Husbandry Guidelines
for

Weedy Seadragon (*Phyllopteryx taeniolatus*)

Leafy Seadragon (*Phycodurus eques*)

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Preface

This husbandry manual is designed as a guide for the housing of seadragons in public aquaria and zoos. This document provides guidelines for the successful husbandry, displaying and rearing of these species in a range of aquarium environments. Whilst by no means exhaustive this document combines known aspects of animal husbandry, water quality and exhibit design to provide an overview of current requirements for these species.

This should be considered a "working document" and while best efforts have been made to include the most up to date information, the editors acknowledge that science and husbandry practices are constantly evolving, and hence any comment is welcome for future revisions.

Acknowledgements

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The editors particularly like to acknowledge Alison Edmunds who produced the first Seadragon Husbandry Manual in 2012.

The editors sincerely wish to thank Dr Lisa Hoopes and Leslee Matsushige for sharing the results of their mysid nutritional study.

1. Taxonomy

Seadragons are unique to southern Australian waters and are an amazing fish to display. Seadragons are members of the teleost (bony fish) family Syngnathidae.

The family name, derived from Greek, refers to these fishes' tube-like snouts (*syn* = joined or fused, *gnathos* = jaws). The family shares other similarities such as a bony external skeleton, reduced number of fins, and the male broods the eggs (Lourie 2016).

Common name: **Weedy Seadragon or Common Seadragon**

Scientific name: *Phyllopteryx taeniolatus*

Kingdom	Animalia
Phylum	Chordata
Class	Actinopterygii
Order	Syngnathiformes
Family	Syngnathidae

The weedy seadragon has a distinctive bent body and fabulous markings on its trunk. Its appendages help to camouflage it in its habitat of sea grass and seaweed (Lourie 2016).

Adult length	30 – 40 centimetres
Lifespan	Wild is unknown but is thought to be 5-7 years; in aquariums up to 10 years
Rings	(17 - 18) + (31 - 27)
Pectoral Fin Rays	21 - 22 (20 - 23)
Dorsal Fin Rays	27 - 34
Colour / Pattern	Brown, with white spots on head, trunk with dark bars and profusely spotted, dermal flaps pale with dark edges.
Notable Anatomy	Bent body, 12 long rounded dermal flaps, very long snout, no caudal fin
Depth	3 - 50 metres (10 - 164 feet)
Habitat	Algal beds and rocky reefs
Conservation status (Lourie 2016)	Near Threatened

IUCN Status	Red List – Least Concern

The weedy seadragon is widespread in southern Australian waters from the Sydney region (east coast) to the Perth region (west coast) and to the southern tip of Tasmania (Kuiter 2009). Species that have a large geographical range often show some variation within the species. For example, southern Tasmanian seadragons are typically larger than those of the northern Sydney region. Initially, they were even thought to be a different species, but this has been disproven.

Figure 1 - Map of Australia with blue line showing distribution of the weedy seadragon (*Phyllopteryx taeniolatus*). Courtesy of Wikimedia Commons.

Figure 2 - Weedy or common seadragon (*Phyllopteryx taeniolatus*).

Common name: Leafy Seadragon

Scientific name: *Phycodurus eques*

Kingdom	Animalia
Phylum	Chordata
Class	Actinopterygii
Order	Syngnathiformes
Family	Syngnathidae

The leafy seadragon has a distinctive bent body and well-developed fins that assist with camouflage.

Adult length	30 – 35 centimetres
Lifespan	Wild is unknown but is thought to be 5-7 years; up to 10 years in aquariums
Rings	(17 - 18) + (31 - 37)
Pectoral Fin Rays	21 - 22 (20 - 23)
Dorsal Fin Rays	27 - 34
Colour / Pattern	Yellow, with white stripes on head, trunk with white bars and dermal flaps green with dark spots.
Notable Anatomy	Bent body, 12 long branching dermal flaps, very long thick snout, no caudal fin
Depth	3 - 20 metres (10 - 66 feet)
Habitat	Algal beds, rocky reefs and piers
Conservation status (Lourie 2016)	Near Threatened
IUCN Status	Red List – Least Concern

Figure 3 - Map of Australia with blue line showing distribution of the leafy seadragon (*Phycodurus eques*). Courtesy of Wikimedia Commons.

Figure 4 - Leafy Seadragon (*Phycodurus eques*).

A third species of Seadragon was identified for the first time in 2015. The Ruby Seadragon (*Phyllopteryx dewysea*) is found in deep waters off the coast of Western Australia. At this stage it has not been displayed in an aquarium, and due to its deep-water nature may never be displayed.

2. Identification Methods

The easiest method to identify individual seadragons is to initially sex them and then use variations in their appendages to differentiate individuals. Their appendages, just like fingerprints, are different shapes and sizes with different markings. Depending on a seadragons history, particularly if they are wild caught, there may be appendages or parts of appendages that are missing.

Technology now provides for more detailed identification methods. Computer programs are available that analyse photographs of weedy seadragons, examining spot and blotch patterns on the lateral surface of the abdomen. This technique has been used successfully in the wild for scientific data collection (Martin-Smith 2011). It is only a matter of time before it will be used in the public aquarium and zoo industry. Most aquaria currently use photographs with labelling of distinctive variation to identify individuals.

2.1 Sexing Methods

Juvenile Seadragons are thin when viewed laterally, from dorsal to ventral. At about 12 months of age, the females begin to deepen in the abdomen and their dorsal area may become rounder. The distance from the dorsal to ventral when viewed laterally is greater in females than males. Refer to Figure 5.

The male's tail tends to become thicker along its entire length compared to the females tail which is more slender. This is probably due to the fact, that the male carries the eggs attached to the ventral surface of his tail.

2.2 Individual Identification

It is best practice for individual identification records to be made for each animal with pictures including labelled appendages that are referenced. Please see Figures 6 and 7 for two examples.

See Figure 6 for Seadragon #2, which is identified by its crown appendage and its neck appendage. In this case ther colouration and shape are unique, so no more features are needed to differentiate it from other individuals.

Figure 5 - Sexing weedy seadragons (female at top with a deeper abdomen and male below). Compare the lengths of the red arrow.

Weedy Seadragon # 2

Identifying characteristics:

- Dorsal fins (double fin) large and good shape.
- Fourth tail fin very small
- Neck appendage (Located behind the pectoral fins)

Figure 6 - First example of an individual identification record for a weedy seadragon.

Weedy seadragon # 6

Identifying characteristics:

- White patches present throughout leaves
- First tail fin LHS leaf missing
- Second fin from head has several white spots

Figure 7 - Second example of an individual identification record for a weedy seadragon.

3. Natural History

Weights and Measurements

The average weight of a seadragon is between 35 and 40 grams (based upon aquarium adult animals). The average adult length is 35 centimeters.

Distribution and Habitat

Seadragons are found in southern Australian waters from Sydney all the way to Perth and around Tasmania. Colour and leafy appendages can vary drastically depending on the depth that they are found at and geographical location of the individual.

Both species are found primarily in densely weeded areas as well as around piers, in southern Australian waters. See Figures 1 and 3 for each species distribution.

Social Structure

Seadragons are solitary for the majority of the year.

Feeding Behaviour

Because they possess a short, straight intestinal tract, they consume small quantities of food regularly. They are constantly grazing on very small fish and aquatic invertebrates (particularly mysid or mysis shrimp).

Reproduction

Female seadragons use their ovipositor to attach their eggs to the tail of a receptive male; it is here they will be fertilized and gestated externally. Before breeding, the male's tail will become dark and spongy in preparation to receive the eggs. Pairing and courtship behaviour in the wild occurs during spring and summer (October to January in the Southern Hemisphere).

Courtship occurs for a few weeks prior to the egg transfer. A male and female seadragon will sit side by side close to the bottom of the exhibit and mirror each other's movements.

They curl their tails away from each other and swim ("dance") in circles, weaving in and around the exhibit items and theming, generally spiraling towards the surface. Once they approach the surface, they break apart and swim back down to the bottom where they may repeat the process multiple times.

Eggs are transferred from the female to the base of the male's dark and spongy tail (see Figure 8). It has been consistently noted in aquariums that egg transfers occur at or shortly after the full moon.

The eggs adhere to the tail, which creates multiple craters for the eggs to sit in. The gestation period is approximately 56 days (8 weeks) at 16 to 17 °C (60.8 to 62.6 °F) with a litter size of up to 250 eggs. This period may be longer at lower water temperatures. On hatching, the fry break free from the egg and are free swimming. The parents are not involved with rearing their young.

Figure 8 - Male weedy seadragon (*Phyllopteryx taeniolatus*) carrying eggs at the Melbourne Aquarium (first successful egg transfer in 2004).

4. Aquarium Husbandry

4.1 Exhibit Housing and Environment Guidelines

An ideal seadragon display will be large, which provides an opportunity to add kelp, rocks, pylons, substrate and other forms of theming. A large space, with these theming items, allows the seadragons to hide from view when needed, as well as permitting natural behaviour with swimming patterns and social interactions to occur. This large space is also critical for allowing the courtship dance to occur with minimal hindrance.

A wide tank (over 2 metres or 6.6 feet) provides opportunity for variation in habitat, water flow, light intensity etc. Depth (over 1.5 metres or 4.9 feet) is also very important if breeding is desired. Smaller displays may still be very successful for maintaining seadragons as long as breeding is not the main focus of the display. In fact, it can be an excellent way of inhibiting breeding if, for example, the display is holding many siblings or related animals where breeding outcomes would not be desirable.

As an example of a very successful breeding display:
SEA LIFE Melbourne Aquarium currently has two seadragon exhibits, which are a mirror image of each other. They each have two large acrylic windows that that are 1700 mm (high) X 2100 mm (wide) and cover most of the front of the display. See Figure 9 and 10. Each display tank has its own Life Support System (LSS). The volume of these displays is 8,000 litres (2,113 US gallons) each.

For various reasons, in the past many aquariums and zoos have had issues maintaining good health in their seadragons. Following a few simple rules will ensure an exhibit full of happy, healthy seadragons throughout their full life expectancy. As with all fish, the best LSS, ensuring excellent water quality is a major factor in having healthy seadragons.

Seadragons are relatively sensitive fish, and as such it is important to minimize all noise and vibration in their environment.

Figure 9 – One of the two SEA LIFE Melbourne Aquarium seadragon tanks.

The display shape is rectangular with a triangle attached to one end. See Figure 10.

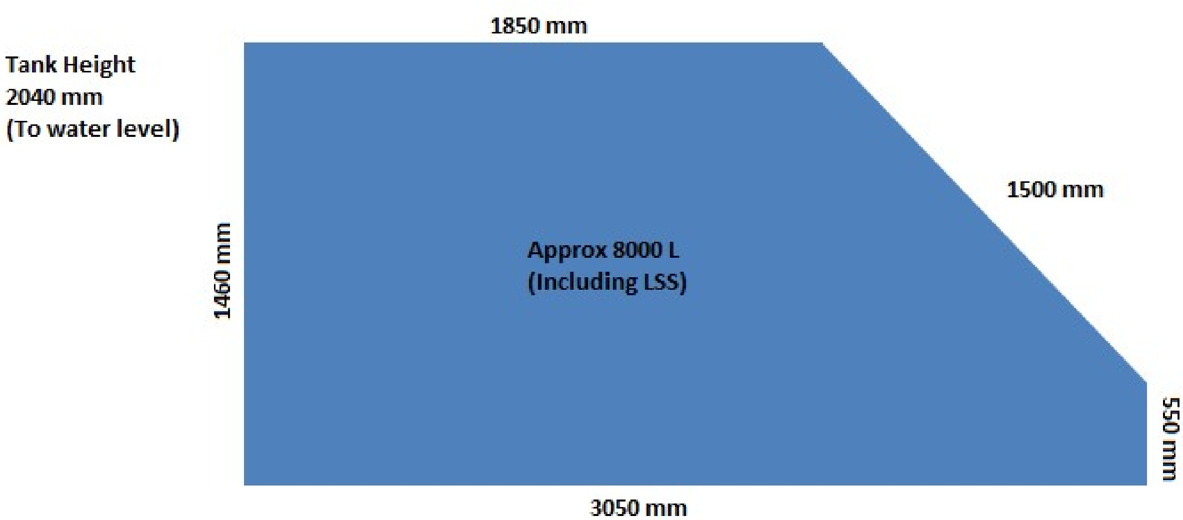


Figure 10 - Surface area of one of the SEA LIFE Melbourne Aquarium seadragon displays.

Life Support System

An ideal Life Support System (LSS) for a seadragon display would consist of the following:

- Sand Filter(s) (SF)
- Heater / chiller
- Air lift(s)
- Ultraviolet (UV) unit (large)
- Biofilter(s)
- Foam Fractionator(s)
- Pump(s)
- LSS alarming which includes phone call, SMS and email when a high or low alarm is triggered; alarms to include temperature, dissolved oxygen, water flow, water level

Built-in redundancy in any LSS is very important e.g. in case of a chiller or pump failure, having spare capacity can prevent a catastrophic LSS failure.

If breeding is intended, then a rearing tank located near the primary display, which may be attached to the same LSS, would be ideal. A rearing tank should be between 300 to 500 litres (79 to 132 US gallons) in size.

Water flow through the LSS should complete the volume of the display and its system once every 60 to 90 minutes (turnover).

Care must be taken in exhibit design to ensure that seadragons are not getting drawn onto pump suctions points. One method to avoid this is to have the water drawn from the aquarium under the gravel (using SF laterals) and from behind the back wall of theming (make lots of very small holes in the theming). Ideally water from the display should flow into the pump and then through the sand filter(s), after this then entering the heat exchanger. Following this the water should go to the biofilter and finally the UV sterilizer before returning to the tank. Return lines to the tank are best dispersed through a spray bar at the base of the display facing upwards. This design creates a Kriesel-like effect in the system with a circular water flow.

It is critical that any seadragon display incorporates a seasonal temperature and photoperiod cycle. This should be based upon a southern region where the seadragons are found. SEA LIFE Melbourne Aquarium uses Flinders Pier, Victoria, as the site for mimicking these cycles. This is discussed in more detail later.

As with any aquarium display, it is essential to keep the display very clean in order to prevent the buildup of detritus. Some seadragon displays do not have gravel (substrate) to aid in maintaining a clean tank. However, this is not ideal for creating a natural appearance to the display and may impact negatively on the seadragons welfare.

As mentioned previously, adequate biological filtration within the LSS is critical to maintain zero ammonia and nitrite, as well as low nitrate levels.

Flow intakes need to be safe with low flow (suction), so that seadragons are not drawn to or sucked onto intake guards. Weak seadragons tend to sit high in the water column and are therefore at higher risk of being trapped on overflows if suction flows are too strong. Pump returns near the substrate may be used and will aid in the prevention of detritus build up or accumulation on the gravel floor. However, if flow is too high, it may make it difficult for seadragons to navigate safely or cause exhaustion.

Generally, seadragon tanks stay relatively clean for two reasons. Firstly, their ideal diet of live mysid shrimp are not particularly meaty and secondly, these displays usually have a low stocking density. For these reasons, seadragon displays tend not to build up high waste levels compared to a similar sized display containing other fish. Having said that, vacuuming the substrate either from the surface or with a diver is still critical to maintaining a clean display and this should be performed at least once a week. This is the ideal time to change some of the water, with around 10-20% of the display volume each week being optimum. Water changes should be performed with water of similar water chemistry parameters such as temperature, pH and salinity. It is detrimental to the health and welfare of the seadragons if these parameters change suddenly during water changes.

Ultraviolet Sterilization

Ultraviolet (UV) sterilization is one of the most important parts of the LSS required for successful seadragon husbandry. UV greatly benefits the cleanliness of the tank and is now considered essential to help prevent external and internal parasite issues.

The size of the unit is dependent on the display volume and specifications. However, bigger is better because the difference in size of the UV unit can mean success or failure in controlling parasites such as scutociliates (see 4.3 Health Care).

Case Study: One aquarium with an 8,000 litre (2,113 US gallons) display housing six seadragons using a 40 watt UV unit had constant issues with scutociliates (protozoan parasite) in their system, resulting in disease. However, when the UV unit was changed from a 40 watt unit to a 120 watt UV unit even increasing the number of seadragons up to 80 at times (many juveniles during breeding), scutociliates were no longer seen. When designing a seadragon LSS the ideal UV dose is 180 mJ/sec/cm with a tank turnover of between 60 and 90 minutes.

As for any UV unit the quartz sleeve housings should be kept clean to maintain effective UV dosing. Furthermore, for maximum effectiveness, UV globes should be changed regularly as per manufacturer guidelines, or at least every 12 months.

Ozone

Ozone can be used safely in seadragon tanks, providing there is no residual bromine levels and with an Oxidation-Reduction Potential (ORP) of up to 340 mV. It is unlikely to be necessary, due to the generally low waste nature of seadragon exhibits as previously mentioned.

If using ozone in a display with seadragons then it is recommended to test the Bromine levels a minimum of once daily. Any values of 0.01 ppm or greater should be considered as dangerous and the ozone generator should be turned off until the levels return to 0 ppm.

Temperature

Water temperature should be maintained between 12°C (53.6°F) in winter and 18°C (64.4°F) in summer. This is within the normal seasonal temperature fluctuations reported in the wild for both the leafy and weedy seadragons.

The changes to seasonal temperature variations between summer and winter should be made gradually throughout the year. Do not allow the temperature to climb above 21ºC (69.8 °F) as the seadragons may begin to stress. Interestingly, at Melbourne Aquarium in 2004, a chiller failed and the tank temperature spiked up to 20ºC (68.0 °F) for a short time (a few hours). This seemed to stimulate the animals rather than stress them resulting in a successful egg transfer event. However, several controlled repeats of this temperature spike did not cause a repeat egg transfer, suggesting this was probably unrelated to the initial successful egg transfer.

Temperature can also be used as an aid if food availability is low, because seadragon energy and nutritional requirement will drop with a lower water temperature (slower metabolism at lower temperatures).

Water Flow

Water flow should vary throughout the tank, so seadragons do not have to swim constantly against a strong current. If the water flow is along the bottom of the tank, food such as frozen mysids may be consumed more readily as they roll along giving the appearance of swimming. For this reason, some sites use upwelling currents for feeding frozen mysids as it keeps them suspended longer giving the seadragons more opportunity to feed and therefore produces less waste. Seadragons will rarely pick up frozen mysids from the substrate, preferring to feed within the water column.

Water flow in the tank can also impact the ability of seadragons to court and dance. Too strong a flow at the wrong position or direction can ruin a potential egg transfer.

Water flow across the surface is very important for seadragons as this disrupts the water surface of the display. The surface is often where seadragons can injure themselves because when stressed they swim straight up to the surface. When stressed, seadragons spend time at the surface; they will often have their snouts out of the water which can desiccate the snout tip or cause damage by impacting objects above the surface e.g. lights or theming. Surface agitation is also very useful as it causes a ripple effect, which casts shadows throughout the exhibit. This will aid in the seadragons being able to differentiate the borders of their exhibit as well as in their orientation.

Finally, water flow is an extremely valuable source of enrichment, and as such can be altered from time to time within safe levels.

Theming

It is important to avoid areas in the tank with small confined spaces where a seadragon may swim through or into. Seadragons have spiky bodies and can potentially get stuck in tight places. When this happens, they will often stress and die. In their natural habitat, seadragons are found from thick kelp to sparse seagrass and open sandy areas, sometimes swimming into currents or taking refuge in a sheltered position. They are not accustomed to tight or confined areas.

Due to their nature, providing variation in habitat seems important as their preference for different habitats can change over time. Having the option to be out in the open in full view or sit behind a pylon may well be an important aspect of their adaptability within the display. Providing habitat variation and therefore choice is very important for the animal's welfare.

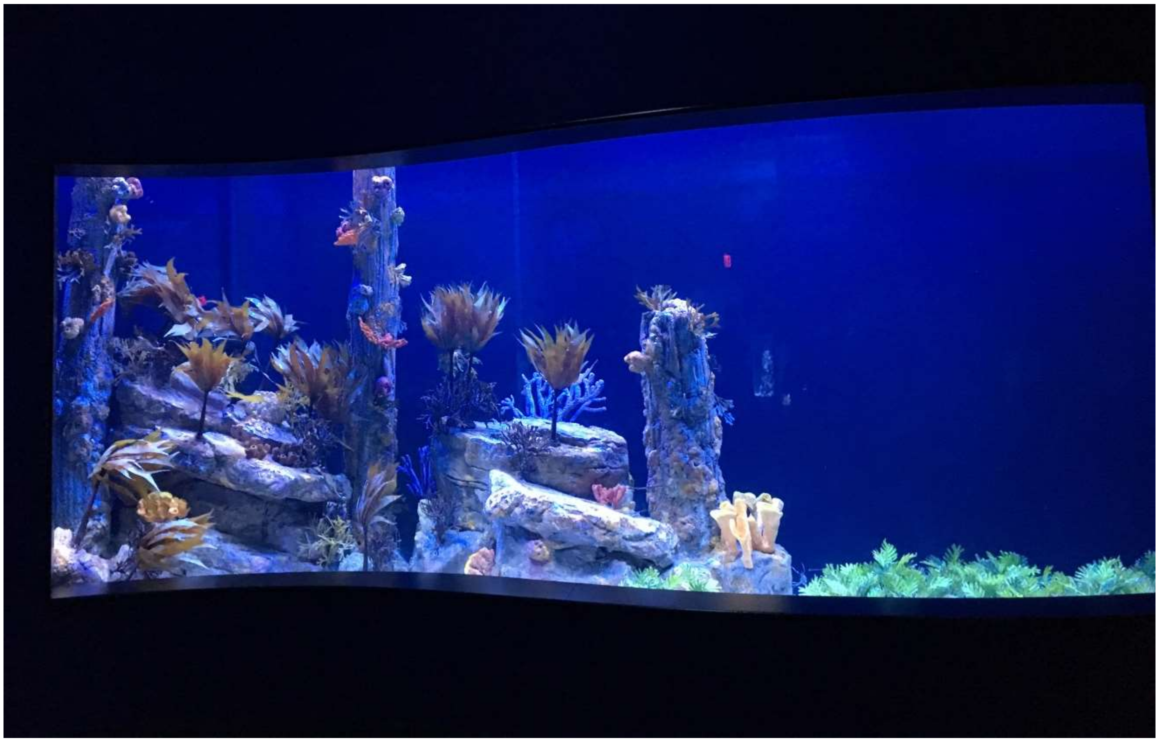
For displays designed for breeding it is very important to keep an open area in the display for courtship to occur. This courtship dance is quite intricate and for a successful egg transfer to occur, there must be a clear area where artificial plants or other theme work does not get in their way. The egg transfer often happens when they swim vertically so keep horizontal theming to a minimum.

An example of a well-designed display is the new (2019) seadragon tank at the Birch Aquarium in La Jolla, San Diego (see Figure 11). Note at the right side of the display the open clear area over very short sea grass which at this stage would appear to be an excellent display area to maximize breeding. The display has just a little less than three meters (9.8 feet) in water depth, which as previously mentioned is critical for successful egg transfers.

Lighting

There should be a distinct night and day cycle. During the day the display should be well lit but not intensely bright. Seadragon displays are typically not as well-lit as compared to other fish tanks. As mentioned previously surface agitation will cause a ripple effect and brightness variations. Offering the choice of different areas of varying lighting intensity is a good from a welfare viewpoint, so the seadragons can choose where they prefer to be at different times.

If lights suddenly go on or off, seadragons will stress and often head straight for the surface. This response is caused by stress and if not corrected can be detrimental to the animals. This situation is easily avoided by using modern LED lighting which can be programmed to fade on and off mimicking natural dawn and dusk. Alternatively, in the past when these modern lights were not available multiple lights were employed which were on separate timers, set to turn on and off, creating a gradual change (sunrise and sunset effect).



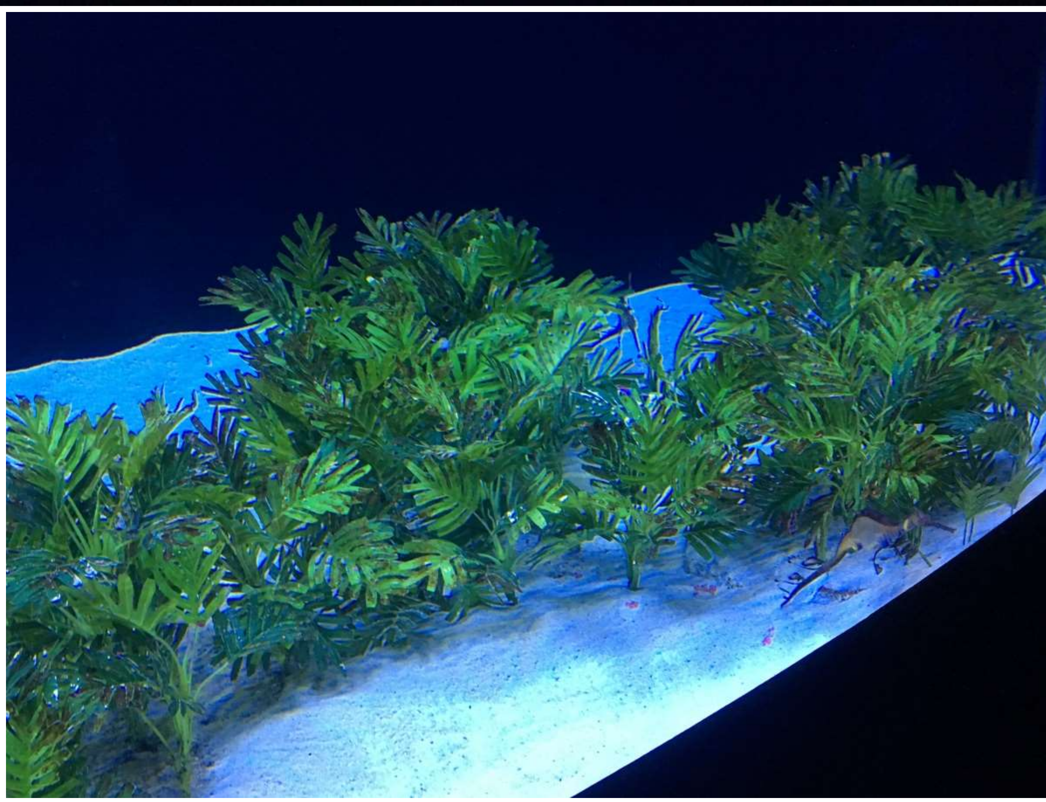


Figure 11 – Top – New seadragon display at Birch Aquarium. An overview of the display. Bottom – close-up of the short sea grass with an open area above it which is ideal for the courtship dance.

Lighting must be phased on and off and a 24-hour background light must be maintained.

Night lighting is also critical for seadragons; a low-level blue light simulating moonlight is required. Seadragons kept in displays that are very dark at night will stress during the dark nights spending a lot of time at the surface with known complications mentioned previously. In most aquaria the night light is left on 24 hours per day and the day-time lighting turns on and off when required. The night light should be bright enough to see relatively clearly into the tank.

Furthermore, emergency lighting should also be considered. When blackouts or power is lost, having emergency lighting will avoid the seadragons stressing in dark displays. Ensure this emergency lighting is regularly tested and will last longer than any possible power outage.

As an example of a successful seadragon display, SEA LIFE Melbourne Aquarium's lighting uses simple fluorescent lights. There is a one 2-foot night light which stays on 24 hours per day and two 4-foot double fluorescent lights used during the day (see Figure 12). Interestingly LED lighting was trialled unsuccessfully, and so fluorescent lighting was re-installed. LED lighting has improved drastically over the last few years and several sites are now using this with good success.

Lighting that has a UV component (around the 400 nm range) is advisable as seadragons can see in the UV range. They have UV-reactive pigments that they respond to and it may be important in recognition and breeding.

Figure 12 - Fluorescent lighting above the seadragon tank at SEA LIFE Melbourne Aquarium. The smaller light to the left is the night light and is blue in colour.

Tank Mates

Seadragons are constant grazers and relatively slow swimmers. Other fish tend to be much faster swimmers and more aggressive feeders. They will quickly eat all the food they can find, out competing the seadragons.

Seadragons are best kept only with other seadragons

Seastars have been known to grab unsuspecting seadragons and seahorses so it is best not to keep these together. Crabs also may also pose a threat to seadragons. Glass Shrimp (*Palaemon serenus*) seem to be good tank mates as they clean up any uneaten food and debris and don't tend to pose much threat to a healthy seadragon. Also, if the glass shrimp breed, their offspring can provide another food source for the seadragons.

Water Quality

Water quality for seadragons, should be maintained within the following ranges (see Figure 13).

Parameter	**Lower limit**	**Upper limit**	**Ideal**
Dissolved Oxygen (DO)	90 %	100 %	95 %
Ammonia ppm	0	0.05 ppm TAN	0
Nitrite ppm	0		0
Nitrate ppm	0	100	< 40 ppm
pH	7.6	8.4	8.0 to 8.3
Salinity	30 ppt	36 ppt	35 ppt
Temperature	12 °C	20 °C	14 to 18 °C
Total Gas Pressure (TGP)	90 %	103 %	100 %
ORP	320	350	340
Total Residual Oxidants (TRO) *	0.00 ppm	0.05 ppm	0.00 ppm

* In systems using ozone

Figure 13 - Recommended water quality parameters for seadragons.

Environmental Hygiene and Cleaning

It is important that the LSS is properly maintained to ensure that it provides excellent water quality. Exhibits should be checked at least once daily and cleaned of any uneaten food items or deceased animals that may adversely affect water quality. Depending on the display size, LSS, stocking density and composition of the exhibit, at least once weekly cleaning of the exhibit by divers will be required. This should include vacuuming the substrate and rockwork/theming of debris, as well as cleaning of viewing windows. Take care when vacuuming as the presence of divers and equipment can stress the seadragons.

The DO level, ORP, daily bromine residuals (if ozone used) and temperature as a minimum should be checked on a daily basis, if no constant monitoring system is in place. A range of other water quality parameters should be tested weekly for an established and stable system; more frequently (daily) for new or unstable systems. These include pH, salinity, ammonia, nitrite and nitrate.

As with good aquarium husbandry in general, it is essential to ensure there are no *Aiptasia* spp. (glass anemones) on the sides or bottom of the display. These, if present, may sting the seadragons resulting in white areas on the skin at the end of the tail, body or jaw. This can be a serious condition. If this occurs, the recommended treatment is to move the seadragons to a quarantine tank and treat the display with a 400 ppm formalin treatment (Paul Hale, pers. comm.). After this 24-hour treatment, rinse and refill the display. Taking the biofilter off-line during the treatment will allow you to re-start the system immediately with a functional biofilter. If this is done it must be noted that *Aiptasia* may still be present in the system and may return to the display within a short period of time.

4.2 Behaviour

Getting to know the individual seadragons in your care is important. Daily routines can change, particularly in the establishment stage of the display. Aquarists need to know how the seadragons are responding to the exhibit and their normal behaviors. They can then be aware of subtle events which negatively impact seadragons causing stress and eventual disease.

For example, some seadragons like to scratch on each other or the theming. This behavior may be normal if occurring infrequently. However, if it becomes constant, scratching may be a sign of increased skin irritation (possibly due to external parasites) and this needs to be investigated promptly.

Seadragons may experience stress more than other fish, which can quickly lead to injury and disease. One key to success is recognizing this stress and eliminating it before it progresses to a health issue. With any health problem, it is important to deal with the underlying stress as well as the disease (infection or parasitism).

Stressors can be many things but is often an accumulation of several smaller stressors. Some aquariums find that **Flash Photography** is a stressor; while other aquariums find no issues relating to flash photography.

Seadragon respiratory rates are quite variable depending on what is occurring at the time. A relaxed seadragon can breathe as little as nine times per minute. The respiratory rate is counted as every time the operculum opens and closes in one minute.

4.3 Health Care

There are various health problems that are seen in seadragons. The most common are discussed below.

Scutociliates (often called Uronema)

Scutociliates are a group of ciliated protozoan parasites often present in aquariums, that can affect many fish. However, seadragons appear to be particularly susceptible to them. A particular scutociliate (*Philasterides dicentrarchi*) that infects mainly seadragons has been recognized (Rossteuscher *et al.* 2008).

Prevention is the best option, because once a seadragon is infected, the damage is usually too advanced and the seadragon cannot be saved. Immediate action on the system is imperative to prevent other seadragons becoming infected. *P. dicentrarchi* may not always be found on a skin scrape but is often found on histopathology provided the pathologist is familiar with the parasite.

P. dicentrarchi has been found on the skin and fins, in muscle tissue, within the gut, spinal cord, kidneys, heart, even the muscles behind the eyes. It is very aggressive and will kill seadragons within a day or so of a white pastiness appearing on the body or the eyes bulging outward (exophthalmia). See Figures 14 and 15.

It seems that *P. dicentrarchi* can both burrow through the epidermis or be ingested. Managing *P. dicentrarchi* infestations can be done by regular freshwater bathing (see later) and by the use of Oxytetracycline, an antibiotic. It is believed that whilst the *P. dicentrarchi* are not susceptible to the Oxytetracycline, it reduces the bacteria in the system, which is the main food source for the protozoan.

A scutociliate infection in Pot-bellied seahorses (*Hippocampus abdominalis*) was treated successfully with metronidazole. Metronidazole baths at a dose of 50 mg/L (ppm) was administered daily for 10 days, with a complete water change each day and more drug applied (Di Cicco *et al*. 2013). This can be used if the infection in the seadragon is not too far advanced.

Prevention is the best method of dealing with *P. dicentrarchi*. This involves feeding only clean, uncompromised mysids and regular vacuums to remove detritus which *P. dicentrarchi* feeds upon. This practice combined with a massive UV unit to decrease bacterial numbers, which are the normal food source of *P. dicentrarchi*, will keep the population of *P. dicentrarchi* to a minimum in the tank.

Figure 14 - Typical presentation at death in a weedy seadragon (*Phyllopteryx taeniolatus*) by *Philasterides dicentrarchi* infection.

Figure 15 – Histopathology of seadragon skin (x 400) showing a mass of scutociliates (labelled Uronema) under the skin associated with necrotic tissue (H&E stain).

IMPORTANT NOTE

Tank cleaning is essential to keep scutociliates under control as well as a large UV unit on the system.

Coccidiosis

There are several hundred species of coccidians that infect fish, with the vast majority being of low pathogenicity (not causing disease). Coccidia have a direct life cycle, with many stages that include both sexual and asexual reproduction. Most fish coccidia belong to the family Eimeriidae, with *Eimeria spp.* being very common in the intestinal tract of fish.

Eimeria phyllopterycis has been identified and described in seadragons (Upton *et al*. 2000). The majority of infections will be asymptomatic and be found incidentally at a necropsy or on a faecal examination, but in some cases illness and death may occur.

Oocysts (eggs) are passed in the faeces and permit spread of the infection. The oocysts each contain four sporocysts, each of which in turn contains two sporozoites (see Figure 16).

At SEA LIFE Melbourne Aquarium, coccidia have been found in the faeces of juvenile Seadragons but as yet not in adults. SEA LIFE Melbourne Aquarium treated the coccidia by feeding 72 hour brine shrimp (*Artemia*) bathed in Trimethoprim Sulpha. The *Artemia* were then fed to mysids which in turn were fed to the seadragons. It is not certain whether this treatment cured the coccidia or whether the seadragon immune system developed protection and the disease resolved.

The seadragons which were known to have had coccidiosis seem to have a thinner abdomen. One of the seadragons diagnosed with this condition lived to a healthy nine years of age (A. Edmunds *pers. comm*.).

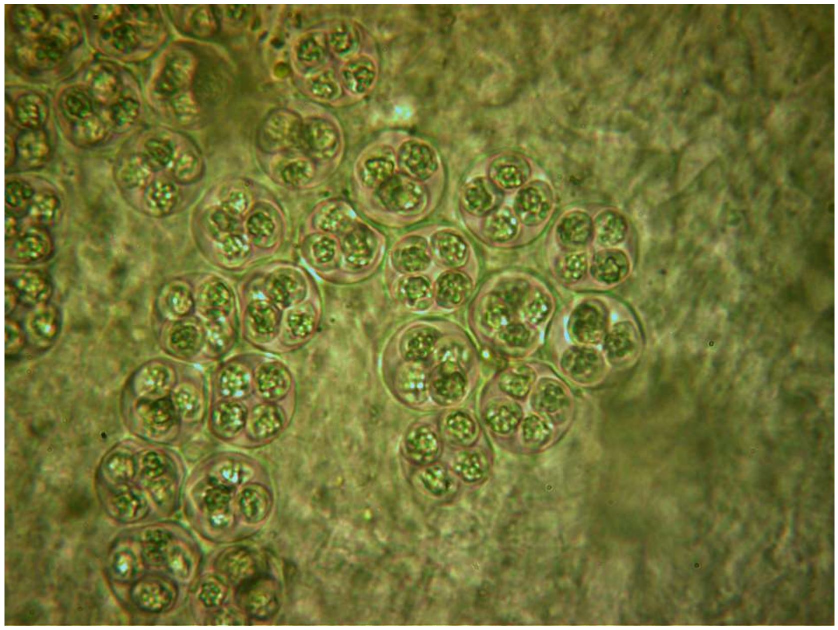


Figure 16 - Oocysts of *Eimeria* spp. in a faeces wet preparation (400 X magnification).

Fungus – *Exophiala* spp.

Members of the genus *Exophiala* spp. are known to infect seadragons. *Exophiala* spp. is a melanised fungus ("black fungus") and is ubiquitous in the soil and environment.

Infections caused by *Exophiala spp.* are increasingly occurring in the aquarium and aquaculture industries. In the aquarium industry, it is a major issue in the Syngnathidae family, especially in weedy seadragons (*Phyllopteryx taeniolatus*) and leafy seadragons (*Phycodurus eques*) (Nyaoke *et al.* 2009).

Stress and old age appear to be major contributing factors in the development of the disease due to their immunosuppressive properties and this presumably allows the pathogen to enter and cause disease.

Exophiala spp. causes an infection of the skin (see Figure 17), sub-cutaneous tissue and internal organs. The initial lesion seen is often an area of darkened skin, which enlarges and ulcerates. A fungus infected wound has a black edge. The seadragon is often lethargic and anorexic. Death will ensue as the infection spreads internally. In some cases, there may be no external lesions and the disease is completely internal, affecting particularly the kidneys and the nervous system.

Figure 17 - *Exophiala* spp. infection in the dorsum of a weedy seadragon (*Phyllopteryx taeniolatus*).

Signs often commence initially at the bony tips of the dorsal appendages where the tip has a clear round point to it rather than a non-rounded, brown or white edge. In several cases freshwater baths did not assist in treating the fungus, and the stress of capture and bathing may in fact have contributed to the growth of the fungus.

Skin scrapes (wet preparations) of the external lesions often reveal fungal hyphae, which are branching and septate hyphae (see Figure 18).

At necropsy there may be no lesions other than the external skin lesions. Histopathology will confirm the presence of fungal hyphae (see Figure 19).

One seadragon ("Randy") was born at SEA LIFE Melbourne Aquarium in 2005 and was still alive in 2012, despite having suspected *Exophiala spp.* (A. Edmunds *pers. comm.*).

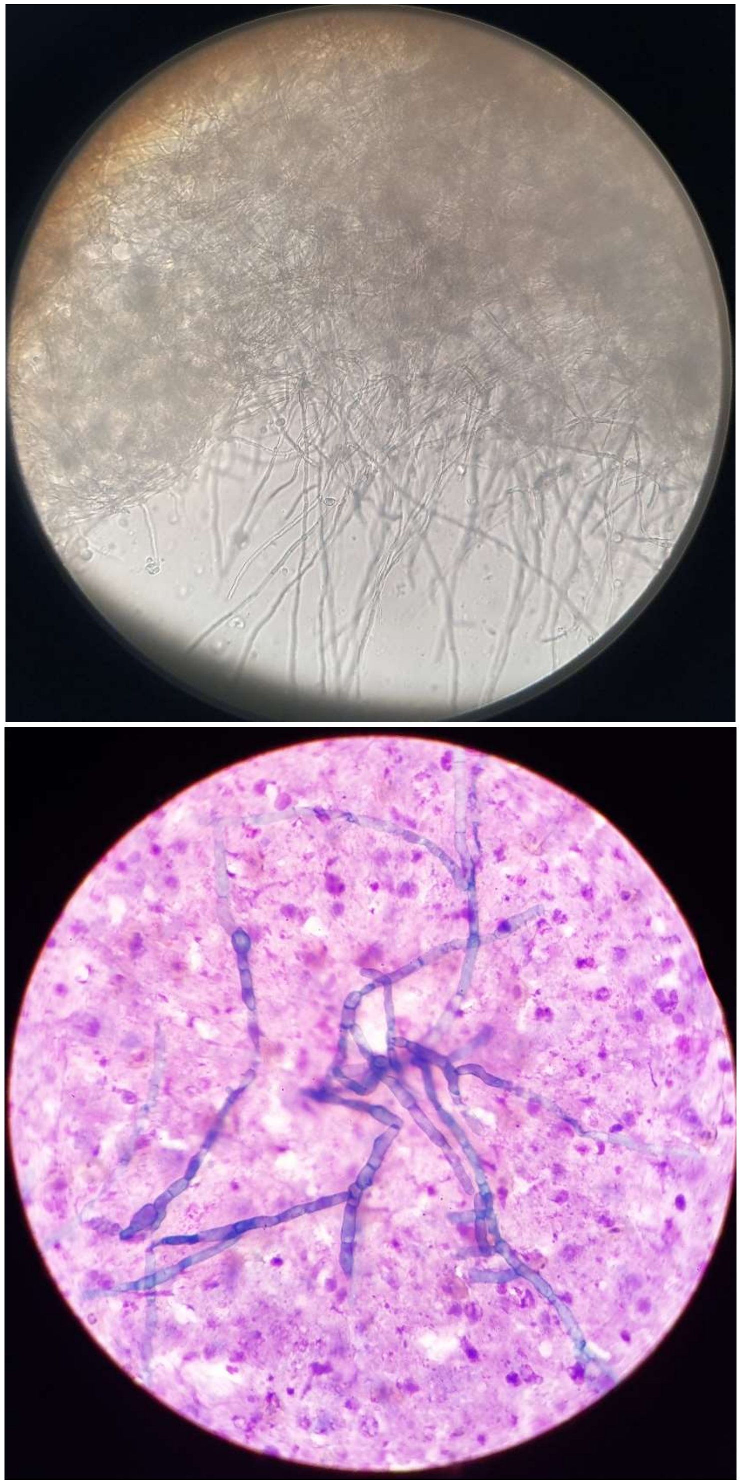


Figure 18 – Top: Wet preparation cytology of *Exophiala spp*. (magnified 400x); Bottom: Diff Quick Stain (magnified 1000x) from a seadragon showing the blue fungal hyphae.

There appears to be no successful treatment available at present however various anti-fungal drugs have been trialed either as baths or given orally with limited success. The best prevention appears to be maintaining a stress-free environment.

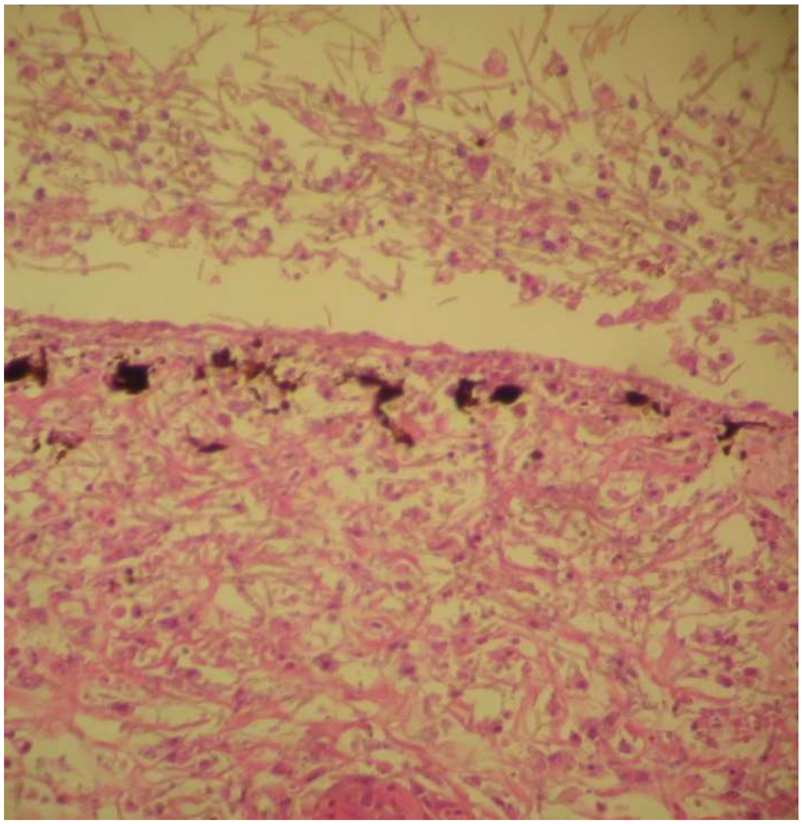


Figure 19 – Histopathology of seadragon skin (magnification x 400) with fungal mass (*Exophiala* spp.) above the skin and penetrating into the skin (H&E stain).

Amoebic Gill Disease

Amoebic gill disease (AGD) is a well described disease in aquaculture fish, however, is also a common finding in temperate syngnathids, including seadragons. AGD is caused by *Neoparamoeba spp*. The pathogenic species commonly described in the literature are *N. perurans*, *N. pemaquidensis* and *N. branchiphila*. The major aetiological agent of amoebic gill disease in Atlantic salmon in Tasmania is *N. perurans*.

The amoeba reside on the surface of the gills, causing gill epithelium hyperplasia, lamellar hypertrophy and fusion, and goblet cell hyperplasia. Initially, primary focal neutrophilic inflammatory infiltrates may be seen, with mononuclear infiltration later in the disease progression.

In teleosts, gill biopsy is used for diagnoses, however in syngnathids the fused operculum prevents biopsy and diagnosis is generally a necropsy finding on histopathology. A combined Alcian blue (AB, pH=2.5) and periodic acid-Schiff (PAS) stain can help increase visibility of *Neoparamoeba* in histopathology slides. Furthermore, a PCR assay that is specific and highly sensitive to the 18s rRNA of *Neoparamoeba perurans* has been developed (contact local veterinary pathology lab for availability).

The amoeba is ubiquitous in the environment and spread via water. Infestations tend to occur in higher salinity and are exacerbated by temperature. Stress to the animals may also contribute. In a study, 24 seahorses *Hippocampus abdominalis* were experimentally inoculated by *Neoparamoeba* from AGD infected Atlantic salmon (*Salmo salar*). The results showed that in the seahorses, they were asymptomatic, and only 9 (37.5%) tested positive in H&E histology and immunohistochemistry tests (Douglas-Helders 2002).

Treatment options:

- Long term hypo-salinity treatment for Syngnathids:
    - Decrease salinity by 3 ppt. per day going down to 20 to 22 ppt. salinity
    - Hold at this level for six weeks
    - Bring salinity back up at only 1 ppt. per day to the normal level

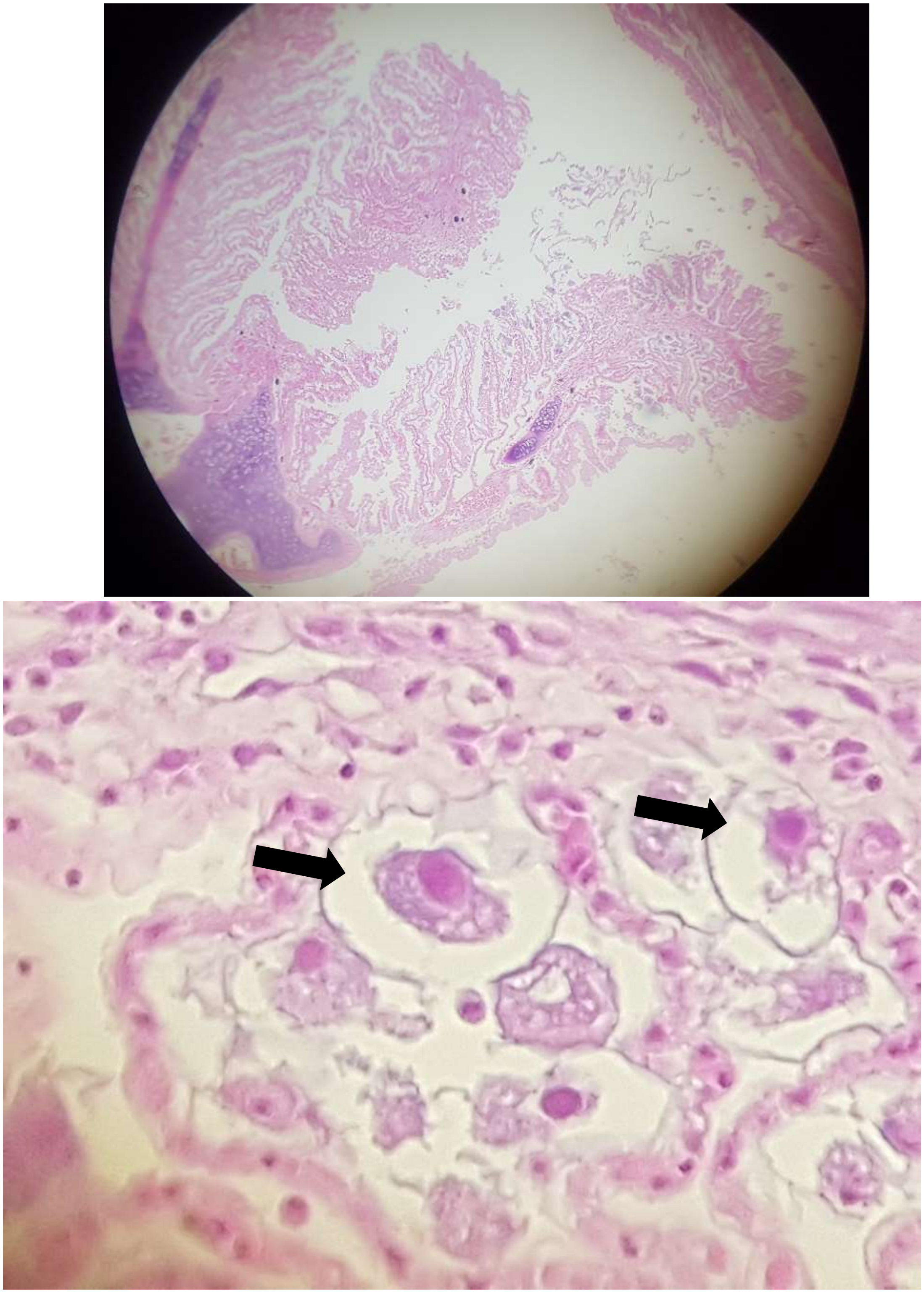


Figure 20 – Top: Histology revealing fusion of the secondary lamella of the gills in a weedy seadragon (magnified 40x); Bottom: Amoeba (arrows) present within the secondary lamellae (magnified 400X).

- Potential treatments described in aquaculture:

    - Bithionol is a mammalian anthelmintic that has shown efficacy in treating amoebic gill disease in Atlantic salmon (*Salmo salar*). Method of administration is as a bath by adding 1 mg/L for 60 minutes in seawater, but there is a risk of toxicity. Another method is by giving oral medication at 1% body weight/day or 25mg/kg for two weeks. This method uses bithionol as a prophylaxis, which can help delay onset and reduce the severity of AGD.
    - Levamisole at 1.25-5ppm in fresh water for two to three hours induces increased resistance to reinfection. Higher doses of levamisole in seawater with pH adjustment seemed to yield very promising results in returning the gill epithelium to normal, however there was toxicity noted.
    - Narasin fed at 50-60mg/kg bodyweight was found to reduce AGD gill lesions, however there is palatability problem and the study was not continued.
    - An all-in all-out management may also help, as there is evidence that virulence increases with increased passage on fish.
    - No vaccination is successful at this stage.

Buoyancy Issues

Occasionally when a new animal arrives or an animal becomes stressed e.g. after a freshwater bath, they bob around at the surface, unwilling to swim down. As discussed in the lighting section, issues with lighting can cause this stress behaviour. With time at the surface the snout tip can dry out, causing problems which often results in the death of the seadragon. For seadragons which are momentarily startled from a stress event, a complete cover of plastic or ideally bubble wrap can be placed directly on the water surface, preventing surface penetration. Make sure there is no air trapped under the bubble wrap. See Figure 21.

Figure 21 - Bubble wrap on surface as used successfully at SEA LIFE Sunshine Coast (Mooloolaba). In this case the seadragons were stressed upon introduction to their new display. The behaviour resolved within 24 hours and the seadragons were uninjured.

If a seadragon is positively buoyant (floating), it is important for their protection that the seadragon be placed in a large clear plastic bag which has been hole punched (i.e. four rows of four holes per side). An open shape in the bag must be maintained, weight it and sink it to the bottom of the tank (ideally at least 2 meters or 6.6 feet deep) and preferably leave overnight. See Figure 22.

If the condition is purely stress related from a freshwater bath, lighting issue, or some explainable event which has resolved, the animal will generally swim back down to that depth after releasing it from the bag.

If the buoyancy problem is an over-inflated gas bladder it may take days or weeks to resolve and the seadragon should be placed at a depth at which it attains neutral buoyancy. Offer mysids close to the animal as most will eat happily even if lying on their side. If the seadragon is not feeding you may need to assist feed (see Supplementary Feeding section).

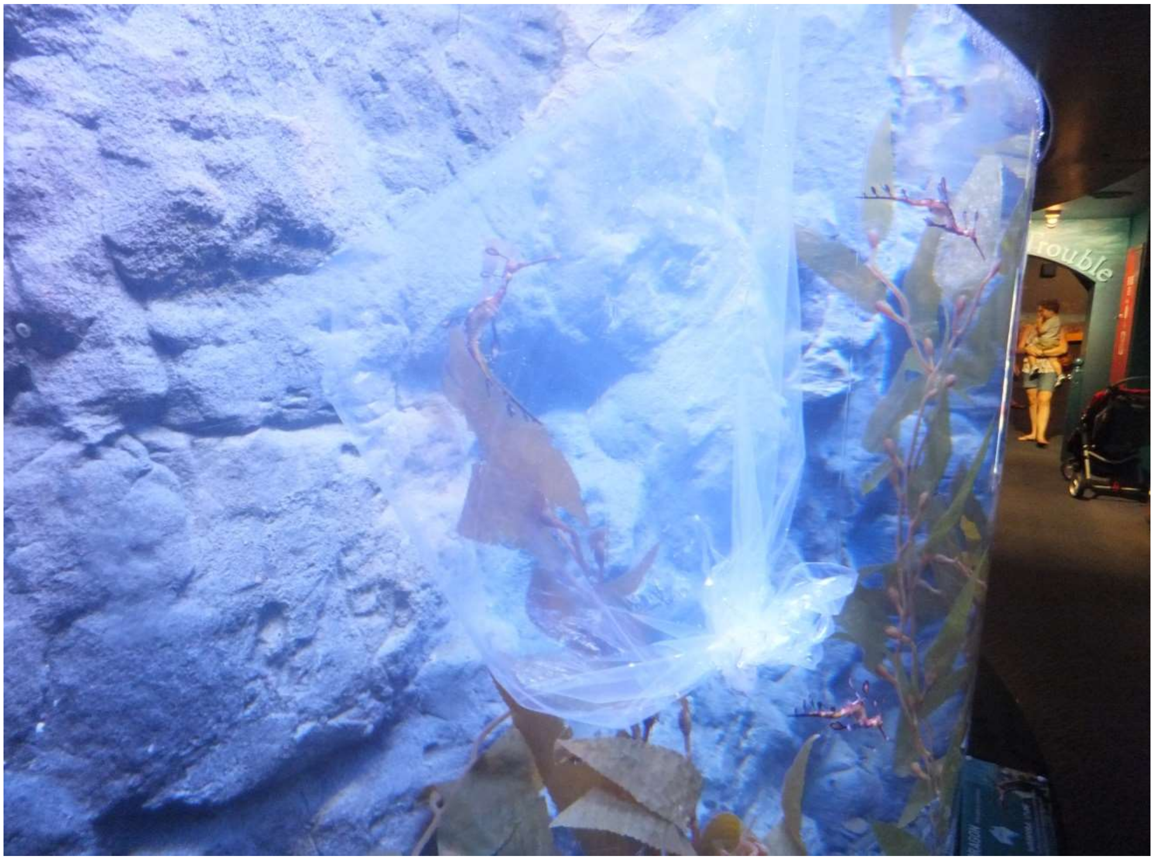


Figure 22 - Weedy seadragon (*Phyllopteryx taeniolatus*) inside a weighted plastic bag.

Mouth Damage

Mouth damage often follows head bobbing at the surface and subsequent drying of the snout. This can be very difficult to treat, especially if the tip of the snout is damaged. The tip of the snout must form a seal in order for the seadragon to eat. When a seadragon feeds or yawns, the hyoid apparatus enables the seadragon to change the pressure in the snout / mouth cavity. This creates a vacuum within the mouth and then upon opening the mouth, water and hopefully food is drawn in. If the hyoid bone is not functioning or is dislocated, feeding will not be possible.

Betadine (a providone-iodine compound diluted to 10%, do not use undiluted) can be applied topically to the snout tip, to aid resolution of infection. During the time the mouth is damaged the seadragon may not feed itself and supplementary feeding will need to be undertaken. Where there is damage to the skin, a secondary scutociliate infection may become an issue, so regular freshwater bathing (dipping) is necessary. See next section for details on this.

Freshwater Baths

There is still debate as to whether a freshwater bath (0 ppt.) kills scutociliates or not. From experience it does seem to assist in the control of external scutociliates. It will not assist if they are already internal. Freshwater baths are also very useful at removing many other external parasites and pathogens. Mysids do not tolerate fresh water and therefore cannot be treated in this way to remove scutociliates as a preventative.

The freshwater used must be either reverse osmosis (RO) water, distilled water or dechlorinated tap (town or municipal) water. Freshwater baths can be repeated regularly if required. Some aquariums will routinely bath seadragons once per month for long periods of time without causing any health issues.

Seadragons are best freshwater bathed inside a clear bag, floating in their tank. Unlike a bucket, the sides of a bag are soft and give way if the seadragon touches the sides, thus protecting their snout. Allow time for the fresh water to become the same temperature as their display. Add some sodium bicarbonate ($NaHCO_3$) to raise the pH to equal that of the display water. The amount of sodium bicarbonate will vary depending on your tap water but about one teaspoon per litre raises Melbourne tap water pH from 7.6 to 8.2.

When the water in the bag is ready, guide the seadragon up to the surface being careful not to snag them on the net or cause them to stress. Gently lift the seadragon in your wet gloved hand and place them in the freshwater bag tail first allowing any air to exit the snout.

After four minutes (use a timer), lift the seadragon out of the freshwater bag and place back in the display again tail first. They will usually immediately swim down to the bottom. The seadragon may exhibit some change in behaviour such as a sudden violent swim with much sideways action. This usually only lasts a second or so, but for this reason place them back in the tank in an area away from the walls or theming. They may also cough a few times.

Occasionally, in particular the leafy seadragon, may become considerably disorientated. If after a few minutes the seadragon is rolling upside down and looks in danger of damaging itself it may need to be placed in a bag with holes for water exchange, and sunk to the bottom (see previous section). If left overnight, they are usually normal the next day. Most seadragons can be seen to feed and participate in courtship within minutes of leaving the fresh water and resume their normal behavior.

Supplementary Feeding and Tube Feeding

For a seadragon with some strength, supplementary feeding with a pipette is a worthwhile procedure. A pipette with a wide opening is best, the opening should be large enough for mysids to be squirted through it without being squashed. Suck up as many live mysids as possible in the pipette. Holding the seadragon so that its mouth is under water, position the pipette at the mouth (not touching) and when the seadragon breathes in, squirt mysids into its open mouth so that seadragon is forced to suck them in. The seadragon will normally eat some and also spit some out. Count and record how many are eaten.

Seadragons have a simple linear digestive tract, running from the snout directly to the vent. Mysids swallowed will line up along it and give you an idea of how many may be enough. This method has been used successfully to assist seadragons over several weeks before self-feeding resumes.

If pipette feeding is not working, then tube feeding is the next step. The insertion of a tube down the mouth must be done with caution as it may cause damage to the snout. The distance down the snout into the oesophagus can be gauged by measuring the distance on the outside of the seadragon. Using the snout length as a guide, make a mark on the outside of the tube about twice the snout length as the distance to which the tube is inserted.

Intravenous or urinary catheters with lengths of between 10 and 20 centimetres and diameter of between 1.0 – 1.3 millimetres should be used (see Figure 23).

Mysids may not be able to be crushed fine enough to squirt down this feeding tube, so a commercial product such as Hills A/D (a tinned cat food) mixed with water may be a better option. Always keep the animal underwater and you can use the breathing to assist insertion. When the tip of the snout moves to draw in water insert the tip of the tube. Extend the head, depressing the hyoid bone to allow insertion through into the pharynx.

Any seadragon that has progressed to the stage of requiring tube feeding has a very poor prognosis.

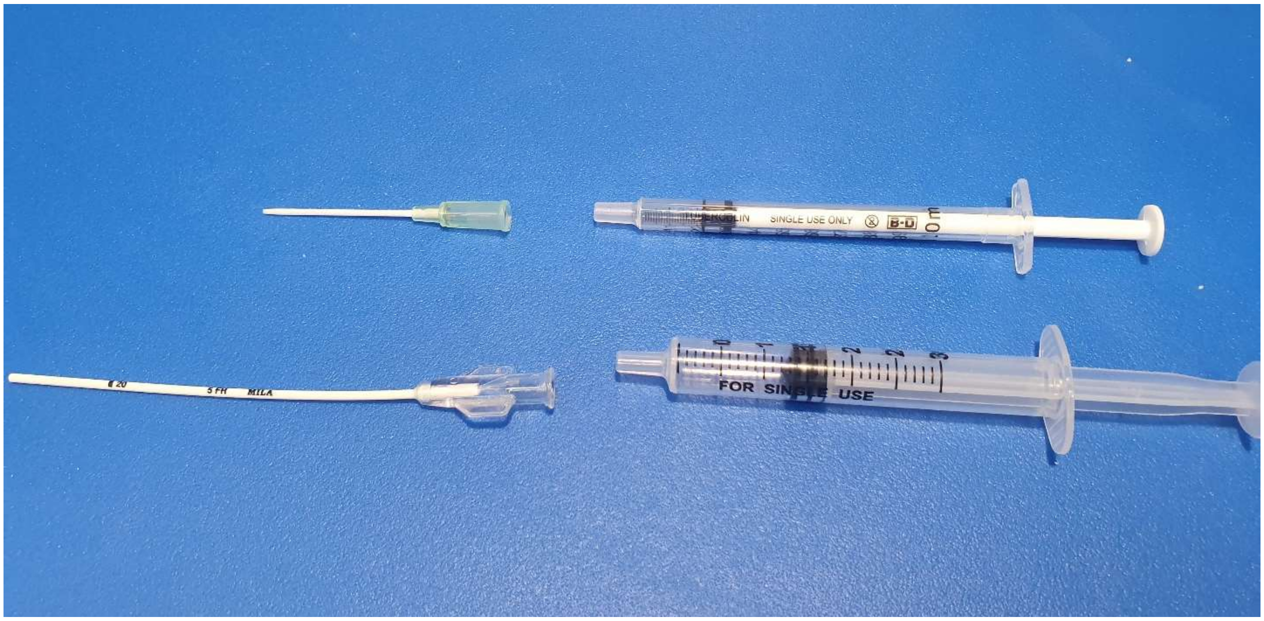


Figure 23 – Examples of feeding tubes suitable for seadragons.

Injections

The dorsal part of the seadragon has the largest area of muscle / fat tissue. The abdominal organs of seadragons run along the ventral section of the neck and abdomen to the vent, with the gas bladder located in the middle of the body (see Figures 24 and 25).

Seadragons have a blood vessel located along the tail medially and ventrally, it is only about 1 – 2 mm under the skin. Whilst this should be a suitable place for blood sampling or intravenous injections, in practice it is almost impossible to access this blood vessel.

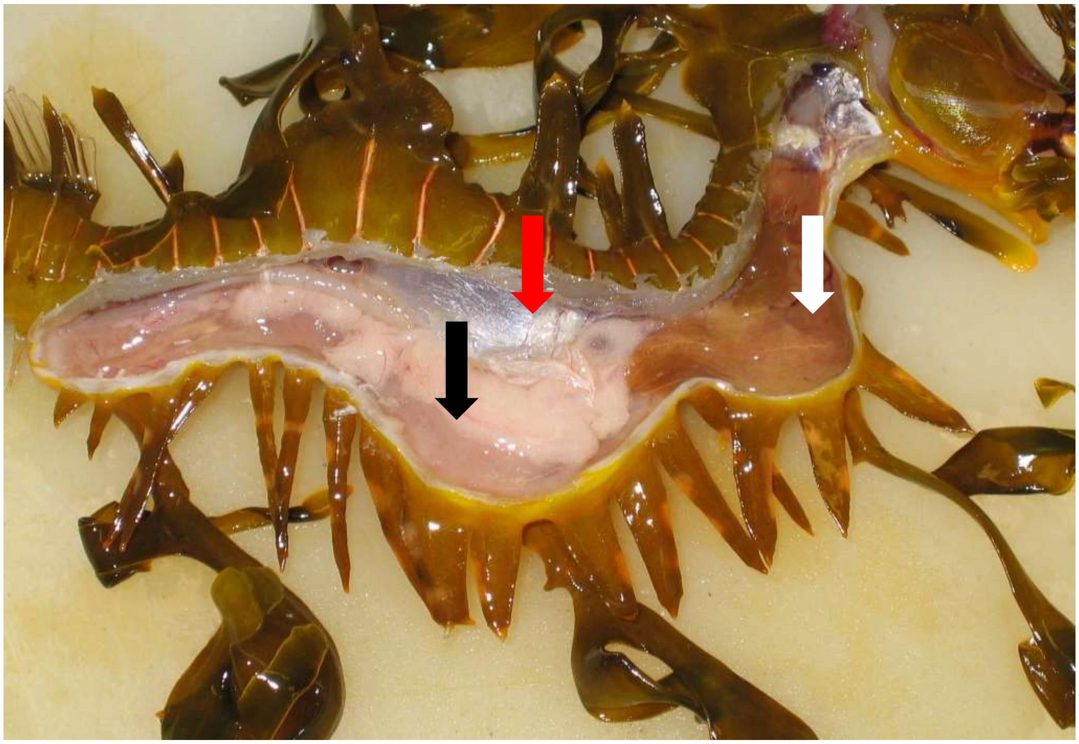


Figure 24 - Leafy seadragon (*Phycodurus eques*) liver (white arrow), gas bladder (red arrow) and intestinal tract (black arrow).

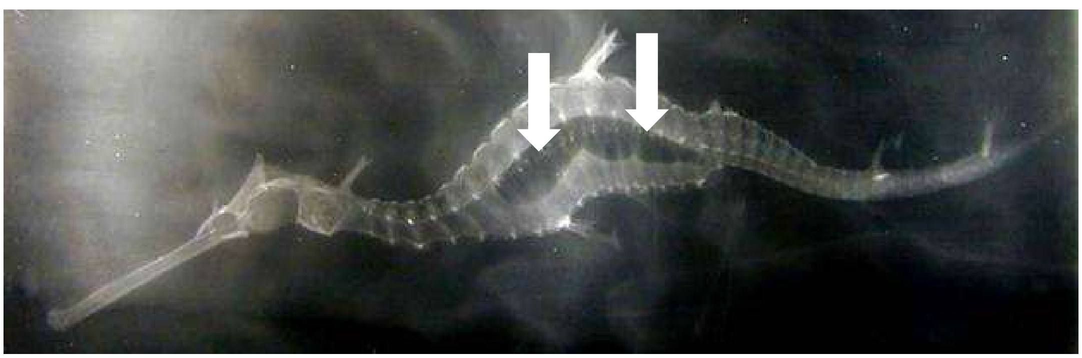


Figure 25 - Weedy seadragon (*Phyllopteryx taeniolatus*) radiograph demonstrating a slightly over inflated gas bladder (indicated by the arrows).

HANDY HINT

To visualize the gas bladder of a seadragon, place a waterproof torch underneath the seadragon, shining through the body., The dark gas bladder will be visible.

Chlorine sterilization

When sterilizing the tank or associated implements (nets) chlorine is very effective. It is best to have the water pH between 5.0 and 7.0 before adding the chlorine. There are two chlorine concentrations commonly used for different purposes.

200 ppm concentration for tank disinfection

Sodium hypochlorite solution (NaOCl) (12.5 % available chlorine) should be added at 1.6 ml of solution to 1 litre of water (1.6 litres solution to 1000 litres).

Calcium hypochlorite $Ca(OCl)_2$ powder (usually 65-70% available chlorine) should be used at 0.30 grams powder per 1 litre of water (300 grams per 1000 litres of water).

Allow to sit for at least one hour and agitate for at least 10 minutes to be effective. It is most effective if the display is empty, as organisms can 'hide' from the chlorine in substrate or theming.

50 ppm concentration for weekly net disinfection

Hypochlorite solution (12.5 % available chlorine) should be added at 0.4 ml of solution to 1 litre of water (0.4 litres or 400 ml solution to 1000 litres).

Calcium hypochlorite powder (usually 65-70% available chlorine) should be used at 0.075 grams per 1 litre of water (75 grams per 1000 litres of water).

Sodium thiosulphate ($Na_2S_2O_3$) can be used to neutralise chlorine prior to discharge. For water treated with chlorine at 200 ppm, then the sodium thiosulphate is added at a rate of 1.25 grams (2.5 ml of 50 percent sodium thiosulphate solution) per 1 litre of treated wastewater. It is then agitated for not less than 10 minutes before discharge to a general sewage line.

4.4 Nutrition

Seadragons are constant grazers and need to be fed regularly. Seadragons in aquaria mainly eat mysid shrimp (Family Mysidae), both live and frozen. Juveniles are capable of switching onto frozen mysids relatively easily; adults often seem determined to eat live mysids or starve but can be switched with persistence. If feeding live mysids, it is important to visually check each day that there are some always present in their display.

Glass Shrimp (*Palaemonetes paludosus*) have been found in wild seadragon faeces. Glass shrimp are good to have in the tank as they breed productively and provide a second food source to seadragons.

Live adult brine shrimp (*Artemia* spp.) are also a potential food source as long as they have been appropriately fed and enriched.

Ideally all feed sources can be enriched, including frozen mysids. Live mysids will eat 72-hour brine shrimp. A common enrichment method is to soak frozen food prior to feeding in Super Selco or the Vitalis Liposome Spray. The only case where enrichment may not be necessary is if live mysids are fed routinely and they are not held onsite for more than 48 hours before being fed out. Longer than this, they should be fed and enriched to ensure good nutrition is supplied to the seadragons.

Please Note - Live mysids are easily killed in low salinity and freshwater so it is very important if you have live mysids not to alter the salinity suddenly. If a salinity change occurs suddenly all the live mysids may die off creating the perfect opportunity for scutociliates and other detritivores to increase their numbers and cause issues in a seadragon tank.

With live mysids, all pieces of seaweed, juvenile fish and cephalopods (any ‘hitch-hikers’) should be removed and not allowed to enter the tank. If seaweed is accidentally added to the display, and begins to die, detritivores such as scutociliates will then have opportunity to feed and multiply. Juvenile fish and cephalopods may grow and become a predation risk; they can also act as pathogen vectors.

Mysid Shrimp Nutritional Study

A detailed nutritional analysis of mysid shrimp has been undertaken by Dr Lisa A. Hoopes, Ph.D., Director of Research, Conservation, and Nutrition at Georgia Aquarium, USA, in conjunction with Leslee Matsushige, Associate Curator at Birch Aquarium at Scripps Institution of Oceanography, San Diego, USA.

In this study, wild mysids from Victoria, Australia, were caught, frozen and then analyzed at a nutritional laboratory in Melbourne, Australia. They were compared with live USA mysid shrimp as well as various commercial brands of frozen mysids commonly fed in aquariums. The methodologies between the USA and Australian laboratories were comparable. In the USA some of the live and frozen mysids are from fresh water and not the ocean.

The following parameters were tested:

- Moisture
- Fat
- Protein
- Ash
- Energy value
- Total Carbohydrate
- Complete fatty acid profile
- Minerals (calcium, magnesium, sodium, potassium, phosphorus, iron, sulphur, zinc, copper, manganese, cobalt, selenium)
- Vitamins (A, C and E)

Comparing Australian live mysids with the USA live mysids, the significant difference was a much greater level (ten times) of Vitamin C in the Australian mysids. Although it should be noted that sample sizes are small. The results are available in Appendix One.

Freshwater sourced mysids were higher in fat than seawater sourced mysids. This may be useful to assist with feeding thin or inappetent animals. However, essential omega 3 fatty acids (required for successful reproduction via egg and sperm development in fishes) in freshwater sourced mysids were much lower than those measured in seawater sourced mysids.

Whilst further study is required, it appears that freshwater mysids should not comprise the entire diet for seadragons, rather they can be fed with a predominately sea water sourced diet.

4.5 Breeding Requirements

If breeding is to be successful, several environmental factors need to be addressed. These are discussed below. It should be noted that consistent breeding is yet to occur in aquariums. At SEA LIFE Melbourne Aquarium, egg transfers have occurred with either a massive water change (approximately 50%) or a temperature spike by a few degrees Celsius, due to a chiller failure. However, it has not been possible to replicate these events so they may be a coincidence.

Temperature Schedule

Altering the system temperature on an annual cycle will match the seadragons natural environment. This helps to prevent constant egg production and consuming fat reserves. It assists the seadragons to maintain their body condition and results in an increased likelihood of consistent egg production during the breeding season. See Figure 26 for the temperature schedule used at SEA LIFE Melbourne Aquarium.

Tanks 51 and 52												
Photoperiod &	January				February				March			
Temperature	1	2	3	4	1	2	3	4	1	2	3	4
Light 1 ON	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM
Light 1 OFF	11:00 PM	11:00 PM	11:00 PM	11:00 PM	10:00 PM	10:00 PM	10:00 PM	10:00 PM	9:00 PM	9:00 PM	9:00 PM	9:00 PM
Light 2 ON	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM
Light 2 OFF	10:30 PM	10:30 PM	10:30 PM	10:30 PM	9:30 PM	9:30 PM	9:30 PM	9:30 PM	8:30 PM	8:30 PM	8:30 PM	8:30 PM
Hours daylight	15.5	15.5	15.5	15.5	14.5	14.5	14.5	14.5	13.5	13.5	13.5	13.5
Temp	18°C	18°C	18°C	18°C	18°C	18°C	18°C	18°C	17.8°C	17.6°C	17.4°C	17.2°C
Photoperiod &	April				May				June			
Temperature	1	2	3	4	1	2	3	4	1	2	3	4
Light 1 ON	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM
Light 1 OFF	8:00 PM	8:00 PM	8:00 PM	8:00 PM	7:00 PM	7:00 PM	7:00 PM	7:00 PM	6:00 PM	6:00 PM	6:00 PM	6:00 PM
Light 2 ON	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM
Light 2 OFF	7:30 PM	7:30 PM	7:30 PM	7:30 PM	6:30 PM	6:30 PM	6:30 PM	6:30 PM	5:30 PM	5:30 PM	5:30 PM	5:30 PM
Hours daylight	12.5	12.5	12.5	12.5	11.5	11.5	11.5	11.5	10.5	10.5	10.5	10.5
Temp	17.0°C	17.0°C	17.0°C	17.0°C	16.5°	16.5°C	16°	16.0°	15.5°	15.0°	14.5°	14.0°
	July				August				September			
	1	2	3	4	1	2	3	4	1	2	3	4
Light 1 ON	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM
Light 1 OFF	6:00 PM	6:00 PM	6:00 PM	6:00 PM	7:00 PM	7:00 PM	7:00 PM	7:00 PM	8:00 PM	8:00 PM	8:00 PM	8:00 PM
Light 2 ON	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM
Light 2 OFF	5:30 PM	5:30 PM	5:30 PM	5:30 PM	6:30 PM	6:30 PM	6:30 PM	6:30 PM	7:30 PM	7:30 PM	7:30 PM	7:30 PM
Hours daylight	10.5	10.5	10.5	10.5	11.5	11.5	11.5	11.5	12.5	12.5	12.5	12.5
Temp	14°C	14°C	14°C	14°C	15°C	15°C	15.5°C	16°C	16.5°C	17.0°C	17.0°C	17.0°C
	October				November				December			
	1	2	3	4	1	2	3	4	1	2	3	4
Light 1 ON	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM	7:30 AM
Light 1 OFF	9:00 PM	9:00 PM	9:00 PM	9:00 PM	10:00 PM	10:00 PM	10:00 PM	10:00 PM	11:00 PM	11:00 PM	11:00 PM	11:00 PM
Light 2 ON	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM
Light 2 OFF	8:30 PM	8:30 PM	8:30 PM	8:30 PM	9:30 PM	9:30 PM	9:30 PM	9:30 PM	10:30 PM	10:30 PM	10:30 PM	10:30 PM
Hours daylight	13.5	13.5	13.5	13.5	14.5	14.5	14.5	14.5	15.5	15.5	15.5	15.5
Temp	17.2°C	17.4°C	17.6°C	17.8°C	18°C	18°C	18.0°C	18.0°C	18.0°C	18.0°C	18.0°C	18.0°C

Figure 26 - Annual light and temperature cycles for the seadragon tanks at SEA LIFE Melbourne Aquarium.

Lighting Schedule

To mimic the natural environment for seadragons, their exhibit should be on a lighting schedule which closely follows the sunrise and sunset of the locations where they are found. In Melbourne, this is based on the sunrise and sunset of Port Phillip Bay which is where weedy seadragons are found. Refer back to Figure 26 for the lighting schedule used at SEA LIFE Melbourne Aquarium.

It is also important to include a 'moon light' or night light over the exhibit. This light should be blue and produce only a low light level and serves primarily to help the seadragons position themselves in the darkness and prevent them from swimming or bumping into theming. There has been a definite correlation noted between egg laying in aquariums and the full moon stage of the lunar cycle.

It is important that the lighting has a UV component around the 400 nm range. Seadragons can see in the UV range and have pigments on their body surface that react to the UV. These UV-reactive pigments may be important in courtship behaviour.

Feeding

It is important whilst mimicking the temperature and lighting cycles, that food is also fluctuated through the seasons as well. During cooler months of the year, seadragons have less opportunity to feed and therefore have a period of reduced intake.

As the system begins to warm in spring, it is important to increase the food until the peak of summer. This will follow the natural populations of their food source in the wild and will also assist in matching the reproductive cycles of the males and females. Additional food doesn't only have to be live food, frozen mysid of good quality can be used to add condition.

Hatching of seadragon eggs normally takes place over a two to four day period. During this time monitor the display carefully for the presence of fry and using a bag inside an aquarium net, gently collect them and transfer them into the rearing vessel (back of the tank and same LSS).

When rearing young seadragons, 24-hour old *Artemia* combined with small live mysids will provide the best possible diet to encourage good survival rates and growth. Seadragons are born at about one centimetre in length and increase in size by almost a centimetre per week for the first few months. Juveniles need a constant supply of food to graze upon to achieve this rapid growth rate.

If possible, rearing solely on live mysid is the best option. Brine shrimp does not contain an adequate nutritional profile for rearing syngnathids (even though they are used widely due to convenience). As hatchlings, seadragons are large enough to eat small mysids immediately. After a few weeks introducing frozen mysids is possible and a mixture of live feed with frozen mysid can then be fed. Another option would be larval glass shrimp.

Figure 27 – Newly born weedy seadragon (*Phyllopteryx taeniolatus*) at Melbourne Aquarium.

Methods of Controlling Breeding

At this stage there are no published methods of controlling seadragon breeding other than separating males and females. However, designing shallower displays with depths of less than one meter has been shown to be successful in preventing egg transfer. SEA LIFE Sunshine Coast have seen several unsuccessful egg transfers over a seven year period with no successful breeding events. At this aquarium breeding was not wanted as all the seadragons were aquarium bred siblings.

4.6 Transport

Seadragons transport well in clear plastic bags. Younger animals appear to cope better with transport, than mature adults. Seadragons are packed in the plastic bag **without air**. This prevents possible drying out of their snout should they become distressed. Individuals should be packed separately to avoid damaging each other. In a standard fish bag 15 to 18 litres (3.96 to 4.76 US gallons) of water is enough water for a sub-adult seadragon without the addition of oxygen, to travel interstate (travel time up to 4 hours). See Figure 28. For longer international transports, of up to 48 hours, oxygen can be bubbled into the transport water raising the Dissolved Oxygen (DO) level up to 140%, without the use of airspace.

A small LED that lasts up to 48 hours, can be attached to the floor of the foam box so a steady low light is present. This assists in avoiding stress when the lid is removed. An outer cardboard box is placed over the foam box for extra security.

If there is a possibility that the shipment will be greater than 48 hours, then the use of an air space with oxygen may assist in the event that there is a delay. The trade-off is that without an airspace, if the seadragon becomes stressed, they cannot bob their mouth out of the water and dry out their mouth. With an airspace, seadragons can survive transports which are delayed. One transport from PQ Aquatics, with an airspace, was delayed and the seadragons survived five days in the same transport water.

Figure 28 - Packing a seadragon for transport. Note no air space in a water filled bag and only one seadragon per bag.

4.7 Quarantine

The critical factor with any newly arrived seadragons is to **minimize stress** following transport. For any seadragon quarantine tanks it is important to have a low level of lighting, minimum background noise and vibration, and the avoidance of any sudden loud noises. The Quarantine tank must have suitable LSS capable of maintaining all water quality parameters to the same extent as the final display tank.

As discussed previously, having bubble wrap that can be placed directly on the water surface, with a complete cover, will prevent surface penetration and snout issues. Having a tank of good depth (absolute minimum of 1 metre or 3.3 feet) will also assist in recovery.

It is essential that all solid quarantine tanks (not clear tanks) used for seadragons have black stripes on them. This helps the seadragons orient themselves. See Figure 29.

Figure 29 - Quarantine tank for seadragons at SEA LIFE Melbourne Aquarium showing the black stripes.

On arrival, it is advisable to keep the seadragons isolated for a minimum of thirty (30) days for observation and to allow them to recover. Maintaining excellent water quality as well as good nutrition during this period is essential. Careful observation is important to ensure they are feeding and showing normal behaviour.

Seadragons generally do not have many diseases and so minimal (if any) prophylactic medication is needed during quarantine. Collecting faecal samples and performing a microscopic faecal analysis will assist in showing if there are any internal parasites present. Any mortality that occurs during the quarantine period needs to be investigated further with necropsy and histopathology.

Providing the seadragons are behaving normally, feeding well and have negative faecal tests no prophylactic medication is required. Treat quarantine seadragons with medications on a case by case basis, and only as required.

5. Record Keeping

Records are important for a variety of reasons. They are great reference points for referral and keeping track and up to date on the seadragons and their system.

The records that should be kept include:

- daily system checks
- weekly water quality parameters
- any treatments
- any daily information that may be important

Daily information can include such details as:

- water changes
- feed amounts
- any abnormal behaviour
- colour changes
- swimming behaviour
- courtship behavior
- successful or unsuccessful egg transfers
- any other items that may be important

It is very important that aquarists know their animals individually and are able to detect problems as early as possible. Seadragons generally only give subtle hints of any health issues. Hence the vital importance of careful observation by aquarists and detecting any subtle or early changes in behaviour. Observing and recording potential breeding behaviour is also essential. Other records that are kept include breathing rates and feeding snick rates.

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Appendix One – Mysid Nutritional Analysis

The results of the detailed nutritional analysis of live mysid shrimp undertaken by Dr Lisa A. Hoopes (Georgia Aquarium) and Leslee Matsushige (Birch Aquarium).

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	Florida Wild Mysis	**California Wild Mysis**	**Australian Wild Mysis**
Laboratory	NPAL	NPAL	DTS
As Fed Values			
Moisture, %	82.1	83.1	83.8
Protein, %	12.6	10.8	10.6
Fat, %	1.01	0.896	1.5
Ash, %	2.8	3.18	3.5
Ca, %	0.5358	0.2813	2.000
P, %	0.2769	0.2211	0.200
Mg, %	0.08931	0.1203	0.120
K, %	0.2679	0.2508	0.210
Na, %	0.3232	0.5036	0.680
Fe, mg/kg	9.678	12.67	19
Zn, mg/kg	10.77	8.144	8.8
Cu, mg/kg	4.981	2.771	8.1
Mn, mg/kg	2.437	<1	2.3
Mo, mg/kg	<1.00	<1	
Co, mg/kg	<1	<1	0.017
S, %			0.280
Se, ppm	0.313	0.466	0.56
Vitamin A, IU/kg	7253	2932.2	8999.1
Vitamin C, ppm	<4.00	<4.00	46
Vitamin E, IU/kg	47.5	21.2	41.72
Energy, kcal/100g	82.0	72.0	58.76

	Florida Wild Mysis	**California Wild Mysis**	**Australian Wild Mysis**
Laboratory	NPAL	NPAL	DTS
DMB Values			
Protein	70.4	63.9	65.4
Fat	5.6	5.3	9.3
Ash	15.64	18.82	21.6
Ca, %	2.99	1.66	2.10
P, %	1.55	1.31	1.23
Mg, %	0.5	0.71	0.74
K, %	1.5	1.48	1.3
Na, %	1.81	2.98	4.2
Fe, mg/kg	54.07	74.97	117.28
Zn, mg/kg	60.17	48.19	54.32
Cu, mg/kg	27.83	16.40	50
Mn, mg/kg	13.61	<6	14.2
Mo, mg/kg	<6	<6	
Co, mg/kg	<6	<6	0.105
S, %			1.728
Se, ppm	1.75	2.76	3.46
Vitamin A, IU/kg	40520	17350	55550
Vitamin C, ppm	<22	<23	284
Vitamin E, IU/kg	265.4	125.4	257.5
Energy, kcal/100g	458.1	426.04	362.7
Ca:P	1.93	1.27	1.71

Complete fatty acid profile of live mysids

Product		Florida	Florida	California	Australia
	Saturated FA (SFA, g/100g)	0.230	0.322	0.275	
	Monounsaturated FA (MUFA, g/100g)	0.110	0.140	0.113	
	Trans FA (TFA, g/100g)	<0.0400	<0.0400	<0.0400	
	Polyunsaturated FA (PUFA, g/100g)	0.280	0.450	0.448	
	Total Fat (g/100g)	0.680	1.01	0.896	1.5
	C4:0				<0.1
SFA	**C6:0 Caproic (%)**	<0.100	<0.100	<0.100	<0.1
SFA	**C7:0 Heptanoic (%)**	<0.100	<0.100	<0.100	
SFA	**C8:0 Caprylic (%)**	<0.100	<0.100	0.820	<0.1
SFA	**C9:0 Nonaoic (%)**	<0.100	<0.100	<0.100	
SFA	**C10:0 Capric (%)**	<0.100	<0.100	<0.100	0.1
SFA	**C11:0 Undecanoic (%)**	<0.100	<0.100	<0.100	
SFA	**C12:0 Lauric (%)**	0.350	0.140	<0.100	0.3
SFA	**C13:0 Tridecanoic (%)**	<0.100	<0.100	<0.100	
SFA	**C14:0 Myristic (%)**	2.090	1.75	3.01	3.9
MUFA	**C14:1n5 Myristoleic (%)**	<0.100	<0.100	<0.100	<0.1
SFA	**C15:0 Pentadecanoic (%)**	1.160	2.71	0.970	1.3
MUFA	**C15:1n5 10-Pentadecenoic**	<0.100	<0.100	<0.100	

SFA	C16:0 Palmitic (%)	21.400	18.4	20.9	20.2
MUFA	C16:1n7 Palmitoleic (%)	4.080	2.72	2.27	5.4
SFA	C17:0 Margaric (%)	1.630	2.51	1.01	1.3
MUFA	C17:1n7 Margaroleic (%)	<0.100	<0.100	<0.100	0.5
PUFA	C16:2 Hexdecadienoic (%)	<0.100	0.26	0.120	
SFA	C18:0 Stearic (%)	6,26	6.05	4.05	3.2
MUFA	C18:1n9T Elaidic (%)	0.160	0.18	0.100	0.1
HUFA	C16:3n4 Hexadecatrienoic (%)	<0.100	<0.100	<0.100	
MUFA	C18:1n9C Oleic (%)	8.750	7.82	7.19	11.5
MUFA	C18:1n7C Vaccenic (%)	3.630	3.81	2.73	
MUFA	C18:1 Other cis Isomers (%)	<0.100	<0.100	<0.100	
SFA	C19:0 Nonadecanoic (%)	0.250	0.420	0.200	
PUFA	C18:2 Other trans Isomers (%)	<0.100	<0.100	<0.100	
HUFA	C16:4n1 Hexadecatetraenoic (%)	<0.100	<0.100	<0.100	
PUFA	C18:2n6 Linoleic (%)	1.690	0.88	1.57	1.4
SFA	C20:0 Arachidic (%)	0.570	0.48	0.390	0.8
HUFA	C18:3 Trans Isomers (%)	<0.100	<0.100	<0.100	0.1
HUFA	C18:3n6 Gamma Linolenic (%)	0.160	0.16	<0.100	0.4
HUFA	C18:3 Octadecatrienoic (%)	<0.100	<0.100	<0.100	
MUFA	C20:1n11 cis Eicosenoic (%)	0.800	0.730	0.860	

HUFA	**C18:3n3 Linolenic (%)**	0.720	2.16	1.17	1.1
SFA	**C21:0 Heneicosanoic (%)**	0.210	0.11	<0.100	
HUFA	**C18:4n3 Octadecatetraenoic (%)**	<0.100	0.400	1.02	0.3
PUFA	**C20:2n6 Eicosadienoic (%)**	0.610	0.650	0.610	0.1
SFA	**C22:0 Behenic (%)**	0.660	0.860	0.240	0.1
HUFA	**C20:3n6 Homo-Gamma-Linolenic (%)**	0.250	0.280	<0.100	0.2
MUFA	**C22:1n11 Docosaenoic (%)**	<0.100	<0.100	<0.100	
MUFA	**C22:1n9 Erucic (%)**	<0.100	<0.100	<0.100	<0.1
HUFA	**C20:3n3 Eicosatrienoic (%)**	0.200	0.43	0.390	0.3
HUFA	**C20:4n6 Arachidonic (%)**	4.340	5.04	1.81	3.9
SFA	**C23:0 Tricosanoic (%)**	<0.100	<0.100	<0.100	
HUFA	**C20:4n3 Eicosatetraenoic (%)**	0.200	0.29	0.460	<0.1
PUFA	**C22:2n6 Docosadienoic (%)**	<0.100	<0.100	<0.100	<0.1
SFA	**C24:0 Lignoceric (%)**	<0.100	<0.100	<0.100	0.1
HUFA	**C20:5n3 Eicosapentaenoic (%)**	17.3	16.0	20.4	18.3
MUFA	**C24:1n9 Nervonic (%)**	0.100	<0.100	<0.100	0.1
HUFA	**C21:5 Heneicosapentaenoic (%)**	0.310	0.230	0.260	
HUFA	**C22:5n6 Docosapentaenoic (%)**	0.800	1.03	0.440	<0.1

HUFA	**C22:5n3 Docosapentaenoic (%)**	0.990	1.04	0.590	0.8
HUFA	**C22:6n3 Docosahexaenoic (%)**	15.3	17.1	23.5	19.3
	Others (%)	4.890	5.13	2.36	1.7
Ratio	**DHA/EPA**	0.88	1.07	1.15	1.05
Ratio	**EPA/AA**	3.99	3.17	11.27	4.69
Ratio	**Oleic Acid/DHA**	0.57	0.46	0.31	0.60