations to watch for during the weaning process include (Blum 2004): a) weight loss; b) diarrhea; and c) sucking behavior. If sucking on tails, feet, genitals, etc. is observed between feedings, an additional bottle-feeding should be offered for a few days. R. Green of the Vincent Wildlife Trust recommends putting orange oil on the genitals to discourage sucking; this worked well with *Lutra lutra* and is not harmful to the otter (G.Yoxon, personal communication).

Swimming, terrestrial activities, and behavioral stimulation

Otter pups are not born knowing how to swim, and may even be scared of the water. They will usually start to take interest in the water at 4-8 weeks of age. The pups should be started off in shallow pools, and watched carefully; once comfortable, they can gradually be introduced to deeper water. Pups should be dried off completely and warmed after their swim.

Enrichment is crucial to the development of the pups; toddler safe toys, grooming materials, dens, climbing structures, live food, etc. have all been used successfully. The more items they are introduced to at an early age, the more they will interact with as they age. All toys must be safe and approved by the veterinary staff. The suitability of toys should be regularly re-evaluated, as some may no longer be safe as the otter grows. Due to the tendency of all otters to take things into the water, the use of cardboard or other paper-type items, especially for young animals, is not recommended. Cases of these items becoming water logged and congealing in an animal’s mouth or over their nose have been reported.

Pup development

The following information provides a summary of pup development. More specific information can be found in the Otter Husbandry Manuals (Lombardi et al. 1998; Reed-Smith 2001). See Appendix C for pup weight charts.

A. cinereus:

- Eyes begin opening at between 17 and 28 days, fully open by day 45
- Teeth begin erupting about day 20 and canines erupting ~ day 91 (Webb 2008)
- Thermo regulating well on their own about day 38 (Webb 2008)
- Moving on their own between day 39 and day 50
- Urinating and defecating on their own (hand reared animals) by day 59 (Webb 2008)
- Generally born with mostly grayish fur, darkens by 6-7weeks
- Solid food 7-8 weeks; weaned 82-120 days
- Hand reared animals eating solid well by day 92 and weaned on day 130 at a weight of 2336 grams (Webb 2008)

A. capensis: At this time there is no information available on pup development. More research is required.

L. maculicollis: Pups are born with white on their lips. After a few days, patches of white/orangish colored hair develop on their chest or groin area. These patches change to an orange color, before changing back to cream or white as the pups reach full growth or maturity. The age at which these color changes occur appears is highly variable and is currently being documented (D.Benza, personal communication; R.Willison, personal communication).

- First spots seen ~6 days, whitish but turned orange in a few days. More orange spots developed by day 42
- Eyes open at 34-46 days
- First crawling at about 20 days, crawling well 42 days
- First teeth erupting at 23-29 days, all teeth in ~78 days
- Walking well at ~ 37 days, running 59 days
- Leaving den on own at about 57 days
- Playing in water bowl ~ 61 days
- First going in to water on their own at about 57-91 days; variation comes from water tub versus pool exploration
- First pool swimming lessons ~ 86 days (timing may be due to when family is allowed into the exhibit)
- First eat solids at about 60-73 days

L. canadensis: Consult the North American River Otter Husbandry Notebook 1st & 2nd editions for more detailed information (Reed-Smith 1994, 2001).

- Birth weight: 120-135g
- Born blind with dark brown fur
- External ears are flat against the head, and claws and toe webbing are well formed.
- Deciduous upper and lower canines erupt at about 12 days
- Eyes fully open at 28-35 days
- Walking at about 35-42 days, first swimming lesson generally at 28-56 days
- Beginning to play ~25-42 days
- Leaving nest box on their own ~49 days
- Pelt change 28-56 days, born with all dark fur
- First solid food taken at 42-56 days
- Localized latrine use ~49 days
- Pups should be weaned by 3-4 months of age

Contraception

The information in this section is all taken from recommendations made by the AZA Wildlife Contraception Center (2008). In addition to reversible contraception, reproduction can be prevented by separating the sexes or by permanent sterilization. In general, reversible contraception is preferable because it allows natural social groups to be maintained while managing the genetic health of the population. Permanent sterilization may be considered for individuals that are genetically well-represented or for whom reproduction would pose health risks. The contraceptive methods most suitable for otters are outlined below. More details on products and application can be found on the AZA Wildlife Contraception Center (WCC) webpage: www.stlzoo.org/contraception.

The progestin-based melengestrol acetate (MGA) implant, previously the most widely used contraceptive in zoos, has been associated with uterine and mammary pathology in felids and suspected in other carnivore species (Munson 2006). Other progestins (e.g., Depo-Provera[®], Ovaban[®]) are likely to have the same deleterious effects. For carnivores, the AZA Wildlife Contraception Center now recommends GnRH agonists, e.g., Suprelorin[®] (deslorelin) implants or Lupron Depot[®] (leuprolide acetate) as safer alternatives. Although GnRH agonists appear safe and effective, dosages and duration of efficacy have not been systematically evaluated for all species. GnRH agonists can be used in either females or males, and side effects are generally those associated with gonadectomy, especially weight gain, which should be managed through diet. Suprelorin[®] was developed for domestic dogs and has been used successfully in African clawless otters, North American river otters, Asian small clawed otters and sea otters.

Gonadotropin releasing hormone (GnRH) agonists

GnRH agonists (e.g., Suprelorin[®] implants or Lupron Depot[®]) achieve contraception by reversibly suppressing the reproductive endocrine system, preventing production of pituitary (FSH and LH) and gonadal

hormones (estradiol and progesterone in females and testosterone in males). The observed effects are similar to those following either ovariectomy in females or castration in males, but are reversible. GnRH agonists first stimulate the reproductive system, which can result in estrus and ovulation in females or temporary enhancement of testosterone and semen production in males. Then, down-regulation follows the initial stimulation. The stimulatory phase can be prevented in females by daily Ovaban administration for one week before and one week after implant placement (Wright et al. 2001).

GnRH agonists should not be used during pregnancy, since they may cause spontaneous abortion or prevent mammary development necessary for lactation. They may prevent initiation of lactation by inhibiting progesterone secretion, but effects on established lactation are less likely. New data from domestic cats have shown no effect on subsequent reproduction when treatment began before puberty; no research in prepubertal otters has been conducted.

A drawback of these products is that time of reversal cannot be controlled. Neither the implant (Suprelorin®) nor the depot vehicle (Lupron®) can be removed to shorten the duration of efficacy to time reversals. The most widely used formulations are designed to be effective either 6 or 12 months, but those are for the most part minimum durations, which can be longer in some individuals.

Although GnRH agonists can also be an effective contraceptive in males, they are more commonly used in females, because monitoring efficacy by suppression of estrous behavior or cyclic gonadal steroids in feces is usually easier than ensuring continued absence of sperm in males, since most institutions cannot perform regular semen collections. Suprelorin® has been tested primarily in domestic dogs, whereas Lupron Depot® has been used primarily in humans, but should be as effective as Suprelorin®, since the GnRH molecule is identical in all mammalian species.

If used in males, disappearance of sperm from the ejaculate following down-regulation of testosterone may take an additional 6 weeks, as with vasectomy. It should be easier to suppress the onset of spermatogenesis in seasonally breeding species, but that process begins at least 2 months before the first typical appearance of sperm. Thus, treatment should be initiated at least 2 months before the anticipated onset of breeding.

Progestins

If progestins (e.g., Melengestrol acetate (MGA) implants, Depo-Provera® injections, Ovaban® pills) have to be used, they should be administered for no more than 2 years and then discontinued to allow for a pregnancy. Discontinuing progestin contraception and allowing non-pregnant cycles does not substitute for a pregnancy. Use of progestins for more than a total of 4 years is not recommended. MGA implants last at least 2 years, and clearance of the hormone from the system occurs rapidly after implant removal. Progestins are considered safe to use during lactation.

Vaccines

The porcine zona pellucida (PZP) vaccine has not been tested in otters but may cause permanent sterility in many carnivore species after only one or two treatments. This approach is not recommended.

Ovariectomy or ovari hysterectomy

Removal of ovaries is a safe and effective method to prevent reproduction for animals that are eligible for permanent sterilization. In general, ovariectomy is sufficient in young females, whereas, removal of the uterus as well as ovaries is preferable in older females, due to the increased likelihood of uterine pathology with age.

Vasectomy

Vasectomy of males will not prevent potential adverse effects to females that can result from prolonged, cyclic exposure to the endogenous progesterone associated with the pseudo-pregnancy that follows ovulation. This approach is not recommended for otters.

CHAPTER 8: Behavior Management

Animal Training

Otters are excellent candidates for behavioral training programs (See Appendix A for target and crate training photo) focusing on routine and non-routine husbandry tasks, such as shifting, weighing, entering squeeze cages or crates, stationing for close visual inspections or injections, etc. Standard positive reinforcement behavioral training techniques are used successfully on river otters at numerous facilities. As far as possible, all animals should routinely shift into a holding area and readily separate into specific holding areas on cue. Animals should be trained to come to the keeper when called for daily health checks, and remain calm and not aggressive during these checks.

Keepers should avoid use of aversive stimuli in the daily management of otters. Profound aversive stimuli such as squirting with hoses, loud noises, harsh words, and long-term withholding of food are inappropriate unless serious injury of keeper or animal is imminent (e.g., serious fight). In general, otters respond to profound aversive stimuli with fear and/or aggression. It is best to maintain positive and pleasant keeper/animal interactions. Assessing the animal's motivation (e.g., why should it "want" to come in? Why does it "want" to stay outside? What is the animal's motivation, and how does it relate to the animal's behavior in the wild?) are useful exercises when training problems occur. Patience and planning are keys to success (Wooster 1998). See Table 13 for a list of commonly trained otter behaviors, as well as relevant cues and criteria. Successful training programs include those that involve establishing training goals set by the entire staff. These goals include a list of behaviors that facilitate desired husbandry procedures. Goals are accomplished by developing training plans that define training steps, cues, and criteria for the desired behaviors. Progress of training plans should be monitored and evaluated. Once desired behaviors are achieved, they should be maintained with practice on a regular daily basis. See Appendix D for additional training information and Appendix F for training resources.

Otters can be trained through positive reinforcement for almost all behaviors required for husbandry procedures, whether it is routine or a not-so common event. Non-routine husbandry behaviors can include procedures such as hand injection, ultrasound, nipple manipulation/milk collection (for larger species in particular), and tactile body exams. A *P. brasiliensis* female was successfully trained to allow manual milk pumping and ultrasounds to detect pregnancy and uterine condition (Gatz 2002). Giant otters also have been trained to allow tactile body exams, the taking of body temperature, weight, heart and respiration rates, as well as to participate in other husbandry procedures (Sykes-Gatz 2005). The size of the giant otter may make the milking process easier in this species but other otter species should be trained to participate in the other husbandry procedures mentioned.

Otters respond quickly to voice commands via operant conditioning. Training can be done on or off exhibit. Otters respond to a protected contact and free contact situation. In general, the otter species should be trained in a protected contact situation (i.e., keeper and animal should be separated by a mesh barrier). Exhibits should be designed with mesh at a particular area specifically for training. There are some species (*A. cinereus*) or cases (*L. canadensis* particularly males) where an institution feels that protected contact training may not be called for, but these decisions should be carefully evaluated on an ongoing basis. If institutional philosophy permits, otters can be a part of an educational talk or keeper talk in a free contact area within their exhibit.

It is recommended that all facilities have holding areas in order to shift animals into/out of their primary enclosure. Husbandry training may occur anywhere the individual animal seems to feel comfortable, and where the keeper can safely access them. Managers and caretakers should decide if food rewards can be hand fed, or if a meat stick should be used to deliver the food.

The following table (Table 13) provides some examples of husbandry training cues and criteria for behaviors trained with otters at various AZA institutions. Mckay (2009) describes some basic approaches to training otters.

Table 13: Sample behaviors & training cues for otters (provided by: *Indianapolis Zoo; **Bronx Zoo; ***Toledo Zoo; ^Santa Barbara Zoo; ^^Point Defiance Zoo; & +Oklahoma City Zoo)

Behavior	Verbal cue	Visual cue	Criteria for reinforcement
Down *	“down”	Hand flat in front of abdomen- moved in a downward motion	Animal lays down quietly
Up *	“up”	Index finger moved in upward motion to place you want them to target to	Animal moves to position of index finger
Up ^	“up”	Left index points into the air	Animal stands up
Stand **	“up”	Use left hand and give the thumbs- up sign	Otter keeps both back feet on the ground while standing up against the cage. Front feet should be hanging onto target pole place against the bars.
Kennel *	“in”	Index finger used to point into the kennel	Animal goes in kennel and allows door to be closed
Entering a crate **	“box”	Hand begins in fist in front of chest. As command is said, swing arm out and up in direction of the box and open hand into a high five.	Animal will enter crate and lie down at the far right end. Animal will wait in position until bridged.
Squeeze/Crate ***/^^	“crate”	Target into squeeze cage or point to crate	Animal enters and allows the door to be closed
Crate +		Hand placed on chain link near back of crate	Animal enters and stands in the crate, tail completely in
Scale *	“scale”	Index finger used to point to scale	Animal gets on scale & waits
Target *	“here”	Closed fist presented to front of mesh	Nose placed at position of fist
Target **	“target”	Hold up target pole	Animal grabs with both hands without biting – ASC otters
Target ***/^	“target”	Show target pole	Nose placed on target and holds until bridged
Target +		Show 15’ broom handle on fence	Put nose to target
Stay **	“stay”	Right hand palm down and out. While in this position, push slightly toward animal while saying verbal cue.	Animal stands/sits still while trainer moves away and returns
Stay/remote stay ^	“stay”	Hold hand up, palm towards the animal Hold fist up	Animal stays calmly
Hold	“hold”	Hand cue	Animal stays in place

Behavior	Verbal cue	Visual cue	Criteria for reinforcement
^^ Lying parallel to cage front	"lie"	Palm flat out and facing down. Sweep arm in direction animal should face.	Animal lays down parallel to and touching cage front. Remains calm and quiet until bridged.
Shift	"over"	Arm begins up and parallel to chest, index finger pointed up. (Use arm that is in the direction you want the animal to shift. Move arm and corresponding foot in a sweeping motion indicating the direction you want the animal to go).	The animal goes to the area indicated, comes to front of cage, stands quietly with eyes on trainer
Come in *	3 whistles- flat tone	None	Animal moves in to location of person whistling
Recall +	Clicker		Animal moves off exhibit to catch area
Station **/^^	None	Trainer stands in specified location with hands at their sides, beginning of training set	Animal comes to the front of the cage, stands quietly with their eyes on the trainer
Station ^	-----	Point using two fingers of either hand to station desired	Animal moves to the spot and stays calmly
Follow	"come"	Say come and walk in direction you want the animal to go	The animal follows and stops directly in front of the trainer
Foot present	"toes"	Begin with right arm up parallel to body, index and middle fingers pointed up. Extend arm straight down (palm side down) continuing to point both fingers.	Animal should place both feet under the bottom of cage while lying down in front of trainer. It should be lying still and focused on the trainer.
Paw	"paw" "right" "left"	Visual signal for stand; point or target foot wanted.	Cue each foot to right or left, can use target or catch less dominant foot when opportunity rises; most have dominant foot they learn easily.
Ultrasound **	"up"	Cue as for up, trainer body can be low	Same as stand, animal should wait while being touched on abdomen with pole or wand.
Ultrasound ***	"touch"	Show wand	Otter stands on back legs and touches target with nose while abdomen/kidneys ultrasounded through cage mesh.
Paint ***	"paint"	Show painting apparatus	Animal grabs paint brush and puts paint on canvas.
Nipple presentation	"nipple"	Target up while standing on hind legs. Slowly reach with fingers	Animal presents chest or abdomen against cage mesh for

Behavior	Verbal cue	Visual cue	Criteria for reinforcement
*** Ventral present +		extended, toward otter Target placed high on fence	manipulation Animal climbs fence until all feet off the ground and ventrum placed on fence
Jumping into the pool **	“water”	Use right hand with food in it. Start with hand in a fist in front of chest. With a sweeping motion, move fist up to cage. Arm should be parallel. Open hand palm up and out. Tap cage with palm to push the food into the pool	The animal should jump into the water to retrieve food.
Water ^	“water”	Right hand motions towards the water	Animal goes in the water
Circle ^	“circle”	Make a circle with right hand	Animal turns in a circle
Steady ^	“steady”	Verbal cue only	Used to keep the animal calm during tactile body examination

Environmental Enrichment

Development of enrichment ideas should be goal-oriented, proactive, based upon the animal’s natural history, individual history, and exhibit constraints, and should be integrated into all aspects of their captive management. Providing the appropriate enclosure designs (e.g., land/water ratios, pool/land designs), substrates, and furnishings for each otter species are essential components of any enrichment program. Enrichment should encourage otters to behave as they would in the wild, as closely as possible. Successful enrichment techniques include, variation of exhibit schedule or exhibit mates (where appropriate only), re-arranging of exhibit furniture/features, complete change of furniture (some of the old should always be retained to maintain the animal’s scent and an element of the familiar), scents, sounds, toys (natural and artificial), herbs, spices, different substrates for digging/rolling, food items, and novel presentation of food items. It is important that enrichment items are not merely thrown in an exhibit and allowed to stay for extended periods – an enrichment program is only successful and useful if actively managed and constantly reviewed to ensure it encourages natural behaviors. The AAZK Enrichment committee provides the follow general guidelines about enrichment:

“The goal of enrichment should be to maximize the benefit while minimizing unacceptable risks. All enrichment should be evaluated on three levels: 1) whether the enrichment item itself poses an unacceptable risk to the animals; 2) what benefit the animals will derive from the enrichment; and 3) whether the manner of enrichment delivery is apt to lead to problems.

A written plan of action that eliminates the most dangerous risk factors while maintaining the benefits of a challenging and complex environment can help animal managers develop a safe and successful enrichment program. Keepers should evaluate new and creative enrichment ideas with their managers and staff from other departments (curatorial, janitorial, maintenance, veterinary, nutritional, etc.) to decrease the frequency of abnormal and stereotypic behaviors or low activity levels, and to fine-tune enrichment ideas. For enrichment to be safely provided, it is strongly recommended that each institution establish enrichment procedures, protocols, and a chain of command that keepers can follow.” (AAZK Enrichment Committee)

The AAZK Enrichment Committee also provides an excellent cautionary list for the various types of enrichment provided (accessed through www.aazk.org). This list includes key questions that should be answered for all enrichment items or programs to assess potential hazards. For example:

- Can the animals get caught in it or become trapped by it?

- Can it be used as a weapon?
- Can an animal be cut or otherwise injured by it?
- Can it fall on an animal?
- Can the animal ingest the object or piece of it? Is any part of it toxic, including paint or epoxy?
- Can it be choked on or cause asphyxiation or strangulation?
- Can it become lodged in the digestive system and cause gut impaction or linear obstruction?
- In a multi-species exhibit or other social grouping, could a larger or smaller animal become stuck or injured by the object or get hung up on it?
- Can it destroy an exhibit?
- If fecal material is used for enrichment, has it been determined to be free from harmful parasites?
- Is food enrichment included as part of the animals' regular diet in a manner that will reduce the risk of obesity?
- When introducing animals to conspecifics or in a multi-species exhibit, are there sufficient areas for them to escape undesirable interactions?
- Can the manner of enrichment presentation (i.e., one item or items placed in a small area) promote aggression or harmful competition?
- Has browse been determined to be non-toxic?
- Do animals show signs of allergies to new items (food, browse, substrates)?
- Does the enrichment cause abnormally high stress levels?
- Does the enrichment cause stimulation at a high level for extended periods of time that do not allow the animal natural down time in the species' normal repertoire (e.g., constant activity for public enjoyment when the animal would normally be inactive in its native habitat)?

AAZK Enrichment Committee, Enrichment Caution List

Dietary Enrichment

- Food enrichment, if uncontrolled, can lead to obesity, tooth decay and deviation from the normal diet can cause nutritional problems. Keepers can consult with the nutritionist or commissary staff to determine the best method of introducing novel food items.
- New food items introduced without analysis may cause colic, rumenitis or metabolic acidosis in ungulates.
- Food items can spoil and cause animal illness if left in the exhibit for extended periods of time. Enrichment food items should be removed within a reasonable amount of time to prevent spoilage.
- Animals can have adverse reactions to toxic plants and chemicals. Keepers should be able to correctly discern between toxic and browse plants, ensure that browse is free of fertilizers and herbicides and wash plants to remove free ranging bird and animal feces and debris.
- Foraging or social feedings may give rise to aggression and possible injuries within the animal population.
- Competition for enrichment items may lead to social displacement of subordinate animals. These concerns can be minimized by providing enough enrichment to occupy all of the animals within the population.
- Carcass feedings for omnivores and carnivores may be hazardous if the source of the carcass is not determined and appropriate precautions taken. Diseased animals, chemically euthanized animals or those with an unknown cause of death are not appropriate for an enrichment program. Freezing the carcasses of animals that are determined to be safe to feed to exhibit animals can help minimize the risk of parasitism and

disease. Providing enough carcasses in group feedings can minimize competition and aggression within an exhibit.

- Carefully introducing a group of animals to the idea of social feedings can be done by moving carcass pieces closer together at each feeding until the animals are sharing one carcass. This can allow social carnivores to exhibit normal dominance posturing while minimizing the possibility of aggression. During live feedings, prey animals may fight back. Care should be taken to ensure such prey can only inflict superficial wounds on zoo animals.
- Cage furniture may interrupt flight paths or entangle horns and hooves if poorly placed. Careful planning can prevent this.
- If unsecured, some items may fall on an animal or be used as a weapon and cause injuries.
- If position is not thoughtfully considered, limbs and apparatus may provide avenues for escape or may block access into exhibit safety zones, leaving subordinate animals feeling trapped and vulnerable.
- Animals that crib or chew wood should be provided with non-toxic limbs and untreated wood furniture.
- Water features should be tailored to the inhabitants to prevent drowning and ensure that animals such as box turtles can right themselves if they flip over on their backs.
- Animals can be injured in filtration systems if water intake areas are not protected.
- Substrates should provide adequate traction and not cause an intestinal impaction if ingested.
- Caution should be exercised when ropes, cables, or chains are used to hang or secure articles to prevent animals from becoming entangled. Generally, the shortest length possible is recommended. Chain can be covered with a sheath such as PVC pipe; swivels can be used to connect the chain to the enrichment item to minimize kinking.

Olfactory Enrichment

- Scents from different animals or species can lead to aggression if there is an assertion of dominant animals or subordinate animals attempting to use enrichment to advance their status in the hierarchy.
- Animal feces used for olfactory enrichment should be determined to be parasite free through fecal testing and as with other animal by-products such as feathers, sheds, wool and hair, come from only healthy animals. Many of these items can be autoclaved for sterilization.
- Perfumes can be overwhelming to some animals (and keepers) and are therefore best used in open, ventilated areas.
- Some spices may be too strong or toxic to some animals.

Auditory Enrichment

- When provided with audio enrichment, animals may be less threatened by deflected sounds rather than those directed at the animals.
- Some animals may have adverse reactions to recordings of predator calls and should be closely observed when this type of enrichment is provided.
- Providing the animals with an option for escape or the means to mobilize for confrontation when predator calls are played can lessen the stress of this type of enrichment and allow the animals to investigate the sounds and their environment over a period of time.

Manipulable Enrichment

- Individual parts or enrichment devices may be swallowed resulting in choking or asphyxiation.
- If ingested, indigestible enrichment items may cause a gut impaction or linear obstruction.
- Broken items may have sharp edges that can cut an animal. Only items that are appropriate for the species should be provided. For example, some devices will hold up to the play of a fox but not a wolf
- When building or designing enrichment items from wood, it may be wise to use dovetail cuts and glue rather than screws and nails. Rounded corners and sanded edges can prevent the animals from getting splinters.
- Many paints and other chemicals are toxic if eaten. When providing enrichment involving paint or other chemicals, only non-toxic items should be used.
- If used, destructible items such as cardboard boxes and paper bags should be free of staples, tape, wax, strings or plastic liners. In general the Otter SSP advises against using these items.

Factors that should be considered when determining how often behavioral or environmental enrichment is offered include the species and individual(s) involved as well as the physical characteristics of the exhibit. Large, complex exhibits with appropriate enclosure designs, substrates, and furnishings may offer ample opportunities for animals to exercise natural behaviors with infrequent enrichment (once daily). Other exhibits or individuals may require more frequent enrichment (multiple times per day). Husbandry staff should monitor all individuals in an exhibit and structure an enrichment schedule for the needs of those animals, providing them opportunities several times a day to interact positively with their environment. Enrichment should never be offered on a regular schedule, instead times, items, and delivery methods should be rotated so there is always an element of novelty associated with each item or activity. It is important to note that the provision of well-designed, complex environments is the foundation of a successful enrichment program. This is particularly true for some of the more sensitive otter species such as *P. brasiliensis*, but applies to all of the otter species due to their inquisitive nature and high-activity level.

More information: Appendix E provides a list of enrichment initiatives used at several institutions housing mustelids/otters; Appendix F provides a list of enrichment resources. All enrichment items should be approved by the appropriate management staff, including the veterinarian, curator, horticulturist, and/or nutritionist. Appendix G provides a list of resources for enrichment and training.

Staff and Animal Interactions

Otters are easily trained, and work well for positive reinforcement. Trained management and veterinary care behaviors include: weighing, crating, foot inspection, tooth inspection, injections, abdominal presentation and palpation, and tail inspections. It should be kept in mind that otters are capable of inflicting severe bites (particularly sexually mature females and have been known to turn on their trainers). In general, otters should be trained in a protected contact situation (i.e., keeper and animal should be separated by a mesh barrier). There are some species (*A. cinereus*) or cases (*L. canadensis* particularly males) where an institution may feel that protected contact training may not be called for, but these decisions should be carefully evaluated on an ongoing basis.

Keeper safety should be kept in mind when designing otter exhibits. Animals should be shifted off exhibit for cleaning, maintenance, etc. Animal safety should be considered and exhibits constructed, as far as possible, that prohibit the public from throwing potentially harmful items or food into the animals' space.

Staff Skills and Training

The following skills are recommended for all animal caretakers involved in the management of captive otters:

- Keepers and managers should have an in-depth understanding of the species natural history and the individual's history.
- Keepers and managers should have an in-depth understanding of the individual's behaviors, an understanding of the function of those behaviors, and the ability to describe those behaviors orally and in writing.
- Keepers should be able to recognize signs of illness and injury in the otter species they are working with and to communicate those signs orally or in writing to managers and veterinarians.
- Keepers should be able to accurately assess the appropriate level of cleanliness and safety of the animal's exhibit, holding area, and food-prep area.
- Keepers should have the skills to safely capture or restrain the otter species in question.
- Keepers should have some understanding of the species natural diet and foraging style.

- Keepers and managers should have an understanding of enrichment concepts and have a commitment to consistently enhance the environments of the species in their care.
- Keepers should understand the concepts of animal learning and training, be able to use a variety of techniques (e.g., habituation, operant conditioning) to train the animals under their care, and to create a training plan (identifying training steps, cues, and criteria). See www.animaltraining.org for additional information.
- Managers should understand the concepts of animal learning and training, be able to coach keepers in all aspects of training, review their training plans, look for consistency among keepers in their training techniques, and help their teams prioritize training, enrichment, and other husbandry goals.
- Keepers and managers should have an understanding of the enclosure conditions and husbandry practices needed to maintain the otters' physical and behavioral health, as well as to promote a successful pup-rearing environment.

CHAPTER 9: Education/Conservation Messages and Tools

Conservation Messages

Otters are excellent conservation and wildlife ambassadors; they are appealing to the public, active, and represent well the issues faced by many of the small carnivores.

African spotted-necked otter:

"Spotted-Necked Otters are very aquatic and require permanent water sources with high fish densities. They prefer larger rivers, lakes and swamps with open areas of water. They appear to only make use of fresh water habitats. Because they mainly hunt by sight, they need clear, unpolluted water where there are numerous small fish, or fish, crabs and frogs. Long reeds, grass and bushes are essential to provide cover, and holes or other shelters are also needed. The most suitable habitat is the large fish-rich African lakes and the deep, clear areas of Botswana's Okovango.

"The distribution is large, but with some local declines. It occurs in all countries south of Sahara, from Senegal to Ethiopia and south to the Cape provinces where there is suitable habitat.

"The main threat throughout the range is habitat destruction by land drainage or pollution in response to increasing human population density, and direct persecution as competitors for fish. There is some hunting for bushmeat and ceremonial practices. In some lakes, introduced large fish such as Nile Perch out compete the small fish, which comprise the otters' historic food base, reducing prey availability.

Although international and national level legal protection is in place, enforcement is needed. There is a need for increasing local awareness of the species." (IUCN Otter Specialist Group)

The population is considered to be decreasing and there are some indications that pressure from traditional medical uses, bushmeat consumption, and persecution as competitors for fish on some populations (Lake Victoria) may be increasing (J.Reed-Smith, personal knowledge).

Asian small-clawed otter:

"Small-Clawed Otters prefer shallow water, with a good food supply, and moderate to low bankside vegetation. They demonstrate a high climatic and trophic adaptability, occurring from tropical coastal wetlands up to mountain streams. They make use of freshwater and peat swamp forests, rice fields, lakes, streams, reservoirs, canals, drainage ditches, rice paddies, mangroves, tidal pools, and along the coastline. In mountainous areas, they frequent swift-flowing forest streams with rocks and boulders. Their preferred food is crustaceans and molluscs. Across much of their range they are sympatric with Eurasian Otters (*Lutra lutra*), Smooth-Coated Otters (*Lutrogale perspicillata*) and Hairy-Nosed Otters (*Lutra sumatrana*), and there is clear evidence of niche separation between the species.

"Although the species' range appears large, in the last decade, actual distribution has shrunk, especially in the west, compared to historical records. They are currently found from the Himalayan foothills of Himachal Pradesh eastward throughout south Asia, extending up to Philippines and down through Indonesia.. A small isolated subpopulation has been reported from southern Indian hill ranges of Coorg (Karnataka), Ashambu, Nilgiri and Palni hills (Tamil Nadu) and some places in Kerala. They were formerly found in Sri Lanka, but their current status there is unknown. The only areas in which these animals are today known to be common are Peninsular Malaysia, especially in Kedah, and in the western forests and southern marshes of Thailand.

"The main threat throughout Asia is habitat destruction because of deforestation (loss of the smaller hill streams), agriculture (especially tea and coffee plantations in India, draining of peat swamp forests, and destruction of coastal mangroves for aquaculture) and settlement. Water courses are being polluted with pesticides from plantations and other intensive agriculture, and heavy metals, affecting the gill-feeders on which this species depends, and interfering directly with otter physiology. Prey biomass is also being reduced by overexploitation, and the vast aquaculture industry regards otters as pests and persecutes them directly.

"Although international and national level legal protection is in place, local legislation is needed. The impact of protection measures on livelihoods needs to be assessed and answered. Habitat protection and inter-population corridors need to be established. Research on all aspects of this species biology and ecology is needed." (IUCN Otter Specialist Group web site)

The population is considered to be decreasing.

North American river otter:

This species also is referred to as the Nearctic otter, whatever you call it; the river otter represents a North American conservation success story. From a historic high when their range extended throughout most of North America river otter populations fell until:

“During the late 1800’s and early 1900’s, the synergistic effect of wetland destruction, pollution, and overexploitation for furs was devastating to North American river otter populations. Additional otter losses were due to road kills, accidental drowning in fishing nets and ‘incidental take during beaver trapping’.” (Foster-Turley et al. 1990)

By the 1970’s, Nilsson & Vaughn (1978) estimated that the river otter was found in only 33% of its former range. They listed the causes of this as: intensive trapping, pollution, destruction of habitat by clearing land, draining marshes, and channelizing streams. However, since 1976 over 4,000 otters have been reintroduced in 21 states and provinces throughout their former North American range (including Canada).

As a result of conservation and reintroduction measures the river otter has reoccupied much of its former range (it is still considered locally vulnerable, endangered, or extinct in some states and provinces). Many states and provinces where the populations were never threatened or have recovered allow a sustainable harvest of this species for fur. While, “current harvest strategies do not pose a threat to maintaining otter populations; harvest may limit expansion of otter populations in some areas. Oil spills present a localized threat to otter populations, especially in coastal areas. Water pollution and other degradation of aquatic and wetland habitats may limit distribution of otters and pose long-term threats if enforcement of water quality standards are not maintained and enforced. Acid drainage from coal mines is a persistent water quality problem in some areas that eliminates otter prey and thereby inhibits recolonization or expansion of otter populations. Recently, there has been discussion of the long-term genetic consequences of reintroduction projects on remnant otter populations (Serfass et al. 1998). The threat of disease to wild otter populations is poorly understood and has received little study (Serfass et al. 1995). Similarly, many perceived threats to otters such as pollution and habitat alterations have not been rigorously evaluated. Additional research is needed to clearly delineate the impact that various forms of water pollution, agricultural and other development along riparian habitats, industrial and housing development in coastal areas, cumulative impacts related to loss or alterations of wetlands, large flood control structures, and interactions that these and other factors have on otter populations. Threats to otter populations in North America vary among regions and are influenced by type, distribution, and density of aquatic habitats and characteristics of human activities.” (IUCN Otter Specialist Group)

Recently concern has been growing that river otters are being demonized as voracious eaters of sport-fish species; this position has been used to justify elimination of river otters from some watersheds to placate special interest groups. Some research has been conducted on the percentage of sport fish species taken by river otter that indicates the true impact is not as great as claimed by many (Hamilton, 1999 & unpublished 2004) See Appendix G. The impact of river otter on sport-fish populations and the growing characterization of the river otter as the primary cause of localized falling fish populations is something that should be researched and monitored.

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APPENDIX A: Photos

Included here are a sampling of photos representing exhibit and management approaches discussed in this document. It is the goal of the OCT to create a photo album that will contain more detail in these areas.

EXHIBITS

Otter Zentrum, Hankensbüttel, Germany – *Lutra lutra* exhibit. This enclosure offers multiple enrichment opportunities for the otters and a glimpse of the otters natural habitat.



Nearctic otter in a tree. All enclosure plantings should be removed from proximity to the perimeter containment.



Lincoln Park Zoo, Chicago, Illinois, USA – *L. canadensis* exhibit. This represents good use of a small space, varied substrates and exhibit levels. The other photos show the indoor and outdoor off-exhibit holding.



This photo shows one of the next boxes used at Otter Zentrum. The box faces up to a hole in the wall accessing the exhibit. It can be removed from the wall and used as a transport crate. Access for cleaning is from the top.



Squeeze cage design used by several facilities for otters. The otters can easily be trained to enter the crate on cue then hand injected or transported to the medical facility.



Target training an otter (Indianapolis Zoo, Indianapolis, Indiana, USA)

APPENDIX B: Description of Nutrients (US National Library of Medicine)

Protein: Protein is the main building blocks of animal structure on a fat-free basis. In addition to being an important constituent of animal cell walls, protein is one of the nutrients responsible for making enzymes, hormones, lipoproteins, and other crucial elements needed for proper bodily functions. Protein also is essential for building and repairing body tissue, as well as protecting the animal from harmful bacteria and viruses. Furthermore, protein aids in the transportation of nutrients throughout the body and facilitates muscle contractions. The requirements for crude protein are effectively requirements for dietary amino acids. The requirements are based on the needs of the animal, the quality of the protein, the source of the protein, and the digestibility of the protein available.

Fat: Dietary fat plays an important role in the manufacture of certain hormones. It also plays a crucial role in a wide variety of chemical bodily functions. Also, fat functions as a concentrated energy source, serves as a carrier for fat-soluble vitamins (Vitamins A, D, E, and K), and provides essential fatty acids. The requirements for fat are effectively requirements for dietary fatty acids.

Vitamin A: Vitamin A is a fat-soluble vitamin essential for maintaining good vision and healthy mucous membranes. It contributes to the differentiation and growth of skin tissue and bone formation (including teeth), as well as bone remodeling in growing animals, and glycoprotein synthesis. Vitamin A can improve skin and hair/fur conditions, help to increase resistance to certain infections, and improve fertility in both genders. In many cases, a vitamin A requirement is effectively a requirement for carotenoids (precursors to vitamin A).

Vitamin C (Ascorbic Acid): Vitamin C is a water-soluble antioxidant, which plays an important role in biochemical oxidation-reduction reactions, as well as in the formation of collagen, an important protein needed for the formation of skin, scar tissue, tendons, ligaments, and blood vessels. Because of this, Vitamin C is crucial to an animal's ability to heal wounds and repair and or maintain cartilage, teeth, and bones. It also may reduce infection by increasing immunity.

Vitamin D: Vitamin D is a fat-soluble vitamin necessary for active calcium absorption, calcium metabolism and resorption from bone. Requirements for vitamin D can be totally or partially met by exposure to sunlight or artificial UV light (vitamin D is biosynthesized in the skin of animals or in some plant cells upon exposure to the appropriate wavelength of UV light; 285-315nm).

Vitamin E: Vitamin E is a fat-soluble antioxidant that helps to maintain the structure of cellular and subcellular membranes by preventing oxidation of unsaturated fatty acids. It also protects tissues from free radicals, which are substances known to harm cells, tissues, and organs. Vitamin E is essential in the formation of red blood cells and aids the body in Vitamin K utilization.

Thiamine (B-1): Thiamine is a water-soluble vitamin, which functions as a necessary coenzyme in carbohydrate metabolism (converting carbohydrates into energy) and is hypothesized to play a role in nerve or neuromuscular impulse transmission. Thiamine also is important in the proper functioning of the heart, muscles, and the nervous system.

Riboflavin (B-2): Riboflavin is a water-soluble vitamin. It functions in two coenzymes: Flavin adenine dinucleotide or "FAD" and flavin mononucleotide. Riboflavin is important for growth and the production of red blood cells. It also helps the body to release energy from carbohydrates. Microbial synthesis of riboflavin occurs in the gastrointestinal tract of some animals, but synthesis appears to be dependent on the type of animal and the source of dietary carbohydrate.

Niacin (Nicotinic Acid): Similar to Riboflavin, niacin is a water-soluble vitamin which functions in two coenzymes: Nicotinamide adenine dinucleotide or "NAD" and nicotinamide adenine dinucleotide phosphate or "NADP". Niacin plays a crucial role in assisting the normal functioning of the digestive, skin, and nerve systems. Like riboflavin,

niacin helps the body to convert energy from food. The niacin requirement of many animals theoretically could be satisfied by synthesis of the vitamin from the amino acid tryptophan. However, removal rate of an intermediate in the pathway to create niacin is often so rapid that virtually none is produced.

Pyridoxine (B-6): Pyridoxine also known as B-6 is a water-soluble vitamin, which aids the body in the synthesis of antibodies by the immune system. It also plays a role in the formation of red blood cells and helps to promote healthy nerve functions. Pyridoxine is required to produce the chemical activity necessary for protein digestion.

Choline: Choline is an essential nutrient, which contributes to the function of nerve cells. It is a component (helps to form phosphatidylcholine, the primary phospholipid of cell membranes) of the phospholipid lecithin (found in cells throughout the body) and is critical to normal membrane structure and formation. It also functions as a “methyl donor”, but this role can be completely replaced by excess amounts of the amino acid methionine in the diet.

Folacin (Folate, Folic Acid, B-9, Pteroylglutamic Acid): Folacin, or folate, is a water-soluble vitamin, which assists the body in the formation of red blood cells. It also plays a major role in the formation of genetic material (synthesis of DNA, the hereditary and functioning blueprint of all cells) within all living cells. Folacin functions as a coenzyme, which is important at the cellular and subcellular levels in decarboxylation, oxidation-reduction, transamination, deamination, phosphorylation, and isomerization reactions. Working in conjunction with Vitamin C and B-12, Folacin assists in digestion and protein utilization and synthesis. This vitamin may be used to increase appetite and stimulate healthy digestive acids.

Vitamin B-12: Vitamin B-12 is a water-soluble vitamin, which functions as a coenzyme in single carbon and carbohydrate metabolism. In addition to playing a role in metabolism, B-12 assists in the formation of red blood cells and aids in the maintenance of the central nervous system.

Pantothenic Acid: Pantothenic acid is a water-soluble vitamin and part of the B vitamin complex. It is needed to break down and use (metabolize) food. Pantothenic acid also is needed for the synthesis of both hormones and cholesterol.

Calcium: The mineral calcium (in association with phosphorus) is a major component of the body and is largely associated with skeletal formation. It is important in blood clotting, nerve function, acid-base balance, enzyme activation, muscle contraction, and eggshell, tooth, and bone formation and maintenance. It is one of the most important minerals required for growth, maintenance, and reproduction of vertebrates.

Phosphorus: In addition to acting as a major component of the body and being largely associated with skeletal and tooth formation (in conjunction with calcium), phosphorus is involved in almost every aspect of metabolism (energy metabolism, muscle contractions, nerve function, metabolite transport, nucleic acid structure, and carbohydrate, fat, and amino acid metabolism). Phosphorus is needed to produce ATP, which is a molecule the body uses to store energy. Working with the B vitamins, this mineral also assists the kidneys in proper functioning and helps to maintain regularity in heartbeat.

Magnesium: Magnesium is a mineral, which serves several important metabolic functions. It plays a role in the production and transport of energy. It also is important for the contraction and relaxation of muscles. Magnesium is involved in the synthesis of protein, and it assists in the functioning of certain enzymes in the body.

Potassium: Potassium is a mineral that is involved in both electrical and cellular functions in the body. (In the body it is classified as an electrolyte.) It has various roles in metabolism and body functions. Potassium assists in the regulation of the acid-base balance and water balance in blood and the body tissues. It also assists in protein synthesis from amino acids and in carbohydrate metabolism. Potassium is necessary for the building of muscle and for normal body growth, as well as proper functioning of nerve cells, in the brain and throughout the body.

Sodium (salt): Sodium is an element, which the body uses to regulate blood pressure and blood volume. Sodium also is critical for the functioning of muscles and nerves.

Iron: Iron is a trace element and is the main component of hemoglobin (oxygen carrier in the blood), myoglobin in muscles (oxygen carrier with a higher affinity for oxygen than hemoglobin), and many proteins and enzymes within the body. It also functions in immune defenses against infection.

Zinc: Zinc also is a trace element that is second only to iron in terms of concentration within the body. Zinc plays an important role in the proper functioning of the immune system in the body. It is required for the enzyme activities necessary for cell division, cell growth, and wound healing. It plays a role in the acuity of the senses of smell and taste. Zinc also is involved in the metabolism of carbohydrates. Zinc is essential for synthesis of DNA, RNA, and proteins, and it is a component or cofactor of many enzyme systems.

Manganese: Manganese is essential for carbohydrate and lipid metabolism, for synthesis of one of the precursors to cartilage formation, and for proper bone formation. Manganese plays a key role in the growth and maintenance of tissues and cartilage, specifically proper bone development. It particularly aids in development at the ends of bones where new bone formation takes place. This therefore helps to reduce the risk of osteoporosis. Manganese also helps to produce certain hormones, metabolizes fat, and is part of superoxide dismutase (SOD) an antioxidant. Studies on humans have shown that manganese also may lower the frequency of epileptic seizures and enhance immune functioning.

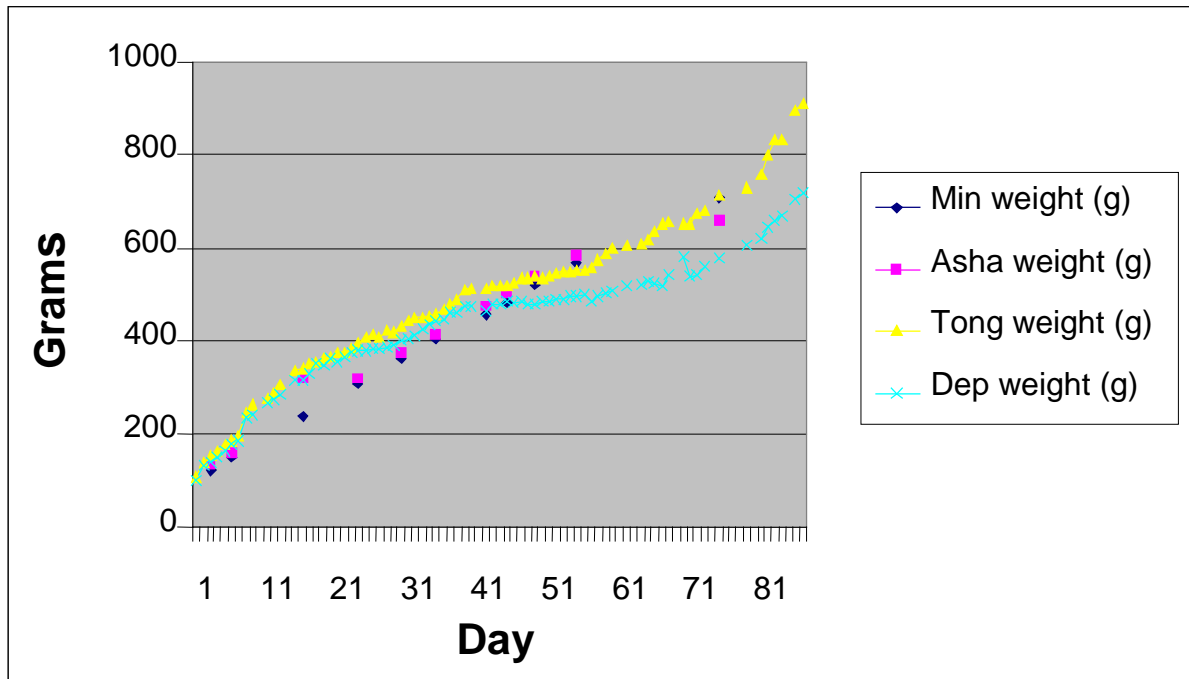
Copper: Copper is an essential trace mineral present in all body tissues. Copper, along with iron, helps in the formation of red blood cells. It also helps in keeping the blood vessels, bones, and nervous and immune systems healthy.

Selenium: Selenium is an essential trace element. It is an integral part of enzymes, which are critical for the control of the numerous chemical reactions involved in brain and body functions. Selenium has a variety of functions. The main one is its role as an antioxidant in the enzyme selenium-glutathione-peroxidase. This enzyme neutralizes hydrogen peroxide, which is produced by some cell processes and would otherwise damage cell membranes. Selenium also seems to stimulate antibody formation in response to vaccines. It also may provide protection from the toxic effects of heavy metals and other substances. Selenium may assist in the synthesis of protein, in growth and development. In humans, selenium has been shown to improve the production of sperm and sperm motility.

Iodine: Iodine is a trace mineral and an essential nutrient. Iodine is essential for the normal metabolism of cells. It is a necessary nutrient for the production of thyroid hormones and normal thyroid function.

APPENDIX C: Pup Weights of Captive Bred Otters

Asian-small clawed otter (*A. cinereus*) pup weights (mother-reared) at Indianapolis Zoo (N = 1.3)



Spotted-necked otter (*L. maculicollis*) pup weights (mother-reared) at Phoenix Zoo N=1.0

Age in days	Weight (kg)	Age in days	Weight (kg)
28	0.75	98	1.9
35	0.95	107	1.9
42	1.2	113	1.95
49	1.4	120	2.1
56	1.5	127	2.7(after eating)
65	1.6	134	2.5
72	1.65	140	2.6
77	1.8	148	2.5
84	1.75	155	2.45
91	1.9	-	-

North American river otter (*L. canadensis*) pup weights (mother-reared). Data taken from AAZK Zoo Infant Development Notebook 1994, Little Rock Zoo, Grassmere Wildlife Park, John Ball Zoo (Reed-Smith 2001).

Males (N = 9)				Females (N = 8)			
Age/days	Weight (g)	Age/days	Weight (kg)	Age/days	Weight (g)	Age/days	Weight (kg)
1	110-170	32	0.992-1.03	1	170	32	0.971
2	177-184	33	0.998-1.09	2	177	33	-
3	193-220	34	1.08-1.11	3	198	34	1.01
4	204-241	35	1.11-1.14	4	213	35	1.05-1.15
5	241-276	36	1.13-1.19	5	248	36	1.06
6	249-298	37	1.16-1.18	6	262	37	1.09-1.23
7	266-333	38	1.20-1.25	7	298	38	1.13
8	280-354	39	1.23-1.28	8	333	39	1.15-1.30
9	325-376	40	1.28-1.34	9	347	40	1.23
10	353-404	41	1.35-1.36	10	383	41	1.28
11	364-425	42	1.32-1.41	11	397	42	1.25-1.35
12	398-453	43	1.35-1.39	12	411	43	1.28
13	414-475	44	1.40-1.43	13	439	44	1.35
14	496	45	1.45-1.57	14	454	45	1.39
15	531-539	46	1.52-1.62	15	489	46	1.43
16	499-574	47	1.43-1.62	16	517	47	1.34-1.48
17	595	48	1.59-1.69	17	546	48	1.46-1.60
18	617-624	49	1.59-1.67	18	560	49	1.58
19	624-645	50	1.69-1.79	19	609-685	50	1.62
20	666-680	51	1.62-1.74	20	637	51	1.56
21	687	52	1.67-1.87	21	652	52	1.53
22	765-780	53	1.74-1.88	22	660-730	53	1.62
23	780-808	54	1.74-1.92	23	723	54	1.64
24	810-843	55	1.71-1.96	24	758-850	55	1.66-1.81
25	822-858	56	1.54-1.68	25	720-795	56	-
26	829-872	57	1.71-2.03	26	772	57	1.93
27	850-872	58	1.87-2.10	27	794	58	1.76
28	865-910	59	1.90-2.06	28	815-900	59	1.80
29	907-921	60	1.52-2.12	29	872	60	1.86-1.70
30	935-978	61	1.97-2.15	30	907	61	1.84-2.33
31	971-1000	62	1.96-2.24	31	928-1060	62	1.88

APPENDIX D: List of Commonly Trained Behaviors for Otters

(Adapted from AAZK Animal Training Committee)



Commonly Trained Behaviors for: Mustelids, Procyonids, and Viverrids

Purpose of the list and source of the data:

The following list of behaviors was derived using data from a 2003 survey conducted by the American Association of Zoo Keepers Animal Training Committee (AAZK, ATC). The goal of the survey was to census the existence and depth of training programs for species in AZA facilities. For each species trained, each respondent was asked to list trained behaviors, types of reinforcement and conditioned reinforcers used. Additional information about facility design, training tools, and general comments was also requested.

Survey results pertaining to the list of behaviors:

219 AZA facilities were surveyed. There were 71 respondents. 31 of these train species within the Mustelid, Procyonid and Viverid taxonomic group. Because many similarities were found within taxonomic groups, commonly trained behaviors were compiled to serve as a reference for animal training programs. Of the 31 respondents that train within this group, the percentage that train each behavior is listed next to the behavior.

Facility Differences and Individual Animals:

Not every behavior will work for every animal. The appropriateness of a behavioral goal for an individual will depend on management policy and building design of the facility, as well as the needs and disposition of the animal.

The ATC hopes that this data will aid in the design of training programs for the Mustelid, Procyonid, and Viverrid taxa. Where appropriate, these commonly trained behaviors can greatly enhance the husbandry of species in this group. For questions or comments about this list or the Trained Behaviors Survey, please contact the AAZK Animal Training Committee at www.aazk.org. See next page for chart.



Animal Training Committee AAZK, Inc.

Commonly Trained Behaviors for: Mustelids

MUSTELIDS (Behavior and % of responding institutions)

Otter (river, small-clawed, & sea)

Shifting	83%
Separations	66%
Target	79%
Scale	59%
Squeeze entry/crate	76%
Anal/genital present	7%
Back	10%
Belly	21%
Ears	7%

Otters (continued)

Eyes	14%
Head presentation	14%
Mouth	21%
Paws/feet	52%
Sides	10%
Oral meds	21%
Brushing teeth	3%
Injection w/ syringe	7%
Stethoscope	3%
In-water behaviors	31%
Vocalization	7%
Stay (hold)	10%
Retrivals	17%
Station	59%
Fecal Collection	7%
A to B	10%
Climb	24%
Flashlight	7%
X-ray	3%
Ophthalmoscope	3%
Blood collection	3%

Skunk (striped and spotted)

Shifting	33%
Separations	17%
Target	67%
Scale	33%
Harness training	17%
Crate/Squeeze entry	83%
Nail trim	33%
Back	17%
Belly	17%

Skunk (continued)

Paws/feet	33%
Tactile desensitization	50%
Station	17%

Badger

Shifting	100%
Target	0
Scale	0

Wolverine

Belly	50%
Paws/feet	50%
Separations	100%
Shifting	100%
Station	50%
Squeeze/crate	50%
Flashlight desensitization	50%
Scale	50%

APPENDIX E: Enrichment Items Commonly Provided to Otters

Natural	Exhibit Furniture	Non-edible manmade	Live Food	Edibles
- Soil, sand, mulch	- Climbing areas (available in all exhibits, i.e., cliffs, ledges)	- Boomer balls and other products like the "spoolie", "bobbin" & "ice cube".	- Fish (smelt, shiners, goldfish, trout, mackerel, tilapia salmon)*	- Ice blocks w/fish, fish-sicles, fish cubes, etc.
- Grass, wheat grass, sedges, etc.	- Logs (on land, submerged, floating; hollow and/or solid)	- Ice blocks, cubes, pops.	- Crayfish	- krill cubes, clam cubes, etc.
- Trees	- Rocks (not artificial)	- Snow & ice	- Crickets	- Frozen or thawed sand eels
- Vines "vine hoops"	- Stream	- PVC cricket feeder	- Giant mealworms	- Fish pieces
- Aquatic plants	- Sticks	- Buckets	- Earthworms	- Chicken necks
- Hay, straw, grass, leaves, wood wools as bedding	- Browse (leafy branches on land and/or floating)	- Blankets, burlap, non-fraying rags, towels	- Freshwater clams	- Mice
- Grass piles	- Slides	- Barrels of water	- Mussels	- Whole-fish -frozen or thawed
- Leaf piles	- Tunnels	- Frisbees	- Krill	- Whole apples/oranges
- Rocks, all sizes for play and manipulation	- Stream bed	- Tubs of water	- Eels- naturally found	- Fruit & berries incl. grapes, blueberries, strawberries
- Knot holes	- Running water	- Carpet over board	- Shrimp	- Small pumpkins and squash
- Bark sheets	- Holts	- Rubber-coated heating pad*	- Aquatic insects - naturally found	- Omnivore biscuits
- Pine Cones	- Jacuzzi-like jets in pool	- Astro turf	- Mice- naturally found	- Chub
- Mud	- Islands in pool	- Floating plastic toys	- Frogs – naturally found	- Minnows
- Sod	- Bridges made from logs, etc.	- Phone books	- Grubs	- Bluegill
- Bank over-hangs	- Stumps	- Swim through plastic ring	- Chub	- Clams
- Floating wood	- Natural fiber mat	- Kids puzzle balls, billiard balls, hard balls	- Minnows	- Mud minnows
- Blocks	- Movable sand box	- Pieces of PVC pipe and fittings	- Frogs – naturally found	
- Pine needles	- Logs brought from other exhibits	- Kong chews	- Grubs	- Chub
- Other animal urines	- Log ladder	- Metal bowls and pans	- Chub	- Minnows
- Powdered scents and herbs	- Non-sprayed evergreen trees	- Plastic tubs and bottles	- Chub	- Bluegill
- Fresh herbs	- Moving soil pots	- Bread tray	- Chub	- Clams
- Extracts, i.e., vanilla, etc.	- Hanging logs with holes for food	- Plastic slide, house	- Chub	- Mud minnows
- Grapevine balls	- Snow piles	- Stock tank	- Chub	
- Shells	- Piles of ice cubes	- Hanging tub*	- Chub	
- Turkey feathers		- Warm water hose	- Chub	
- Corn stalks		- Vari-kennel tubs with substrates	- Chub	
- Blowing bubbles into exhibit		- PVC tube hung for climbing in	- Chub	
- Kudzu vines			- Chub	
- Cow hooves			- Chub	

The table below lists items used at various North American facilities for behavioral and environmental enrichment of otters.

* These items should be monitored for safety.

The following list provides more examples of enrichment initiatives offered to otters at the Point Defiance Zoo and Aquariums and Columbus Zoo and Aquarium:

Point Defiance Zoo and Aquarium – ASC otter

Non-food items

- Boomer balls & Jolly balls
- Bowling pins
- Brushes
- Bucket lids
- Beer kegs, feed barrels & trash cans
- Feed bags
- Clover clumps
- Milk crates, Plastic wagons & Plastic logs
- Water cooler bottles
- Grass flats/clumps
- Hang paper maché figures
- Hollow coconut shells
- Oscillating fan, wind chimes, & bubble machine (outside of enclosure)
- Large logs, rearrange furniture, etc.
- Leaves, sand, and rock piles
- PVC tubes
- Towels, clothes, blankets
- Cardboard boxes and tubes (caution needed when using paper products that can become wet)
- Laser pointer
- Nature tapes
- Perfume/body sprays & Glad scented sprays

- Traffic cones
- Hummus
- Ice piles
- Rose petals
- Burlap sacs
- Straw piles
- Reindeer antlers
- Varied of feeding devices & times
- Nyla bones
- Spices and extracts
- Mirror

Food items

- Honey smears
- Blood popsicles
- Cooked chicken
- Crickets
- Horse meat
- Meal worms
- Peanut butter
- Pinkies
- Dry cat food
- Milk bones
- Tuna

Columbus Zoo and Aquarium – N. A. river otter/ASC otter

Non-food items

- Bobbin with smelt rubbed on it
- Whole coconuts to roll around
- Yellow pages
- Bengay™ ointment inside a boomer ball
- Log switching between animal exhibits
- Regular Alka Seltzer® in PVC tube (very small holes in PVC)
- Corn stalks
- Blocks of recycled plastic with holes drilled in them to dig food items out
- Crickets in PVC tube feeder
- PVC shaker toys
- Milk crates, cardboard box, use with caution
- Pinecone soaked in scents
- Extracts – vanilla, almond, lemon & spices
- Elephant manure
- Deodorant spray
- Reindeer antlers & pronghorn sheaths
- Paper maché

- Pig ears and cow hooves
- Painting
- Mustard or tomato sauce
- Large black kong toy
- Floating PVC tube to swim through

Food items

- Liver
- Anchovy paste
- Hard boiled eggs, apples, pumpkins, carrots, blueberries
- Gelatin jigglers
- Live crawdads, live trout in pool, crickets
- Frozen smelt ice blocks
- Blood popsicles
- Knuckles
- Beef hearts
- Mice and rats

APPENDIX F: Resources for Enrichment and Training

(S. Maher, Disney Animal Kingdom)

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"The Shape of Enrichment" Newsletter – A newsletter devoted entirely to enrichment of captive wild animals. Published by The Shape of Enrichment, Inc., V. Hare & K. Worley, (eds.). 1650 Minden Drive, San Diego, CA 92111. Phone: (619) 270-4273. Fax: (619) 279-4208. E-mail: shape@enrichment.org. Website: www.enrichment.org

The American Association of Zoo Keepers Enrichment Committee www.aazk.org

Disney Animal Kingdom - www.animalenrichment.org

AAZK Enrichment Notebook 3rd ed. 2004 ISBN1-929672-11-X, <http://www.aazk.org/2004enrichnotebookcd.php>.

Fort Worth Zoo's Enrichment Online: www.enrichmentonline.org/browse/index.asp

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APPENDIX G: Missouri Fish and Wildlife Otter Stomach Contents

(Missouri Fish and Wildlife - <http://www.mdc.mo.gov/conmag/1999/11/40.htm>) MDC Online November 1999, Vol. 60, Issue 11. D. Hamilton

Otter Stomachs containing identifiable fall prey items

Type	Percent
Crayfish	61
Fish	51
Frogs	17
Muskrats	3
Ducks	1
Empty	4

Ozark otter stomachs containing identifiable fish species

Species	percent
Bass (sunfish family)	39
Suckers and Carp	31
Minnows	14
Shad	11
Pike (chain pickerel)	6
Trout	3
Catfish	3
Drum	3
Unidentified Fish	19

Age of Game Fish in Ozark Otter Stomachs

Age	Percent
1-3 years	40
4-6 years	40

Age of Game Fish in Ozark Otter Stomachs

Age	Percent
7-9 years	20

APPENDIX H: Basic Considerations in the Design and Maintenance of Otter Exhibit Life Support Systems

Juan Sabalones, Maryland Zoo

FOREWORD

This document fulfills two objectives, 1) providing information on maintaining pools in otter exhibits (see Appendices) and 2) providing information to those who are thinking about building a new otter exhibit (or renovating an existing one) some of the basic variables to consider. In our experience many operational problems stem from the design phase and it can sometimes be useful to go back to the design and construction phase for answers.

Those with an existing exhibit and/ or with a specific issue may skip past the Planning and Design sections straight to the appendices.

APPENDICES

- 1 Glossary of relevant terms**
- 2 Request for proposal (RFP) [abridged form]**
- 3 Disinfection**
- 4 Skimmer boxes**
- 5 Algae Control**

Those with more detailed questions may contact the author at: juan.sabalones@marylandzoo.org

INTRODUCTION

Aquatic systems in zoos include:

1. Aquariums
2. Aquatic exhibits which feature aquatic animals (otters, polar bears, crocodilians, etc.). Fish may or may not be displayed.
3. Water features i.e. ponds, lakes, waterfalls and streams (natural and man made) which may or may not feature deliberately introduced exhibit animals
4. Interactive experiences such as water rides and children's "splash zones". Swimming pool regulations may apply.
5. Various combinations of the aforementioned systems

Otter exhibits generally fall into the second category. Anyone planning to build a new otter exhibit or to renovate an existing one will have a variety of issues to consider. Each institution will have varying circumstances affecting how they approach the project. Nevertheless, there are number of basic steps that can be followed regardless of the situation. While it is beyond the scope of this chapter to go into any great detail we have included some appendices to expand on some of the more salient issues.

PLANNING AND DESIGN

Typically, a planning and design team will be formed for the initial phase of the project. In addition to management and exhibit designers, to achieve the best results they need the expertise of the following parties:

- Operations

The husbandry, maintenance, engineering and exhibits, etc. staff have dealt with the idiosyncrasies of exhibiting particular flora and fauna. At this initial stage, the designers can use their input to help make the system more practical and ergonomic. Once the project gets past a certain point in the construction phase, changes becomes very difficult if not, for all practical purposes, impossible.

In addition, because each aquatic system is a custom installation, problem solving is much easier if the operating staff has a good understanding of the design and construction phase of their system.

- **Project Manager**

Someone must serve as liaison and coordinator between the staff, the contractors and the part of the institution that approves the financial expenditures. Experience in designing, building and operating similar exhibits can be very useful. Experience with both roles, i.e. in managing contractors and in being a contractor, is also highly desirable.

A project manager **must strike a balance between what is desired and what is possible within the constraints of the overall master plan/budget** and then bring the balance to all relevant parties and work with them to implement it, **on time** and **on budget**.

Once the team does its due diligence, if the decision is to hire outside contractors, it is best to have its plans as much in order as possible prior to engaging one. This saves on expensive consulting time and also helps focus the institution on the task at hand. Regardless of the level of expertise of the contractors hired, an institution should maintain this involvement and focus as much as possible throughout the project. There is a cliché that you get what you pay for but the reality is more that many projects could have been completed for much less had the planning and design team been more efficient and effective.

CONTRACTORS

If they have the wherewithal they may choose to handle all aspects of such a project in-house but most institutions will have to hire contractors to handle major portions of the job. For new exhibit construction or renovation each institution will have its own procedures for hiring contractors. These can generally be categorized as follows:

- A. Hiring a life support designer and a separate installer and managing the operation in- house.
- B. Hiring a design firm (many institutions already have relationships with one) who will then subcontract a life support designer and a separate installer. The institution will handle any other related work.
- C. Hiring a firm that will handle all of the aspects of building or renovating an entire exhibit (design and construction of the exhibit, its décor, life support system and all associated aspects) in what is often referred to as a “turn key” operation.
- D. Some combination of these procedures.

Each institution will have to weigh the positives and negatives of each approach. In terms of what to look for in designers and installers, building or renovating an exhibit in a zoo or aquarium represents a unique challenge for most contractors and adapting to that environment takes time and money. The ideal contractor will be able to adjust to the particular institution’s environment quickly and successfully:

- **Life Support System/Filtration System Designer Traits**
 - **Balance.** A competent designer will be able to come up with a design that balances the needs of the staff with the temporal and budget parameters set by the institution. A bad designer can set you back significantly.

- Practicality. Some designers have the technical capabilities but lack the practical sense to translate them into a workable, affordable design in a zoo or aquarium setting. Closely scrutinize the consultant's CV particularly when it comes to previous projects cited. Current operators of those projects should be interviewed. Bear in mind other institutions may be reluctant to be candid about a contractor's shortcomings.
- Experience. The best designers have some operating and maintenance experience with the types of systems they are designing and can therefore relate well with the operating staff.
- Installer Traits
 - Expertise. A good installer will be able to take the designer's plans and build a system that works as designed. This is harder than it sounds.
 - Ergonomics. Besides the normal technical competencies one would expect, it is important they demonstrate a good understanding of operational ergonomics (see Appendix 5) as it relates to such systems. The easier it is for staff to access and operate machinery and controls, the more likely they are to properly operate and maintain them. Ideally you should inspect their most recent installation.
 - Experience. Installing an aquatic system in a zoo or aquarium is often an unorthodox project even for the experienced contractor. Hiring the local swimming pool installer may be cheaper, until the time spent by the designer, project manager and operating staff guiding them through the project and correcting mistakes is added up.

WATER QUALITY MEASUREMENT

"If it cannot be measured it cannot be managed"

Nolan Karras, Speaker of the House, Utah House of Representatives

The key to properly managing any aquatic system is to have the best handle possible on the water quality. A good water quality lab is staffed by people with the experience to interpret the data. Along with good record keeping, this is an invaluable aid in problem solving. Here is a suggested equipment list:

- Well Equipped (>\$50,000)
 - Liquid Spectrophotometer
 - Ion Chromatograph
 - Travel liquid spectrophotometer
 - Data Sonde
 - Dissolved Oxygen Meter
 - Turbidity Meter
 - Flame Spectrophotometer
 - Temperature compensated pH Probe
 - Refractometer
 - Micro scale
 - Small scale
 - Large scale
 - Micro Pipette
 - Autoclave
 - Large Spinner Plate
 - Small Spinner Plate
 - Testing Kits (CO₂, Alkalinity, Hardness)

- Microbiology Incubator
- Fume hood
- Cabinetry / Island
- Miscellaneous testing materials
- Miscellaneous safety equipment
- Moderately Equipped (\$20,000-\$49,999)
 - Liquid spectrophotometer
 - Colorimeter
 - DO meter
 - Temperature compensated pH probe
 - Refractometer
 - Small Scale
 - Large Scale
 - Small Spinner plate
 - Testing kits
 - Fume Hood
 - Cabinet / storage closet
 - Misc. Testing material / Tools
 - Safety Equipment
- Minimally Equipped (<\$20,000)
 - Colorimeter or Drip test kits
 - DO meter
 - Temperature compensated pH probe
 - Refractometer
 - Small spinner plate
 - Test kits
 - Safety equipment
 - Testing materials

Some institutions may only have one or two exhibits to deal with and a very limited water quality testing budget. Other institutions may wish to explore a relationship with entities such as the local municipal water treatment plant or the local public aquarium especially when it comes to more involved testing such as coliforms.

REQUEST FOR PROPOSALS

After the planning and design team has done their due diligence and developed a plan, they are then ready to issue a request for proposal (RFP).

We have included sections from an actual Request for Proposal (RFP) for the design of a life support system for an Otter Exhibit (see Appendix 2). Due to its length it has been abridged but enough remains to give you an idea of what is entailed. Other institutions have their own basic version of such a document so they will have to modify the pro forma language to suit their requirements. A performance specification for the exhibit has been included. The performance of a life support system is measured by its water quality and water clarity. Those parameters can and should be quantified as they give the client a point of reference with the contractor as to whether the design has met expectations.

This RFP does not address the issue of temperature control because this particular exhibit did not require it. Otters in general seem to be tolerant of a wide range of temperatures depending on the species (see Chapter 1.1). Nevertheless, each institution should determine as early as possible if water temperature is a concern. If

there is any doubt it should be included in the performance specifications as addressing it after the fact is usually very cost prohibitive.

APPENDIX 1: GLOSSARY OF RELEVANT TERMS

Aquatic Life Support Systems

There are two types of aquatic life support systems; open or closed. Open systems are only possible in certain locations. The primary advantage is (usually) lower cost for construction and, potentially, ongoing operations. The primary disadvantage is less control over exhibit water quality due to the inability to control the water quality of the primary water source.

Open

An open or flow through system takes water from a source outside the exhibit such as a river, lake, stream or even the ocean, and runs it through the exhibit at such a rate as to reduce the need for filtration and then returns the water to that source. Such systems are not possible for all locations and are far from ideal. The question of how much an open system costs versus a closed one, for example, is difficult to answer. It depends upon how open the system is and what the water quality is adjacent to the intake. If the otter exhibit is located where an open system is a viable option (i.e. all the proper parameters can be met) then the primary considerations, especially in regards to salt water, involve a need for some pretreatment (usually some form of sterilization and mechanical filtration). Depending on the regulations in your local jurisdiction, there may be a need to treat the water prior to returning it to the source. Zoos have long practiced a variation on this known as “dump and fill” where the water leaving the exhibit goes straight to a drain.

Closed

A closed system, ideally, recycles the water so that water changes are performed only because of evaporation and should keep all the required water quality parameters at appropriate levels. In reality, even the best-designed and best-operated closed systems can only increase the amount of time between water changes. Nevertheless, in many locations they may be the only option.

Closed systems are generally more expensive to build than an open counterpart. This would include capabilities such as, raw make-up (for salt water systems) and storage, proper mechanical, biological and chemical filtration, denitrification, aeration, organics control and backwash water recovery and especially, a top-notch water quality laboratory.

Water Parameters

In the United States the United States Department of Agriculture has certain coliform counts that need to be performed for exhibits that fall under the marine mammal category. Otters do not fall under that category and therefore water tests are not required by any federal regulatory agency. Nevertheless it is prudent to perform at least weekly water quality tests for bacterial counts and daily tests of chemical additive levels. Records should be maintained and available for inspection and reference if problems arise.

Coliform bacteria:

Coliform bacterial counts are used to monitor filtration system efficiency and keep track of potentially harmful bacteria. Coliform counts should be done at least every other week and more often if there are multiple animals using the pool (a policy regarding coliform testing should be set by the institution). Often a MPN (Most Probable Number) per 100ml is given as an acceptable limit. However, a more accurate measure is the total or fecal coliform count (NOAA 2006). There are no standards at this writing established for fresh-water otter pools. At this time, it is suggested that coliform levels be maintained at or lower than levels established for rescued pinnipeds by NOAA. These are:

- *Total coliform counts should not exceed 500 per ml water, or a MPN of 1000 coliform bacteria per 100ml water.*

- *Fecal coliform count should not exceed 400 per ml. If animal caretakers are routinely exposed to pool water, an institution may establish a higher standard of 100 per ml, which is the level considered safe for humans; this should be based on institutional policy.*

Temperature

More detailed research is required into optimal water levels for the tropical otter species; however, at this time the AZA Otter SSP recommends the following temperature guidelines:

-

A. cinereus: The water temperature for A. cinereus should be maintained between 18.3-29.4°C (65-85°F), preferably at the warmer end of this scale (Petrini 1998).

-

A. capensis, L. canadensis: The water temperature for A. capensis and L. canadensis does not appear to be critical.

-

L. maculicollis: Water temperature in successful L. maculicollis exhibits has ranged from 8.9-15.6°C (48-60°F). Temperatures in the 15.6-21.1°C (60-70°F) range may encourage this species to spend more time in the water, however, this has not been objectively demonstrated at this time.

-

Each individual institution will have to determine whether their exhibit must be heated or chilled and the most efficient way to do that.

Turnover Rate

The size and capacity of a life support system is based on turnover rate (the given unit of time it takes the total amount of the exhibit water to pass through the filtration). This is usually given as gallons per minute (GPM).

The turnover rate is based on the volume of the exhibit combined with the amount of organic matter likely to be put into the water by the animals and the environment (leaves and branches, etc.). For example a hippopotamus pool is likely to require a much higher turnover rate than an otter in the exact same sized pool. The dirtier the water is likelier to be the higher the turnover rate should be.

A proper turnover rate is crucial as a system with a turnover rate that is too low will always be laboring to catch up and a system with a turnover rate that is too high is wasting money.

Filtration

Biological Filtration

This is the use of bacterial [colonies](#) to convert ammonia to nitrite and then nitrate through nitrification.

In aquariums with fish ammonia and nitrite are harmful and should be kept as close to 0.0 as possible. With the exception of certain invertebrates in salt water systems nitrates are not considered harmful. Otters should have no problem with ammonia and its derivatives but an excess of nitrates in an otter pool is undesirable as they are a primary source of nutrients for algae.

Nitrate levels can be kept in check with water changes or by a number of different denitrification methods.

Mechanical Filtration

The mechanical removal of particulate matter suspended in the water column before it decomposes.

The matter is moved to the filter which must then be cleansed. Until the filter is backwashed, the particulate matter is still in the system. Rapid sand, screen, drum, bag, diatomaceous earth, protein skimmers and bead filters are most commonly used in this application. Water clarity is most directly affected by the quality of the mechanical filtration.

Chemical Filtration

The use of any filtering substance designed to chemically attract pollutants in order to remove them from the water column.

- Activated Carbon
- Reverse Osmosis is a method of filtering water by pressing the water against a semi-permeable membrane that sits inside filter housing. This membrane allows water molecules to pass through, but not others. Minerals, trace and other elements are removed producing pure raw water.
- Ion Exchange resins are a water filtration medium comprised of natural and synthetic resins in a flow-through pouch. They selectively remove ammonia, nitrite and nitrate from freshwater.

APPENDIX 2: REQUEST FOR PROPOSALS (RFP) [ABRIDGED VERSION]

OTTER EXHIBIT LIFE SUPPORT SYSTEM RENOVATION.

The following specifications shall define the scope of this design/build project for installing a Life Support System's (LSS) mentioned above at the Generic Zoo.

Bidders:

You are hereby invited to submit a proposal to the Generic Zoological Society, Inc. (the "GZS") for the design and construction of:

OTTER EXHIBIT LIFE SUPPORT SYSTEM RENOVATION.

I **Bid Documents**

- A. RFP Project Description
- B. Project Scope of Work and Specifications attached.
- C. Bid Form (attached to this RFP)
- D. Contractor's Qualification Form (attached to this RFP)
- E. Generic Zoo, Zoo Contractors Policy
- F. General Condition form
- G. Standard AIA Contract
- H. Prevailing Wage Rates

PROJECT DESCRIPTION

Project: **Otter Exhibit Life Support System Renovation**

The Otter Exhibit Life Support System Renovation project consists of designing and installing a replacement Life Support System for the existing Otter Exhibit as described in the following specifications.

Contractor Responsibilities

1. Where specified standards are in conflict, the more stringent of the two shall apply.
2. Site verification of specifications during the bid process and post award period.
3. Visit the site to determine the extent of work, which may or may not be shown in the plans.
4. Any Owner property damaged as a result of the work associated with this project shall be restored to its original condition at Contractor's expense. Contractor is responsible for documenting existing conditions.
5. Coordinate the marking of any underground utility lines, which are within the proposed limits of construction.
6. The Site shall be kept clean at all times. Contractor shall keep the project site clean from worker-related debris, including surrounding lay-down areas, parking areas, walkways and lawn areas. All debris shall be constantly picked up and properly disposed to reduce impact on guest experience and so that winds do not carry the debris to other areas of the grounds.
7. The Zoo has adopted a limited smoking policy. All vendors may only smoke in areas permitted by the designated Zoo representatives, and the contractor is responsible for the workmen, including those of sub-contractors disposing of cigarette butts in identified containers.

Bid Documents

1. Request for Proposal
2. Project Description
3. Contractor's Qualification Form
4. Bid Form
5. Project Scope of Work and Specifications
6. Generic Zoo Contractors Policy
7. General Condition form
8. Standard AIA Contract

CONTRACTOR'S QUALIFICATION FORM

The undersigned certifies under oath the truth and correctness of all statements and all answers to questions made hereinafter.

A. QUALIFICATION OF LIFE SUPPORT SYSTEM CONTRACTOR

1. In order to be the Life Support System Contractor on this project, bidders are to submit the following information to the Zoo not less than ten (10) days prior to the bid opening date.
2. Experience:
3. Statement certifying that the Contractor has been in business a minimum of Six (6) years and has extensive experience in the construction of mechanical life support systems for live animal exhibits of similar size and scope.
4. Contractor must have experience designing and building similar LSS.
5. References of at least one (1) recent project at an AZA Accredited Zoological Facilities within the last year demonstrating experience and ability to install projects of similar size and complexity as those described in the RFP. Include the name of the person responsible for the project; phone number and approximate contract amount.
6. Contractor shall submit full documentation of his/her construction crews and lead personnel and detailing the experience of each person listed and their ability to perform all phases of the Work to the Zoo's satisfaction.
7. Site Superintendent must have supervised ten (10) or more LSS installations during his/her employment with the Contractor
8. Site Superintendent must have experience in installing ozone systems
9. Site Superintendent must show proof of 30-hour "OSHA 500" safety certification course.
10. Contractor shall be a member of the American Zoo and Aquarium Association.

The Zoo reserves the right to require additional information and/or request a visit to completed work to make a determination of the bidder's qualifications to produce work as described in the Construction Drawings and Specifications.

Project Identification: Life Support Systems Installation

_____	_____
Name	Title
_____	_____
Company Name	Phone
_____	_____
Address	City/State/Zip
_____	_____
Fax	FEIN
_____	_____
Signature	DATE

(If more space is needed, please answer on the back of this sheet)

Is your organization licensed to do business in the State of.....?

Have you ever failed to complete any work awarded to you? If so, note when, where, and why? (If more space is needed, please answer on the back of this sheet.)

Please list all work which your firm will be self performing.

List Subcontractors. Use back of sheet if necessary.

List four or more projects executed by your firm within the past three years that were similar in nature and scope to this project. Additional projects may be listed on a separate sheet.

A) Project Name: Location: Year:

Project Cost: Owner Name and Phone Number:

B) Project Name: Location: Year:

Project Cost: Owner Name and Phone Number:

C) Project Name: Location: Year:

Project Cost: Owner Name and Phone Number:

D) Project Name: Location: Year:

Project Cost: Owner Name and Phone Number:

If you have State of..... and/or..... MBE/WBE certification for you or any subcontractors, provide Certification Numbers, Expiration Dates, and Disciplines/SAIC numbers for which you or they are certified.

Provide names of key personnel to be employed on this project. Indicate the projects listed above with which they were involved.

Name	Years Experience	Years w/ Firm	Projects listed	Project Role
------	------------------	---------------	-----------------	--------------

- 1.
- 2.
- 3.
- 4.

If you wish, attach photographic documentation of projects listed in above that illustrate work that you have completed that is most comparable in style, technique and workmanship to the project.

BID FORM

Generic Zoological Society, Inc.

Life Support Systems Installation Request For Proposals

Deliver To: Construction Department
 Generic Zoo
 Smallville, USA, Planet Earth

In submitting this bid, the Undersigned declares that they are the only person, or persons, interested in said bid, that it is made without any connection with any person making another bid for the same contract; that the bid is in all respects fair and without collusion, fraud or mental reservation, and that no employee of the OWNER is directly or indirectly interested in said bid, or in the supplies or work in which it relates, or in any portion of the profits thereof.

The Undersigned also declares that they have examined the Request For Proposals, including the drawings and specifications contained therein, and that by signing this proposal, they waive all right to plead a misunderstanding regarding the same.

The Undersigned agrees to submit a bid bond, payable to the Generic Zoological Society, Inc., in the amount of five percent (5%) of the total bid amount, along with the bid.

The Undersigned further understands and agrees that they are to furnish all material, equipment and supervision to complete entire work for the indicated project and to accept in full compensation therefore the stipulated sum or sums as stated herein.

On acceptance of the proposal for the construction portion of said work, the Undersigned does hereby agree to provide the Generic Zoological Society within ten (10) days Payment and Performance bonds in the amount of one hundred percent (100%) of the total bid price to provide construction services for the consideration named herein.

The Undersigned agrees to hold open this Bid Proposal for a period of ninety (90) days following the submission of this Bid Proposal.

The Undersigned agrees to provide evidence of insurance coverage along with their bid submission, including areas and amounts such as umbrella insurance, general liability, automobile liability, garage liability, excess liability, and workers compensations and employers' liability. On acceptance of this proposal for said work, the Undersigned agrees to provide the Generic Zoological Society, Inc. with a Certificate of Insurance adding the Generic Zoological Society, Inc. as an Additional Insured.

The base bid price of the proposal shall be inclusive of the following:

- Price to provide the design of the LSS
- Price to complete the installation of all LSS piping, equipment, accessories, valves in accordance with these specifications.
- A one-year warranty from substantial completion on all parts, labor and material.
- Performance and payment bonds on the construction phase.
- Factory representative onsite for initial start-up of all systems.
- All labor at Davis-Bacon Act Prevailing Wage Rate.
- Detailed listing of all equipment, labor and materials.
- Guarantee of performance of LSS to meet criteria.
- LSS shall be designed and built to maintain the exhibit animals in a healthy condition (see 1.04B).
- LSS shall be designed and built to maintain high water clarity suitable for overhead viewing.

OTTER EXHIBIT LIFE SUPPORT SYSTEM RENOVATION

A. PROJECT SCOPE/SPECIFICATIONS

1. Contractor

- a. Design and Install a new Life Support System (LSS) for the Otter Exhibit at the Generic Zoo. This scope of work shall be split into two contracts. The first phase shall cover the design of the LSS. The deliverables for the first phase shall include completed designs to meet the project budget and a proposal to provide the construction of the LSS. The second phase shall include the construction of the LSS.
- b. Remove all existing LSS equipment and piping. Please provide an alternate to perform this work.
- c. Piping will connect to existing main drains, surface skimmer, returns, waterfall, overflow, waste and domestic water lines.
- d. 8 hours LSS Startup and Zoo staff operator training.

2. Zoo

- a. Exhibits will be emptied of all water and animals.
- b. The Zoo is responsible for the integrity and functioning of existing underground and through-wall piping and electrical service.
- c. Provide all electrical connections from existing electrical panels. (See Alternates)

B. BASE EXHIBIT DATA

Otter Exhibit

- a. 20,000-gallon fresh water pool.
- b. Exhibit pool is outdoors.
- c. Fresh water provided by existing domestic water supply.
- d. Exhibit maximum capacity to be two River Otters.
- e. Exhibit filtration consists of sand filtration with manual backwash operation.
- f. Exhibit disinfection currently done by bromine additions.

C. LSS DESIGN PARAMETERS

1. The LSS equipment will be sized to meet or exceed the following minimum requirements. If the minimum requirements appear insufficient, provide an explanation for concerns on the sizing. Any additions, deletions or substitutions must be approved by the designated representative of the Zoo.
 - a. Turnover rate for the Otter system shall be at least 60 minutes.
 - b. System shall have flow meters appropriately placed to monitor the turnover rate.
 - c. Waterfalls in the exhibits shall be on a separate loop (with a dedicated pump) from the LSS.

- d. Both systems shall have skimmers adequately sized and located to deal with the heavy leaf litter problem. Skimmer openings shall be screened to protect against accidental intrusion by live exhibit tenants.
 - e. If sand filters are specified they will be sized to less than or equal to 10 gpm/sqft of filter area at 100% of system flow. Backwash shall be manual or hydraulic in operation.
 - f. Exhibit disinfection shall be provided by an automated ozone injection treatment system.
 - g. Ozone system will be sized for a 20% side-stream and a contact time of 2-3 minutes. It shall include an ozone destruct unit. There shall be no residual ozone in the exhibit.
 - h. There shall be a trickle filter sized for the full system flow at 15 gpm / sq. ft (of tower cross section). The tower shall have enough height to provide adequate gas exchange and prevent air entrainment in the exhibit.
 - i. All domestic freshwater supply lines shall have flow meters.
 - j. All equipment shall be able to be disconnected with unions or flanges from the system.
 - k. All equipment will be fully by passable.
 - l. Valved water sampling ports will be provided in the LSS equipment area.
 - m. Two primary filtration pumps that will each have the capacity to run the LSS at design capacity will be installed so that a full backup pump is accessible with the turn of two valves. Piping on the suction side of the filter pumps shall be sized to handle the designed system flow at less than 4 ft/second. Piping on the discharge side of the filter pumps shall be sized to handle the designed system flow at less than 6 ft/second. Gravity piping will be sized to accommodate the design flow at less than 2.5 ft/sec.
 - n. Contractor to verify new equipment will fit in the area of the existing pump room obtained by removing existing equipment.
 - o. Contractor to verify prior to bid that existing piping to remain is appropriately sized for new LSS.
 - p. Contractor to install all systems according to local code and arrange for all inspections.
2. The LSS contractor will be required to guarantee the performance of the LSS once installed. If in the opinion of the bidding contractor, the above criteria will not meet the quality standards set forth here or meet the LSS contractor's own standards, those deficiencies should be detailed in the proposal. The design must allow the system to achieve the following parameters under normal operating conditions :

Parameters

Temperature	(appropriate to species specific range)
Calcium Hardness	100- 200
ORP	300-400 pool, 750 - 800 contactor
Ozone in Water	0 ppm
Total Alkalinity	80-120 ppm
Dissolved Oxygen	90-100% saturation
Free ammonia	0
Nitrite (NO₂)	<0.1 ppm
pH	7.5 - 7.8
Coliforms (MPN)	< 1000

D. EQUIPMENT AND MATERIALS (ANY ADDITIONS, DELETIONS OR SUBSTITUTIONS MUST BE APPROVED BY THE DESIGNATED REPRESENTATIVE OF THE ZOO)

E. EXECUTION

1. Inspection

- a. Examination: The contractor shall examine surfaces for conditions that will adversely affect execution, permanence and quality of work.
- b. Unsatisfactory Conditions: The contractor shall correct unsatisfactory conditions before proceeding with the work.
- c. Operating Instruction. Upon completion of work and acceptance of operation and maintenance manuals, the contractor shall provide bound operational instruction books to the owner.
- d. Instructions shall include the operation of the treatment system for a period of 8 hours, at a time designated by the owner. Upon completion of such instruction, the contractor shall obtain from the owner a dated and signed statement certifying the completion of such instruction.
- e. Project Close out requirements
 - 1) The contractor shall provide the following items as prerequisite to the issuance of certificates for final payment and formal acceptance of the project:
 - a) As Built Drawings
 - b) Reproducible Record Drawings.
 - c) Valve Identification Chart.
 - d) Maintenance and Operating Manuals.
 - e) Operating Instructions and Certified Statement.
 - f) Certified Statement of Successful Test.

2. Installation

- a. Pipe and Equipment Installation
 - 1) The contractor shall install all piping, valves, and equipment in a manner and in locations to avoid obstructions and keep openings clear. Pipe and/or equipment shall not be installed where it will present a potential tripping hazard or below 7'-0" above finished floor, where it would be a potential head knocking hazard. Installation shall permit direct access to all valves and pieces of equipment that will require maintenance. The contractor shall make any changes as directed by the owner, at no additional expense, which may be necessary in order to accomplish this purpose.
 - 2) Before being placed in position, all pipe, pipe fittings and accessories shall be cleaned, and shall be maintained in a clean condition. Piping shall be installed and aligned in accordance with the Drawings with a tolerance of + 1/8-inch in the horizontal and vertical directions.
 - 3) All work specified and not clearly defined by the Drawings shall be installed and arranged as directed and in a manner satisfactory to the owner.
- b. Installation of Pressure Filter Gravel and Sand
 - 1) Preparation of Filters: Before placing the media, the contractor shall determine that all holes in the underdrain system are open.
 - 2) Placing of Gravel: The gravel shall be deposited in such a manner as to avoid endangering the header laterals. Each layer shall be brought up to the required elevation and made level over the entire filter bed area, and shall be smoothed down to a true surface. Care shall be taken not to injure equipment piping and coatings in the filter units by walking on or dropping gravel upon them.
 - 3) Placing of Sand: In placing of the sand in the filters, extreme care shall be taken to avoid disturbing the internal piping. Extreme care shall be taken to protect the

internal filter coating. Sand shall be placed to the appropriate depth specified and shall be level.

c. Installation of Piping

- 1) All PVC Pipe will be transported, stored and installed with regard to manufacturer's recommendations. Bolting of PVC flanges shall be in accordance with manufacturer's recommendations and shall not be unduly stressed through the use of excessive torque while tightening bolts. Use of torque wrench will be required.
- 2) All life support piping shall be flushed clean prior to connection to equipment or tanks.

d. Installation of Pumps and Motors

- 1) Pumps and motors shall be installed in accordance with the Manufacturer's Recommendations.
- 2) Pumps shall be installed with an isolation valve on the suction side of the pump. This valve shall be a true-union ball valve unless it is 4" or greater, in which case it will be a gate valve. A compound gauge shall be installed between the pump and the isolation valve.
- 3) Pump shall be installed with an isolation valve on the discharge side of the pump. This valve shall be a butterfly valve. Between the pump and the isolation valve a swing check valve is required. A pressure gauge shall be installed between the check valve and the isolation valve.
- 4) Unless otherwise noted, all pumps shall be installed on concrete housekeeping pads.

e. System Startup

- 1) The contractor shall provide one full-time mechanical technician who is familiar with the system for a period of 3 days to aid the owner in starting and operating the system.

APPENDIX 3: DISINFECTION

Bromine

Bromine is unsuitable for outdoor usage as it is broken down very quickly by sunlight

Ozone-Chlorine comparison

The common perception is ozone systems are more elaborate and expensive than chlorine. In truth, both systems will require that water parameters be measured. If the operator starts with more or less a blank slate, the level of sophistication required to safely and effectively operate and maintain a properly designed chlorine disinfection system vs. the level of sophistication required to safely and effectively operate a properly designed ozone disinfection system may just about be equal.

Indeed, one could argue the chlorine system operator needs a higher level of sophistication and dedication, needs to work harder and be more attentive, than if they had an ozone system. As we are talking about otters, when comparing an ozone system to a chlorine system, the latter system is **more likely** to harm the animals (or their human caretakers).

Ozone

If you have a well designed, installed and maintained system, the operator will keep the various filters and probes clean. They might occasionally turn a few dials but other than that, operation consists primarily of monitoring the system and recording data. Every year or so you should get a visit from an ozone tech for the more serious maintenance issues depending on your system but that is about it.

Advances in design now allow us to use much smaller dosages of ozone than in the past with the resulting decrease in safety concerns.

The oxidation process with ozone occurs in the contact chamber, away from the animals, and any residual ozone is unlikely to be anywhere near as harmful, if at all, to the otters as chlorine residuals. The by-products of ozonation can be dealt with.

Chlorine

In the United States, many municipalities add chlorine to their water, and readings from tap water of 1ppm or higher are possible. For this reason, many aquariums run their city supplied water through carbon filters prior to use. While otters generally show no adverse effects from these levels, it is not known what the overall impact is to their health and the water repellency of their coats. For this reason, the AZA Otter SSP recommends that otters should not be exposed to chlorine levels higher than 0.5ppm for prolonged periods, and ideally chlorine should be kept at a non-detectable level. The addition of sodium thiosulfate will neutralize any residual chlorine (see below).

The most efficient and effective way to do this is to use an automated system

<http://www.polarispool.com/products/details.asp?ID=34>

This would cost you about \$5000.00 to buy and install. Because chlorine is most effective between the pH of 7.2-7.8 such automated systems draw from sodium hypochlorite barrels and muriatic acid barrels. Without an automated system, the pool will have to be tested daily and chemical adjustments made manually. Even with the automatic controller this system is inherently more labor intensive than an ozone system.

The oxidation process with chlorine occurs in the water with the animals who are exposed directly to the chemicals. Therefore an overdose of chlorine or muriatic acid would affect the animals. Increasingly, evidence is mounting that chlorinated pools may cause health problems in humans:

http://swimming.about.com/od/allergyandasthma/a/cl_pool_problem_3.htm

Therefore all things being equal, one has to wonder how sensible and ethical it is to continue using chlorine with otters.

Chlorination produces carcinogenic byproducts know as Trihalomethanes (THM).

http://www.epa.gov/enviro/html/icr/gloss_dbp.html

Sooner or later, this may become a regulatory issue and we have no way of removing THM from the process.

In the end, the decision on the type of disinfection to use is an equation. Your particular institution may have a set of circumstances (access to highly trained personnel and sophisticated water quality measuring equipment, inexpensive sources of sodium hypochlorite and muriatic acid, lots of cheap labor, etc...) that will sway the equation towards chlorine. And in cases where algae is out of control chlorine may be the most immediate and cost effective solution.

However, all things being equal, our experience has been that when you add up the total cost of doing it correctly over a number of years, having an ozone disinfection system works out to be cheaper, less dangerous and far less labor intensive. Time is money.

Basic Manual Chlorination Device

In manually applied situations the two most common forms of chlorine used are granular and liquid.

Granular

Granulated chlorine is designed to dissolve slowly over time so it needs someplace (typically a skimmer or a floating chlorinator) where it can dissolve away from direct human or animal contact.

DERBY DUCK FLOATING CHLORINATOR



Large capacity holds up to six 3" tabs (or 1" tabs or sticks). Adjustable to regulate the amount of chlorine dispensed. Made of heavy duty resin – child resistant lock.

Liquid

In its liquid form (sodium hypochlorite) the chlorine is more concentrated. It would be used if the need is to raise the levels of chlorine quickly. Sodium hypochlorite is very corrosive and proper procedures (and suitable personal protection) need to be taken when using it.

Gas

Chlorine gas is also available commercially available but this is typically for industrial applications and should be considered too involved and dangerous for most institutions.

Automated Chlorination Device

The **Polaris Watermatic Pro System L-1 and L-2SC** are complete systems for feeding sodium hypochlorite (liquid) and muriatic acid (liquid). Easy to install, operate and maintain, these systems include controllers that plug into any 120V outlet and provide built-in receptacles for the peristaltic pumps. The L-2SC System further provides easy-to-use graphic displays and adjustable-rate pumps.

Benefits

- Complete liquid system
- Integrated Flow Cell
- Easy to install and maintain



Drawbacks

Need to buy, handle and store toxic chemicals such as sodium hypochlorite and muriatic acid. Exposes animals and workers directly to potentially caustic substances.

Chlorine Removal

Chlorine can be used, if necessary, when the otters are not present. Chlorine is a volatile chemical and sufficient aeration can lower levels dramatically in twenty four hours. In situations where time is an issue, sodium

thiosulfate can be added and run through the system for an hour before the otters are allowed access again. To remove chlorine with sodium thiosulfate:

Amount Sodium Thiosulfate (grams) = aquarium volume (gal) x 0.0038 x [7 x tested chlorine level (mg/l)]

Example

Problem: 20,000 gallon tank. Chlorine test results show 0.5mg/l of chlorine in the system following water change and refill. To remove the chlorine you will need ____ grams of sodium thiosulfate.

Solution: $20,000 \times 0.0038 \times (7 \times 0.5) = 266$ grams Sodium Thiosulfate

APPENDIX 4: SKIMMER BOXES

All skimmer boxes should be protected with appropriate screening to prevent live animals from getting trapped, though this should not be a concern with healthy animals. Screening also prevents foreign objects from harming pumps. A skimmer box can be placed outside the exhibit tank or inside

There are commercially available skimmers typically found in pond and swimming pool supply houses but they are usually are too small for most large otter exhibits so chances are skimmer boxes must be fabricated by the installer. Ideally, the pool should have outflows at three points

- A drain from its lowest point
- A midlevel drain
- A skimmer box drain

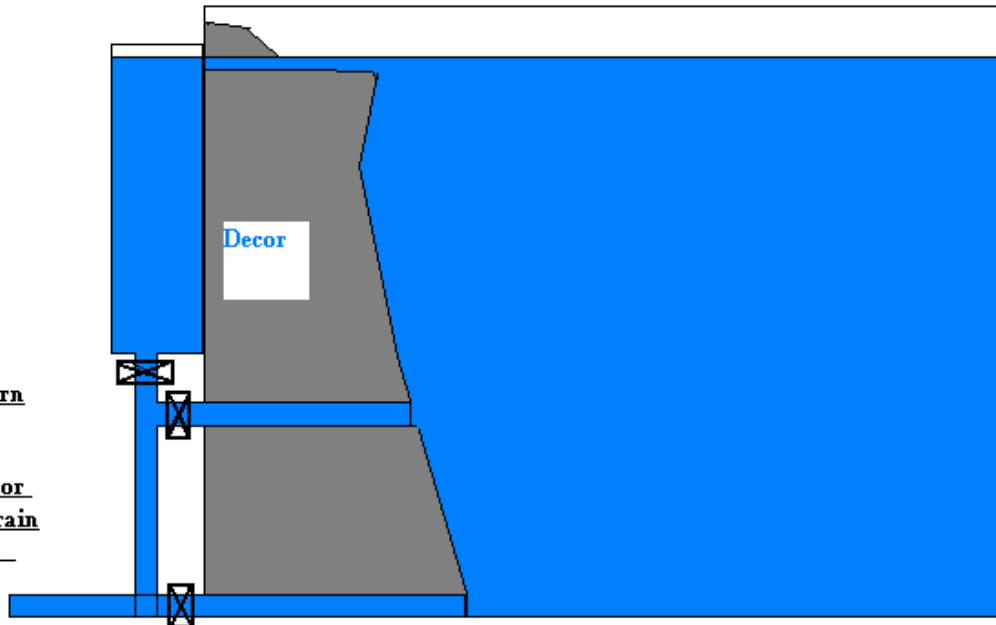
Skimmers should be mandatory especially in outdoor pools. They aid in the removal of floating organic material (leaves, twigs, etc.) most commonly associated with such pools

**SKIMMER BOX
OUTSIDE THE EXHIBIT
TANK**

**SKIMMER
BOX**

Mid level return

**Line to filter or
to sanitary drain**



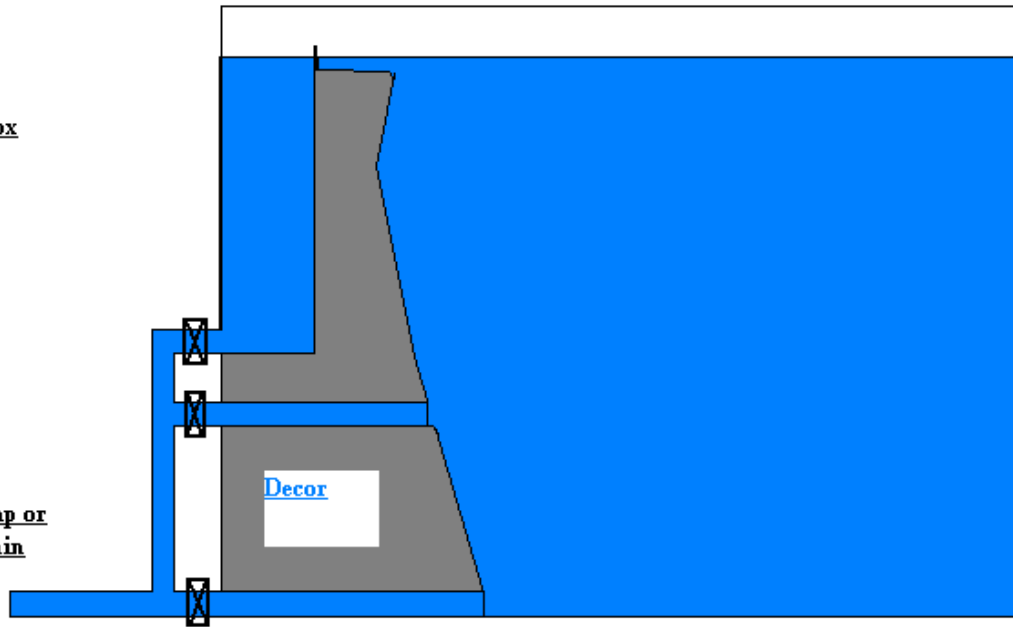
SS

SKIMMER INSIDE
TANK, HIDDEN BY
DECOR

Skimmer Box

Mid level
return

Line to pump or
sanitary drain







APPENDIX 5: ALGAE CONTROL

Algae in an otter exhibit pool does have some benefits. A manageable amount can help control nitrate levels. However, if the level of algae exceeds manageable limits, it makes the water unsightly, reduces oxygen levels, and potentially reduces water circulation.

Algae need light, appropriate temperature and nutrients. Control is a concern particularly in outdoor otter pools exposed to significant amounts of sunlight. By providing for a suitable amount of shade and controlling the amount of available nutrients it is possible to keep algae manageable. Therefore controlling algae is best addressed in the design phase of the exhibit when solutions to these concerns can be built into the exhibit design. Some of them can be added after the fact but it is usually more expensive and troublesome to do so.

Light

If the exhibit is located where the amount of direct sunlight is a problem, a suitable shade structure should be found or fabricated. Coloring agents added to the water can limit the penetration of light to the algae growing below the water's surface by coloring the water. It seems most of them turn the water various shades of blue. Without light, the algae cannot grow. If you have Ultra Violet (UV) disinfection devices on your filtration system, coloring agents will render them useless and the colored water may be an aesthetic issue. They claim to have no effects on animals but blue tinted otters would be very unsettling.

Trees provide shade but they may also provide falling leaves and branches which foul the water. They also may be toxic in some instances. In such cases it would be worthwhile to mount some sort of structure such as a net, to deflect the material from the water.

Nutrients

Algae need nutrients to grow. Nitrates and phosphates are the main concerns.

Nitrates come mostly from decaying organic material from a variety of sources such as animal waste, uneaten leftover food or decaying leaves and branches. Good hygiene and a properly designed filtration system will help. In an outdoor exhibit, a raised lip around the pool will divert rain runoff around the pond and help keep dirt out.

Phosphates usually come in the source water or in food for the animal. At this writing, they can be dealt with by filtering the source water to remove phosphates (expensive) or by treating the system with lanthanum chloride in its various commercial forms. To the best of my knowledge lanthanum chloride is not harmful to otters but you should check it with your vet regardless.

If possible, additional floating plants in the exhibit can compete with the algae for nutrients and also reduce the amount of available light.

Mechanical filtration and UV Sterilizers

Mechanical filtration moves undesirable organic matter from the water column to the filters. This means the algae have a reduced amount of nutrients available to them. The organic material is typically retained in the filtering material so keeping the filter regularly backwashed and working efficiently is vital.

UV sterilizers are installed in line after the mechanical filter. The cleaner and clearer water helps UV sterilizers function properly. The clearer the water the more effective the UV. When water is pumped through the UV sterilizer, the ultraviolet light that is emitted will break down the cell wall of the algae and the algae will then die. UV's also have disinfectant capabilities.

$$UV \text{ dose} = UV \text{ intensity} \times \text{exposure time.}$$

Make sure to get the appropriate sized UV sterilizer for your pond and also that the water flow through the UV allows for sufficient exposure time. Note that the effectiveness of UV drops dramatically as the temperature goes down. Of course, in terms of algae control in outdoor exhibits algae populations are likely to drop down with the temperature.

Water Additives

Other means for controlling algae including water additives. Most water additives developed for algae control come from the swimming pool and ornamental pond industry. Many of these products are toxic not only to algae but to other forms of life. It is important to take that into account when considering them for use in an otter exhibit. Always check the label and the MSDS sheet to make sure that it is safe for the life in your pool.

Additives can either be algiscidal or algistatic. Algiscidal products kill the algae outright. Most metal ion complexes (copper, silver) fit into this category. Other products, such as barley straw suppress the growth of algae in some fashion and are usually used in a preventative manner. It is important to understand at what stage the algae problem is so that the correct product is used. For example barley straw, an algistatic substance is not as effective after the algae in your exhibit have bloomed. At that stage, it might be best to drain the pool, scrub the algae off the surfaces, refill the pool and then use the algistatic substances to help hold down a recurrence of the problem.

The use of bags of barley straw to filter out algae has been quite publicized. The following links to publications by Carole A. Lembi, Professor of Botany at Purdue University, can provide greater insight into Aquatic Plant Management and the use of barley straw in algae control.

http://www.ces.purdue.edu/extmedia/WS/WS_21.pdf

<http://www.btny.purdue.edu/pubs/APM/APM-1-W.pdf>

References and Further Reading

Dawes, J. The Pond Owners Problem Solver. Tetra Press. Blacksburg, Virginia; 1999.

May, PJ. The Perfect Pond Detective Book 1. Kingdom Books. Waterlooville, England; 1998.

APPENDIX I: Female Otter Reintroduction Plan

By: Jessica Foti, North Carolina Zoological Park

Date: June 4, 2006

This plan was developed to reintroduce two females separated for several weeks. It is offered as a template to follow when introducing females, or any unfamiliar animals. Introductions should be planned in advance and based on individual institution policies, physical exhibit design, and individual animals.

- Begin with one holding cage between them and visual access through mesh in holding.
- Facility allowed for each animal to have one side of a separated exhibit. They were still with one holding cage between them at night.
- After a few days the otters were given continual access to side by side holding dens throughout the day and night.
- Otters were switched between exhibit sides every three days to reduce the chance of creating a territory.
- Historically otters have been introduced in holding then allowed on exhibit.
- The first day of introductions seems to have the most signs of aggression.
- Start with short periods of introduction in holding, varying the time between 20 – 60 minutes. The time will vary according to signs of aggression.
- To reduce territoriality we suggest switching exhibit sides for each otter every couple of days.
- Once the otters appear to be more comfortable with each other progress to introducing them in holding twice a day for a period of 30-60 minutes.
- When both introduction sessions start going well, allow them access to the exhibit.
- Watch for signs of aggression and adjust time together accordingly.
- Each otter should be separated with visual access to one another overnight until confident that there is no chance for injury.

Positive behaviors to look for during the introduction are, playful wrestling, muzzle touching, social grooming, face pawing, submissive rolling over, resting together and friendly vocalizations. These vocalizations are, chirping, grunts or chuckling.

Aggressive vocalizations are screaming, snarling, growling or grunting. Signs to look for requiring separation include: aggressive chasing, aggressive wrestling, tension while dominance mounting, fighting with a lot of screaming, fighting with injuries or sign of one trying to drown the other in the pool.

Tools recommended having on hand when beginning introductions are:

- 3 brooms
- 4 pairs of gloves
- 2 hoses that are ready
- 2 fire extinguishers
- 3 mammal nets
- 1 air horn
- Tongs
- Snake hook
- Extra fish and treats

APPENDIX J: Otter Body Condition Matrix

Cheryl Dikeman, NAG Advisor (cheryld@omahazoo.com), Omaha’s Henry Doorly Zoo

Matrix is still in development, photos of each body condition are being sought.

SCORE	1 Emaciated	2 Poor	3 Ideal	4 Solid	5 Obese
Photo/Drawing					
General Condition	No obvious fat and loss of muscle mass. Lumbar vertebrae all visible, ribs visible, obvious abdominal tuck. Iliac wings pronounced. Poor coat.	Lean, minimal muscle mass	Optimum body fat and muscle tone, well proportioned, ideal coat condition.	Noticeable fat deposits throughout body.	Obvious fatty deposits, no definition between shoulder, stomach and pelvic regions
Neck and Shoulders	Pronounced scapula and lack of muscle over the shoulders, Noticeable shoulder skeletal region.	Visible scapula with little muscle over the shoulders, thin neck. Visible delineation behind shoulders.	Smooth lines over shoulders and scapula. Slight delineation behind shoulder region.	Smooth lines over shoulders and scapula. No delineation behind shoulder region.	No definition, very thickened neck region. Obvious fat deposits over top of shoulders and in neck region.
Abdomen and waist	Very pronounced waist and severe abdominal tuck	Visible waist behind the ribs. No visible abdominal fat present.	No visible abdominal tuck. Some distinguishable abdominal fat present; however, not obvious.	Some rounding in the abdominal region. Noticeable abdominal fat. Waist is not visible.	Obvious abdominal fat deposits and large protruding waist region. Abdominal fat pad drops below the rib cage.
Hindquarter	Pronounced and very obvious hip and iliac region.	Pelvic bones visible.	Hips and pelvis slightly visible and palpable but not obvious.	No skeletal visibility in hindquarter. Smooth lines over entire quarter.	Fat deposits obvious over hind limbs. Fat pad obvious on tailhead.
Vertebrae and rib cage	All vertebrae visible. Visible ribs.	Tops of lumbar and thoracic vertebrae and ribs slightly visible and definitely palpable.	Smooth lines over topline and throughout body. No visible ribs or vertebrae.	Some fat evident over vertebral bodies and/or ribs	Extreme fat pad over rib cage region. Heavy fat deposits over vertebrae.

APPENDIX K: Education Resources

In this section you will find a sampling of the educational tools focusing on otters that are available (puzzles provided by S. Stevens). Below is a list of useful websites:

IUCN Otter Specialist Group - <http://www.otterspecialistgroup.org/>

International Otter Survival Fund – <http://www.otter.org/>

Otternet - <http://www.otternet.com/>

River Otter Alliance - <http://www.otternet.com/ROA/>

Otters in the Water

Find the words from the list below. (Hint: Some words are backwards!) Then use those words to fill in the blanks as you read about river otters.

river otters
streams
nose

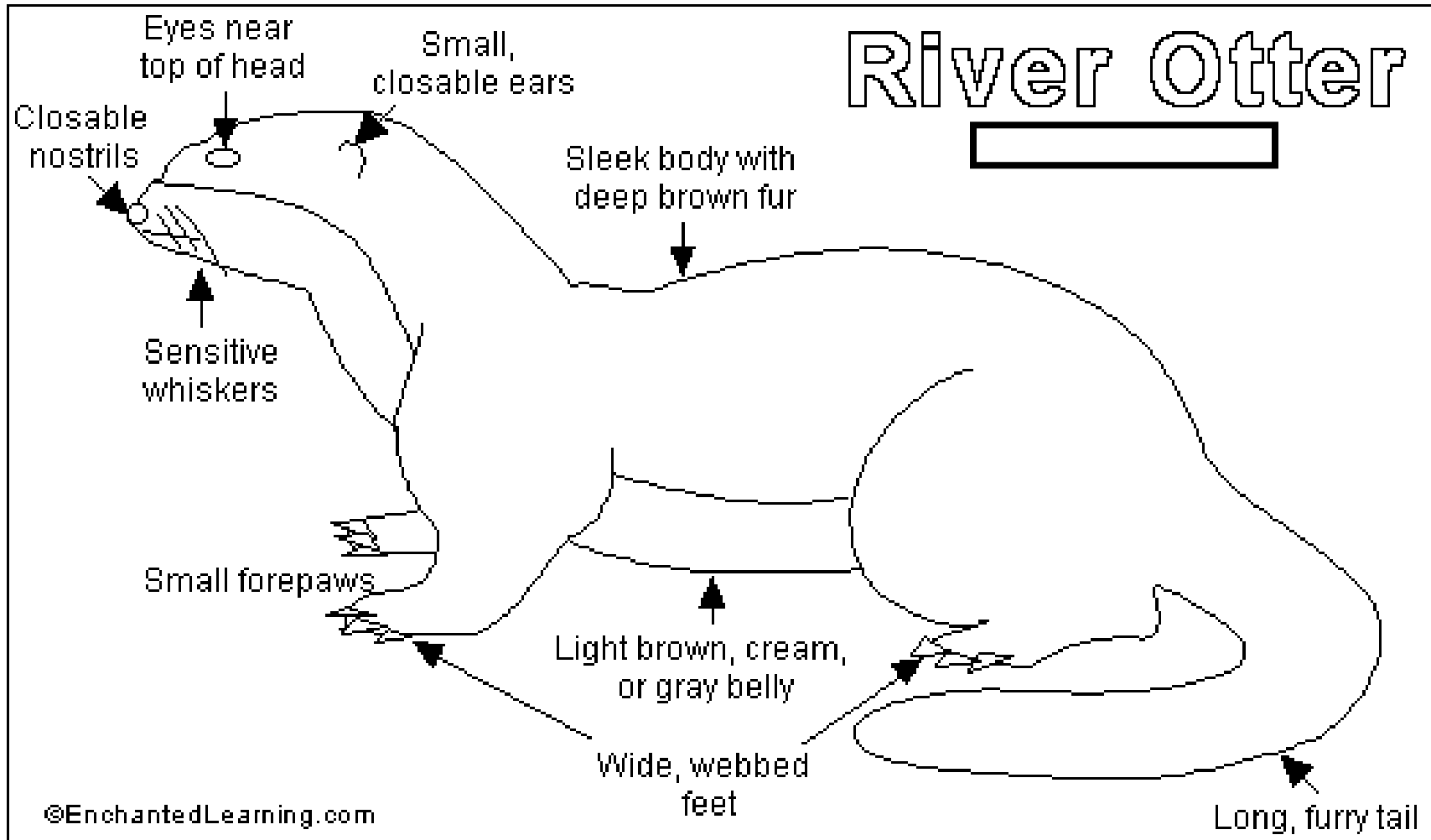
tracks
adaptations
webbed

habitats
whiskers
sleek

lakes
ears
fish

S I Z R S R L C A C L N E E E
K R K C N W I Q N O S E Y X D
O E E Y O P Y P D A X H W K S
C D S T I A R W M E S U E N T
H A B I T A T S J R B E N J R
S S Z I A O N E A I L B C Q E
E J C O T M R E F S K G E S A
K J X V P N N E A I A K V W M
A O L G A L J E V M Z C E G S
L E R B D D R I S I L N N R X
K Q M J A O S K C A R T X O S
T W T G S I L Q A R N Z M H Z
B C C A C V L N E E H S I F O
A L F S Y P J V O J M L B Z L
W H I S K E R S C T S U O G P

_____ live in aquatic _____ like _____ and _____. _____ are their main food, and river otters swim under water to catch them. River otters have many _____ that help them swim well under water. They have _____ and a _____ that close tight when they dive. Their _____ feet and _____ bodies help them swim quickly. Their sensitive _____ help them find food even in muddy water. Next time you visit your favorite lake, pond, river, or stream, keep an eye out for river otter _____!



Otter is
hungry.



Can you help
him find his
dinner?

