Syngnathid Husbandry in Public Aquariums

2005 Manual

With Chapters Contributed by Members of the Syngnathidae Discussion Group

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Seahorses in Public Aquariums

2005 update
Heather Koldewey (Zoological Society of London; heather.koldewey@zsl.org)
2002 version
Michael Mulligan (John G. Shedd Aquarium)

Seahorses, pipefishes and seadragons are marine fishes found globally which belong to the family Syngnathidae. These fishes are very popular within the public aquarium and the hobbyist communities. Historically seahorses were considered very difficult to maintain in a captive environment, but continued efforts by hobbyist and professional aquarium staff have resulted in the development of techniques that now enable aquarists to maintain and reproduce seahorse species successfully. However, there are still difficulties with seahorse husbandry, and although the life cycle for some species has been closed, we are still a long way from understanding all of the husbandry requirements and health management practices for many seahorse species.

More and more public aquariums are utilizing financial and physical resources by displaying these unique animals. Several special seahorse exhibits have been successfully run in public aquariums since 2000, including at The John G. Shedd Aquarium in Chicago, USA; National Aquarium in Baltimore, USA; National Marine Aquarium, UK; Nausicaa, Boulogne, France; Monterey Bay Aquarium, USA; Moody Gardens in Galveston, USA. Smaller displays of seahorses and their relatives are commonplace in aquariums internationally.

There are now over 1,100 zoos and aquariums worldwide with over 800 million visitors annually. In North America alone, there are over 185 zoos, aquaria, oceanariums, and wildlife parks with an annual attendance over 130 million. There are regional associations which represent most facilities, including the American Zoo and Aquarium Association (AZA); European Association of Zoos and Aquariums (EAZA); the European Union of Aquarium Curators (EUAC); Australasian Regional Association of Zoological Parks and Aquaria (ARAZPA); African Association of Zoos and Aquaria (PAAZAB) and South-East Asian Association of Zoos and Aquaria (SEAZA). These organizations support membership excellence in conservation, education, science, and recreation. They also manage breeding programs for endangered species and species that benefit from co-ordinated programmes to advance husbandry and management.

Combined efforts to improve the husbandry, management and conservation of seahorses was initiated at a Project Seahorse workshop at the John G. Shedd Aquarium, Chicago Illinois, on December 7-9, 1998 (Lunn *et al.*, 1999). Thirty-five participants representing 29 institutions and 9 countries attended. Participants came from diverse professional backgrounds including directors, nutritionists, veterinarians, researchers, and husbandry staff.

Suggested outputs from the workshop included the following:

a) Construction of a communication network
b) Creation of working groups to focus efforts
c) Identification of research priorities
d) Creation of guidelines
e) Launching of educational programs

a) To address the need for better communication and to coordinate outputs, the Syngnathid Discussion Group (SDG) was established with 30 members communicating via e-mail. In 2005, the list grew to 284 members and has developed as an effective communication tool. The majority of the discussions relate to disease treatments, exchanges of captive bred animals, other husbandry issues and information dissemination on seahorse-related issues. The listserver is moderated by Colin Grist (Chester Zoo, c.grist@chesterzoo.org).

b) There are specific programs for seahorses and seadragons within the AZA Marine Fish Taxon Advisory Group (MFTAG) and the European (EAZA/EUAC) Fish and Aquatic Invertebrate Taxon Advisory Group (FAITAG). These were established to obtain data, analyze techniques, and develop and disseminate policies and information on these fishes. These groups also promote the conservation of seahorses and seadragons through the support of a regional collection plan, *ex-situ* and *in-situ* research, public display and public education programs.

c) The MFTAG has identified the following species as priority for action in North America: *Hippocampus abdominalis, H. comes, H. erectus, H. ingens, H. kuda, H. reidi*, and *H. zosterae.* The European FAITAG has identified three priority species on which to focus their efforts: *H. capensis, H. guttulatus*, and *H. hippocampus.* The two species of seadragons are also included: *Phyllopteryx taeniolatus* and *Phycodurus eques.*

Population management of seahorses in zoos, aquariums and independent organizations are critical to the goals of North American and European conservation strategies. Well-managed populations, research, record keeping, and education are the stated priorities of these strategies.

The goals for population management are:

1. To provide purebred species lines to zoo and aquaria partners for conservation research and education purposes
2. To assist collection planning
3. To reduce taxonomic confusion
4. To maintain minimum genetic diversity within each captive population, improving the health and fitness of the captive strains.

A space survey was conducted in 2003 which is shown in Appendix 1.

d) Creation of guidelines has been addressed through the production of the first Syngnathidae husbandry manual in 2002 and this 2005 update.

e) Coordination of educational messages and facts through improved communication and sharing of information ultimately leading to increased educational components and appeal of educational program to institutions. Many aquariums are finding that special exhibits are a powerful tool to raise awareness of seahorse conservation issues and engage the public.

By working together as a community and by channeling resources into appropriate actions, it is hoped that zoos and aquariums can continue to play an important role in assisting with seahorse conservation.

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Public Aquarium Syngnathid Census

2005 update
Heather Koldewey (Zoological Society of London*; *heather.koldewey@zsl.org)
2002 version
Colin Bull (Project Seahorse)

In 2005, members of the Syngnathidae Discussion Group were requested to provide details of their seahorse collections. This followed on from a similar census carried out in 2000. A total of 54 institutions responded in 2005, compared to 40 institutions in 2000 (table 1). The composition of seahorse species in each collection was recorded. The complete data are recorded in Appendix 2 (seahorses), 3 (seadragons) and 4 (other syngnathids). Where taxonomic uncertainty remained, seahorses were not included in the survey results.

Aquarium geographic region	**Number of responding aqms 2000**	**Number of responding aqms 2005**
Australia/New Zealand	1	3
Europe	11	22
North America	26	28
South America	2	1
Total	40	54

Table 1: Number of aquariums from different regions responding to seahorse survey in 2000 and 2005.

Eighteen species of seahorse were encountered in public aquariums in 2000 and 16 (plus one hybrid) in 2005 (figure 1). Overall, there has been very little change in the species number and diversity between the two surveys. *H.fisheri* and *H.histrix* were no longer found in aquariums in the 2005 survey, although these were only ever held at low frequencies in 2000. *H.fuscus* and *H. procerus* were reported in the 2005 survey but were not in 2000. There were some issues with species identification in 2000 that may have under-reported *H.fuscus. H.procerus* is a new species name used by Kuiter (2001) and is now being used by some aquariums. Overall the most frequently encountered seahorse species in aquariums were *H. erectus, H.kuda* and *H.reidi* in both surveys.

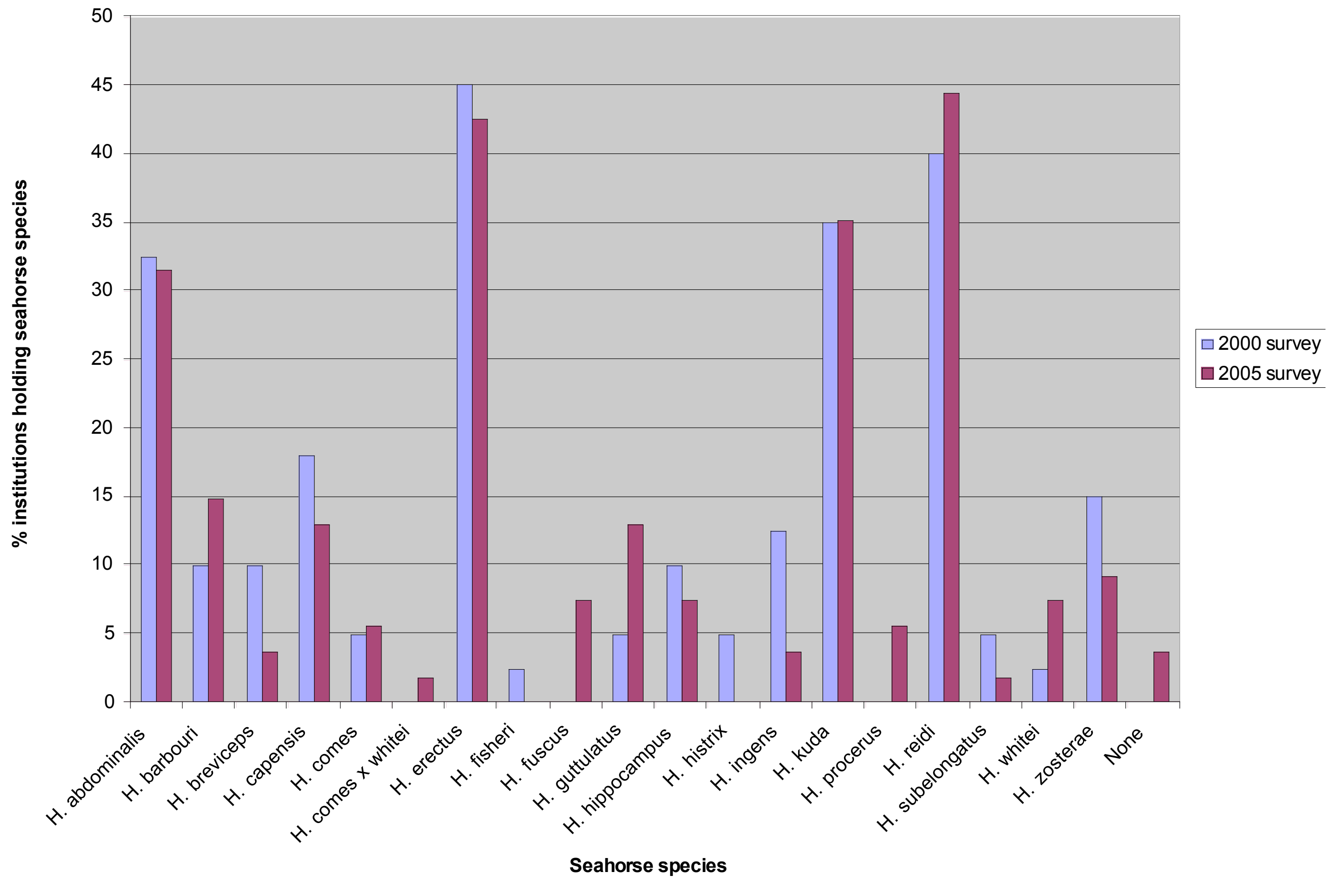

Figure 1: Percentage responding institutions holding different seahorse species in 2000 (N=40) and 2005 (N=54).

Regionally, there were major differences in the seahorses species held (figure 2), although this was skewed by the low number of responses from Australia/New Zealand and Central America (table 1). Species only held in North American aquariums were *H.breviceps, H.ingens, H.subelongatus* and *H.procerus.* The latter represents different use in nomenclature. The two European species (*H.guttulatus* and *hippocampus*) are only held in European aquariums. These are the two priority programme species in Europe. The priority species for programmes in the USA are *H. abdominalis, H. comes, H. erectus, H. ingens, H. kuda, H. reidi*, and *H. zosterae.* However, the number of *H.ingens* in aquariums had decreased from 2000 to 2005 and is currently only held in two aquariums in North America. *H.comes* is only held in one North American aquarium and two European aquariums.

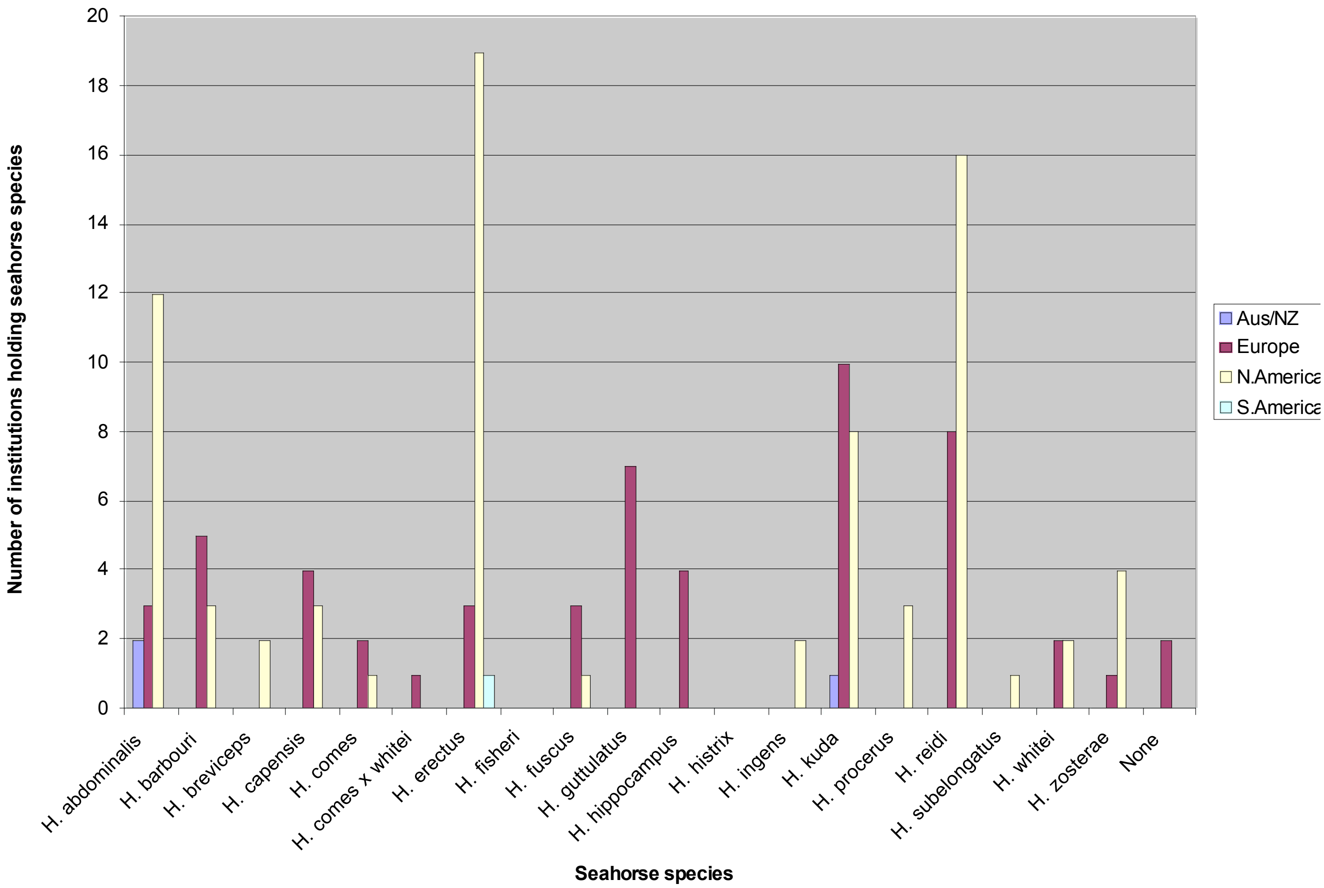

Figure 2: Number of institutions holding each seahorse species in each of the geographic regions surveyed.

Of the 17 species reported in the 2005 survey of seahorses in public aquariums, 16 were reported to show breeding activity (Figure 3). However, only 11 of these are also being reared - defined as offspring reaching reproductive age. While it is recognized that some institutions may actively choose not to breed or rear their seahorses, it is important that these are active management decisions. If breeding and rearing is not possible, then further research should be carried out to improve the husbandry success with these species. This highlights the importance of regular revisions of this husbandry manual.

Of the priority species for the European FAITAG, neither *H.hippocampus* or *H.guttulatus* have been successfully reared, although they are breeding in around 40-50% of holding institutions. This demonstrates that the importance of the first priority of the programme for these two species to successfully and repeatedly close the life cycle. This is now underway. For the few institutions still holding *H.capensis* (the other priority European species), there is successful breeding and rearing. The viability of this programme is under review due to the problems with the small founder population.

Of the priority species for AZA MFTAG programmes, *H. abdominalis* is only being bred in about half of the institutions that are reporting breeding. No institutions holding *H. comes* report rearing, even though there is reproduction occurring. There are institutions breeding and rearing

H. erectus, H. kuda and *H. reidi* although there is a low percentage of rearing reported, particularly with *H.reidi.* This suggests that further work is required to improve the husbandry and survival of these species. No institutions are breeding or rearing *H. ingens.* The percentage of institutions breeding *H. zosterae* is the same as those rearing this species.

These results strongly suggest that the goals of the programmes and the number of species, optimal population size for holding and breeding plans for these species need to be reviewed. They also emphasise the continued importance of husbandry research in public aquariums for seahorses and their relatives.

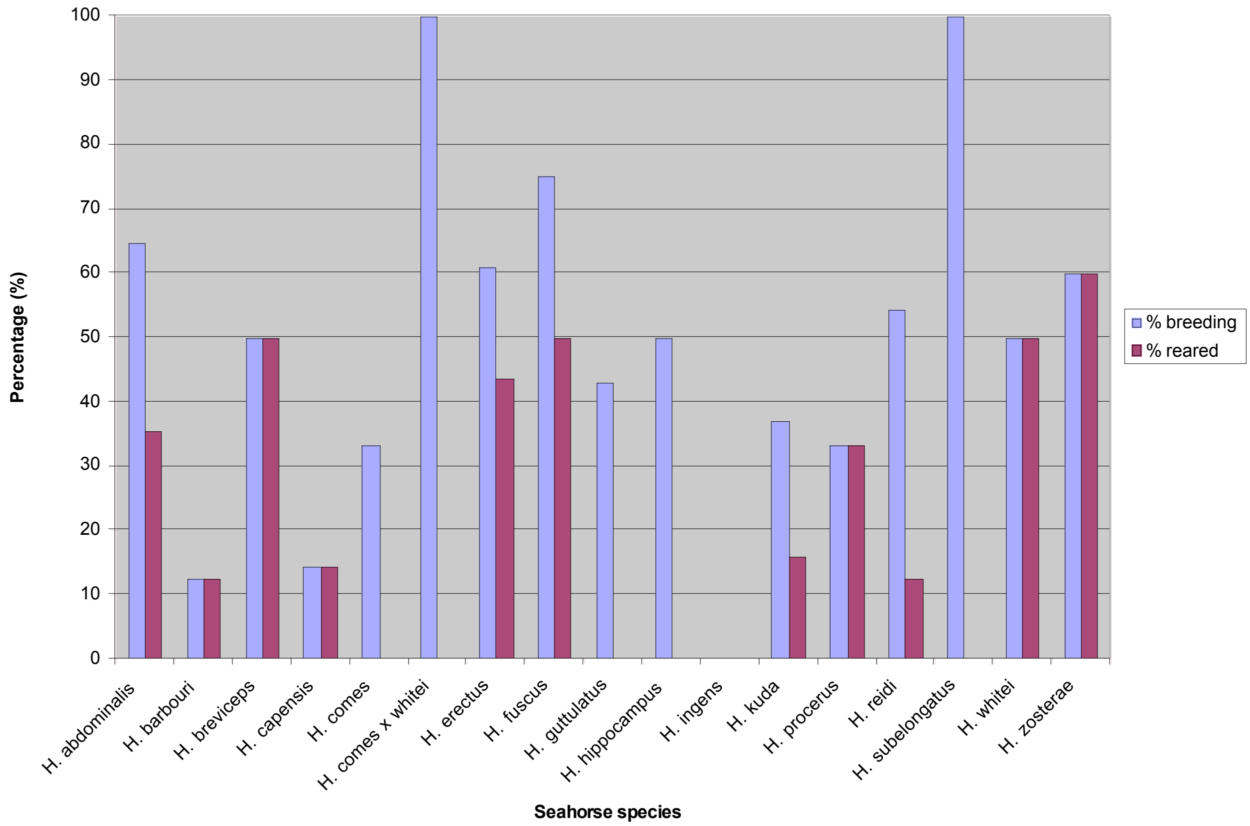

Figure 3: Percentage of seahorses kept in public aquariums that are successfully breeding and reared.

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Seahorses and CITES

2005

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The international community has responded to conservation concerns about seahorses, including the threat of large scale unregulated international trade, by listing all species of seahorses under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), effective May 15, 2004. The intention of an Appendix II listing is to manage trade in wild animals for sustainability. By understanding, and complying with, the basic requirements for international trade of Appendix II species, aquarists will have some assurance that their continued trade in seahorses is not threatening the survival of wild populations.

Seahorses in trade

Seahorses are threatened by direct exploitation, accidental capture in non-selective fishing gear (bycatch), and degradation of their coastal habitats. Most exploited seahorses find their way into large scale, unmanaged and unmonitored international trade. Extensive trade surveys carried out by Project Seahorse have revealed concerning trends. In 1996, it was estimated that at least 32 nations were involved in an annual trade involving more than 16 million and probably close to 20 million animals (Vincent 1996). By 2002 (when the decision was made by the international community to list seahorses under CITES), it was estimated that approximately 24 million animals were traded each year among at least 77 nations[1].

Seahorses are sold dried for traditional medicines, tonic foods and curiosities, and live for ornamental display. Dried trade includes the curio trade and traditional medicine. Dried trade for traditional medicine (TM) is by far the largest of these markets with Traditional Chinese Medicine (TCM) probably accounting for 90% of the trade. The live trade includes seahorses traded for public and private aquaria. Sadly, research suggests that live trade for public and private aquaria, while only representing a relatively small proportion of total trade, can be the largest pressure on certain wild populations.

Conservation Concerns

The impacts of global trade on seahorse populations are considerable, especially when combined with damage to their vulnerable inshore marine habitats. A combination of customs records, quantitative research and qualitative information indicates that in certain places seahorse catches and/or trades have declined markedly. This reflects a loss of population rather than a drawdown of the trade: estimated population declines of between 15 and 50 percent over five-year periods are common[2]. The 2003 World Conservation Union (IUCN) Red List now recognizes one seahorse species as Endangered, nine as Vulnerable, and all other species as Data Deficient (denoting the need for more research) (IUCN 2003). Many countries additionally have established their own domestic conservation assessments or have drawn up regulations that recognize the threat to seahorse populations (see Lourie et al. 2004).

Why CITES?

[1] Project Seahorse, unpublished data
[2] Project Seahorse, unpublished data

CITES seeks to regulate international trade to ensure that such trade is not threatening wild populations. With millions of seahorses being traded on an annual basis, it appeared likely that international trade was contributing to the observed population declines. CITES was widely recognised a mechanism to monitor the apparently expanding trade and its impacts on wild populations, although it had not previously been utilized for marine fish.

How does CITES work?
The species covered by CITES are listed in three Appendices, according to the degree of protection they need. Each Appendix has varying levels of trade regulation, as described by the following table:

	Extent of conservation concern	*Level of trade management*	*Number of species*
Appendix I	Most threatened species	Trade effectively banned with few scientific exceptions	About 1,000 species
Appendix II	Species that are, or might become threatened, by international trade	Trade managed for sustainability – exports require non detriment finding	About 25,000 species
Appendix III	Species threatened only in parts of range	Used by countries seeking international assistance managing trade in species of national concern	About 300 species

In November of 2002, seahorses became the first fully marine species of commercial value to be listed on CITES Appendix II. CITES seeks to achieve sustainable international trade in Appendix II species by requiring exporting Parties[3] to restrict trade in Appendix II species to levels that are not detrimental either to species' survival, or to their role within the ecosystems in which they occur (known as the "non-detriment finding"). Non-detriment findings must be filed prior to being granted an export permit as they certify that the exports will not threaten the survival of the species in the wild.

In addition to filing a non-detriment finding, there are two more requirements under CITES before an export permit can be issued for an Appendix II listed species: the specimens must be legally obtained, and if live, the individuals must be prepared and shipped as to minimize the risk of injury, damage to health or cruel treatment. These three requirements make up Article IV (the backbone) of the Convention (http://www.cites.org/eng/disc/text.shtml#IV) and will be explained in the following sections.

Non-Detriment Findings

Despite the formal requirement for a non-detriment finding, i.e. that the harvest should be sustainable, many species continue to be traded in the absence of information about the impact of

[3] A Party to the Convention is any State or Country which has adopted the present Convention.

such exploitation on the wild population. This is often due to the lack of programmes to monitor both the levels of harvest and the status of wild populations of species exploited for trade. This is especially true for most marine species, including seahorses.

Seahorses have become a test case to see how fisheries management tools could be used to meet the sustainable trade requirements of the Convention. CITES requested (in November 2002) that the Animals Committee[4] suggest a size limit because an earlier CITES technical workshop[5] (in May 2002) had seen this as one possible way Parties could overcome the immediate difficulties of making early non-detriment findings as required by the Convention. Both the workshop and the CITES Parties recognized the challenges of setting quotas or undertaking many other management measures given (a) the dearth of information on the state of existing wild populations and on seahorse trade levels and (b) the considerable similarity in physical appearance of many species.

A single minimum permissible height for all seahorse species in international trade appears to be both biologically appropriate and socially acceptable (Martin-Smith et al. 2004) as a means of making interim non-detriment findings for seahorses, until Parties are able to define management tools more specifically (Foster and Vincent, 2005). Currently, the number of juvenile seahorses in trade bodes poorly for population recovery from overexploitation.

Size-selective regulations are frequently developed to enhance sustainable use of marine species as varied as cod and crustaceans. Limits (maxima or minima) and dimensions are set with reference to the biology, life-history strategy and catch methods for the target species. Ideally, a minimum size limit should be set so as to allow animals to reproduce before being caught.

The CITES Animals Committee confirmed (in April 2004) that a minimum size limit would offer a way for Parties to make non-detriment findings for all seahorse species taken from the wild and entering international trade. The Animals Committee further concluded that a height[6] of 10 cm would currently serve as the most appropriate minimum size for the genus *Hippocampus*. On April 30, 2004, the CITES Secretariat issued a Notification to the Parties advising them of the Animals Committee's recommendations regarding the 10 cm minimum size limit, noting that this size limit could be reviewed at a later date on the basis of further research. The recommendation[7] to adopt a 10 cm minimum height for wild seahorses in international trade took effect when the CITES Appendix II listing for seahorses entered into force on 15 May 2004.

What is a minimum size limit and how will it affect me?

Some aquarists have asked how the possible adoption of the minimum size limit by a Party this will affect them. To answer that question, it is useful to under stand how a minimum size limit

[4] The Animals Committee is one of four committees under CITES. It is a committee of experts that provides technical support to decision-making about species.
[5] CITES Technical Workshop on the Conservation of Seahorses and Other Syngnathids, Cebu, Philippines, 27-29 May 2002
[6] Height in seahorses is measured from the tip of the coronet to the base of the straightened tail.
[7] Parties may choose to make non-detriment findings as they wish; the minimum size limit is being *recommended* as an interim short-term voluntary measures to ensure non-detrimental trade for wild harvest in absence of adequate information about populations and trade.

works, to consider the species traded for aquaria and hobbyists, and to review some exceptions to the use of the minimum size limit.

A minimum size limit is a size below which a fish cannot be landed or traded. The intention of a minimum size limit is to permit the fish to reproduce and replace itself in the population before being caught and traded.

There are a number of advantages to the use of minimum size limits. The concept that a fish must be allowed to grow large enough to reproduce is one that can be easily understood permitting community "buy in". From the perspective of compliance and enforcement, regulators, local wardens and others involved in enforcement can measure specimens that have been retained or that are proposed for trade. Compliance can be readily and objectively assessed.

A 10 cm minimum size limit would permit both reproduction and continued trade in most species that are currently exported. It serves as an initial approach to making non-detriment findings while Parties assess international trade levels, impacts on domestic species, and potential alternative management tools which could supplement or replace the minimum size limit. A minimum size limit of 10 cm should be sufficient to permit reproduction in most species as it is slightly above the currently inferred maximum size at onset of sexual maturity for most species, so should allow reproduction to occur (see Figure at end of section).

Initial research suggests that of the 10 small species of seahorses that generally do not reach the minimum size limit, only four of the ten species under 10 cm are currently in trade, mostly for aquarium display. Two of these, *H. zosterae* and *H. fisheri*, are domestically traded. Since domestic trade is not regulated by CITES, this trade would be unaffected by application of a minimum size limit. For *H. breviceps*, most existing trade appears to be in captive bred specimens. Captive bred specimens are not subject to CITES and the minimum size limit (see section on captive bred specimens below). Of the 10 smaller species, this leaves only *H. camelopardalis* as potentially excluded from existing trade if the minimum size limit is utilized by the exporting country.

It should be noted that not all countries will choose to use the minimum size limit, and that CITES technical advisors have recognized that the minimum size limit may not be appropriate for trade in some of the smaller species (i.e. those that do not grow larger than 10 cm).

Things to remember about the minimum size limit:
- It is *voluntary*: each CITES Party is responsible for determining how to make its own non-detriment findings and chooses whether or not to use the minimum size limit.
- It is *not* intended for use with *captive bred* specimens.
- It does *not* apply to *domestic* trade.
- It may be *interim*: Clearly it is anticipated that other ways to make non-detriment findings may be found as Parties gain knowledge of seahorse biology, populations and trade and it is anticipated that these other measures would be additional components of adaptive management plans[8].

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[8] A CITES technical workshop was held to discuss means of making non-detriment findings for seahorses. For example, in addition to the minimum size limit, recommended complementary auxiliary and voluntary measures included a quota on the export levels at or below current levels, and a cap on the issuance of new licenses. The outcomes of the workshop will be published as a NOAA Technical Memorandum (Bruckner et al. in press).

- It was to be *one* component of an adaptive management plan and a simple, precautionary way for Parties to make *initial* non-detriment findings.

Legal Acquisition

It is a requirement of CITES that specimens were not obtained in contravention of the laws of that State for the protection of plants and animals, i.e. they must be legally obtained. For example, some countries have regulations that make targeted removal of seahorses from the wild an illegal activity, so any broodstock obtained in this way would be illegal. Other countries ban trawling in coastal zones, and so any seahorses obtained incidentally by trawl fisheries in these zones would also be considered illegal. It is essential to review any national legislation that may relate to the acquisition of wild seahorses before you attempt to move them across international borders. Project Seahorse (www.projectseahorse.org; info@projectseahorse.org) can provide more information on such legislation.

Transportation Guidelines

The Convention states that an export permit must not be issued until the Management Authority[9] of the State of export is satisfied that any living specimen will be so prepared and shipped as to minimize the risk of injury, damage to health or cruel treatment. The CITES "Guidelines for Transport and Preparation for Shipment of Live Wild Animals and Plants" can be found on the CITES website (http://www.cites.org/eng/resources/transport/index.shtml). In addition, the IATA Live Animals Regulations (LAR) is accepted by CITES and recognized as the international standard for transport of animals by air. This publication is an essential source on how to ship animals safely, sensitively and cost-effectively. It specifies the minimum requirements for the international transport of animals and wildlife, and indicates what precautions airlines, shippers, cargo agents and animal care professionals should take on the ground and in the air. The publication is available from the IATA website (http://www.iata.org/ps/publications/9105.htm). You should ensure that the transport of any live seahorses conforms to these guidelines. See also section on '***Collection and transportation of seahorses***'.

Permits

Import, export and re-export of any live animal or plant of a species listed in the CITES Appendices (or of any part or derivative of such animal or plant) requires a permit or certificate. Therefore now that all species of seahorse are listed on CITES Appendix II **ALL** transportation of seahorses across international boundaries requires an export permit (live or dead, whole or parts, wild caught or captive bred). Depending upon the law of the country you are importing into, you may also require import permits.

Before attempting to transport seahorses across international boundaries, inquiries should be made of the CITES authorities in the exporting and importing country to determine what each country's specific rules and requirements are. The contact details of each Management Authority can be found on the National contacts page of the CITES website (http://www.cites.org/common/directy/e_directy.html).

Some countries have domestic laws with trade or other controls stricter that those required by CITES. Before attempting to transport seahorses across international boundaries, inquiries should

[9] The national agency responsible for implementing CITES in each country is called the Management Authority. They are responsible, among other things, for issuing export permits.

be made of government authorities to determine whether additional permits or approvals are required.

Captive bred specimens

While the intention of CITES is to ensure persistence of wild populations, listing a species on CITES Appendix II has consequences for captive bred animals as well. **Animals that were bred in captivity also require permits.** However, where a Management Authority of the country of export is satisfied that any specimen of an animal species was bred in captivity (F2 generation or greater), a certificate by that Management Authority to that effect will be accepted in lieu of any of the permits or certificates required under Article IV.

A second CITES technical workshop[10] concerned with the implementation of the CITES listing for seahorses came up with recommendations for Parties concerning aquaculture operations for seahorses. Participants felt that the certification or registration of captive breeding facilities, along with experimentation in methodology to tag captive bred seahorses, is necessary to improve the capability of law enforcement at differentiating wild from aquacultured species. Until marking methods are developed, a paper document would suffice to distinguish wild and aquacultured seahorses. Separating seahorses from other tropical fish shipments would also assist law enforcement, as would packing individuals in transparent containers. Additional taxonomic work is needed to resolve the identification of similar species and to develop tools to assist in identification of live specimens.

Participants also recommended general criteria for acceptable and "non-detrimental" aquaculture operations, with emphasis on rearing capacity, prevention of release of aquaculture product into the wild, reliance on wild broodstock, and controls to minimize disease and mortality. CITES requires non-detriment findings for aquaculture operations producing F1 specimens from wild-origin broodstock, but participants recommended that there is no need to impose a standard minimum export size for aquacultured seahorses produced in non-detrimental facilities. See Bruckner et al. (in press) for more information on the outcomes and recommendations of this workshop.

Where do I find more information?

For more information about CITES, visit the CITES web site (www.cites.org). On that site, you will find links to the CITES contacts for the member countries. These are found by clicking "national contacts" on the CITES home page and then clicking on the country you wish to find information about. For many countries, there are links to that country's web site where information specific to the country in question can be found. For the UK, you will find more specific information at www.ukcites.gov.uk. For the United States, information can be found at http://international.fws.gov. For many countries, applications for CITES permit applications can be printed from these sites.

Please also note that in some countries, there are additional permit, transportation and handling requirements. If you are considering exporting or importing seahorses or other CITES listed species, it is recommended that you contact the government authorities in the country of export and the country of import to determine whether other requirements apply.

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[10] The International Workshop on CITES Implementation for Seahorse Conservation and Trade, Mazatlan, Mexico, 3-5 February 2004

What can I do?

Obtain seahorses from reputable sources. The Marine Aquarium Council site (http://www.aquariumcouncil.org) contains information about traders who have a stated commitment to conservation.

Before purchasing seahorses ask where the animal is from. Since the vast majority of species favoured by public aquariums and hobbyists are either cultured or domestically available, you should be able to avoid purchasing animals from threatened wild populations by asking where the animal has come from.

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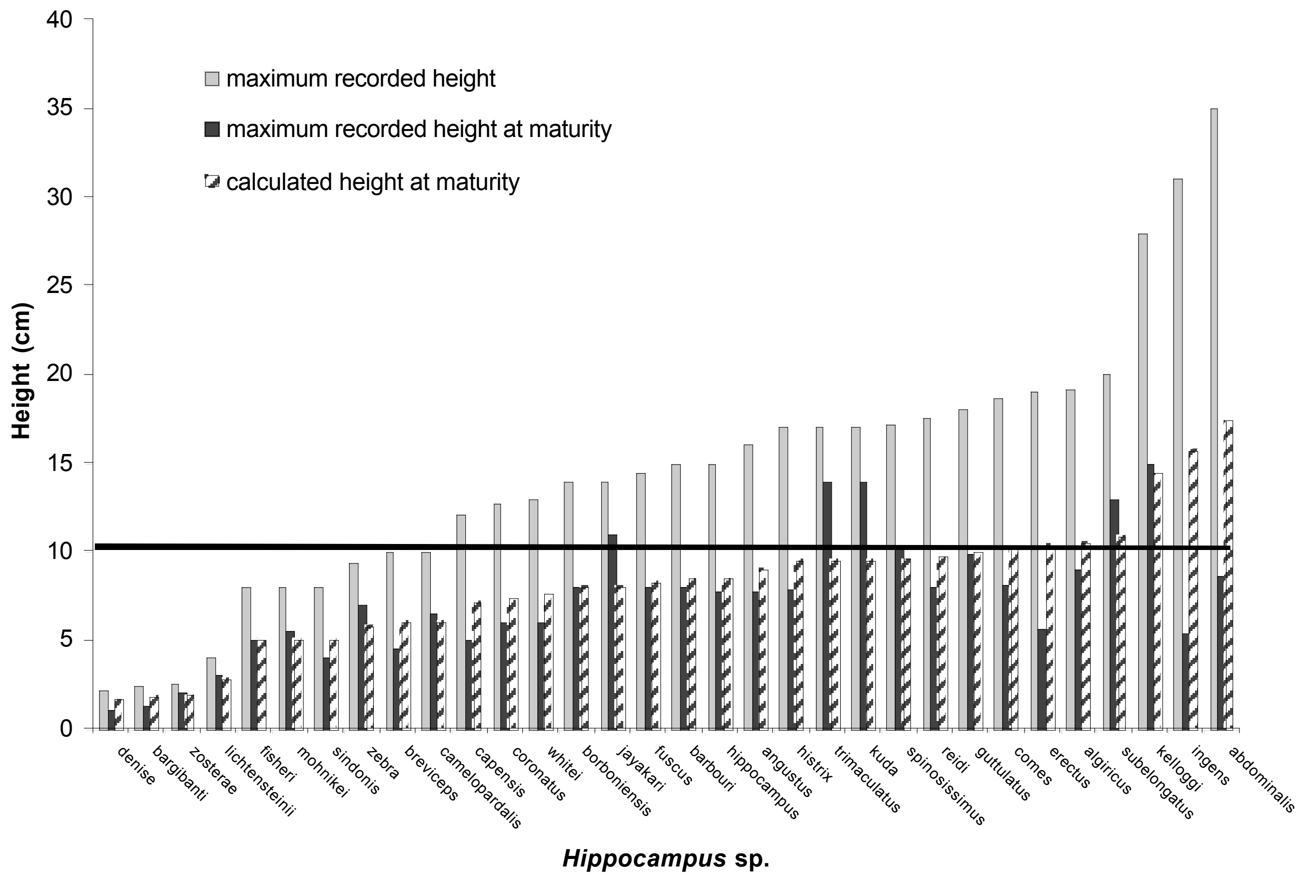

Figure 1. Maximum recorded height, height at maturity obtained from literature, and calculated height at maturity for 32 of 33 seahorse species (no data available for *Hippocampus minotaur,* with height of < 5 cm). The horizontal line indicates the suggested size limit of 10-cm for the trade of wild seahorses. As published in Foster and Vincent (in press).

Collection and Transportation of Seahorses

2005 update
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2002 version
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Introduction

Seahorses are acquired for public aquaria from a number of sources:

1. Purchased from wholesale importer of seahorses collected by target fisheries in source countries.
2. Purchased from wholesale importer of seahorses collected as by-catch from non-specific food fisheries.
3. Purchased from wholesale importer of seahorses from captive-bred commercial suppliers.
4. Direct acquisition from small-scale private breeding ventures.
5. Direct acquisition from Customs confiscations.
6. Direct acquisition from animal exchanges between public aquariums.
7. Direct acquisition of native species from aquarium collection trips.
8. Direct acquisition from public donations.

Seahorses in the hobbyist aquarium trade still mostly come from wild sources, although captive-bred seahorses are becoming available to hobbyists from aquaculture companies. Advances in techniques associated with seahorse breeding have undoubtedly led to an increase in captive-reared seahorses in the hobbyist community in recent years. Coupled with these advances, increased communication amongst public aquariums has also led to an increase in the movements of captive-bred fish within this community. A survey of 21 North American public aquaria in 2000 revealed that 62 % of seahorse acquisitions were derived from captive-bred sources (total number of seahorses acquired by these 21 aquaria in 2000 = 1093).

Seahorses are prone to bacterial and fungal infections that may be brought about by stress associated with poor water quality or nutrition. It is essential to maintain good water quality and maintain regular feeding to keep seahorses healthy. Unfortunately, water quality deteriorates and feeding is rarely undertaken during collection and transport, a process that may take several days to a week depending on location. Seahorse mortality rates in the aquarium trade have not been accurately recorded, but conditions vary markedly between collectors, buyers, and exporters in source countries. Seahorses are likely to suffer relatively high mortality rates. Mortality generally occurs either during transport or within weeks of arrival at the destination as a delayed physiological stress response to collection handling and transport conditions. Stress-related damage is most likely to be highest between collection and export, as conditions for holding and transport are poorest at this level. Collectors may also damage the seahorse's epidermis and create a site for secondary infection by bacteria or fungus.

There are still difficulties with seahorse taxonomy, and acquisitions from wild sources (especially from Indo-Pacific areas with multiple similar species) often end up with misidentification of species and incorrect information being given to the public. As the mission of most public aquariums is education and conservation, every effort must be made to ensure that the correct information is being transferred to our guests. These missions are rarely achieved at present by acquiring seahorses from wholesale importers who are receiving shipments from many locations, and are unaware of the species or collection practices.

Data is sparse on the sustainability of the aquarium trade in seahorses. Evidence accumulated thus far by Project Seahorse indicates that the wild target fisheries for seahorses in many developing countries are not operating under a management regime that will ensure sustainable collection and protection of the seahorse populations. Declines in seahorse occurrence and abundance are being recorded in areas such as the Philippines, where subsistence communities rely upon collection of seahorses to supplement their income. Overfishing in recent years is leading to the collapse of these fisheries with negative implications for species persistence in some areas with highly overexploited populations.

The international zoo and aquarium community is establishing captive-breeding programs for seahorses (with formal registries of populations) to allow distribution of popular exhibit species to interested institutions. While this approach will improve the potential for interpretation and the condition of the captive populations in public facilities, it is recognised that wild collection for the aquarium trade will continue to be required. Public aquariums have the potential to play an important role in the conservation of wild seahorse populations. For those institutions that wish to display seahorses, captive-bred animals should be considered before wild-caught animals. This goal should be achieved through the coordinated breeding program, or institutions should attempt to use only aquarium dealers that participate with Marine Aquarium Council (MAC) initiatives (outlined below) and make efforts to address conservation concerns. Project Seahorse also has a new initiative (in close conjunction with MAC) underway to assess the relative conservation costs and benefits of seahorses from different sources in the live aquarium trade.

Marine Aquarium Council Certification

The Marine Aquarium Council (MAC: www.aquariumcouncil.org) is developing certification to ensure the collection, culture, and commerce in marine ornamentals, including seahorses, is sustainable and environmentally sound.

The MAC Core Standards outline the requirements for third-party certification of quality and sustainability in the marine aquarium industry from reef to retail. There are three MAC Core Standards covering the "reef to retail" supply chain.

- The Ecosystem and Fishery Management (EFM) Core Standard addresses *in-situ* habitat, stock and species management and conservation by verifying that the collection area is managed according to principles that ensure ecosystem health and the sustainable use of the marine aquarium fishery.

- The Collection, Fishing and Holding (CFH) Core Standard addresses harvesting of fish, coral, live rock and other coral reef organisms, handling prior to export, holding, plus packaging and transport to ensure the health of the collection area, sustainable use of the marine aquarium fishery and optimal health of the harvested organisms.

- The Handling, Husbandry and Transport Core Standard addresses the handling of marine life during export, import and retail to ensure their optimal health, their segregation from uncertified organisms and proper documentation to show that they pass only from one MAC Certified industry operator to another.

Customs Seizures

A number of public aquariums are regularly approached by local Customs authorities to house live seahorses that have been seized. In 2004, London Zoo Aquarium set up an agreement with HM Customs and Exise at London Heathrow airport to take all live seahorse seizures. Five species were received in 2004 (*Hippocampus barbouri, H.comes, H.kuda, H.spinossissimus, H.trimaculatus*) all of which were misidentified in the paperwork accompanying the shipments or lacked paperwork. Shipping conditions for the animals were generally poor and only *H.kuda* survived the quarantine period. These are now reproducing. Only one seizure of 10 *H.kuda* was received since the CITES listing on May 15th. In 2005, two species were received; *Hippocampus fuscus* (x 14), *H. reidi* (x 300). After re-habilitation, the *H.fuscus* were re-homed to Omaha Zoo, USA and the *H.reidi* to 10 aquariums in the UK, Spain and Kuwait. Ongoing records are being kept of all seized seahorses.The Birch Aquarium at Scripps, San Diego, USA, Long Beach Aquarium (USA) and Vancouver Aquarium (Canada) are also known to be working with seahorse Customs seizures. It is recommended that any aquariums that receive Customs-seized seahorses maintain records on initial conditions, survival and reproduction. This will help provide important information to establish the impact of CITES listing on the live trade in seahorses. For more information and examples of data collection sheets being used in the UK, contact Alex Cliffe at the Zoological Society of London (alex.cliffe@zsl.org).

Transport Guidelines

IATA Live Animals Regulations

The IATA Live Animals Regulations are the worldwide standards for transporting live animals by commercial airlines www.iata.org. Countries such as the member states of the European Union also enforce the IATA Regulations for the transportation of live animals to, from and within the communities. Government agencies, such as the U.S. Fish and Wildlife, and the management authorities of the Convention on International Trade in Endangered Species (CITES) also enforce the IATA Regulations for the packaging of endangered species for international transport. The Live Animals Regulations is available in print or CD ROM format and can be ordered from sales@iata.org.

CITES

All seahorses were listed under CITES Appendix II in November 2003 and the implementation of the listing took place in May 2004. A separate chapter in this manual provides more details of the impacts of CITES listing on the live trade in seahorses for public aquariums.

CITES also has Guidelines for Transport and preparation of live wild animals and plants. The ‘Guidelines for transport and preparation for shipment of live wild animals and plants' were adopted by the Conference of the Parties to CITES at its second meeting (San José, 1979).

In Resolution Conf. 10.21, on Transport of live animals, the Conference recommends that:

a) suitable measures be taken by the Parties to promote the full and effective use by Management Authorities of the Guidelines for Transport and Preparation for Shipment of Live Wild Animals and Plants and that they be brought to the attention of carriers, freight forwarders and international organizations and conferences competent to regulate conditions of carriage by air, land and sea or inland waterways; and
b) Parties invite the above organizations and institutions to comment on and amplify these Guidelines, so as to promote their effectiveness.

As the printed version of the Guidelines is not widely available, the Secretariat is providing access to them on the CITES website in order to promote their use http://www.cites.org/eng/resources/transport/index.shtml. In the hope that the Guidelines can be improved, the Secretariat would welcome comments, which should be addressed to the Scientific Support Unit. The guidelines for the transport of fish in plastic bags is appended to this chapter.

Transportation of Seahorses

During transportation seahorses are enclosed in a restrictive container that does not allow for ideal water quality parameters and is subject to unpredictable movement orientation and noise levels. The following points, therefore, should be taken into consideration:

1. Transit time must be minimized wherever possible
2. Only healthy individuals should be selected for transportation
3. Packaging must be adequate.
4. Seahorses should be packed with compatible animals. Packing seahorses in the same box with corals and live rock is not recommended.

The number of seahorses per container should relate to:

1. The transit time
2. The size of the seahorses
3. The sensitivity of the seahorse
4. Temperature fluctuations (if any) that are expected
5. Changes in transference between transit vehicles
6. Type of transit vehicles
7. Water quality parameters at loading
8. Water quality parameters at destination (transit time can be substantially longer due to acclimation time at destination)
9. Whether individuals are captive-bred, caught directly from wild, or have recently been transferred through various exporter/importers

Bags should be designed to allow for minimum slop (tall cylinder shapes work well). It is better to have fewer individuals per bag with the use of more bags rather than large bags with a lot of individuals. It is often recommended that seahorses are packed in individual bags. This system is particularly relevant if a seahorse dies in transit. Oxygen should be used to inflate the shipping bags. Juvenile seahorses and some adults have been transported (from east coast to west coast USA) by saturating the water with oxygen and then sealing the bag so no gas remains above the water surface.

The most usual method for transporting seadragons is to pack the bags with all water and no air/oxygen above them. This is done to prevent the seadragons from "piping" and getting air/oxygen gas entrained within them. If done correctly, there is enough oxygen dissolved in the water to sustain the animals for quite some time. Other aquariums, howver, report the successful shipping of seadragons packed with oxygen.

Seahorses have been transported long distances successfully using breathable bags, such as to California and Italy from the South East USA. The bags that have been used successfully are Kordon Breathable bags http://www.petsforum.com/novalek/kordonp.htm. These bags do much better for long distances than the standard bags with oxygen. No oxygen is added to these bags, and the top of the bag is tied off at the surface of the water. Seahorses shipped this way do not get sloshed out of the water in transit and pipefish and seahorses shipped this way do not accidentally ingest air from snapping at the water line in the bag. The bags should be placed into a styrofoam container and that is inside a cardboard box. However, they require the inside of the styrofoam container to be packed with styrofoam peanuts, or shredded newspaper and these bags must not touch each other.

For most species, particularly smaller ones, the use of holdfasts in the bag is also recommended. It allows these fish that naturally spend a lot of time holding onto something, a place to rest and conserve energy to reduce their metabolism during shipping. Types of holdfasts that have been used include thin twisted pieces of PVC rod and small plastic plants.

Containers should be constructed out of molded polystyrene with a secure lid. If the box is too large and there are no other bags of fish to be included newspaper or a empty inflated bag(s) should be used to ensure the bags do not move within the box during transport. Strong containers with good thermal retention qualities should be used (i.e. polystyrene) to allow for external temperature fluctuations. Heat/coolpacks can be used should the transit conditions dictate. Packs must not be placed directly next to the water.

Apart from strength and temperature controls, containers should be watertight. Handlers could reject the shipment at any stage in the transfer due to water leakage. Documents or inscriptions on bags within the containers providing details of the marine life contents will make unpacking at the final destination much easier. This approach would also be useful if the consignments are transported between countries and subject to custom clearance.

4. Communication is vital. Communicate clearly with the final destination of the consignment so that the seahorses will not be delayed. Clearly mark container with the correct labels and make sure that all the shipment documents are complete and with the correct persons. Clearly state to the transit handlers the importance and sensitivity of the consignment.

5. Records need to be kept of success/failure of transport segments, which will allow for clearer communication to all concerned and for modification of the system, if necessary. Education through sharing of information should gradually improve conditions in the trade.

<u>*Seahorses and Education in Aquariums*</u>

2005 update on Special Exhibits
Compiled by Heather Koldewey (Zoological Society of London, UK)
2002 version
Stacey Shepard (Aquarium of Americas), Holly Gay (Ft Worth Zoo), Doreen Williamson (Cornell Cooperative Extension), Jen Nightingale (Bristol Zoo), Linda Schubert (John G. Shedd Aquarium)

Zoos and aquariums reach a large audience globally, and it is estimated that over 130 million guests visit North American institutions alone each year. When the number of people reached through publications, the Internet, and outreach programs are also included one can appreciate the enormous influence our organizations can have on people's knowledge and understanding of animals.

A great variety of methods are employed at these institutions to tap into this tremendous educational potential. Some of these include exhibits that take you to another world, classes for people of all ages and interests, and electronic media that reach well beyond the physical location of the exhibits.

With the ability to influence so many people, what sort of an effect do we want to have? For an ever-increasing number of institutions, the answer lies in the connections amongst animals, their environment, and people. Educators strive not just to inform people about these topics, but also to urge them to action, both locally and on a global scale. We hope to help our guests understand that their actions can change the natural world around them.

How Education is Achieved and Its Benefits to Marine Life

The public's interest in live animals fuels a curiosity and energy that can be instrumental as an opening to educate that public. Exhibits are the first step in reaching our audience about the unique biology of the animals, their habitats, and life history. Interpretive staff holding talks, conducting activities, and hosting animal encounter sessions in front of exhibits help audiences better understand the messages of that exhibit. Zoos and aquaria also serve as venues for education events such as lectures from guest authors and researchers. Teacher training and other methods of reaching classrooms are common and have a multiplication effect allowing more complex messages to reach larger audiences. Through these, and many other means, zoos and aquaria have the opportunity to reach numerous people and help them to make better connections to broader conservation messages.

Through education, we can energize the public about what is in need of protection in the marine environment and gather public support for conservation initiatives. Marine education has started many grassroots initiatives for marine conservation, of which the 'Save the Whales' and 'Dolphin Safe Tuna' campaigns are examples. Focusing on a single animal, such as the seahorse, excites the interest of a large number of young people and allows us to teach identification with nature, which may influence them to become environmentally concerned adults. Whether we help the public understand how they can protect a single species, a group of animals, or a habitat, our efforts can continue to have an enormous impact on the world we live in.

The Role of Seahorses with Regards to Education, Their Popularity as Exhibits, and Their Flagship Value

Seahorses, those aquatic quirks of nature, are extremely popular with the public. With the continued improvements in husbandry success, more and more aquaria are exhibiting them. In addition to their unusual appearance, the seahorse's life history is also fascinating to visitors, with elaborate courtship, monogamous mating practices, and male pregnancy all making engaging stories.

Seahorses are ideal species to use as a flagship for conservation as they allow us to highlight some serious and unique conservation concerns. They allow us to discuss the dangers of environmental loss, as seahorse species inhabit some of the world's most endangered habitats: estuaries, mangroves, reefs, and seagrass beds. They are not only an example of an animal exploited as a non-food fishery, but also vulnerable to being caught as by-catch. Seahorses also provide an example of how human consumer choices can affect the fates of species. If we look at their use in the traditional medicine, aquarium and curiosity trades, we can then highlight the usage and trade in animals taken from the wild.

Basic educational messages may simply focus on species information, habitat, and distribution. Behavioral information may include descriptions of mating behavior and reproduction, as well as information on hunting, predation, and camouflage. More detailed educational messages may encompass statements regarding habitat loss, overfishing, traditional medicine, and other factors threatening wild seahorse populations. As the popularity of seahorses increases, so must the level of the educational messages that we portray.

Future Challenges and Opportunities

As research continues and more information becomes available about the life history of seahorses, new opportunities arise for education. Lesson plans, informational videos, and literature are tools that are necessary in the classroom. While academic learning is critical, trips to aquaria and zoos energize and excite budding scientists and naturalists. Consequently, the importance of creative graphics and interactive signage increases. Special programs focusing on a flagship species such as seahorses can further expand the public's awareness of the marine ecosystem.

Special Syngnathid Exhibits (2005 update)

Table 1 gives details of special exhibits for syngnathids held at various aquariums in Europe and North America. Generally, such exhibits have been considered successful and a number of temporary exhibits have now become permanent. Conservation messages and educational materials have been developed and promoted in all these exhibits.

Table 1: Special Exhibits for Syngnathids in Public Aquariums

Institution	Contact Name & e-mail	Special Seahorse/ Syngnathid Exhibit?	Dates of Operation of Exhibit	Spp. Exhibited? (with any comments about problem species/most popular ones)	Perceived/measured success of exhibit	Estimated no. of visitors	Conservation Messages	Educational Materials Produced?	Images available?	Other info
Acuario de Veracruz, México. (Veracruz Aquarium, Mexico)	Antonio Martinez caballitosdemar@acuariodeveracruz.com)	YES	365 days/yearOpened in May 2003	*Hippocampus erectus*	There is no specific measured success for this exhibition	1million visitors per year	Yes. The exhibition tank shows information explaining their captive bred origin and the limited presence in the Veracruz Reef System. (VRS)	Yes. -During the Summer Course for children (5-7 years old) the Education Depatment has installed a seahorses tank in order to show the kids some biology and conservation aspects. -The guide's training manual includes information about the aquarium's seahorses husbandry program in order to offer complete information to visitors. - The aquarium staff offers conferences to university students from aquaculture and marine biology careers. - Now the aquarium advices and supports the thesis process of two Biology graduated students about *Hippocampus erectus* reproduction and histology.	YES	Colouring book is in progress
Toledo Zoo	Jay Hemdal jay.hemdal@toledozoo.org	Seadragons only	4/2005 - 10/2006	Komodo dragon Dragon eel Dragon wrasse Frilled dragons Four leafy seadragons	Remains to be seen, but we are hopeful it will be well received	700,000 per year (based on 1,000,000 per year facility attendance)	Where applicable, in graphics	Panel graphics only	Not sure yet	
Tennessee Aquarium	Kathlina Alford kfa@tnaqua.org or Shelly Simpson sss@tnaqua.org	Yes, originally a 2 year temporary gallery of syngnathids was planned. However,	May 2002 - Present	*H. reidi* *H. erectus* *H. whitei* *H. subelongatus* *H. abdominalis* *H. breviceps* *H. procerus* (high susceptibility to gas bubble	very good success	2,575,000	Yes, graphics are used to teach about Project Seahorse and seagrass bed conservation. Videos are also used	Yes: - Chapter in "Docent Training Manual" compiled to focus on Syngnathid exhibit and distributed to staff and volunteers at the Tennessee Aquarium. Information on natural history, conservation information, and species	Available on request	

		such a good response was seen that the gallery will now be permanent.		disease, holding air in the pouch or under the skin in the tail region) *H. zosterae* *H. kuda* *H. ingens* (experienced gas bubble disease issues) *S. scovelli* *S. fuscus* *P. eques* **most popular *P. taeniolatus* **most popular			throughout the gallery as conservation education tools. Touch screens allow visitors to learn at their leisure on computer screens.	specifics are included in this chapter. - Docent interactive station in the gallery allows staff and volunteers to use biofacts and other props to educate the general public face to face. - Exhibit also features 3 interactive computer programs (touch screens) highlighting habitats and conservation of Syngnathids. "AquaQuest" activity sheets are available to any school group coming to the aquarium. These pages give students activities, questions and things to look for as they travel through each exhibit in the aquarium. These handouts are accompanied by an "AquaGuide" which is in depth information for teachers. - Aquarium website also features a section dedicated to the Seahorse Exhibit (coloring pages, conservation, species information, and links to Project Seahorse)		
Anglesey Sea Zoo	Karen Tuson zooteam@angleseyseazoo.co.uk)	Yes	Since 1996	*H. capensis* *H.comes* (difficult to rear) *H.kuda* *H.guttulatus* - current *H.hippocampus* – current *H.reidi* - current (difficult to rear) *H.whitei* – current Most popular are the *H.guttulatus* and *H.hippocampus* as many of our visitors do not realise that these species can be	Seahorses are a definite favourite. Press releases regarding the seahorse species that we have on display do bring people to the aquarium.	Approx. 100,000 visitors per year.	Information boards are up around the seahorse exhibits. Outlining both general and specific species information. We also have a notice board which is kept up to date with new Project Seahorse news and other relevant seahorse information.	We have not produced any leaflets for visitors to take away with them. However we do conduct guided tours and spend time discussing seahorse conservation during this time. During 2004 we had two special Seahorse Conservation Events for our visitors. This year we are incorporating this into our Conservation Event during Whitsun.	Yes	

				found around the UK. On the whole we do find that the most colourful seahorses are the most popular!			In 2003 the Anglesey Sea Zoo adopted Project Seahorse as their 'Charity of the Year'			
The Aquarium at Moody Gardens	Shawna Reiner *sreiner4@yahoo.com*	Yes, Seahorse Symphony	March 2001-December 2002	*Hippocampus reidi* (popular) *Hippocampus kuda* *Hippocampus jayakari* *Hippocampus fuscus* *Hippocampus erectus* *Hippocampus abdominalis* (popular) *Hippocampus barbouri* *Hippocampus capensis* *Hippocampus comes* *Hippocampus subelongatus* *Hippocampus zosterae* (popular) *Autostomus maculates* (popular) *Sygnathoides bioculeatus,* *Doryhamphus jahssi* *Doryhamphus excisus* *Doryhamphus baldwini* *Doryhamphus multiannulatus* (popular) *Doryhamphus dactyliophorus*	Very successful with visitors	2001: 560, 000 2002: 430,000 2003: 340,000	YES, Project Seahorse. We still have signs, posters, and a video that plays daily.	Not Seahorse Symphony but we did use Project Seahorse media through video and graphics.	No, nothing archived but we could get.	Seahorse Symphony was a package from Shedd. We have continued monetary support through poster sales and some conservation monetary donations from Project Seahorse
Dallas Aquarium at Fair Park	Brian Potvin (Aquarium Curator dallasaq@airmail.n	Seahorse Rodeo – special	Opened October, 2004 to run	White's Seahorses Lined Seahorses	Too early to tell (lots of happy women when	As of May 1, 2005 --- (88,643)	YES (Graphic similar to Project	NO not yet	Yes & No (but can provide on	Using wishing well to make annual

	et)	exhibit	indefinitely	(Glugea mortalities) Sticklebacks Trumpetfish Dragon Face Pipefish Shrimpfish Banded Pipefish Blue Stripe Pipefish Snipefish Pot Bellied Seahorses (most popular!!) Brazilian Giant Seahorses Yellow Banded Pipefish Alligator Pipefish Dwarf Seahorses (Glugea mortalities)	they learn the males give birth)		Seahorse poster)		request)	contributions to Project Seahorse and well as % of proceeds from seasonal gift shop sales

Syngnathid Health Management

2005 update
llze K. Berzins (Florida Aquarium, USA; IBerzins@flaquarium.org)
2002 version
Martin G. Greenwell (John G. Shedd Aquarium, Chicago, USA)

Normal Anatomy and Behaviour

Syngnathid fishes (seahorses, seadragons, pipefishes, seamoths and shrimpfishes) represent a unique family of primarily marine and brackish water teleosts. They possess some novel anatomical and behavioral characteristics with which the veterinary clinician should become familiar in order to render an accurate health evaluation. The majority of the following discussion will focus on seahorses but information on the other groups will be introduced when appropriate.

The Syngnathidae possess bony-plated body armor rather than scales. This hard, outer skin can make even simple procedures such as injections a bit of a challenge. They have a small mouth at the tip of a tube-shaped snout. Only the lower jaw is protractile. They have unique, lobate gill filaments termed lophobranchs that possess fewer lamellae than other teleosts. Grossly, the gills appear as hemispherical structures that have been compared to small chrysanthemums or grape-like clusters. In addition, the gills of syngnathids are fairly inaccessible since the operculum has a membranous attachment to the body with only a small opening at the dorsal aspect. These 'semi-closed' branchial chambers make gill biopsies prohibitive.

Seahorses possess pectoral fins, a dorsal fin, and a small anal fin. Swimming in a head-up, tail-down, vertical position, they propel themselves with their dorsal fins using their 'ear-like' pectoral fins for steering and stabilization. Seahorses also exhibit sexual dimorphism. The reproductive and anal openings of the female seahorse are both cranial to the small anal fin. In contrast, the anal fin separates the male's genital and anal openings. The elongated, genital opening of the male located below the anal fin represents the opening to the brood pouch. The brood pouch or brood pouch area is one of the features that is used to distinguish separate families.

The alimentary tract of the seahorse consists of an esophagus that leads to a small, pouch-like stomach with no evident pylorus. The stomach is located just past the bend in the seahorse's neck. Seahorses possess a gall bladder at the anterior end of the liver. The liver itself is best visualized at necropsy on the right side of the body extending from the bend in the neck to between 1/3 to ½ of the length of the coelomic cavity.

As in other teleosts, seahorse kidneys are paired, retroperitoneal organs. No grossly visible divisions of the cranial and caudal kidney exist. The number of glomeruli in the syngnathid kidney is greatly reduced with some species having almost aglomerular renal tissue. The swim bladder is a simple, single-chambered sac with no anatomical connection to the gut. It begins at the bend in the neck and extends to about 1/3 of the length of the coelomic cavity. In leafy seadragons however, in radiographic contrast studies, it has been noted to possibly consist of a two chambered sac (I. Berzins, The Florida Aquarium, personal communication) but anatomical dissections are incomplete at the moment.

In discussing the normal habit and behavior of seahorses, it is sometimes helpful to think of them as "aquatic chameleons." Like chameleons, seahorses are essentially 'sit-and-wait' or ambush predators. Except for their exuberant morning greeting and courtship rituals, they tend to spend most of their day in a rather sedentary mode, grasping some sort of holdfast such as seagrass stems, coral heads, or gorgonians with their muscular, prehensile tails. They gently sway to-and-fro with the surge, patiently waiting for small invertebrate prey to come within striking distance. Like the terrestrial chameleon, seahorses are masters of disguise that not only can change their colors to match their surroundings, but can also grow extra skin filaments or cirri in imitation of algal fronds. Some seahorses even host encrusting organisms such as bryozoans, hydroids, or algal filaments to further enhance their camouflage. Seahorses' eyes move independently in a constant search for suitable prey items just like the eyes of their terrestrial analogue, the chameleon.

Physical Examination

Visual Assessment

When performing an initial physical exam, the posture and buoyancy of the seahorse should be closely scrutinized. A seahorse bobbing at the surface is abnormally and positively buoyant. Buoyant animals will often struggle to maneuver deeper into the water column. They should be evaluated for air entrapment problems such as air in the brood pouch (males) or hyperinflated swim bladders. If the tail is extended outward caudodorsally or 'scorpion-style,' examine the subcutis of the tail for gas bubbles (subcutaneous emphysema). Subcutaneous emphysema of the tail segment also appears to be a condition restricted to males. Just as abnormal is a seahorse that is lying horizontally at the tank bottom for extended time periods. This may be an indication of generalized weakness or it may indicate negative buoyancy associated with swim bladder disease or fluid accumulation in the brood pouch or the coelomic cavity.

Evaluate the seahorse's feeding response. Seahorses normally forage almost constantly during daylight hours. An individual that consistently refuses appropriately sized live food is behaving very abnormally and should receive nutritional support to meet its caloric needs.

The rate and pattern of breathing should also be evaluated. Rapid breathing and 'coughing' (expulsion of water in a forceful manner through the opercular opening or the mouth) suggest gill disease. The entire body surface including the fins should be examined for hemorrhagic regions, erosions, ulcerations, excessive body mucus, unusual spots, lumps or bumps as well as the presence of subcutaneous gas bubbles. Evaluate both eyes for evidence of periorbital edema, exophthalmia, and any lenticular or corneal opacities. Since seahorses are visual predators, maintaining normal vision is absolutely essential to successful foraging. The tube snout is also very important to normal feeding activity. It is utilized like a pipette to literally suck prey out of the water column. Evaluate the tube snout for evidence of edema, erosions, and successful protraction/retraction of the small, anterior, drawbridge-like segment of the lower jaw. Close evaluation of the tail tip for erosive/necrotic lesions should also be performed. Finally, the anal region should be closely evaluated for redness, swelling, or tissue prolapse. For closer evaluation it may require getting the seahorse in hand. If this is the case, wear non-powdered latex gloves to prevent injury to the integument of the animal.

Diagnostics

As noted above, there are several potential etiologies when an animal is experiencing buoyancy problems. If the pouch appears asymmetrically distended or symmetrically distended with attendant buoyancy problems, a percutaneous fine needle aspirate should be performed on the pouch contents. Any fluid aspirated should be dried and stained with Wright-Giemsa stain, Gram stain, and acid-fast stain. The pouch can also be flushed with sterile saline and the aspirate sent for culture.

If a hyperinflated bladder is suspected, a bright light can be directed from behind the animal to visualize the location and borders of the distended organ. This is useful when attempting to deflate the bladder. The needle should be directed between the scutes/plate margins for ease of penetration through the skin. The external area can be rinsed with sterile saline or a drop of a triple antibiotic ophthalmic solution applied prior to needle penetration.

Diagnostic dips or baths or diagnostic washes of the branchial cavities can be performed to obtain an etiologic diagnosis since the gill tissue itself is so inaccessible. Because of the semi-closed nature of the branchial cavities, branchial washes with sterile, 0.9% NaCl are far easier and much less traumatic than traditional gill biopsies.

Skin lesions should be swabbed with a few sterile, wet (using sterile saline), cotton-tipped applicators and evaluated by wet mount, gram stain, acid-fast stain, and/or Wright-Giemsa stain. Skin 'scraping' is possible but quite difficult in practice due to the irregular surface architecture of the bony-plated armor. Follow-up diagnostics to the initial skin swab include aerobic bacterial culture, mycobacterial culture, and cytological exam by a pathologist familiar with fish. Fin clips can be performed if fin lesions are observed.

Any unusual lump, bump, should be worked up with a fine needle aspirate (27 gauge needle & TB Syringe) and sent for culture, wet mount and/or staining.

Feces can be obtained by the wait-and-watch method or a colorectal wash under MS-222 (tricaine methanesulfonate) sedation using a tuberculin syringe, 0.9% NaCl, and a 3.5 gauge red rubber catheter. Oftentimes, the seahorse will void feces reflexively after anesthetic induction with MS-222.

Blood collection is technically very difficult due to the relative absence of accessible peripheral veins and the small size of most syngnathids. However, small amounts were obtained in a recent study on CBCs and cortisol levels in *H. erectus* (P. Anderson, K. Harr and D. Heard, University of Florida, unpublished data). They were able to successfully draw 0.2 mls from animals, even up to 0.4 mls in some animals. Another 0.2 cc from the same two animals approximately 18 days later. Blood was drawn at the basal part of the tail from a ventral approach. Cardiac sticks were unsuccessful.

Radiography can be a very helpful diagnostic tool. The ideal machine for taking radiographs of seahorses is a mammography unit in terms of optimal radiographic detail and contrast. Important structures to evaluate include swim bladder (size, shape, presence or absence of fluid), coelomic cavity (free air, fluid, masses), alimentary tract (aided by a small bolus of barium sulfate if needed), liver position and size, kidney position and size, gonadal position and size, and brood pouch contents. Larger seahorse species as well as the seadragons are particularly at risk for foreign body (usually substrate) ingestion which can easily be ruled in or out with plain film radiography. Ultrasonography of brood pouch contents should be made possible by using the smaller transducers (7.5-MHz – 10.0-MHz) employed in ophthalmologic evaluations.

Sedation and Anesthesia

MS-222 at the standard fish dose of 50 – 100 ppm works quite well for most of the syngnathids. In low-alkalinity water it is recommended to buffer the solution at a ratio of 2 parts sodium bicarbonate:1 part tricaine (wt:wt). The seadragons have a prolonged recovery time at 100 ppm and 50-75 ppm is the recommended dose for these two species. In a prolonged anesthetic recovery situation, it is advisable to ventilate the animals with fresh seawater containing no MS-222. Because of the long, rather narrow tube snout and the semi-closed nature of the branchial cavities, assisted ventilation is easily achieved with a 3.5 to 5.0 French red rubber catheter inserted through the tube snout to the level of the pharynx. A syringe filled with fresh saltwater is then attached to the end of the red rubber catheter and pumped in a pulsatile manner every few seconds until the animal is spontaneously breathing at a normal rate. The success of assisted ventilation is easily assessed by watching the opercula move in and out. This technique has also been successfully used to resuscitate animals in respiratory arrest. Long-term anesthetic procedures should employ a flow-through system with oxygen supplementation in the sump or reservoir.

Diseases

Bacterial Disease

Vibriosis has been the most frequently encountered clinical problem among all of the syngnathids maintained at the Shedd Aquarium. Vibriosis is typically a peracute to subacute process with high morbidity and mortality. It almost inevitably occurs in the first week or two of acclimation. There are three clinical presentations that are commonly encountered: erosive/ulcerative dermatitis often involving the tail tip, sudden death with no premonitory signs, and a syndrome characterized by bilateral edema of the periorbital tissue and edema of the soft tissue around the tube snout. Some cases present with edematous facial tissue as well as an erosive/ulcerative dermatitis. Post-mortem findings can include ulcerative dermatitis, bacterial cellulitis/myositis, and/or bacterial septicemia. Osteomyelitis and peritonitis are infrequently encountered. Septic fish often had one or more of the following histological changes: reactive endocardium, pericarditis, necrotizing hepatitis, and renal necrosis. *Vibrio alginolyticus* is by far the most frequently isolated species from post-mortem kidney and liver cultures of syngnathids at Shedd Aquarium. *Vibrio alginolyticus* is a fairly ubiquitous microbe and is often isolated from random water samples as well as the live food items fed to the syngnathids, i.e., adult *Artemia*, *Artemia* nauplii, and mysid shrimp. Most of our syngnathids were initially acquired through the pet trade. Therefore, it has been postulated that, due to the time it takes to make it through the trade route from native collector to our tanks when combined with the fact that newly collected animals are obligate live food eaters and are probably not being offered live food en route, new syngnathid acquisitions are often on a very poor plane of nutrition. This has been substantiated by post-mortem exams wherein fat stores have often been completely depleted in many of the newly acquired specimens; in other words, the fish arrived in an emaciated condition. This malnutrition combined with the stress of capture, crowding, and possible substandard water quality conditions result in an immunocompromised fish host susceptible to both opportunistic and/or mildly virulent bacterial infections. Early and aggressive treatment with injectable antibiotics is indicated, but has been only moderately successful. *In vitro* antibiotic susceptibility patterns from over fifty *V. alginolyticus* isolates has suggested that ceftazidime and chloramphenicol would be the drugs-of-choice. At Shedd, we administer ceftazidime at 30 mg/kg intracoelomically every 48 hours for a minimum of five injections. Injecting into the tail and vertebral column (the back) musculature is also possible. In an attempt to emphasize prevention rather than treatment, DC-DHA Selco has been incorporated as a live food soak as well as dips with a bivalent vibrio bacterin discussed later in the Quarantine section. Additional measures worthy of investigation for the prophylaxis of *Vibrio* infections might include the use of an immunostimulant such as a beta-glucan to enhance the animal's immune response to the bacterin and the installation of UV sterilizers through which water from the live food holding tanks can be recirculated in order to minimize the incidence of food-borne vibriosis.

Moraxella spp. has been isolated in *Hippocampus abdominalis*, and *Vibrio vulnificus* in *Phycodurus eques* and *Phyllopterus taeniolatus* (Nuno, P., Oceanario Lisboa, personal communication). A recent paper reports that *Vibrio harveyi* causes disease in seahorse, *Hippocampus sp.*

Mycobacteriosis (a bacterial disease of special concern*)*

Mycobacteriosis in syngnathids is caused by the nontuberculous or atypical *Mycobacteria* species (also known as MOTT – **M**ycobacterium **O**ther **T**han **T**uberculosis). The vast majority of documented mycobacteriosis cases in these fish at Shedd Aquarium have been caused by the two rapid-growing species, *M. chelonae abscessus* and *M. fortuitum.* The slower growing, photochromogenic species, *M. marinum* has been encountered but at a much lower frequency. Mycobacteriosis is a significant cause of morbidity and mortality in captive syngnathids. At Shedd Aquarium, Alligator Pipefish (*Syngnathoides biaculeatus*) and Longsnout Seahorses (*Hippocampus reidi*) were the two species of syngnathids that were most frequently reported as having mycobacterial infections according to culture results and histopathology reports. But as more facilities exhibit syngnathids, mycobacteriosis is being frequently encountered in many other species (I. Berzins, personal communication).

Mycobacteriosis can present as a peracute to chronic disease. Typically, it is encountered as isolated, sporadic cases but tank epizootics have been documented as well. In the peracute syndromes, affected individuals may be found dead without any premonitory signs. More often, however, it presents as a subacute to chronic, pyogranulomatous infection that may involve skin, subcutis and/or underlying skeletal muscle characterized by pyogranulomatous abscesses and/or draining fistulous tracts. Acid-fast stains applied to the exudates from these lesions will reveal acid-fast bacilli. Moreover, infections are not usually limited to the skin and subcutis. The skin lesions tend to be the superficial signs of systemic infections involving any combination of organs and organ systems which often including the spleen, liver and kidney. There are cases that no obvious gross lesions are noted on any tissue, but on histological evaluation, abundant numbers of acid-fast bacteria are dispersed through organs such as the liver and kidney. Culture results so far have always been positive for *M. chelonae* (I. Berzins, personal communication).

To date, treatment of mycobacteriosis in syngnathids has not been attempted at the John G. Shedd Aquarium for a few reasons. Successful treatment would entail long-term administration of 'cocktails' of two or more antibiotics some of which have been shown to be fairly toxic to fish. In addition, there is every chance that antibiotic-resistant strains of these mycobacteria might be inadvertently created during long-term antibiotic treatments if the treatment dosages and durations happen to be insufficient or inconsistent. This fact, coupled with the subsequent exposure of unaffected fish and human caretakers, makes treatment of mycobacterioses in fish a rather risky proposition. In the event of a true mycobacterial epizootic, it is advised that all of the specimens in an affected tank should be humanely euthanized, the tank substrate and décor should be discarded, and the tank itself should be disinfected with a disinfectant with antimycobacterial properties. If a decision is made to treat a case of mycobacteriosis in a syngnathid due to its rarity or economic value, antibiotic choice(s) should be based upon sensitivity of the isolate to one or compounds from the following suite of therapeutants: amikacin, cefoxitin, clarithromycin, doxycycline, minocycline, trimethoprim-sulfa, and imipenem. This list of antibiotic choices is based upon the current recommendations for management of atypical mycobacterial infections in man. Barrier protection with latex gloves is recommended when working with fish known to have mycobacterial infections.

Parasites

Metazoans
The majority of the parasitic diseases that have been encountered at Shedd Aquarium involve metazoan endoparasites. Extraintestinal metazoa were the most frequently encountered group and usually involving encysted, quiescent digenetic trematodes or cestodes. These quiescent parasites represent very little threat to their syngnathid hosts, which the parasites are undoubtedly using as intermediate hosts with larger, predatory fish being the probable final or definitive hosts. Intestinal metazoa were the second most frequently encountered parasite group with cestodes being encountered more frequently than nematodes or digenetic nematodes. Both praziquantel and fenbendazole can be prophylactically administered during the quarantine period to decrease the intestinal metazoan parasite burden.

It is noteworthy that monogenetic trematode infestations have not been reported in syngnathids in any of the fish parasitology literature. However, the veterinary department at the National Aquarium in Baltimore has documented monogenean infestations in a species of pipefish that responded to treatment with difluorobenzuron (B. Whitaker, National Aquarium in Baltimore, personal communication).

Branchiuran parasites (*Argulus sp.*) have been reported in syngnathids (Whitaker, personal communication) and were effectively treated with the chitin synthesis inhibitor, difluorobenzuron. Lernaeopodid copepods were observed in the branchial cavities of two Lined Seahorses (*H. erectus*) upon post-mortem examination.

Protozoa
At Shedd Aquarium, protozoal and dinoflagellate parasites have been encountered, but at a much lower frequency than the metazoa. One very notable exception has been the enteric coccidian, *Eimeria phyllopteryx*, encountered in three out of the four wild-caught, adult, Weedy Seadragons (*Phyllopteryx taeniolatus*) originally acquired by the Shedd Aquarium. These Seadragons exhibited signs of buoyancy/postural problems as well as complete anorexia three to seven days prior to death.

An outbreak of amyloodiniosis (*Amyloodinium ocellatum*) in a group of Dwarf Seahorses (*H. zosterae*) responded very well to continuous, immersion bath administration of chloroquine diphosphate at 8-10 ppm.

An *Ichthyobodo*-like flagellate resulted in moderate to high morbidity and mortality in a group of Alligator Pipefish (*S. biaculeatus*) as well as in a group of Giant Seahorses (*H. ingens*). In both of these species, the gills were the primary target tissues and the fish presented with rapid, labored breathing and anorexia. The flagellates were discovered on post-mortem wet mounts of gill tissue. Treatment with a continuous immersion bath using a proprietary malachite green/formalin cocktail at twice the labeled freshwater fish dose effectively controlled these outbreaks.

Several cases of uronemiasis caused by the parasitic, scuticociliate, *Uronema marinum,* have been documented in a variety of syngnathid species. *Uronema* infestations are peracute to subacute and have historically been very difficult to treat. Limited success in treating uronemiasis in Pot-bellied Seahorses (*H. abdominalis*), a temperate species, has been achieved using a proprietary malachite green/formalin cocktail at twice the labeled freshwater fish dose. In one case nitrofurazone 20 ppm/5 hours/7 days was efficient in 2 of 3 H. abdominalis.

Three cases of biliary microsporidiosis associated with histories of sudden death were reported in Spiny Seahorses (*H. barbouri*). *Glugea heraldi* is a microsporidian infection that has been identified in *H. erectus* and presents as whitish pustules or boils on the skin. Large, elliptical spores are easily identifiable by examining wet mounts of the lesions. There is no know treatment for this disease and culling of infected animals is recommended. If there is a ready supply of animals available, it is advisable to breakdown the entire system, disinfect and reestablish a new set of exhibit animals.

It is noteworthy that no cases of cryptocaryonosis or 'marine ich' caused by *Cryptocaryoon irritans* have been observed in the Shedd Aquarium (nor at The Florida Aquarium) syngnathid collection.

Cryptobia-like parasites were isolated from mucous patches on symmetrical skin lesions in *Phyllopteryx taeniolatus* (Nuno, P., Oceanario, personal communication). There were no mortalities but there were several recurrences. After various treatment regimes, a formalin immersion at 15ppm every 48hours with a 50%water change every 24 hours post treatment for a total of 3 treatments total proved to be efficient.

Viral Diseases

An adult Coronetfish (*Fistularia sp.*) with a fatal viral encephalitis presented in status epilepticus (continuous seizure activity) at the Shedd Aquarium. A viral agent was also encountered in a group of Tiger Tail Seahorses (*H. comes*), which resulted in very high morbidity and mortality in this species (B. Whitaker, National Aquarium in Baltimore, personal communication).

Fungal Infections

There have been several case studies of a cutaneous of systemic phaeophyomycosis identified from submissions of various sygnathid fishes to the pathology service of the Connecticut Veterinary Medical Diagnostic Laboratory (UConn, Storrs, CT). In particular, morphologic and molecular identification of several *Exophiala* species, one isolated from systemic lesions of seadragons (*Phyllopteryx taeniolatus* and *Phycodurus eques*), and another (*E. pisciphila*) from *Hippocampus abdominalis*. More frequent attempts at culture have isolated several other hyphomycetes, e.g. *Paecilomyces lilacinus*. However, the range of clinical and pathological conditions of these isolates remains to be determined.

Air/Gas-related Problems

Among the syngnathids, gas entrapment disorders have thus far been restricted to seahorses (as opposed to pipefish) at the Shedd Aquarium. These disorders are characterized by low morbidity and mortality rates. Gas entrapment problems typically present as either gas entrapment in the brood pouch, subcutaneous emphysema of the tail segment and/or overinflation of the swim bladder (which does occur in seadragons as well). Subcutaneous emphysema of the tail and, of course, brood pouch gas accumulation are almost exclusively encountered in male seahorses. These latter two conditions are the most frequently observed gas entrapment problems. Affected fish have postural and buoyancy problems. Often, but not always, brood pouch gas entrapment presents as a grossly and symmetrically overdistended pouch. In caudal emphysema, the gas bubbles in the soft tissue of the subcutis of the tail can be easily observed with the naked eye. Histological findings often include gas-filled 'pseudocysts' lined with endothelial tissue suggestive of gas-dilatation of lymphatic vessels. Chronic cases often exhibit fibrosis. Mild granulomatous inflammation may also be present, especially in the subacute to chronic cases. No infectious agents have been identified. To date, no association with gas supersaturation of the water column has been established. It has been postulated that the extensive vascular bed that supports the physiologically dynamic brood pouch of male seahorses may be uniquely predisposed to gas embolization. Treatment attempts are most successful in cases that are caught early in which the gas accumulation tends to be more discrete, less diffuse and wherein there has been minimal to no fibrosis. Under MS-222, discrete gas bubbles or 'pseudocysts' are first aspirated with a 27 ga. Needle. The carbonic anhydrase inhibitor, acetazolamide, is then administered by injection at 2 mg/kg SQ, IM, or ID every 5-7 days until the lesions no longer reoccur. The veterinary staff at the National Aquarium in Baltimore has found that the additional use of the antibiotic, ceftazidime at 22 mg/kg SC or IM every 5 days has improved the survivorship of these fish and also seems to diminish the likelihood of reoccurrence (B. Whitaker, National Aquarium in Baltimore, personal communication).

Nutrition

Nutrition of syngnathids is a subject that is truly in its infancy. We know that they feed on tiny invertebrates in nature. Some species, such as the Seadragons, appear to be fairly specialized in their diets and primarily forage for mysid shrimp. In captivity, live, adult *Artemia*, *Artemia* nauplii, ghost shrimp, and mysid shrimp are the primary food sources. Many of the species can be induced to accept frozen foods with a little patience using a slow, gradual introductory method. It has been a standard practice to supplement *Artemia* with highly unsaturated fatty acids. It is very important to realize that this group of fishes constantly forages in nature. There intestinal transit time is fairly rapid and their fat stores tend to be rather minimal. These may be evolutionary trade-offs that are complementary to having bony-plated armor. Consequently, syngnathids are at a high risk for loss of body condition. With this in mind, anorectic seahorses and pipefish almost always require nutritional support. At Shedd Aquarium, anorectic syngnathids are tube fed a high quality, commercial fish flake food gruel. Because of the very small, vestigial stomach, only limited volumes of gruel can be administered at any given time, i.e., 0.05 to 0.10 cc for most seahorses and up to 0.25 cc or more for the large *Hippocampus sp.*, trumpetfish, and the seadragons. Offering nutritional support can mean the difference between survival and death in sick and/or anorectic syngnathids.

Tumors

There are very few case reports available on tumors in syngnathids. A recent study describes a fibrosarcoma in the brood pouch of a *H. erectus*. As with many of the diseases in the syngnathids, much is still unknown.

Stress and syngnathids

Some new studies are focusing on possible anthrogenic stress factors on captive seahorse populations, notably pump noises on breeding behaviors, fecundity, morbidity and mortality (H. Masonjones and P. Anderson, personal communication). Results from such investigations may assist in improved tank design and husbandry techniques.

Quarantine Protocols

The quarantine protocols in use for syngnathids at the John G. Shedd Aquarium have seen many changes as data from clinical pathology records, necropsy records and histopathology reports have accumulated over time. There is probably no such thing as a universally reliable quarantine protocol for all syngnathids. This should be intuitive when one contemplates the diversity of this group; different species in different situations may have altogether different disease problems. For example, the enteric coccidiosis (*Eimeria phyllopteryx*) that is fairly prevalent in Weedy Seadragons (*Phyllopteryx taeniolatus*), has not, to my knowledge, been observed in other syngnathids. On the other hand, devastating infections with *Uronema sp.* have been problematic in Leafy Seadragons (*Phycodurus eques*) in some institutions. With these caveats in mind, veterinary clinicians are encouraged to tailor their own quarantine protocols to address the common problems in the particular species that their respective institutions choose to exhibit. That having been said, the following quarantine protocol is currently employed at the John G. Shedd Aquarium where the most prevalent disease problem accounting for the highest morbidity and mortality to date is acute to subacute vibriosis. Newly acquired specimens are kept in isolated quarantine tanks for a minimum of 30 days.

(1) Live food (*Artemia*) soaked in DC-DHA SELCO is fed during the first week of acclimation. This product is purported to have antimicrobial properties. This was adopted into our protocol to prevent early colonization of the gut with *Vibrio sp.* of clinical significance. DC-DHA SELCO is a product of Artemia Systems, INVE Aquaculture NV, Hoogveld 91, 9200 Deudermonde, Belgium.

(2) A bivalent *Vibrio* bacterin against *V. anguillarum* and *V. ordalii* (Apha Dip 2100, made by Syndel International Inc., Vancouver, B.C.) is administered as a dip on day 1 and day 15 of quarantine per manufacturer's labeled recommendations. We have not challenged vaccinated syngnathids with pathogenic field isolates of *Vibrio* sp. to assess the protectivity of this bacterin. This work should be performed and compared with the protectivity of autogenous bacterins derived from in-house isolates cultured from post-mortem specimens.

(3) Live *Artemia* is soaked in fenbendazole to achieve a concentration of 0.25% to 0.5% of the wet weight of *Artemia*. This is fed out for three consecutive days (days 8,9, and 10 of quarantine). This three-day regimen is repeated in two weeks (days 22,23, and 24 of quarantine). This is administered to combat enteric nematodes. However, recent studies evaluating actual concentration of drug absorbed by the *Artemia* may be quite low (A. Stamper, Living Seas at EPCOT, personal communication). Further studies are needed.

(4) Praziquantel baths are administered on day 14 and day 28 of quarantine. Praziquantel is administered at 1-2 ppm for a minimum of 24 hours. This is done primarily to combat enteric cestodes and trematodes since, to date, ectoparasitic monogenetic trematodes have not been found in any syngnathid in our collection (nor are there any published reports of monogeans in syngnathids anywhere in the fish health or parasitology literature).

(5) A dip (10 minutes in either a low salinity bath or 45 minutes in a 200 ppm formalin bath) is performed at the end of quarantine primarily as a final therapeutic treatment against any putative ectoparasites. In addition, the sediment in this dip is concentrated and examined under the dissecting microscope for the presence of any protozoan or metazoan parasites before the fish are deemed suitable for exhibition.

Aside from the final therapeutic dip/bath, there is no provision in the above protocol for prevention of protozoal infections. Do they occur? Certainly. How frequently are they encountered? We have only documented a handful of clinically significant protozoal infections in syngnathids at the Shedd Aquarium. Initially, we were putting all of the syngnathids through a two-week treatment in citrated copper sulfate as we do most other marine teleosts. Copper toxicity was never a problem at the therapeutic dose of 0.18 – 0.20 ppm. However, vibriosis was **so** commonly encountered and **so** devastating that we decided not to use copper sulfate because of the potential immunosuppressive effects that it has been shown to have on teleosts. This would, we felt, potentially aggravate the problem of vibriosis. Moreover, the primary value of prophylactic use of copper sulfate, in my opinion, is in the prevention of cryptocaryonosis (*Cryptocaryon irritans*). To date, we have not encountered a single case of cryptocaryonosis in any syngnathid at Shedd Aquarium. I cannot imagine that it simply does not occur; it has, however, in our syngnathid acquisitions, been a nonissue thus far. Next we started using chloroquine diphosphate at 7 – 8 ppm for two weeks for protozoal prophylaxis. After some mysterious losses of specimens under chloroquine treatment, this regimen was also abandoned. Our current approach to managing protozoal infections is to treat them as they occur.

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Seahorse Research in public aquariums

2005 update
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2002 version
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There are many public aquariums rearing seahorses, and there is enormous potential to combine resources to produce valuable, high quality information to improve future husbandry conditions and to assist field conservation programs.

Husbandry research: Seahorses have been kept in public aquaria for many decades during which time significant husbandry advances have been made. The genus still provides serious challenges to the aquarist and unfortunately there is a general scarcity of structured research programs being undertaken to address these concerns. This is reflected in the limited number of peer-reviewed scientific papers on the biology and ecology of seahorses when compared to many other popular aquarium or aquaculture species. Many advances in husbandry have arisen from investigations and small-scale research projects relying more on trial and error than sound scientific method. This has resulted in a great deal of variation in interpretation of the results and success in holding and rearing methodologies. While the subtle changes and actions taken by aquarists to improve situations in their tanks may constitute research to many, the lack of rigorously tested information is undoubtedly hampering progress in the aquarium community.

Conservation research: Field conservation efforts often need to balance the biological requirements for the maintenance of wild populations with the requirements of human populations as users of the environmental resource. Conservation-minded fisheries management initiatives require biological information when considering regulation and sustainability of any fishery. Small-scale seahorse aquaculture developments would benefit from the same biological baseline information when attempting to turn seahorse fishers into seahorse farmers and lessen fishing pressure. Public aquariums can assist these projects by providing basic biological data on the growth and reproductive output of animals in their care.

Standard methods for recording biological information are required to allow baseline information to be collected and compared among species and between institutions to further our knowledge. Examples include recording juvenile growth, describing tank parameters, establishing husbandry routines, and fixing methods used in the identification of the seahorses in question. These are being addressed by using agreed terminology, using scientific units and providing data to be collated and analyzed. Public aquariums are being requested to keep standard record forms for seahorse tanks and collect data on seahorse broods for inclusion in larger analyses.

Priority areas for research in public aquariums include:

Taxonomy and Species Identification

Despite major advances in seahorse taxonomy in recent years, difficulties still remain in identifying a number of species complexes. Aquaria could assist with advancing our knowledge of taxonomy by keeping detailed records of each individual seahorse, requesting information on the exact source of seahorses acquired, and retaining any mortalities (dried or preserved) or photographs for future identification.

Lifespan in captivity

Aquaria can provide useful information on longevity by recording the birth dates of captive-bred seahorses and keeping track of their offspring. Records could be kept of age at which they first produce young, when they stop producing young, and when they die.

Lifetime reproductive output

We still lack information on the total lifetime reproductive output of seahorses. We do not know reliably whether some males of certain species consistently produce small numbers of large juveniles while others produce higher numbers of small juveniles. Aquariums could assist by recording the numbers of juveniles produced by known males (or identifiable pairs of seahorses) over an extended period along with additional information on tank and population parameters.

Male size and reproductive output

As yet we have few reliable estimates of brood size for each species kept in aquaria. This information is extremely useful for field conservation efforts. Aquariums could assist by allowing pregnant males to give birth in isolation where young can be collected without being lost to filters or predators. Recording the number of young produced by males on a regular basis could be undertaken in conjunction with measuring the size of the males.

Juvenile survival

In the wild, predation will undoubtedly claim the majority of juvenile seahorses. Estimating what percentage of each brood can survive under optimal conditions in aquaria might provide important information to identify critical stages in development resulting from pressures other than predation. Aquariums can assist by counting broodsize from a known male and by recording daily mortality in the juveniles.

Juvenile dispersal patterns

Juveniles of each species of seahorse behave differently, and these differences have implications for the distances that fry might be able to disperse in the wild. Aquariums could assist by noting down positions of juveniles in tanks at regular intervals following release from the pouch.

Growth monitoring

We still know relatively little about the normal growth rates of seahorses. Aquariums can assist by monitoring the growth of selected seahorse broods or individuals using a standard technique (available on the Syngnathidae listsever) to allow comparison between species.

Influence of environment

Aquariums often differ in their holding conditions for seahorses. It is extremely likely that an optimal set of environmental conditions will exist for each species and probably for each life stage. Aquariums could assist by recording the growth and survival of seahorses under their set of environmental conditions to allow comparisons.

Nutrition

One of the most apparent bottlenecks in successful reproduction for seahorses occurs during the first few weeks following birth when high mortalities are often attributed to poor nutrition. Few studies have addressed the possible effects of altering nutrition on growth and reproductive success in the adult stage. Most studies have been focused only on juvenile stages. There remains the need to examine the effect of various enrichment agents on such variables as size-at-maturity and the reproductive success of the individual.

Health/disease issues

Standardizing disease prevention protocols, disease description, and treatments would greatly assist efforts to overcome some of the health challenges. Aquaria could assist by providing samples of various seahorse species and life stages to a designated person or location offering to undertake the task of developing an atlas of normal and abnormal histology. Digital photography could be used to record normal healthy states to compile a library for comparative diagnostic uses. Aquaria could also assist by supporting efforts to collate existing veterinary databases, allowing access to medical and pathology records and participating in trials of vaccines and treatment protocols.

Individuals or institutions wishing to engage in seahorse research are urged to contact the Syngnathidae Discussion Group or the relevant TAG chair to seek advice. By informing other aquariums, duplication of effort can be avoided, and complementary research programs can be developed.

Syngnathid Discussion Group

The Syngnathid Discussion Group (SDG) Listserver is an e-mail based group of scientists, researchers, educators, aquarists and other individuals. The SDG is a forum for discussing diseases, juvenile care, feeding and other relevant issues. It allows different point of views to be expressed as well as important information to be shared in a very timely basis. Colin Grist (c.grist@chesterzoo.org) leads the Syngnathid Discussion Group.

Research Needed For Conservation and Management

In 2004, the most comprehensive review of seahorse life history and ecology was published in the Journal of Fish Biology (Foster and Vincent, 2004). This publication can be downloaded at the following site http://seahorse.fisheries.ubc.ca/publications.html. In this paper, recommendations were made for research on seahorses that is urgently required for conservation and management. With permission of the authors, this section is copied below:

A good understanding of a wide array of life history parameters is required in order to plan for long-term persistence and recovery of depleted populations. Robust information is required on taxonomy, global occurrence and habitat suitability. Data on individual movement, survival, growth and reproduction, by age and stage – and how these parameters respond in the face of exploitation pressure and habitat change – will then contribute to the construction of models of possible management schemes, and the evaluation of population level responses to such scenarios (Caswell 1989). For example, important parameters related to survival might include natural mortality, age at first maturity, age at entry into the fishery, and generation time (Froese & Binohlan, 2000; Reynolds *et al*., 2001). Ecological interactions affecting seahorses (e.g. competition, prey, predators) and the gene flow that may connect and sustain populations are also priority areas for research.

Distribution and Movement

The distribution of most seahorse species remains relatively unknown (e.g. Lourie *et al*., 1999; Kuiter, 2001; Choo & Liew, 2003). An important step in determining the global occurrence of seahorse species will be to reach a consensus on seahorse taxonomy. Accurate identification of different species based on a reliable set of characteristics (e.g. number of tail rings or spines, rather than colour or filaments, Lourie *et al*., 1999), will be vital to the effective implementation of domestic and international management, the accuracy of global trade data, and future research on the genus. In this context, it is imperative that, when referring to seahorses, researchers provide (a) the standard species name, (b) the reference identification guide used to designate the species name, and (c) information about the geographic locality of the individuals: for example, *Hippocampus comes* (Lourie *et al*., 1999; central Philippines).

Both fisheries-dependent and fisheries-independent abundance estimates are required for many populations worldwide. Published population estimates for seahorses are limited and usually buried in reports on fish community assemblages (e.g. Monteiro, 1989) such that population inferences must instead often be drawn from trade surveys (e.g. Vincent, 1996). While fishers' and traders' reports and records of changes in trade volumes are invaluable, they often lack information on the effort involved in obtaining the animals, thus diminishing the worth of the data for population estimates.

Since populations of marine fauna are usually connected into metapopulations, and are reinforced through such connections (Gilpin & Hanski, 1991; Crowder *et al*., 2000; Hixon *et al*., 2002), more research is required on seahorse movement and dispersal, particularly for newly released young. Small sub-adult and adult home ranges may mean that seahorses are slow to recolonise heavily fished areas (Vincent, 1996), unless such minimal movement is offset by high dispersal of newly released young. The corollary, however, is that small home ranges may allow small protected areas to support viable seahorse populations (Kramer & Chapman, 1999).

Understanding partitioning of habitat by size- and/or age-classes, or life history stage, can be important for developing management strategies, especially when addressing the effects of non-selective fishing gear (Vincent, 1996). For example, a greater understanding of how seahorses segregate by size or sex would enable spatial management of trawls and other non-selective gear to reduce indiscriminate fishing pressure on vulnerable cohorts or classes. If it is known that reproductively active animals are concentrated in particular areas (e.g. Baum *et al.,* 2003), then trawling could be redirected away from this region during important breeding periods. Also, if subadult seahorses are found in water shallower than adult seahorses (e.g. Dauwe, 1992; Perante *et al*., 1998), then the elimination of trawling activities from shallow zones might reduce the risk of recruitment overfishing.

Survival

Data on natural mortality / survival rates of seahorses, particularly if age- or stage-specific, are critically important parameters for modelling population viability and devising management plans (Macpherson *et al*., 2000), but are virtually nonexistent for seahorses. In the absence of direct estimates of survival, analyses of population age- or size-structure would allow us to model survival, and to plan management efforts. For example, a minimum size limit might be set where the trade off between growth and mortality maximises yield per recruit (Beverton & Holt, 1957).

Fishing mortality remains virtually unknown for most seahorse populations, despite the importance of such data in formulating catch guidelines for a sustainable fishery. Some research indicates that fishing mortality of individuals that have spawned once must be lower than natural mortality for the fishery to be sustainable (Myers & Mertz, 1998). For *H. comes*, even with high estimates of natural mortality in some parts of their range, fishing mortality exceeded those rates (Martin-Smith *et al*., unpublished data; J.J. Meeuwig, unpublished data). Presumably as a consequence, fishers reported that *H. comes* catches in a Philippines village had declined 70% in the 10 years from 1985 to 1995 (Vincent, 1996), with associated changes in the length-frequency distribution of the catch (Perante *et al*., 1998); more data of greater precision are needed to determine whether fishers had begun targeting smaller seahorses or whether the size structure of the seahorse populations had changed under exploitation.

Growth

Age- or stage-specific survival rates could be married to an improved knowledge of growth rates to fill a critical gap in our biological understanding of seahorses. The von Bertalanffy equation provides the most commonly used model for growth in fishes: $L_t = L_{inf}\,(1\text{-}exp^{(-K(t\text{-}to))})$ where L_t = length at age t in years, L_{inf} = maximum theoretical length, K = growth coefficient (yr^{-1}) and t_0 = theoretical age at zero length (von Bertalanffy, 1938). Age-based population assessments would enable researchers to determine K, and then to compare growth rates among species while applying them to management models. Ageing will, however, require analyses of seahorse otoliths or application of other ageing methods not yet validated on seahorses.

Age at first maturity (a_m) is a common biological reference point in fisheries models (Hilborn & Walters, 1992), and therefore determining a_m in the wild for various seahorse populations should be a research priority. Estimates of a_m would involve accurate determination of age in the wild. An understanding of a_m has been useful for determining other important life history parameters, such as life expectancy, in other fish species (Frisk *et al*., 2001)

Reproduction

A greater understanding of seahorse mating patterns and reproduction is important for conservation. Exploitation could disrupt seahorse social structure by disturbing pairs more quickly than they are established. Removing a member of a monogamous pair could decrease short-term reproductive output, by leaving the remaining animal without a partner, and possibly by reducing the size of its later broods if familiarity enhanced brood success (e.g. *H. fuscus*, Vincent, 1994a). Sex-selective fishing would also have important effects on a population, especially in monogamous populations where members of the more abundant sex might be less likely to find a mate. More needs to be discovered about how mating patterns respond to environmental and social parameters. For example, three pipefishes of the genus *Corythoichthys* were shown to be strictly monogamous on the Great Barrier Reef where an equal number of males and females were available to mate (Gronell, 1984). However, a fourth *Corythoichthys* species, in Japan, exhibited a highly polyandrous mating pattern, in a situation where more females than males were available to mate (Matsumoto & Yanagisawa, 2001).

The dearth of estimates of intrinsic rate of increase for seahorse populations poses a great challenge in conservation management. Fecundity rates are difficult to measure and do not necessarily determine resilience to exploitation (e.g. Sadovy, 2001; Denney *et al*., 2002). Rather, great effort should be dedicated to estimating recruitment rates of seahorses to the breeding population and to the fishery, in order to understand population dynamics and to predict response to exploitation, such as recruitment compensation (Goodyear, 1980). Too little is known about survival rates of seahorse juveniles compared to other fish, although the considerable parental care probably enhances survival in early life (McCann & Shuter, 1997).

More research on age- or size-specific reproductive output could allow us to tailor fisheries plans more usefully. For example, if further research confirms that brood size increases with male size, then maximum size limits might be considered for fisheries, in order to allow the most fecund animals to continue reproduction. Realistically, however, such a management measure, no matter how apparently desirable, might prove politically difficult to implement given that larger seahorses fetch a higher price (Vincent, 1996).

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Species Chapters

Introduction

Members of the Syngnathidae Discussion Group contributed the following chapters using their current knowledge and husbandry techniques. These chapters are not to be considered exhaustive or comprehensive. They will be regularly updated with current and new knowledge. This set of essays should be considered a 'starting point' for future information. Newly developed techniques or information should be sent to the species coordinator for updating these chapters and should also be shared on the Syngnathidae listserve as a means of updating individuals before the next manual is published.

<u>Big bellied Seahorse, *Hippocampus abdominalis*</u>

Heather Koldewey (Zoological Society of London, heather.koldewey@zsl.org)

Introduction

For a variety of reasons, we were unable to write a species chapter for *Hippocampus abdominalis.* However, there are some excellent references for the culture of this species that should be used for husbandry guidance (Woods, 2000a; 2000b; 2002 and 2003).

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<u>Cape or Knysna Seahorse, *Hippocampus capensis*</u>

2005 update
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2002 version
Brian Zimmerman and Heather Koldewey (Zoological Society of London)

Species Information

Habitat degradation presents the major threat to *Hippocampus capensis* (Whitfield 1995, Day 1997, Lockyear 1999), the only seahorse species listed as endangered on the 1999 IUCN Red List of Endangered Species. This species, commonly called the Knysna seahorse, is known from only three localities on the southern coast of South Africa: the Knysna, Swartvlei and Keurbooms estuaries (Lockyear 1999). Around all three of the estuaries, human settlements and associated industrial, domestic, and recreational activities are increasing (Whitfield 1995). The Knysna lagoon, which is the largest of the four estuaries, counts among the most heavily used waterbodies in South Africa, and construction developments around the lagoon are known to have impinged on the estuarine ecosystem (Toeffie 1998).

While pollution and other disturbances of the estuaries will undoubtedly affect the seagrass beds inhabited by *H. capensis* (Whitfield 1995), little is known about the impact of these disturbances on the seahorse population. However, anecdotal evidence suggests that Knysna seahorses are extremely vulnerable to changes in their environment. Since 1985 three mass mortalities of *H. capensis* have been recorded (Lockyear 1999). The largest of these occurred in 1991, when—following the flooding and subsequent breaching of the estuary mouth—3000 dead seahorses were observed in the Swartvlei estuary (Russell 1994). However they also have a strongly developed osmoregulatory system because of regular fluctuations in salinity.

The Knysna seahorse is protected; South Africa's Sea Fisheries Act of 1973 forbids the catching and disturbance of these animals and limits their exploitation by aquarists and exporters (Day 1997). In addition, two of the estuaries *H. capensis* is home to—Knysna and Swartvlei—fall under the protection of South Africa's National Parks Board (Whitfield 1995). Yet, the paucity of data on population size, ecological requirements, and population dynamics leaves attempts at managing the species fraught with difficulty (Bell, 2003; Day 1997).

Perhaps best studied is the animal's reproductive ecology. Individuals become sexually mature within one year at a standard length of approximately 65 mm. Breeding occurs during the summer months when water temperature reaches about 20°C (Whitfield 1995). All other seahorse species investigated so far (Vincent 1990; Vincent & Sadler 1995; Masonjones & Lewis 1996), *H. capensis* appears to mate monogamously (Grange & Cretchley 1995) and displays conventional sex roles despite male parental care (Fourie & Cherry, in press). Monogamy may not be the case in an aquarium environment, but this needs further study. The male carries the brood in its pouch for up to 45 days and bears between 30 and 120 young (Whitfield 1995). The heavy investment in parental care, a comparatively small brood size, the fragile social structure that arises from strict monogamy, a generally sparse distribution, and low adult mobility suggest that seahorse populations could be severely perturbed by mass mortalities like those recorded in the Swartvlei estuary (Lockyear 1999).

Little information is available on the ecological requirements and abundance of *H. capensis* (Bell, 2003). The fish are usually found in association with submerged aquatic plants, such as the eelgrass *Zosterae capensis* and macroalgae of the genus Codium. Juvenile *H. capensis* feed exclusively on zooplankton; adults primarily consume small crustaceans (Whitfield 1995). While known to survive salinity ranges from 1-59 ppt (Whitfield 1995), preliminary surveys suggest that *H. capensis* occur most abundantly where salinity approximates seawater conditions (34 ppt) (Toeffie 1998). Individuals are patchily distributed and occur singly or in small groups (Whitfield 1995). A survey conducted in the Knysna estuary between August and November 1990 encountered only 15 seahorses (Lockyear, Hanekom, and Russell 1991).

The distribution of *H. capensis*, while undoubtedly limited, is not well understood. The three estuaries in which the seahorse is said to occur—Knysna, Swartvlei, Keurbooms—together cover less than 50 km^2 (Lockyear 1999). Indeed no recent records exist for the species from the Klein Brak estuary (Lockyear 1999). In contrast, Knysna seahorses may also inhabit the Breede River, Duiwenhoks, Kaffirkuils, and Groot Brak (Grange *Pers. comm*. 1999), but there is no recent evidence.

The extent to which *H. capensis'* genetic makeup varies across its range is not known. Knysna seahorses are hypothesized to comprise the relic of a population which once moved freely along South Africa's southern coast but became confined to estuaries when sea temperatures dropped (Toeffie 1998; Teske 2003). Today the species' distribution is clearly fragmented (Lockyear 1999); its three home estuaries are isolated from one another by stretches of open sea. The genetic makeup of *H. capensis* populations may, therefore, differ between estuaries (Toeffie 1998; Teske 2003; Teske et al., 2003).

If the species and its habitat are to be managed effectively, a better understanding of *H. capensis*' distribution and ecological requirements is imperative. Given the species' vulnerability to ecological perturbations and the very real threat of habitat degradation, such basic biological parameters as abundance must be determined quickly for action to be taken in time. Further information on *H.capensis* can be found in a report by Oakley (2004) and a management report on the Cape seahorse by Oudegeest (2005).

Selection and Suitability

H. capensis is one of the more suitable seahorse species for captive culture. It lives naturally in estuarine habitats that fluctuate in temperature and specific gravity. This ability to tolerate extremes makes it able to withstand changing parameters in the aquarium. The young are quite large when born and can take newly hatched *Artemia* immediately, making them easy to feed. Rotterdam Zoo reports higher survival rates when also offering the juveniles rotifers during the first two weeks after birth. *H. capensis* does not seem to mind being handled and transported as much as other species of seahorse, although they do display a number of stress responses when handled frequently (such as active flight behaviour, clicking etc). However, it does fall victim to the usual range of seahorse diseases when placed under excessive stress or overcrowding. These include *Mycobacterium*, gas bubble disease, *Vibrio* sp. and *Pasturella* sp. *H. capensis* responds well to treatment for bacterial infections by using antibiotics in the live foods offered.

Habitat Parameters (display tank)

Population:	60-70 adult individuals
Volume:	1338 l
Height:	80 cm
Circulation:	closed

Water:	natural seawater
Filtration:	plenum with live sand bed, Eheim power filter with mechanical and carbon.
Substrate:	coral sand with “live” sand.
Holdfasts:	*Caulerpa prolifera*, netting, live rock.
Light:	2 HQI metal halide, 150 watts each, 10,000 Kelvin.
Photoperiod:	11 hours
Temperature range:	23-26 ^{o}C
NO_2:	0
NO_3:	<20ppm
NH_4:	0
pH:	8.2
Specific gravity:	1.022-1.025

Habitat Parameters (holding tanks)

Population:	average is 20.
Volume:	55 l
Height:	30 cm
Circulation:	closed
Water:	natural seawater
Filtration:	Double Algarde air driven sponge filter
Substrate:	thin layer of coral sand
Holdfasts:	artificial sea grass, live rock.
Light:	fluorescent room light (no light directly above tanks)
Photoperiod:	11 hours.
Temperature range:	22-26 ^{o}C
NO_2:	0
NO_3:	<50ppm
NH_4:	0
pH:	8.2
Specific gravity:	1.022-1.025

Holding tank set-up

Tanks consisted of 1 cm deep coral sand, a piece of live rock (~10x8x8 cm), ten short artificial plants (10.5 cm tall), and a long artificial plant (30 cm tall) arranged to create a sea grass bed effect. The contents were positioned to maximize the seahorses' welfare, and the complex nature of the environment created in the tank was based on a previous study (Tops 1999) that demonstrated that creating a number of different environments encouraged more “natural” behavior. Tanks contained 47 liters of natural seawater, a double sponge filter (Algarde 200 Biofoam), and an extra airline to increase airflow, primarily to aid food circulation.

Husbandry

Husbandry varies for the seahorses depending on their set-up. The display tank is a much more stable environment than the holding and rearing tanks. Filtration for each type of tank is different as is the stocking density. Therefore, the following reflects the two different systems the London Zoo employs.

Water changes
Frequency of changes depends on the stocking density of the tank. Heavily stocked tanks can have as much as 50% water changes weekly. Low stocking levels allow for smaller water changes less frequently. On average, our display tank receives a 20% change every other week. Holding tanks are siphoned of debris and uneaten food daily, and so 2-5% of the water is changed daily.

Cleaning & Hygiene
Holding tanks are siphoned of debris and uneaten food daily. In the display tanks, small hermit crabs, black sea cucumbers, brittle stars and even bristle worms help tremendously with uneaten food. A healthy growing *Caulerpa* stand helps remove phosphates and nitrates. It is harvested regularly to keep it growing well. A buildup of hydroids or polyps can occur in the holding tanks. When numbers reach a high density, the entire tank is stripped down and rinsed with fresh water; the sand is cleaned and soaked in fresh water overnight. *Aiptasia* anemones are dealt with by *Berghia sp.* nudibranchs. A colony of these sea slugs is kept on reserve. When *Aiptasia* are spotted in the seahorse tanks, slug egg cases are introduced. The slugs are very effective at controlling the anemones, but they rapidly die off when the food supply is exhausted. Sponges from the filters in holding tanks are rinsed with tank water every week, or more often, depending on stocking levels. Each holding tank has a piece of live rock to provide extra biological stability. In the display tank, an Eheim power filter with carbon and filter wool provides chemical and mechanical filtration. In all tanks, a very strong airflow with multiple airlines is used helping to keep food in suspension longer and bringing it to the seahorses without the risk of powerheads. All frozen foods (*Artemia, Mysis*) are rinsed very thoroughly in freshwater through a fine net before feeding. This helps reduce the build-up of pollutants from the "juice" given off by thawed foods.

Water quality analysis
Once every two weeks the following are tested using Salifert test kits: pH, dKH, NO_3, and O_2. Temperature and specific gravity are tested more frequently. Temperature is tested three times per day and specific gravity every other day. Temperature (Tropic Marin high precision thermometer, maximum deviation 0.02ºC), pH (Salifert test kit), and Specific Gravity (Tropic Marin high precision hydrometer, maximum deviation 0.0001 at 25ºC) readings were maintained at 23-27.6ºC, 7.7-8.3, and 1.0202-1.0247 respectively, with ideal levels being 25.0ºC, 8.2 and 1.0230. Salifert kits were used to test the following water parameters on a bimonthly basis, with ideal maximum levels stated and those obtained given in brackets: dissolved oxygen 8 mg/l (4-7 mg/l), nitrate 25 m/l (2-90 mg/l), nitrite 0 mg/l (0-1.5 mg/l) and ammonia 0 mg/l (always below 0.5 mg/l). The light regime was ten hours light, 8 am - 6 pm, and fourteen hours darkness.

Feeding

Seahorses were fed *ad lib.* three times daily on a combination of defrosted *Mysis* and *Artemia*, live adult *Artemia* enriched with Super Selco.

Collection Management

H. capensis is a relatively prolific species. Brood sizes average about 50 babies. The largest recorded brood at London Zoo is 122 and the smallest is 1. Since survival rate is high with good husbandry and diet, it is easy to become overpopulated with animals. In order to avoid overpopulation we have tried different ways of managing the population in our collection. Separating the sexes was employed in several tanks. Sexes were kept isolated in groups of 20.

We found that this lead to many problems. The animals exhibited a number of stress signs: disease outbreaks increased and aggression was high between males. Females became swollen with eggs and suspected egg binding occurred. Respiration rates and twitching also increased. Therefore, we decided to separate the sexes of our seahorses no longer. Animals in the display tank are allowed to reproduce as normal, and young are only removed when required. Some young survive in the display tank, feeding on naturally available foods and make it to adulthood. To keep the generations turning over, we can remove up to 20 individuals and raise them in the holding tanks. They can be given special attention there and their growth monitored. This method has worked well for us.

This is considered a priority species for the European Fish and Aquatic Invertebrate Taxon Advisory Group due to its Endangered status. However, this is now under review due to the small founder population outside of South Africa and problems acquiring permits to increase this population. There is also good legislation and management of the species within South Africa and it is most appropriate that any *ex situ* work required for this species is done within South African aquariums.

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Lined Seahorse, ***Hippocampus erectus***

2005 update
Antonio Martínez (Veracuz Aquarium, Mexico; espécies@acuariodeveracruz.com), Todd Gardner (Atlantis Marine World, NY, USA; Fishtail22@aol.com)
2002 version
Dave Littlehale (New Jersey State Aquarium, USA)

Animal Information

Hippocampus erectus is commonly known as the lined or northern seahorse and is found from southern tip of Nova Scotia to Rio de Janeiro (Lourie, Vincent, Hall 1998). It is most commonly encountered from Cape Cod south to Florida and in the northern and eastern Gulf of Mexico. Individuals in southern part of the range may be separate species. As with other seahorses, coloration is variable with gray, orange, brown, yellow, red, and black individuals being found. Most individuals will have silver dots on their bodies.

H. erectus is commonly mistaken for *H. reidi* (with which its range overlaps), *H. hippocampus,* and *H. kuda*. As with *H. kuda*, it appears that there may be more than one species in the *H. erectus* "complex" and specimens from the northern and southern extremes of their range may be distinct species.

Selection and Suitability

H. erectus is quite common in public aquaria and in the hobby trade for a number of reasons:

1) ease of availability
2) relative willingness of adults to readily spawn in captivity

The largest husbandry problem with the species is that the adults are susceptible to a variety of diseases, parasites, and pathogens and that high mortality rates are associated with juveniles. Mortality rates over 75% in a brood are extremely common.

Age, Growth, and Reproduction

Adult *H. erectus* can attain a length of 15.24 cm, though most of those collected are half that size (Quin 1990).

H. erectus are sexually dimorphic: males are longer and weigh more than females (Baum, Meeuwig, and Vincent, In review). Males have been reported to reproduce at 4 months and have developed a brood pouch at 78 mm TL (Vari 1982). Scarratt (1996) reported mating behaviour at 10 months of age. Maximum life expectancy in captivity has been estimated as 3-4 years.

Reproduction has been reported from the early part of April (Roule 1928 in Breder and Rosen 1966) and possibly year-round in Florida (Reid 1954). During courtship there is considerable change in the coloration of the fishes. Some can turn nearly white (Breder and Rosen 1966).

The gestation period for *H. erectus* has been reported as between 20-21days (Lourie, Vincent, Hall 1999) with some variation due to water temperature and the lunar cycle. Gestation periods as short as 11 to 14 days have been observed (C. Bull *pers obs*.). It has been observed for the male to have a birthing period of up to 3 days and then engage again in reproductive displays on the fourth morning.

Reported brood sizes range from 10-800 and published sizes range from 119-550 (550, Vincent 1990; 119, Scarratt 1996; 250-300, Herald and Rackowicz 1951).
Juveniles range in size from 8.9 mm (Vincent 1990) to 13.04 ±0.74 mm (Correa, Chung, and Manrique 1989). This range is apparently dependent on the health and size of the contributing parents. Newborns (possibly juveniles) swim in clusters near surface and are possibly phototropic (Hardy 1978).

In the laboratory, Scarratt (1996) reported that *H. erectus* maintained a positive, linear growth of approximately 0.55 mm per day over a period of 100 days. Matlock (1992) reported that *H. erectus* larger than 20 mm grew about 0.11 mm per day (±0.007 mm/day).

Habitat Parameters

The following information has been collated from responses to husbandry questionnaires by 12 public aquaria.

Height: at least 45 cm and preferably 53 cm to allow egg transfer (if breeding is required)
Holdfasts: artificial sea grass, *Caulerpa spp*., fake coral, and gorgonians
Filtration: protein skimmers commonly used, as are wet/dry and undergravel filters
Lighting: metal halide or fluorescent
Photoperiod: half of the institutions kept 12:12 L:D though it varied from 8:16 to 14:10.
Temperature: range from 13°C-28°C with 4 institutions using average temp of 24.5°C-25.5°C and 5 using 22°C-23°C
Salinity: range from 25 ppt-35 ppt. Five of the 12 institutions kept the salinity slightly brackish and 7 kept it at between 32-35 ppt
NO_4: under 10 ppm
pH: ranged from 7.6-8.3 with most (10 of 12) the average was 7.9-8.2

Co-inhabitants: The common thought is to restrict co-inhabitants to species that will not out compete the seahorse for food and having no Cnidarians that can provide a potent sting seems to be followed. This is the list of commonly kept co-inhabitants obtained from the static husbandry sheet: African blue stripe pipefish, alligator pipefish, chain pipefish, Janns pipefish, northern pipefish, shrimpfish, greater pipefish, dusky pipefish, many banded pipefish, zebra pipefish, *H. capensis*, bluespotted cornetfish, scooter blenny, sailfin molly, *Zebrasoma sp*., Hass' garden eel, *Chelmon rostratus*, *Chaetodon lunula, Pterapogon kauderni*, *Plexora*, *Polythoa*, *Sarcophyton*, *Zoanthus*, *Litophyton*, horseshoe crab, hermit crab, arrow crab, shore shrimp, red-banded coral shrimp, peppermint shrimp, cleaner shrimp, purple sea urchin, feather seastar, flame scallop.

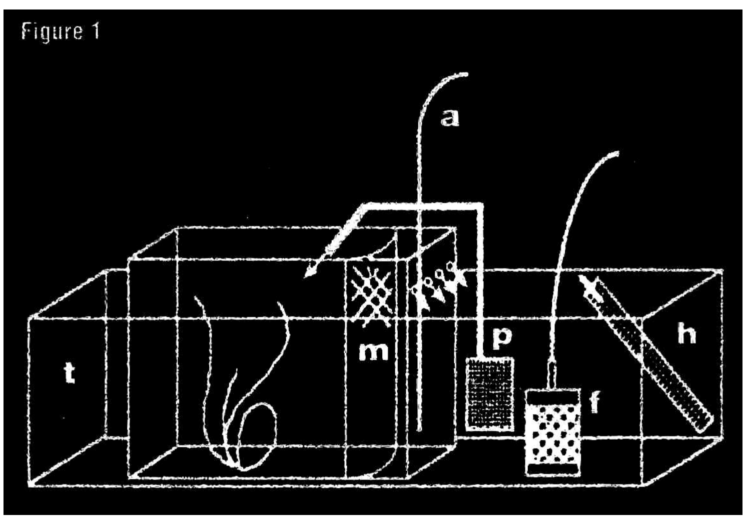
Habitat Parameters (additional information in 2005)

Height: Preferably 80 – 100 cm.
Holdfasts: Artificial sea grass, holding "U shape" structures made with plastic rope and weight in the extremes.
Filtration: Biological filtration.
Water treatment: Chlorine and Ozone

Lighting:	Natural in the husbandry area and fluorescent in exhibition tank.
Photoperiod:	In exhibition tank: 12:12
Temperature:	Husbandry area (outdoor facilities):range from 19-30°C Exhibition: 25°C
Salinity:	Range from 28-30 ppt.
Nitrite:	.007mg/l
Nitrate	9.2 mg/l
Ammonia	0.03mg(l
pH:	The average was 8.3
Co-inhabitants:	No co-inhabitants.

Tank design for fry

A 7 l (28x16x15 cm) nursery tank was used with a 34 l (50x33x20 cm) reserve water sump (t). Several loops of monofilament line attached to stainless steel weights provided attachment sites for the small seahorses. Water is pumped from the sump into the nursery tank by a 30 l per hour submersible pump (p) and overflows back into the sump. Young seahorses were separated from the overflow by a curved screen made from 0.08 mm mesh (m). A 50-watt submersible heater (h) in the sump maintains the water temperature at 23.8 °C. A small corner filter (f) with biologically conditioned dolomite and filter floss provided aeration, as well as biological and mechanical filtration. An air line (a) is placed behind the mesh screen to provide aeration in the tank without the risk of injuring the seahorses with large air bubbles. All nursery tanks were lit with 40-watt cool white fluorescent tubes for 8–12 hours daily. For more details see Scarratt (1996).



One of the biggest problems associated with rearing young (besides inadequate nutrition) is the frequency of juveniles being trapped at the surface with excess air in their abdomen. Juveniles born in deeper tanks appear to show fewer buoyancy problems although this and other possible solutions remain to be tested thoroughly. Kreisel, or pseduokreisel, designs or placing a sponge filter towards the center back of conventional rectangular aquarium to create circulation seems to help alleviate this problem. Blacking out various portions of the tank and eliminating overhead light may also help by concentrating the phototaxic food sources away from the surface.

Additional information in 2005 from Veracruz Aquarium

Fry tank
During the first 10 days, the following set up was used:
60 l closed-system aquariums with 300-400 fry in each.
Monofilament with weights as holdfasts provided attachment sites.
UV filter.
Submersible heater.
Fluorescent light in a 12:12 photoperiod.
An air line with medium size bubbles.

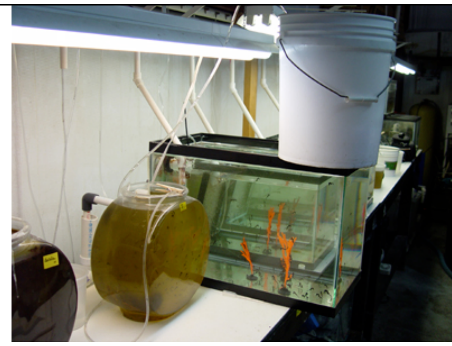
Juveniles/ Adults tank
In day 10 each stock is separated and put in a 2500 l outdoor cylindrical tank (close-system) with no temperature control and natural lightning being fed with bioencapsulated Artemia.
Water exchanges and bottom cleaning are provided daily. Each month all tanks and holdfasts are completely disinfected.

Reproduction tank
Outdoor tank
Natural / Artificial lightning
1000 l capacity
Closed system
Height: 80 cm

***Hippocampus erectus* and *H.reidi* Breeding System**

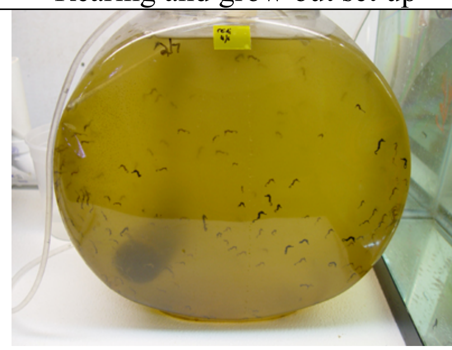
Todd Gardner, Atlantis Marine World, Riverhead, NY, USA

Broodstock tanks

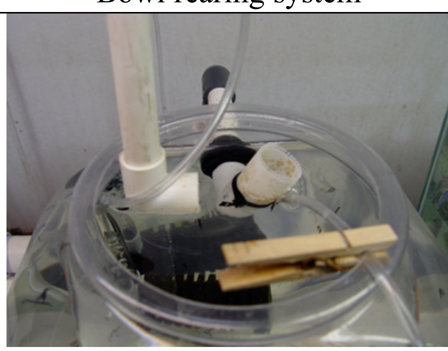


Rearing and grow out set up

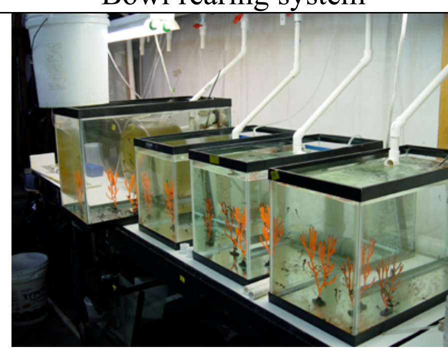
Bowl rearing system



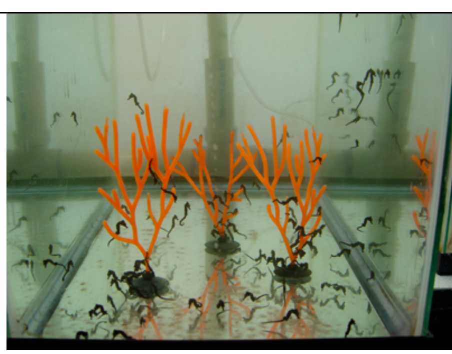
Bowl rearing system



Detail of bowl surface



Grow-out set up



Grow-out tank

Display tank

Diet, Nutrition, and Feeding Techniques

In the wild, *H. erectus* feed on small copepods, amphipods, and other small crustaceans (Leim and Scott 1966 in Vari 1982). *H. erectus* is not a nocturnal predator (James and Heck 1994). Variety, frequency of feedings, and enrichment strategies seem to be the most important aspects in the feeding and rearing of captive-born *H. erectus*.

Live foods commonly used for adult *H. erectus* are adult *Artemia* shrimp, mysis shrimp, grass shrimp, copepods and *Gammarus*, *Poecilid* fry, *Caprellid* amphipods. Frozen foods used are mysis shrimp, *Euphausia pacifica*, and adult *Artemia*. Institutions report feeding frozen mysis to adults 1-3 times per day (most feed 2-3 times). *H. erectus* can be "picky" eaters and may refuse to eat certain food items from time to time. The best way to avoid this problem is to offer a variety of foods. At Veracruz Aquarium (Mexico), seahorses are fed *Artemia franciscana* as live food in all development stages using a combination of several enrichment products: Super Selco and Scott Emulsion.

The enrichment of the food is apparently beneficial for both adult and juveniles, and using a combination of several enrichment products apparently provides better nutrition than relying on only one. Commonly used products are varieties of Selco, Roti-Rich, AlgaMac 2000, amino acid or liquid multi-vitamins, MicroMac 70, Aminoplex, Cyclop-eze, Beta Meal, spirulina powder and live algae cultures (Iso*chrysis galbana*, T-iso, T-weiss, *Nannochloropsis*, *Chlorella*). *Artemia* nauplii and flake food were used to enrich grass shrimp.

Juveniles are most commonly fed A*rtemia* nauplii. Either newly hatched (less than 24 hours) or 24-48 hr enriched and decapsulated *Artemia* nauplii were fed to the juveniles 2 to7 times per day. It is very important that the nauplii first be decapsulated as the cyst can cause intestinal blockages in newborn *H. erectus* that result in death. Adding a small amount of chopped frozen mysis shrimp to nursery tanks immediately after birth may promote feeding and improve survivorship in the fry. Fourteen hours to 24 hours of light per day has been suggested to encourage continuous feeding and growth although its effects remain unsubstantiated. At Atlantis Marine World (NY, USA), wild plankton is substituted for rotifers for the first 4-5 days.

At 3 weeks, juveniles should be of a size capable of ingesting 48 hour *Artemia*. As the seahorses continue to grow, the size of *Artemia* they are capable of eating will increase too. At this point it appears beneficial to wean young seahorses onto frozen mysis. As the young mature, feeding frequencies might vary from 2-5 times a day depending on temperature and competition.

Growth rate for *H. erectus* for the first 28 days was measured at 0.07cm/day at Atlantis Marine World (NY, USA).

H. erectus are susceptible to a variety of diseases, parasites, and pathogens in a captive environment, and steps need to be taken to minimize the potential for transfer in foods or via other husbandry practices.

Reported health problems include:

- Monogenetic trematodes (probably Dactylogyridae)
- Unidentified internal trematodes
- Cestodes
- Gas bubble disease
- *Glugea spp.*

Vibrio spp.
Cryptocaryon spp.
Mycobacterium

Collection Management

H. erectus has been proposed as a priority species by the Marine Fish TAG for a captive breeding program.

Unfortunately, genetic identification still remains a problem for this species creating a challenge for the coordination of breeding efforts. *H. erectus* is often misidentified and distributed by wholesalers throughout the U.S. and Europe. Some institutions reported obtaining specimens from a commercial source distributing captive-bred *H. erectus* that appear to be hybrids of the northern and southern breeding populations. There is even debate as to whether the northern and southern populations are not actually separate species.

In addition, many public and private aquariums breed and distribute these seahorses between institutions. This practice can be detrimental to wild populations as well as to any captive-breeding programs.

Institutions Contributing to this Chapter

Aquarium of the Americas, Birch Aquarium at Scripps, Calvert Marine Museum, Cleveland Metroparks Zoo, Columbus Zoo & Aquarium, Fort Worth Zoo & Aquarium, Mote Marine Laboratories, National Marine Aquarium, UK, New Jersey State Aquarium, Norwalk Maritime Aquarium, John G. Shedd Aquarium, Steinhart Aquarium

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<u>Fishers' seahorse, *Hippocampus fisheri*</u>

2002
Karen Brittain (Waikiki Aquarium)

Animal Description

This species is mainly encountered around the Hawaiian Islands and is therefore frequently referred to as the Hawaiian seahorse. It is a small seahorse in comparison to most other aquarium species, and adults measure up to 8 cm in height (Lourie, Vincent, and Hall 1998). It is frequently golden orange, red or pink in color.

Little is known about the life history of this species; however, *Hippocampus fisheri* differs from most other seahorses as the adults appear pelagic and are often encountered at least a mile offshore in deep water. They are not often seen during daylight hours and may be nocturnal. Most are seen and collected at night, as they are attracted to the lights used by offshore benthic fishermen. Fishermen also report finding them in the stomachs of tuna and other pelagic fishes.

Selection and suitability

H. fisheri are not suited for long-term captivity, as they do not appear to fare well in the shallow tanks of aquaria. Most specimens develop subcutaneous gas bubbles following a few months in captivity and die. It is speculated that this species needs to migrate to depths unachievable in normal aquarium conditions to maintain physiological balance.

Age and Growth

H. fisheri attain sexual maturity in captivity at 4 months. At this age, females measure an average of 3.8 cm in length and males are slightly larger at 4.2 cm. Once sexual maturity is reached, growth rate reportedly slowed. Maximum life expectancy in captivity is unknown.

H. fisheri that have reproduced in captivity have produced an average of 250 juveniles every 15 days. Juveniles measured 6 mm in length. Growth information is not available for this species. Rearing is difficult in smaller tanks as hatchings often form a gas bubble in what appears to be the esophagus, then float at the surface and die. When rearing runs were conducted in larger and deeper tanks, hatchlings remained in the water column and the rearing runs were more successful.

Habitat Parameters

In our experience the most important tank parameter for *H. fisheri* is depth. All *H. fisheri* kept in smaller, shallower tanks (less than 1 m deep) developed subcutaneous gas bubbles.

The following is a description of the adult colony system used at Waikiki Aquarium:

Volume of tank:	132 l
Height of tank:	1 m
Circulation:	closed but maintained by powerhead
Water:	natural
Filtration:	undergravel filter, protein skimmer

Aeration:	large bubbles (no air diffusers)
Fluorescent light:	metal halide bulbs
Photoperiod:	natural
Temperature:	23- 28^{o}C
Salinity:	33-35 ppt
Water changes:	30% every 7 days.

Juvenile Rearing Tanks

A 3785-liter fiberglass circular cone-bottom tank was used. The measurements of the rearing tank are 2.4 m in diameter by 1 m deep. The inside tank surface was a medium blue color. Sunlight provides natural photoperiod through a fiberglass roof. The tank is partially covered by shade cloth. Aeration was provided in the center of the tank using open-ended airline tubing to create large bubbles. Temperatures ranged from 27-28^{o}C.

Diet, Nutrition, and Feeding Techniques

Wild-caught adults are fed live *Artemia* enriched with AlgaMac or Selco, live amphipods, one day old guppies, frozen freshwater mysis, and frozen marine mysis. Transferring wild-caught adults from live feeds to frozen feeds is fairly easy by starting with whole frozen mysis. They seem to recognize the shape although the mysis are quite large. Once the seahorses accept the mysis, this food can be chopped up into smaller pieces and still accepted.

Juveniles were offered rotifers, *Brachionus plicatilis* and the harpacticoid copepod--*Euterpina acutifrons*. A *Tetraselmis chuii* alga was also added. The tank remains a closed system until day 3, and then a very slow flow of approximately 0.3 liters per minute was started. The flow was gradually increased as needed. When juveniles reached three weeks of age, newly hatched *Artemia* enriched on AlgaMac 2000 were used as the main food source.

Gas Bubbles in Adults

Most of the adults, whether captive-bred or wild-caught, developed subcutaneous gas bubbles. Bubbles were located mainly on the tail and sometimes on the neck area. Placing the seahorses in tanks of greater depth could relieve these bubbles. Seahorses were put into a bait bucket and set at the bottom of our shark tank at a depth of 4 meters. After several days the bubbles diminished and the seahorses were returned into their original tanks. This approach was only a temporary fix, as the bubbles would again develop under the skin. The time taken for bubbles to develop after being returned to shallow tanks varied from 3 to 14 days.

Collection Management

There are no plans to include *H. fisheri* in collective breeding or management actions at present as husbandry challenges remain too great.

Sea Pony, *Hippocampus fuscus*

2005
Bobby Curttright (Kingdom of the Seas, USA; bob_curttright@yahoo.com)

Animal Information

Hippocampus fuscus is commonly known as the sea pony or drab seahorse because its most common coloration ranges from a dark brown or black to a faded gray, however, specimens can be bright yellow to orange with marbling across the face, lighter saddles on the back (Kuiter 2000), and/or white and rusty orange dots covering the entire body (pers obs). Their natural range includes the Indian Ocean (Sri Lanka) and the Red Sea (Saudi Arabia & Dijibouti) with possible populations occurring in South Africa and Madagascar. There has been only limited research on *H. fuscus* in wild as of yet. They are found on algal reefs and eelgrass beds (*Zosterae* sp.) in lagoons at depths of 50 cm to 2 m (Lourie, et al. 1999) with 10m being the maximum depth ever recorded (Foster and Vincent, 2004).

Hippocampus fuscus closely resembles *H. barboinensis, H. kuda, and H. hippocampus* with specimens from India believed to belong to the *kuda* complex through genetic data. *H. fuscus* differs from these three species in that it has fewer tail rings and a lower, smoother coronet (Lourie et al. 1999).

Selection & Suitability

H. fuscus is currently uncommon in the public aquariums and trade of the U.S. with only one known source of captive bred specimens. The only other locations reported to have them are the U.K. and Germany. However, *H. fuscus* does have very strong traits to make an excellent choice for display purposes and breeding such as:

1) Ease of raising fry (benthic) with high success
2) Year round breeding with medium sized broods
3) Relatively small breeding enclosure needed
4) Very resistant to disease and tolerable of imperfect water quality
5) Mid-sized and sometimes brightly colored
6) Reproducing as early as 5 months

The limiting factor in the U.S. is the small gene pool that exists, with all known offspring coming from one pair that is possibly of separate broodstock, and the difficulty of acquiring any new broodstock due to their placement on CITES Appendix II (note, please refer to previous section on ***Seahorses and CITES***).

Age, Growth, and Reproduction

H. fuscus reach a maximum adult height (TL) of 15 cm (Kuiter, 2000), but average 8-12 cm (Lourie et al. 1999) that is reached in approximately 1 year (*ex situ*). As the sea pony grows, their spines and coronet will become smoother until they are almost non-existent in adults (pers obs). The males have a have a shorter and thicker snout as well as a longer tail than do females. The shorter snout is believed to be used for snapping at competitors (Shine, 1991) and the longer tail to support their large caudal pouch while still gripping a holdfast and for tail-wrestling when competing for a mate (Vincent, 1990). Males develop a brood pouch at about 2.5 to 3 cm (TL) and have been observed pair bonding at the age of 2 months, with reproduction occurring at 5 cm or as soon as 5 months (per. obs). Maximum life expectancy is not reported but it can be assumed to be similar to other species of the same size and general habitat, which would range from 2 to 4 years.

H. fuscus can be considered monogamous as they develop strong pair-bonds and perform morning greetings that include holding tails, changes in color, and dancing for each other. They will mate throughout the year without changes in temperature or photoperiod (*ex situ*). During courtship the male will turn very pale, almost white, with a dark line appearing ventrally along the mid-section of the trunk. Striping on the snout and face also become more prominent. They can successfully breed in less than 12’’ of water; however, taller tanks have produced larger broods and more frequent breeding.

Gestation period for *H. fuscus* is has been reported to be anywhere from 14 days (Lourie et al. 1999) to 18-24 days depending on temperature (Giwojna, pers com.). Personal experience has shown gestation period to be from 15 to 17 days when kept at 77° F. The male may give birth for up to two days but has always been observed giving birth at night or in the morning and most commonly within a couple hours after sunrise.

Clutch sizes of 30-140 eggs have been reported (Lourie et al. 1999) and brood sizes ranging from 10-130 fry (pers obs.) with an average brood size of 80 fry (Giwojna, pers com.). Interestingly, parent size has not shown any correlation with brood size in *H. fuscus* as full grown adults have been observed to have broods of 10 fry, and specimens half that size have had broods of 130 live fry with similar environments and diets (*ex situ*). Newborns immediately surface, take a gulp of air, and then settle to the bottom suggesting that they are benthic in the wild as well as in captivity. Egg diameter is 1.8mm, and fry are born at a length of approximately 10mm (Lourie et al. 1999). They have a steady linear growth rate reaching approximately 20-30 mm at 2-3 months at which the brood pouch develops in at least half of all specimens. Once they reach a total length of approximately 60mm, or 5-7 months, they begin to successfully reproduce.

Habitat Parameters

The *H. fuscus* that are on display are part of collection of smaller tanks comprising our Oddities display.

Height:	30 cm on display, 30 cm to 45 cm in holding (successfully breeding in both).
Holdfasts:	*Caulerpa spp.,* artificial sea grass, live rock, and plastic netting weighted with epoxy when young.
Filtration:	Wet/Dry filters, protein skimming, UV sterilizers, phosphate reactor.
Lighting:	Standard output fluorescents (URI).
Photoperiod:	12:12 L/D with minor variations.
Temperature:	Ranges from 22.5°C to 26°C
Salinity:	Newborns kept in slightly hyposaline water (26-28ppt), juveniles and adults kept at 30-35ppt.
NH_4:	0 ppm
NO_2:	<.02 ppm
NO_3:	<20 ppm
PH:	8.2-8.4

Nursery tank designs

Newborn – 4 weeks

Being that *H. fuscus* are benthic fry, nurseries serve to keep their food in circulation more than anything else. Many designs will work when raising these relatively large fry, but simple drum goldfish bowls work very well for newborns. A 2 gallon drum with 2 holes drilled on the same side midway up one of the curved sides with rigid airline tubing siliconed in them and connected to an air pump will provided adequate circulation. Control valves in-line help to keep the sides bubbling evenly and allow adjustments in circulation speed. Water changes and siphoning of the bottom are required daily. The ambient air temperature, however, must control water temperature. Anywhere from 25-50 fry should be kept in a nursery of this size.

4 weeks – 4 months
As the fry get larger it is best to move them into larger enclosures and split them apart into similar sized (fry) groups (Mai 2004). A psuedo box-kriesel with 1 or 2 water lines entering downward just above the surface on one side, with the other side screened off to prevent fry from being taken down the overflow works well. On the overflow side of the screen 1 or 2 airstones can be placed to aid in the desired circular flow. Many kriesels can be connected to one central system to stabilize water quality. Daily siphoning is still necessary, but larger water changes can be done less often. Periodic sterilization of tanks and hitching posts may be necessary to get rid of hydroids and bacterial slime (Mai 2004). Survival rates ranging from 80-100% have been achieved when raising *H. fuscus* with this style of nursery.

Diet, Nutrition, and Feeding Techniques

Newborn *H. fuscus* will readily take one day old decapsulated *Artemia* nauplii enriched with supplements like Super Selco, Vibrance, or similar HUFAs. This should be fed 3 to 4 times during the day and a standard 12:12 photoperiod can be used throughout their entire life cycle. Dead or settled *Artemia* should be siphoned before each feeding as well. After one week the fry can be moved onto two day old *Artemia* 2 to 3 times a day. They will remain on this schedule until they are approximately 6 to 8 weeks of age. At that point live *Mysid* shrimp gut loaded with Cyclop-eze can be fed once or twice a day ensuring that there is always food available. Any *Mysid* shrimp caught on the surface of the water should be skimmed off with a net.

From the age of 3 to 4 months juveniles should continue to receive gut loaded live *Mysid* shrimp in the morning and enriched chopped frozen *Mysid* shrimp in the afternoon. Adult *Artemia* can be substituted for the live *Mysid* shrimp once or twice a week. At 4 to 5 months all juveniles should be weaned onto frozen *Mysid* shrimp and will no longer need to be chopped with live food being supplemented a couple times a week.

Adult *Hippocampus fuscus*, wild caught or captive bred, are not picky eaters. Wild caught specimens may need live *Mysid* shrimp or *Artemia* for a few weeks until trained onto frozen foods, however, the transition is usually not hard for them. The natural diet of *H. fuscus* is unknown, but a steady diet of enriched frozen *Mysid* shrimp supplemented with various live foods has proven well for captive specimens.

Collection Management

Wild caught *H. fuscus* are rarely seen in the marine fish trade of the United States and are more frequently found in the European nations. They are collected in India for traditional medicines (Lourie et al., 1999), however, with a maximum TL of 14 cm, few specimens are likely to be collected over the 10 cm legal minimum. They are currently one of the species of seahorses that are included in IUCN’s Data Deficient listing. Populations form India are under Schedule-I of the Wildlife Protection Act (1972) banning all collection and trade as of 2001 (Lourie et al., 2004).

Contributors to this chapter include Pete Giwojna, Project Seahorse and its wonderful staff, Heather Koldewey at the London Zoo, and the Kingdom of the Seas Aquarium at the Henry Doorly Zoo.

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Long-snouted Seahorse, *Hippocampus guttulatus*

2005 update of 2002 version
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Animal Description

This European and North African species is commonly known as the long-snouted or spiny seahorse. The scientific name was previously *Hippocampus ramulosus*, but this was changed after re-examination of the type specimen. *H. guttulatus* is mostly brown in color, with prominent white spots on the body often with dark rings around them. These rings coalesce into horizontal wavy lines. The adult height ranges from 8.5-18.0 cm.

Selection and Suitability

This seahorse has been in aquariums since the early 1900s, however only in recent years have they been successfully kept for any length of time. *H. guttulatus* is commonly found in European public aquarium collections.

Age, Growth, and Reproduction

Adults have been reported up to 16 cm in length (Lythgoe and Lythgoe 1971; Wheeler 1985; Whitehead 1986). Males tend to be larger (between 7.1-10.8 cm total length) than females (6.9-10.7 cm total length) (Reina-Hervas 1989). No information is available on age/size at maturity, but the life span is estimated to be 3-4 years (Boisseau 1967) and, in captivity it is reported as 4-6 years.

H. guttulatus breeds in summer, usually between May and August (Boisseau 1967; Lythgoe and Lythgoe 1971; Wheeler 1985; Whitehead 1986), and the peak mating period appears to correspond with the full moon (Boisseau 1967).

Gestation period is around 21 days at 23°C (Boisseau 1967) to one month (Cabo 1979). No information on brood size is available. Brood sizes in captivity have been reported as being up to 300, and juveniles measure between 8 mm (Cabo 1979) and 15-16 mm length (Whitehead 1986). Juveniles appear to have a planktonic life for approximately 6-8 weeks and then seek out a substrate or holdfast.

Habitat Parameters

Tank Design Parameters

Population:	2 pairs of adults
Volume of tank:	684 litres
Height of tank:	at least 45 cm tall
Filtration:	undergravel filter and external filtration
Substrate:	crushed coral sand
Holdfasts:	driftwood is recommended
Lighting:	variable to provide bright light and shaded areas
Photoperiod:	seasonal variation from 14:8 L:D in summer to 8:14 in winter

Temperature:	Summer 19°C, Winter 14°C
$N0_2$:	0
pH:	7.9-8.3
Salinity :	35 ppt
Water Changes:	20% weekly

Ideal mates for the tank are, hermit crabs, and other similar yet non-aggressive species.

Diet, Nutrition and Feeding Techniques

In the wild, the diet of *H. guttulatus* consists of microinvertebrates, especially microcrustaceans (Cabo 1979). The most suitable food in captivity appears to be live mysis shrimp; however, these may only be available seasonally. *Artemia* enriched with Selco or its equivalent can be used as a supplementary food but should not be fed exclusively. Frozen mysis is a commonly used food for adults and are easier to obtain and maintain. A healthy seahorse should eat up to 30 to 50 mysis shrimp a day. Seahorses should be gradually weaned onto frozen mysis over the course of 8-10 weeks.

Specialist information on juvenile feeding regimes does not appear to be available.

Collection Management

This is a priority species for the European Fish and Aquatic Invertebrate TAG. The current priority is to establish breeding groups at participating institutions and develop husbandry techniques.

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<u>Short-snouted Seahorse, *Hippocampus hippocampus*</u>

2005 update of 2002 version
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Species Description

This European and North African seahorse is commonly referred to as the short-snouted seahorse as its snout is usually less than a third of the length of its head. It is a relatively small seahorse, averaging around 8 cm in height. Colors vary from orange through brown and purple to black. Sometimes they have tiny white dots on their body. Their adult height can range from 7.0-13.0 cm from their head to tail.

Selection and Suitability

These seahorses have been held in public and private aquaria since the early 1900s and are now frequently found in European collections. Only in recent years have they been successfully kept for any length of time and breeding still presents some challenges. *H. hippocampus* have been bred in captivity, and its young have been raised to adulthood.

Age, Growth, and Reproduction

Male size varies between 7.1-9.9 cm TL (n=7), and female size varies between 5.9-9.7 cm TL (n=14) (Reina-Hervas 1989). No information on growth or age/size at sexual maturity is available. The life span in captivity is reported to be 4-5 years.

H. hippocampus reportedly only breeds during the summer months between April and October in the wild (Lythgoe and Lythgoe 1971; Wheeler 1985; Whitehead 1986; Reina-Hervas 1989). Gestation length is around 1 month (Lythgoe and Lythgoe 1971; Cabo 1979), and the brood size in captivity has been reported as being up to 200.

Underwater World (Hastings) reports juvenile size at birth ranges between 5.5-7.5 mm in length. After one study during which growth was recorded throughout the first month the juveniles reached an average size of 18.9 mm.

Habitat Parameters

Tank Design Parameters

Population:	2 pairs of adults
Volume of tank:	684 l
Height of tank:	at least 45 cm tall
Filtration:	undergravel filter and external filtration
Substrate:	crushed coral sand
Holdfasts:	driftwood is recommended
Lighting:	variable to provide bright light and shaded areas
Photoperiod:	seasonal variation from 14:8 L:D in summer to 8:14 in winter

Temperature:	Summer 19°C, Winter 14°C
$N0_2$:	0
pH:	7.9-8.3
Salinity:	35 ppt
Water Changes:	20% weekly

Ideal mates for the tank are hermit crabs and other similar yet non-aggressive species.

Diet, Nutrition and Feeding Techniques

In the wild, the diet of *H. hippocampus* consists of microinvertebrates, especially microcrustaceans (Cabo, 1979). The most suitable food in captivity appears to be live mysis shrimp; however, these may only be available seasonally. *Artemia* enriched with Selco or equivalent can be used as a supplementary food but should not be fed exclusively. Frozen mysis is a commonly used food for adults and are easier to obtain and maintain. A healthy seahorse should eat up to 30 to 50 mysis shrimp a day. Seahorses should be gradually weaned onto frozen mysis over the course of 8-10 weeks.

Juvenile feeding regimes

Underwater World (Hastings) feeds juvenile *H. hippocampus* rotifers and benthic copepods enriched on a mixture of Isochrysis, Nannochlropsis, Tetraselmsis and Colourfin fishvits. The rotifers are added at a concentration of 15 rotifers per ml 3 times a day, alongside the rotifers a diluted solution of the enrichment diet can also be added to the rearing vessel to enable feeding of the benthic copepods. This is continued until day 28. Newly hatched *Artemia* naupli are then used alongside the rotifers and copepods from day 15 to day 60.

Collection Management

This is a priority species for the European Fish and Aquatic Invertebrate TAG. The current priority is to establish breeding groups at participating institutions and develop husbandry techniques.

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<u>Pacific Seahorse, *Hippocampus ingens*</u>

2005 update
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2002 version
Jorge Gomezjurado (National Aquarium in Baltimore) and Colin Bull (Project Seahorse)

Animal description

This large seahorse is commonly referred to as the Pacific seahorse. Coloration ranges from green, brown, reddish-maroon, gray, and to yellow and gold. Most of the body is mottled dark brown covered with small dark and white spots coalescing into longitudinal streaks. Numerous fine light and dark line markings radiate around the eyes. Males commonly have a prominent keel, while sexually mature females often have a dark patch below the anal fin.

Selection and Suitability

Hippocampus ingens are not all that common in public aquaria but have been bred and the life cycle closed in a number of generations. They are popular due to their size and coloration and occasionally appear in the aquarium hobby trade. There is no reason why *H. ingens* is any more difficult to care for than other seahorse species.

Age, Growth, and Reproduction

Adults range in height from 13.0-19.0 cm (n=19) (Lourie et al., 1999) and can reach a maximum size of 30 cm (Dees 1969; Miller and Lea 1972; Humann 1993). Males mature in the wild at a length of 5.4 cm (Groves and Lavenberg 1997) and have been reported to mature at 3 months in captivity (Gomezjurado 1988).

Reproductive activity of *H. ingens* has been observed in captivity after 3 months (Gomezjurado, 1998). At this age females produce small numbers of eggs (~50) and males start to show obvious courtship displays without success. At 6 months, male pregnancy has been observed. The gestation period is reported to be 14days in captivity. Brood sizes of 2000 have been reported.

Juvenile *H. ingens* are approximately 9 mm in length (Gomezjurado 1998) and the development and behavior during the early stages (between one and two months) suggest that the juvenile stage of this species may be pelagic. This observation is based on the size of the dorsal fin and the tendency not to use the tail for anchorage. No growth data for this species are available.

Habitat parameters

Tank requirements are similar to other seahorse species but temperature should be held slightly lower than for Indopacific or tropical seahorses. A chiller may therefore be required.

Tank: deep, wide tanks are recommended (> 1m deep) with turnover of 10 l/min recommended

Filtration: mechanical 75 Micron, Protein Skimmer, biological, and UV sterilization or Ozone

Aeration: additional aeration can be used or not used in adult tank
Substrate: live sand/ bare fiber glass
Holdfast: gorgonians/plastic corals and kelp
Lighting: cool-light fluorescent fixtures maintain 500-800 Lux/ Metal Halides
Photoperiod: 12:12 L:D
Temperature: can be kept at 15-25^oC with optimal temperature of 23^oC
NO_2: < 0.0 mg/l
NO_3: < 10.0/l
NH_4: 0 mg/l
pH: 8.25—controlled by additions of CaOH
Salinity: optimal salinity is 34 ppt (Range 26-34 ppt)
Water change: 5% performed every day.

Juvenile Rearing Tanks

Black pseudo-kreisel design tanks have been used successfully with flows being established by positioning a bubble curtain at one end of the tank. Light blue or black conical tanks also can be used successfully. Density should be kept at not more than 6 juveniles per liter.

Water quality and photoperiod should be maintained as the adult tanks, and 150-200 Lux is the optimal light level. Turbidity is an important factor in the juvenile rearing environment and is created by providing good aeration (through air-wands) and using algae (*Chaetoceros spp.*) at a concentration of t 200,000 cells per μl. The optimal turbulence is at 10 mm/sec, and the feeding will decline at lower or higher levels. Turbulence also breaks the water surface tension, which allows the fish to penetrate the surface and gulp air essential for the successful primary phase of swim bladder inflation.

Diet, Nutrition, and Feeding Techniques

High standards of hygiene should be maintained during food preparation and the maintenance of cultures. Food quality and availability are important regulators of seahorse growth and survival. Tanks are siphoned twice per day.

Adults

The use of nutritious food in adults increases the size of offspring produced, allowing them to ingest relatively large food items such as *Artemia franciscana* metanauplii as first food. Adult seahorses are normally fed 2 times a day with mainly frozen mysid shrimps, *Mysis relicta,* coated with Aquagrow® Advantage and Aquagrow® ARA (Advanced BioNutrition Corp. www.adavancedbionutrition.com) at 0.03g/gram of Mysids, and soluble Vitamin Premix (Aquatic EcoSystems www.aquaticeco.com) at 1mg/gram of mysidsAdults are also feed twice at day with 24 hour adult *Artemia sp* enriched with Aquagrow® Enhance at 0.3 g/liter.

Juveniles

Juvenile nutrition, especially during the first 3 weeks, appears to be one of the major difficulties in seahorse culture. It is necessary to have a chain of live food ready for the first feeding juveniles. This chain consists of phytoplankton, namely species such as *Chaetoceros sp.* and *Isocchrysis galvana,* rotifers *Brachionus plicatilis* enriched with 0.2 g of Algamac 2000/liter of enrichment media (Aqufauna Biomarine, Inc. www.aquafauna.com) brine shrimp *Artemia* *franciscana* nauplii enriched with Aquagrow® Advantage at 0.3 g/200.000 nauplii/liter, and frozen Cyclop-Eeze® (Argent Laboratories www.cyclop-eeze.com) . The algae supply a source of food and nutrition for the zooplankton. Feeding levels depend on the juvenile stocking densities (not more that 6 juveniles per liter) and densities controlled by aerated slow dripping feeders. Recommend levels are 10 rotifers/ml, 15 nauplii/ml, and 3 copepods/ml as initial food densities, with amounts increased depending the demand. Water intakes are reduced during feeding times. The gradual transfer from one live food organism to another is achieved by overlapping feedings at the different weaning stages.

Before use, live food is rinsed in a 2 minute fresh water through a 100 μ strainer. *Artemia sp.* cysts are decapsulated using traditional techniques. Juveniles at the second month are trained to take frozen mysids. In order to facilitate animal food recognition during the training, no enrichment coating is used.

Collection Management

A captive breeding program is being run by the Marine Fish TAG of the AZA and coordinated by Jorge Gomezjurado (jgomezjurado@aqua.org). Anyone with animals to donate to the program or with facilitates to offer the program is advised to contact the coordinator directly.

Animals for this program are currently being held at National Aquarium in Baltimore and Steven Birch Aquarium

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Yellow or Spotted Seahorse, *Hippocampus kuda*

2005 update
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2002 version
Devasmita De (John G. Shedd Aquarium, Chicago, USA)

Animal description

The Indo-Pacific seahorse, *Hippocampus kuda,* is commonly known as the yellow seahorse or the spotted seahorse and reaches a size up to 20 cm (Munro 1958, Smith 1963, Kuronuma and Abe 1972, Coleman 1980, Al-Hassan and Al-Badri 1986). Mean adult size is around 11-13 cm (Marichamy et al.1993, Do et al. 1996). While usually yellow in color with black spots and black line from chest to abdomen, they have also been found to be totally black, a mixture of black and yellow, and pale cream.

H. kuda has often been used to describe any Indo-Pacific seahorse that could not be readily identified. Misidentification occurs because of similar-looking species (e.g. *H. reidi, H. erectus, H. fuscus)* in the aquarium trade. Variation exists amongst animals classified as *H. kuda*, and taxonomy has not yet been fully resolved, the term '*kuda* complex' is being used to describe several similar species.

Selection and Suitability

H. kuda is frequently encountered in the aquarium trade and has been considered as one of the less problematic species to hold. However, little evidence on rearing success exists to support this statement. Juveniles have been reared to adulthood but mostly in a larger scale aquaculture-style environments in South East Asia (Job et al., 2004). In public aquariums, success rates appear to be usually variable with good success at some institutions.

Age, Growth, and Reproduction:

H. kuda apparently have been reported as attaining sexual maturity at an age of 7-8 months (Mi et al., 1998), 9-12 months (Jiaxin 1990), and 4 months (S. Job *pers. comm*.). First spawning has been reported to occur at approximately 8.0 cm length (S. Job *pers comm*.), between 9.0 and 10.0 cm (Truong and Doan 1994) or when the body length is 12-14 cm (Jiaxin 1990). Maximum life expectancy in captivity is presently unknown, but several specimens have been held in aquaria for longer than 2 years.

H. kuda have been shown to breed year round. The peak period of reproduction takes place in April, May, September, and December in Vietnam (Truong and Doan, 1994) and *H. kuda* might breed many times in one year. *H. kuda* have been shown not to be monogamous in laboratory settings (Mi 1993). They have a reported gestation period of 9-10 days at 28-30°C (Truong 1994 in Nguyen and Do 1996) rising to 20-28 days (Mi 1993), presumably at lower water temperatures. Brood sizes have been reported as 20-1000 (Mi 1993) and between 271 and 1405 (Truong and Doan 1994).

Newborn *H. kuda* are approximately 6 - 8 mm in height and weigh 2.5 mg (Mi 1993; Mi, Kornienko and Drozdov 1998). Juvenile growth rates are shown below for captive-reared *H. kuda* held at between 29 and 30°C (S. Job *pers comm*.).

Age (Weeks)	*Mean Standard Length (mm)*
2	*29.7*
3	*42.1*
4	*54.7*
5	*65.47*
6	*72.4*
8	*86.01*
10	*99.67*
12	*111.2*
14	*120.66*

During the first two weeks of independent life, seahorses prefer to stay at the surface of water and only descend to the bottom after 19-22 days. Within the first week, only 20% of fry were capable of attachment to the substrate (Mi et al., 1998).

Habitat parameters

H. kuda do not tend to be held in conditions differing from other Indo-Pacific seahorse species. Juvenile broods are retained in separate tanks with circular flow and 250-micron screens over overflows. The following is a description of the exhibit tank at the John G. Shedd Aquarium, Chicago, where adult *H. kuda* are reproducing frequently and health problems have never been encountered.

Population:	11 animals: 7 males and 4 females
Volume of tank:	684 l
Height of tank:	60 cm
Circulation:	closed
Water:	artificial
Filtration:	wet/dry, UV sterilizer, protein skimmer
Substrate:	crushed coral gravel
Holdfast:	plastic plants, rocks.
Fluorescent light:	2 x 36" twin tube, 75 watt
Photoperiod:	16:8 L:D
Temperature	25^{o}C
NO_2:	
NO_3:	0.025
NH_4:	0.00
pH:	8.2
Salinity:	33.0
Water changes:	50% every 7 days
Tank cleaning:	every 7 days
WQ analysis:	every 7 days

Diet, Nutrition, and Feeding Techniques

H. kuda shows a peak feeding period from 0600 to 0800 during the day in captivity. Gut content analysis showed that they do not feed at night (Do et al., 1996). In captivity, adult animals are usually fed on frozen mysis, live mysis (wild-caught and captive-reared) and adult *Artemia*, river shrimp, frozen krill. Feedings are usually done twice (3-4 times at ZSL) per day. At the Shedd

Aquarium, frozen mysids are given once a day and adult A*rtemia* once a day. Live mysidds are given as an alternative to either the frozen mysids or the adult *Artemia*.

As with many other seahorses, newborn *H. kuda* are fed on day-old and two day-old *Artemia* nauplii, rotifers and copepods. Feedings are usually done 2 to 3 times a day (more often at ZSL – at least 4 times per day), trying to ensure there is always some food in the tank. As the juveniles grow, they are fed on nauplii, small live mysis, and frozen crushed mysis are also introduced. Feedings are done at least twice (4 times at ZSL) a day.

Live Food Enrichment

Live adult *Artemia* are enriched with Selco, DC-DHA Selco and algae (*Nannachloropsis* and spirulina). Live mysis shrimp enriched with *Artemia* nauplii. *Artemia* nauplii enriched with Selco for 12-24 hours.

Collection management

A captive breeding program is being run by the Marine Fish TAG of the AZA and coordinated by Devasmita De at Shedd Aquarium (dde@sheddaquarium.org). Animals in this program are currently being held at the Shedd Aquarium, Chicago; National Aquarium in Baltimore; Aquarium of the Americas, New Orleans and Fort Worth Zoo, Fort Worth, Texas.

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Slender Seahorse, *Hippocampus reidi*

2005 update
Jorge Gomezjurado (National Aquarium in Baltimore, USA; jgomezjurado@aqua.org), Todd Gardner (Atlantis Marine World, NY, USA; Fishtail22@aol.com)
2002 version
Jorge Gomezjurado (National Aquarium in Baltimore, USA)

Animal Description

This large seahorse is commonly referred to in the pet trade as the Brazilian seahorse or long-snout seahorse. Coloration of the *Hippocampus reidi* ranges from a variety of black, brown, and reddish-maroon to yellow and gold. Most of the body is mottled dark brown to black and covered with small dark and white spots. It may have bands across dorso-lateral surfaces, and males commonly have a prominent keel with a black line on the margin and bodies are more mottled dark brown than females. Genetic research suggests that this species is very closed relayed to *H. ingens* (Lourie et al., 1999). *Hippocampus reidi* is distributed from Cape Hateras, United States to Rio de Janeiro, Brazil and Gulf of Mexico (Lourie et al. 1999). There is no published information about abundance of this species. *Hippocampus reidi* can be found at depths between 15 and 55 m (Vari 1982) and found in small groups of up to 4 individuals (Rosa 2002)

Selection and Suitability

H. reidi are very common in public aquaria, some of which report having bred this species and the life cycle closed. Several breeders now are offering captive raised *H. reidi* to the aquarium trade. They are popular due to their size and coloration and commonly appear in the aquarium hobby trade in Europe, Asia and the United States.

Age, Growth, and Reproduction

Adults range in height from 9.5-17.5 cm (n=39) (Lourie et al. 1999). Reproductive activity of *H. reidi* has been observed in captivity after 4 months (Gomezjurado, *pers. obs*. 2005). At this age, male pregnancy has been observed. The gestation period is 14 days in captivity at temperatures between 24-28ºC. Brood sizes of 1200 have been reported. Eggs have an oval shape (2.5 mm TL) with an orange coloration.

Juvenile *H. reidi* are approximately 10mm in length (Gomezjurado, *pers. obs*. 2000). The development and behavior of the seahorses during the early stages (during the first month) suggest that the juvenile stage of this species may be pelagic. This observation is based on the tendency not to use the tail for anchorage until day 25 after born. No published growth data for this species are available.

Habitat parameters

Height: *H. reidi* can mate successfully in relatively shallow tanks (60 cm or less), different from other large seahorse species
Enclosure: turnover of 6 liters/min recommended
Filtration: mechanical (75 µ), biological filtration and UV sterilization (60.000µWsec/cm² @ 95 LPM)
Aeration: additional aeration not used in adult tank

Substrate:	live sand or bare bottom tanks
Holdfast:	live rock. Gorgonians, sponges, or artificial decor
Lighting:	cool –light fluorescent fixtures maintain 500-800 Lux. Also Metal Halides
Lamps:	(175W 6500K) have been used without a problem.
Photoperiod:	12:12 L:D
Temperature:	can be kept at 22-28ºC with optimal temperature of 26ºC
NO_2:	<0.1 mg/l
NO_3:	<10.0 mg/l
NH_4:	0 mg/l
pH:	8.25, controlled by the addition of CaOH
Salinity:	optimal salinity is 34 ppt.(Can range from 24 to 35 ppm)
Water Change:	5-per day

Broodstock facility (Atlantis Marine World)

The broodstock are maintained in a recirculating system of 76-liter (20-gal.XH) aquaria with fine aragonite sand and live *Caulerpa prolifera* for substrate. Central filtration consists of a bio-filter and UV sterilizer. A 50% water change is performed every 2 weeks. Water quality parameters are maintained as follows: Salinity: 25ppt, Ammonia: 0.0, Nitrite: 0.0, Nitrate: ≤ 20ppm, Temperature: 23-26oC. Lighting consists of 96W compact fluorescent bulbs (more for the plants than for the seahorses). Photoperiod is 12-16 hours of light, depending on season.

Juvenile rearing tanks

National Aquarium in Baltimore

The best way to rear this species is using black pseudo-kreisel with flows being established by positioning a bubble curtain or a water jet at one end of the tank. Light blue larval rearing tanks also have been used successfully. Density should be kept at not more than 20 juveniles per liter for the first two months. After the second month animals can be transferred to a rectangular tank with lighter turbulence.

Water quality and photoperiod should be maintained as with adult tanks and 150-200 Lux is the optimal light level. Turbidity is an important factor in the juvenile rearing environment and is created by using algae (*Isochrysis galvana*) at a concentration of about 150,000 cells per ml. The optimal turbulence is at 10 mm/sec, and feeding will decline at lower or higher levels. The turbulence also breaks the water surface tension that allows the juveniles to penetrate the surface and gulp air essential for the successful primary phase of swim bladder inflation.

Atlantis Marine World

Pregnant males are placed in a nursery tank which consists of a 15-liter fish bowl with an air-driven foam filter. The outflow from the filter is directed to create a current at the surface which, in turn, causes water in the bowl to flow in a vertical circulation pattern so that the tank functions effectively as a kreisel. This helps to prevent young seahorses from becoming trapped at the surface.

The rearing system is lighted with 40W fluorescent lights on a 12/12 photoperiod.

Pests in rearing tanks include *Aiptasia* sp. (anemones), hydroids, barnacles, amphipods, and polychaetes. Pests on young seahorses include: *Uronema*, gastrotrichs, a colonial ciliate tentatively identified as *Carchesium*, other unidentified ciliated protozoans, a fuzzy halo that appears to be a filamentous bacteria.

Most pests are controlled with periodic formalin treatments and salinity manipulations. Bacterial infections are controlled only with preventative techniques such as reducing seahorse density as much as possible, keeping clean tanks, and changing out the UV bulbs every 9 months. Past attempts at using antibiotics to control juvenile bacterial infections have been unsuccessful. Antibiotics, therefore, are no longer used in any of our seahorse systems.

Diet, Nutrition, and Feeding Techniques

High standards of hygiene should be maintained during food preparation and the maintenance of cultures. Food quality and availability are important regulators of seahorse growth and survival.

Adults

National Aquarium in Baltimore
The use of nutritious food increases the size of offspring produced, allowing them to ingest relatively large food items such as *Artemia sp metanauplii* as first food. Adult seahorses are normally fed 2 times a day mainly with frozen mysis shrimps (*Mysis relicta*) coated with Vitamin Pre mix 1mg/g Aquagrow Enhance 0.04 g/g of food and Aquagrow ARA 0.4 g/g of food (Martek Biosciences Corporation Columbia, Maryland U.S.A)

Atlantis Marine World
Broodstock are fed 2-3 times per day with previously frozen Mysid shrimp collected from an estuary in China. The diet is supplemented occasionally with live *Palaemonetes pugio*, *Americamysis bahia*, Gammarid amphipods, and frozen squid. Use of the freshwater *Mysis relicta* as the primary broodstock diet appears to result in decreased spawn quality.

Juveniles

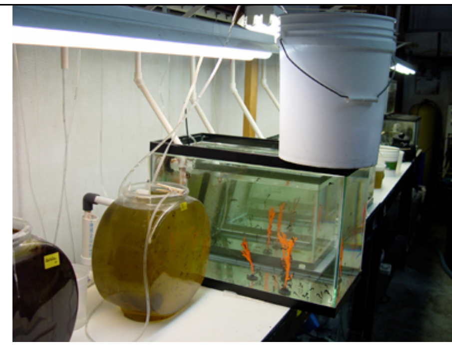
National Aquarium in Baltimore
Juvenile nutrition, especially during the first weeks, appears to be one of the major difficulties in seahorse culture. It is necessary to have a chain of live food ready for the first feeding juveniles. This chain consists of phytoplankton, such as *Tetraselmis sp* and *Isochrysis galvana,* brine shrimp *Artemia sp metanauplii,* nauplii, frozen copepods. The algae supply a source of food and nutrition for the zooplankton. Feeding levels depend on the juvenile stocking densities (not more that 20 juveniles per liter). Recommend levels are 10 rotifers/ml, 8 nauplii/ml as initial food densities, with increasing amounts depending the demand. Live foods are constantly supplied by dripping feeders. The gradual transfer from one live food organism to another is achieved by overlapping feedings at the different weaning stages.

Zooplankton are enriched with essential vitamins, commercial products of Highly Unsaturated Fatty Acids rich in Docosahexaenoic acid (DHA) 50.9%, 22:6 (n-3) such as Aquagrow Enhance containing also Carotenoids such as Astaxanthin. Before use, live food is rinsed with freshwater through a 120 µ strainer. *Artemia sp.* are decapsulated using traditional techniques. Juveniles at the second month are trained to take frozen mysids. In order to facilitate animal food recognition during the training, no enrichment coating is used.

Hippocampus reidi and *H.erectus* Breeding System

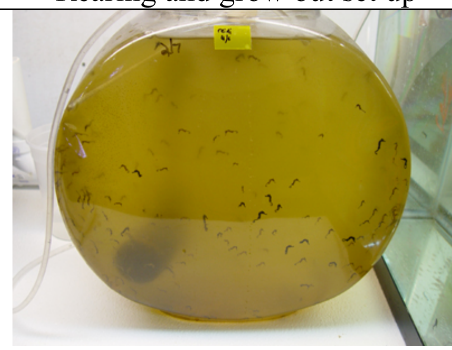
Todd Gardner, Atlantis Marine World, Riverhead, NY, USA

Broodstock tanks

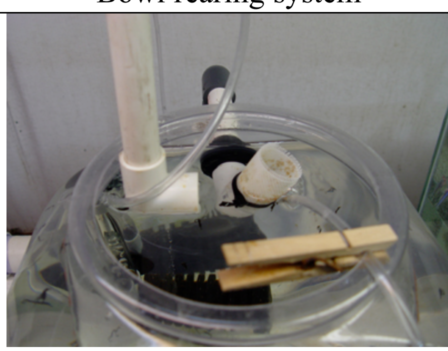


Rearing and grow out set up

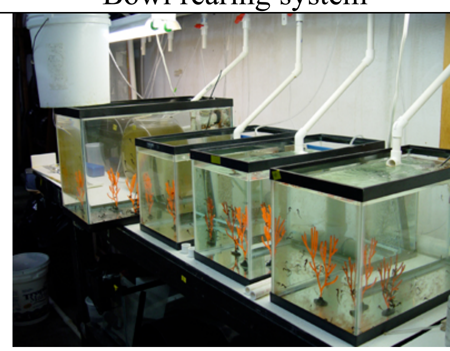
Bowl rearing system



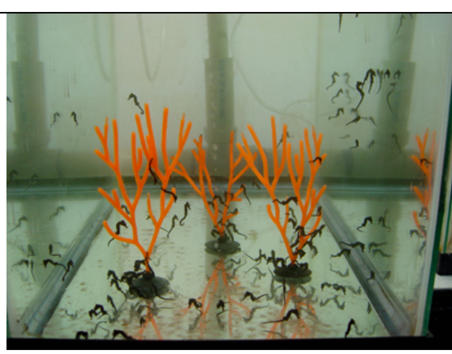
Bowl rearing system



Detail of bowl surface



Grow-out set up



Grow-out tank

Display tank

Atlantis Marine World
During the first week of rearing, the marine chrysophyte, *Isochrysis galbana* is maintained at a density of approximately $2x10^5$ cells/ml in the rearing tanks. Daily additions of phytoplankton, diluted in seawater are made by siphoning the mixture through a length of airline tubing, from a suspended bucket. Tank water is flushed out through a drain, protected by a 500µ screen. After one week, although phytoplankton is no longer added, the same technique is used to perform water changes. At 2-4 weeks of age, seahorses are spread out into multiple larger tanks attached to central filtration consisting of a bio-filter, UV sterilizer and protein skimmer. This is the same system that was used for my thesis research. For a more detailed description of the system, see Gardner, 2003 or contact me for a copy of the thesis.

Feeding regime is as follows: Day 1-4: rotifers at a density of 5-10/ml, Day 3-14: newly-hatched *Artemia franciscanis*, Day 10-60: *Artemia*, enriched with *Isochrysis* and Algamac 2000, Day 14-60: frozen Cyclops. At or around day 30, small frozen mysids are introduced.

Collection Management

A captive breeding program is being run by the Marine Fish TAG of the AZA and coordinated by Jorge Gomezjurado jgomezjurado@aqua.org Anyone with animals to donate to the program or with facilitates to offer the program is advised to contact the coordinator directly.

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Ierecê L Rosa, Thelam

West Australian or Tigersnout Seahorse, *Hippocampus subelongatus*

2002
Michael Payne (Seahorse Sanctuary)

Animal Description

The distribution of *Hippocampus subelongatus* is limited to the waters of the southwest coast of Australia. It is reported to be very common in localized areas but rare outside those areas. In Australia, the species is commonly referred to as the West Australian seahorse and, in the USA, it is known as the Tigersnout seahorse. In the wild, adults can obtain a size up to 20 cm. This seahorse species has an extremely diverse range of colours, including yellow, orange, red, pink, purple, black and white. There appears to be some relationship between sex and colour; red and pink animals are almost always males and yellow individuals almost always females. All specimens have a characteristic striped snout. Some individuals are covered with a reticulated pattern of fine lines.

Previously*, H. subelongatus* and *H. angustus* were considered to be the same species. Laurie, Vincent, and Hall (1999) recognizes them as separate species, with *H. angustus* occurring in the waters of northern Australia. In Western Australia, the vast majority of seahorses destined for the aquarium trade are collected from southwestern regions, and thus are most likely to be *H. subelongatus* rather than *H. angustus.* However, these specimens are still referred to as *H. angustus by* commercial collectors.

Selection and Suitability

Given the limited distribution of this species and the small number of commercial collectors in Western Australia, it is not surprising that *H. subelongatus* is not held at many public aquaria. According to catch return data from these commercial collectors, annual catches of *H. angustus* (most likely *H. subelongatus*) is usually around 200-300. Most of these are sold as aquarium fish either locally or in Asia.

The Aquarium of Western Australia (previously known as Underwater World Perth) has a substantial collection of wild-caught specimens and the author maintains a population of captive-bred specimens. Adult *H. subelongatus* are considered moderately easy to keep in aquaria, especially at subtropical temperatures. While they will readily spawn in captivity, their fry are small and difficult to rear.

Age, Growth, and Reproduction

Little data is available on the growth and development of *H. subelongatus.* The fastest time to production of healthy offspring by captive-bred specimens is 11 months (*pers. obs*.). The same cohort obtained lengths of approximately 5 cm after 3 months, 9 cm after 7 months and 11 cm after 11 months. The largest and oldest specimen maintained by the author is 14.8 cm in height and 4.5 years old.

In the wild, *H. subelongatus* breeds during the warmer months. Water temperature in their natural environment varies from 15–25ºC. In captivity, adults will breed at temperatures around 20-25ºC, although optimum temperatures are reported to be 21 – 23ºC (Lawrence 1998). Brood sizes vary from around 40 (*pers. obs.*) to 623 (Lawrence 1998). Batches of around 200 are usual for pairs of captive-bred specimens of approximately 12-14 cm in height.

Newborn *H. subelongatus* are 12.6 ± 0.2 mm standard length. At two weeks old they are 27.5 ± 2.1mm and 38.6 ± 9.4 mg (wet weight) when reared on copepod nauplii (Payne and Rippingale 2000). Juveniles reared on enriched Artemia do not grow as quickly as those reared on copepods. Also, survival of seahorses is greatly increased on a diet of copepod nauplii (Payne and Rippingale 2000).

Newborn juveniles are entirely pelagic and do not attach to substrate until at least 4 weeks old. High juvenile mortality is associated with the ingestion of air bubbles, causing the animals to float on the surface. This problem is likely to be hyperinflation of the swim bladder and can be prevented by ensuring the complete removal of surface films in the rearing vessels and the elimination of directional lighting from above. Greenwater techniques appear to maximize juvenile feeding responses.

Habitat Parameters

H. subelongatus are typically held in standard rectangular aquaria 40 to 200 l . This species is prone to developing gas bubble disease, usually in the brood pouch but also under the epidermis of the tail and around the eye. Incidence of this disease is reportedly reduced by maintaining specimens in tall (~ 1 m) cylindrical drums (Glen Moore, *pers. obs.*).

A captive-bred population of *H. subelongatus* has been maintained by the author in a recirculating system described as follows:

Population:	27 animals: 12 males and 15 females
Vol. of system:	600 l
Tanks:	12 x 40 l
Height of tank:	40 cm
Circulation:	closed
Water:	seawater
Filtration:	wet/dry, UV sterilizer, protein skimmer
Substrate:	crushed coral gravel
Holdfast:	weighted polypropylene rope
Lighting:	single cool white fluorescent 10 cm above tank
Photoperiod:	14:10 L:D
Temperature	18-25^{o}C
NH_3:	<0.01
pH:	8.0-8.3
Salinity:	32-37 ppt
Water changes:	2% daily
Tank cleaning:	siphon debris daily
WQ analysis:	once a week.

Diet, Nutrition, and Feeding Techniques

Diet:	whole glass shrimp, chopped prawn flesh, frozen mysis, and frozen *Artemia*
Frequency:	once or twice daily (am and pm)

The adult diet is varied according to the availability of dietary items. Chopped prawn flesh is the only food that specimens will not eat once it has sunk to the bottom of the tank.

Growth and survival of juvenile *H. subelongatus* are considerably greatened when fed copepod nauplii enriched with *Isochrysis galbana*. Five-day-old juveniles can eat 214 nauplii per day. Juveniles can be reared using enriched Artemia (AlgaMac 2000 and *Tetraselmis suecica*), although very young seahorses have difficulty digesting them. This problem is partly overcome by ensuring that juveniles are not fed to excess thereby increasing retention time of prey in the gut. Gentle aeration in juvenile tanks and nondirectional light will ensure live prey are evenly distributed throughout the tank.

Juveniles can be weaned gradually onto chopped frozen mysis and *Artemia* at around 2 months old. This weaning process, during which juveniles are fed both live and dead prey, should last at least a month. Unchopped mysis and *Artemia* can be fed as the only diet by the time weaning is complete.

Disease Management

Seahorses maintained in this system are susceptible to gas bubble disease. Specimens with bubbles around the eyes or under the epidermis of the tail are readily treated with acetazolamide (Diamox tablets 250 mg). Mix a very small amount of crushed tablet with water and inject it into several glass shrimp that are then frozen. These are then fed to the target animal at the rate of two per day for four days. Bubbles disappear on the second day. For specimens with bubbles in the brood pouch, the gas is vented from the pouch using a sterile needle and massage. The pouch is then flushed with fresh, sterile water. In about 10% of cases, bubbles continually recur despite treatment. These animals are euthanized.

Collection Management

At present there is no coordinated management of *H. subelongatus* collections. The author intends to continue to maintain an entirely captive-bred population. The Aquarium of Western Australia will also continue to maintain specimens for display.

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Dwarf Seahorse, *Hippocampus zosterae*

2005 update
Kathlina Alford (Tennesse Aquarium, USA; katsseahorses@yahoo.com)
2002 version
Colin Grist (New England Aquarium, USA)

Species Information

Hippocampus zosterae, a relatively small species commonly referred to as the dwarf seahorse, is also known by the synonyms of *H. regulus* and *H. rosamondae*. *H. zosterae* are found in the coastal gulf of Mexico, Bahamas, Bermuda, the Florida Keys, Florida's east coast, Old Tampa Bay, Lemond Bay, Pensacola, and Texas. They are restricted almost totally to seagrass microhabitats in shallow water, particularly in association with the seagrass *Zostera*. They are most common in bays during periods of high salinity. It can be distinguished from *H. reidi* and *H. erectus* that share some similar distribution, by its fin ray counts (there are 12 dorsal fin rays spanning two trunk rings and 11 or 12 pectoral fin rays), and by the fact that adults are significantly smaller than those of these other species. The snout of *H. zosterae* is short and this species has a high, columnar coronet.

Selection and Suitability

This species was regarded as common before 1970, however numbers have steadily decreased over subsequent years, which is most likely due to a reduction in the extent of seagrass beds. Collectors for the aquarium trade rarely target this species nowadays due to the difficulty and time involved in locating them around the Florida Keys (Waters, *personal communication*). There have been no reports of this species in the Mississippi Sound since 1987 (http://lionfish.ims.usm.edu/~musweb/hipzost.htm). Their relatively low fecundity and dwindling habitat make them particularly vulnerable. The IUCN Red List of Threatened Animals classifies *H. zosterae* as vulnerable.

This species was particularly popular in the 1960s when mail order companies commonly sold them as the 'perfect pets', complete with goldfish bowl. These companies were generally not aquarium specialists. This practice still exists over the World Wide Web, where Dwarf Seahorse Starter Kits can be obtained, which includes a small plastic tank, rudimentary equipment, a sachet of *Artemia* (brine shrimps) eggs, and one or two pairs of Dwarf seahorses. There are no records to indicate how many of these seahorses actually survive.

Generally they are regarded as hardy in comparison to many other seahorse species although, in fact, their requirements are not dissimilar. Reports indicate that many aquarists use very simple aquarium arrangements for keeping, breeding, and rearing *H. zosterae* (Breeders Registry).

Age, Growth, and Reproduction

H. zosterae have been recorded as growing to a total mean length of 47 mm according to Vari (1982) although others suggest 44 mm (Ginsburg 1937). Lourie et al. (1999) suggest adult height is 20–25 mm. *H. zosterae* live 1–2 years. One year is common, but to two years is rare, if ever. Growth is rapid during the summer period and reach maturity within 3 months. The gestation period within the male's brood pouch is usually about 10 days with 5 to 25 juveniles developing at any one time. Juveniles are 7–9 mm total length at birth and capable of growing to 18 mm total

length by day 17 (recorded in captive specimens). The adults are iteroparous, producing 2 broods per month. The main breeding period is between mid-February and late October and is influenced by the day length. *H. zosterae* are monogamous (C. Grist *pers obs*).
In some locations, notably Tampa Bay, Florida, their diet is predominantly harpaticoid copepods (Tipton and Bell 1988).

Habitat Parameters

Small aquaria of around 50 liters have been successfully used with simple air-driven sponge filters that are easily maintained. A substrate of aragonite is often used, or no substrate at all. The seahorses require holdfasts, which can be provided by including some suitable grass like plastic plants. Suitable tankmates include polkadotted hermit crabs (*Phimochirus operculatus*). The water quality parameters should be as follows:

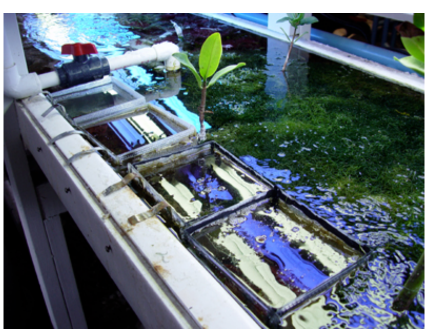
Temperature:	20–22^{o} C although some aquarists have been known to maintain temperatures as low as 18^{o} C
pH:	8.3
Salinity:	1.022 – 1.024
NH_3/NH_4^+ and NO_2:	0
NO_3:	<20

Adults will feed on amphipods and *Artemia* nauplii that has in turn been fed either 'greenwater' or an enrichment diet such as Selco, which should be offered as often as is convenient but not less than 3 times per day. Cyclopeeze can be fed along with the *Artemia* to adults and larger juveniles. Newborn seahorses require a constant supply of *Artemia* or rotifers for between 12 and 20 days before offering them larger brine shrimp. It may be possible to start feeding chopped frozen mysis after the 20th day, but no information on the success of this method has been found.

Although *H. zosterae* are not known to eat their young, it is common practice to rear offspring in a separate aquarium where better control can be kept over their growth and development. The rearing aquarium can be arranged in the same manner as for the adults.

With such large amounts of food being introduced into a relatively small aquarium, regular siphoning is necessary and should be carried out twice a day with the deficit made up with new seawater. It is necessary to clean filters often, but only clean half the medium at any one time to avoid destroying the entire population of beneficial nitrifying bacteria living upon its surfaces.

The success rate in rearing *H. zosterae* to adult is generally good with survival of over 20% being common.



System for *H.zosterae* kept in refugia in reef tank – feed on abundant copepods (Todd Gardner, Atlantis Marine World, Riverhead, NY, USA)

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<u>Weedy Seadragon, *Phyllopteryx taeniolatus*</u>

2005
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(with input from Kathlina Alford, Tennessee Aquarium)

Species Description

The family Syngnathidae includes the seahorses, pipehorses, pipefishes, and two species of seadragons, the weedy seadragon (*Phyllopteryx taeniolatus*) and the leafy seadragon (*Phycodurus eques*). Their unique appearance is characterized by several appendages, and an unusual orange-red color pattern with iridescent blue stripes, yellow markings, and white spots. Syngnathid reproduction is unusual in that the female transfers her eggs to a male who incubates them until they hatch into well-developed, independent young.

The weedy seadragon is endemic to southern Australia ranging from Port Stephens, New South Wales to Geraldton, Western Australia, and to southern Tasmania. Weedy seadragons are associated with exposed rocky reefs from the surface to as deep as 19 meters. They may prefer slightly more protected habitats than leafy seadragons and are often associated with a variety of algal species, such as; *Sargassum* sp., *Ecklonia radiata, Macrocystis angustifolia, Cystophora moniliformis, Cystophora subfarcinata,* and *Cystophora retorta.*

Selection and Suitability

Twenty years ago, few aquariums had weedy seadragon collections. Today, seadragons are popular displays in public aquaria, attracting many visitors. Captive reared juvenile and collected (under permit) adult weedy seadragons are exported from Australia annually for zoo and aquarium displays worldwide. Weedy seadragons are rarely available in the aquarium trade.

The lack of information regarding the basic biology of weedy seadragons can be frustrating for aquarists. Fortunately, Internet listserves have allowed a mode of exchanging vital information regarding seadragon husbandry amongst institutions.

Age, Growth, and Reproduction

A comprehensive study of the species' life history does not exist and there are few studies have focused on this species. It has been estimated that weedy seadragons live to 10 years of age and full-grown adults reach 45 cm in length.

Weedy seadragons exhibit paternal brooding in which the male incubates developing embryos on a brood patch on the underside of their tail. In nature, they probably have only one brood per season with 100 – 300 eggs; each egg becomes embedded in the skin for protection. Incubation lasts 4 – 6 weeks and may be dependent upon water temperature, with a shorter brood time in warmer water.

Weedy seadragons are not sexually dimorphic and it can be difficult to distinguish between males and females. When reproductive, males can be identified by enlarged, broad tails that may become swollen and reddened. When compared to males, females have deeper abdomens and smaller, thinner tails. It should be noted that neither of these observations is exact and the only way to positively determine sex of an animal is by observations of egg droppings, transfers, and pregnant males. Individual weedy seadragons can be identified using markings on the snout, head, and body, or by characteristic appendages.

Captive Breeding

Due to recent advances in the captive husbandry of this species, public aquaria have been successful in establishing propagation programs for breeding and raising weedy seadragons. Both the Aquarium of the Pacific in Long Beach, California and the Tennessee Aquarium in Chattanooga, Tennessee have successfully bred and raised weedy seadragons. In addition, several zoos and aquariums have reported successful egg transfers unfortunately, reports of males dropping the egg mass are common.

It is believed that seadragons may require a deep-water column to mate; therefore, tank height may play an important role in successful egg transfers. Temperature fluctuations may also be important for egg development, mating, and egg transfer. Several aquariums have noted egg production, mating behavior, and egg droppings that have coincided with a raise in water temperature either intentionally by a seasonality schedule or accidentally due to chiller failures.

Juvenile Development and Care

Hatching is staggered and may last several days. In their natural environment this may aid in the dispersal of the offspring and, thereby, decreasing competition for food. Newly hatched seadragons are approximately 2 cm in length and still have a large yolk sac attached. The yolk sac is generally absorbed within a few days of hatching, at which time they are able to feed on their own.

It is recommended that hatchlings be placed in an appropriately sized tank separate from the display tank. Hatchlings have been observed eating at all times of the day and night; therefore, it is recommended that a 24-hour feeding bucket be established. Initially young weedy seadragons eat baby brine shrimp, followed by one-day old live mysids. As the weedy seadragons begin to grow and are able to, larger mysids can be fed. Young weedies begin eating adult mysids at approximately 3 – 4 months of age. Larval white shrimp (*Penaeus vannamei*) reared in shrimp hatcheries have also been successfully used to feed juveniles above 5 cm in length.

Diet, Nutrition, and Feeding Techniques

There are a variety of feeding techniques, what is best is highly debatable. Some institutions feed live mysids 2-3 times a week, others 2 times a day, and still others feed a combination of frozen mysis and live mysids "daily 2-3 times a week" (HUH??). It is recommended that particular attention to individual collections be taken into account when creating diet plans.

It is recommended that food be supplemented prior to feeding. Mysids (*Mysidopsis bahia*) should be supplemented with brine shrimp nauplii (*Artemia salina*). Brine shrimp can be enriched with Selco (Inve Aquaculture, Belgium) for 24 hours and then fed to live mysids, allowing the mysids to feed for 30 minutes. Frozen copepods such as Cyclop-eeze® (Argent Laboratories, Redmond, Washington, http://www.argent-labs.com) can also be used to supplement live mysids. Due to the high concentration of pigments in Cyclop-eeze®, colouration in seadragons can become greatly enhanced.

Replacing live *Artemia* for feeding mysis with microencapsulated high HUFA feeds such as Artemac, not only reduce the chance for disease introduction but also removes the need for maintaing and enriching live *Artemia* cultures. Several institutions are feeding frozen mysis shrimp, however, converting weedy seadragons from live to frozen foods can take some time -- and a lot of patience! Frozen food can be supplemented with vitamins or *Spirullina*.

Recently, there has also been a great deal of discussion with respect to live mysids. Many aquarists and veterinarians believe that wild caught mysids may carry bacteria or parasites that can be transferred to seadragons. There are a few preventative measures that can be taken to "clean up" live mysids. A 24-hour dilute treatment of malachite green and/or a freshwater dip prior to feeding have been used. In addition, several zoos and aquariums are developing mysid cultures of their own. The use of cultured mysis or larval shrimp is an alternative to wild caught mysis, as mentioned previously, and they are typically disease free.

Aquarium of the Pacific Tank Design Parameters

Collection:	2-12 individuals.
Tank mates:	Leafy seadragons (*Phycodurus eques*), Potbellied seahorses (*Hippocampus abdominalis*), Talma (*Chelmonops truncates*), and Pygmy leatherjacks (*Branchaluteres jacksoni*). (At Tennessee Aquarium - Tigersnout seahorses (*Hippocampus subelongatus*), White's Seahorses (*Hippocampus whitei*), cold water invertebrates (e.g. leather stars, bat stars, purple urchin, red urchin, cucumbers)
Volume of tank:	Variable: 500 – 3000 gallons (1893 – 11,356 liters).
Height of tank:	Variable: 3 – 6 feet (0.9 – 1.8 meters).
Circulation:	Closed system recommended. How was ciruclation created in the tank? Was it strong, medium or weak?
Water:	Ozonated or filtered natural seawater recommended. WHY?
Filtration:	Mechanical, biological, chemical, and UV sterilization.
Substrate:	Small – medium sized pebble recommended. Fine sand can be used, however, several aquariums have reported seadragons ingesting sand leading to feeding problems or death.
Holdfasts:	Artificial brown kelp and *Sargassum* plants.
Lighting:	250 Watt, 20,000 Kelvin metal halide lamps (how many? and 3 Watt fixture as a night light.
Photoperiod:	14 hours. Seasonal fluctuations have also been developed (Figure 1).
Temperature:	Variable; 57 - 64 ^{o}F (14 – 18 ^{o}C). Seasonal fluctuations have also been developed (Figure 1).

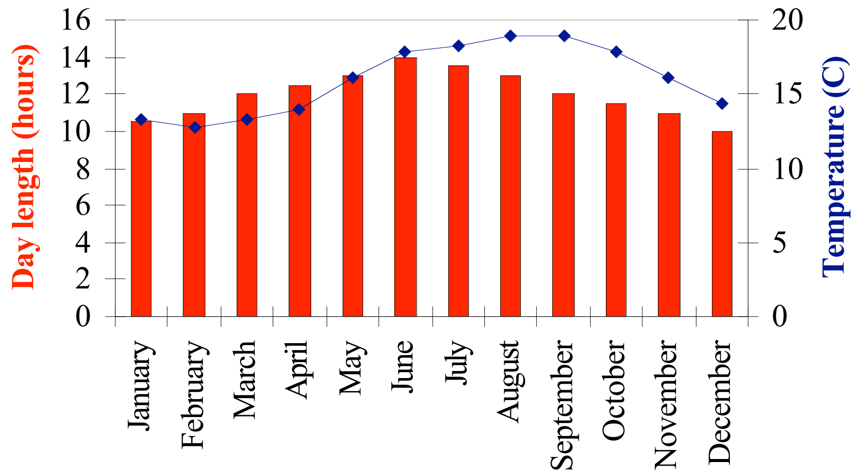

Figure 1. Weedy seadragon exhibit temperature and day length changes occurring monthly mimicking natural seasonal fluctuations in southern Australia. Bars represent day length, while temperature is represented by data points.

Water Quality Parameters

NO_2:	0 mg/L
NO_3:	< 20 ppm
NH_4:	0 mg/L
pH:	8.2
Alkalinity:	2.5 – 3.0 meq/L
Salinity:	32 – 33 ppt
	(At Tennessee Aquarium salinity is 36-38ppt to combat *Uronema*)

Tank set-up notes

Water quality analysis should be examined on a weekly basis. Water changes should be performed regularly, to maintain optimum water quality parameters. A 10-20% water change is recommended weekly, with good water quality results. Poor water quality may require additional water changes. Poor water quality or drastic changes in water chemistry may result in stressed or unhealthy animals. Keep in mind the current water temperature of the exhibit and the temperature of the saltwater make-up, as you do not want the water temperature of the tank to increase or decrease significantly. Debris and any uneaten frozen food should be siphoned daily, tank bottom should be hydro-cleaned on a regular basis.

Collection Management

The International Union for Conservation of Nature and Natural Resources (IUCN) recently listed the weedy seadragon as being at risk of endangerment on its 2002 Red List of Threatened Animals. However, due to insufficient information regarding this species, it has been placed in the 'Data Deficient' category along with several other syngnathid species. Although the IUCN lists the weedy seadragon in a lower risk category, Australia has federally protected this species under the Environment and Biodiversity Conservation Act of 1999. In addition, seadragons are locally protected under state legislation.

Permits are obtained annually for the collection and export of weedy seadragons for public aquaria displays worldwide. However, due to the difficulty in collecting these protected species, only a few distributors are certified to sell seadragons to public aquariums.

Acknowledgements

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<u>Leafy Seadragon, *Phycodurus eques*</u>

2005
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Species Description

The Leafy seadragon, *Phycodurus eques*, the most ornate member of the family Syngnathidae, has long been known to aquarists as one of the most beautiful and unique of all the fishes. Found only in Southern and Western Australian waters, the Leafy seadragon is a master of camouflage. Named for the dragons of Chinese myth, this relative of the pipefishes and seahorses is named for the leaf-like appendages that adorn its body.

Natural Habitat

Inhabiting the rocky coastal areas, at depths of 20-25 meters, the seadragons can be found drifting between the blades of kelp or clumps of *Sargassum*, to which they bear a striking resemblance. Leafy seadragons and their close relatives the Weedy seadragon, *Phyllopteryx taeniolatus*, can be located near piers and jetties sheltered by the seaweeds that grow on them, and at deeper depths with rocky structures and sandy patches. They are often found with seagrasses known as sea nymph *Amphibolus Antarctica*, and brown algaes and kelps such as *Ecklonia radiata*, *Macrocystis angustifolia*, *Cystophora moniliformis*, *Cystophora subfarcinata*, and *Cystophora retorta*. They can also be found in clumps of *Sargassum sp*. (Quong 2002)

A field study describing the patterns of movements and habitat use by Leafy seadragons was conducted by Connolly *et al* near Wright Island in South Australia and found that during their study period ultrasonically tagged Leafy seadragons spent more time over *Posidonia* seagrass and less time over other sea grasses or kelps. The authors state that these findings might result directly from habitat selection by seadragons, or indirectly from seadragons positioning themselves in response to other factors such as water movement or prey abundance. (Connolly *et al* 2002)

Leafy seadragons are found in a temperate climate where the water temperature remains very cool for most of the year. According to information available from the National Tidal Facility (NTF) which runs an Australian Baseline Sea Level Monitoring Project, the temperatures in the coastal areas where seadragons are commonly found ranges from approximately 11 degrees C in the coldest months of June through September, to as high as 23 degrees in the warmer months of December through March. (Moore 1999)

Temperatures recorded from sites frequently visited by collector Pang Quong when observing seadragons in the wild, range from a low of 9 degrees C to 21 degrees C. His observations are similar to those recorded by the NTF (Quong 1999).
Photoperiods in the areas where dragons are most commonly found are based upon the total time between sunrise and sunset. The photoperiods coincide with the water temperature with the shortest days occurring in June (~ 10 hours) and the longest in December (~ 14.5 hours) (Galbraith 2005).

Selection and Suitability

Leafy seadragons can be an expensive and difficult species to display and maintain. To date, the Leafy seadragon has not successfully reproduced in captivity. At the present time, availability of Leafy seadragons is limited to exchange between zoological institutions, or purchase from Pang Quong or an aquarium wholesale facility to which he sells captive raised leafy seadragons. Collection of Leafy seadragons from the wild has been limited to only a few individuals over the past decade. The Leafy seadragon is South Australia's state marine emblem and is considered a fully protected species. (PIRA 2005). The young seadragons available from Pang are very small and have been raised from the eggs pregnant males he is permitted by the South Australia Government to collect from the wild each year. These animals are generally only available in the first few months of the year, and the number of animals available varies from year to year. Freight and import charges can be expensive.

Leafy seadragons have a very selective diet, requiring live or frozen mysid shrimp, or small, cultured or wild caught Penaeid shrimp. Acquiring the live wild caught mysid shrimp can be expensive, and culturing live mysid shrimp can be time consuming.
Should the Leafy seadragon reproduce successfully, the young animals will require live foods until they can be weaned, which can increase the expense in maintaining a collection (Forsgren 2001).

In addition to their limited availability and expense involved in acquiring them, Leafy seadragons have limited compatibility with other fish and invertebrate species. Several zoological institutions have displayed Leafy seadragons with Weedy seadragons, *Phyllopteryx taeniolatus*, and with Pot bellied seahorses, *Hippocampus abdominalis* . A number of invertebrates can be kept safely with seadragons, although problems have been reported with crabs that accidentally grow up from the mysid shrimp shipments.

Age, Growth and Reproduction

Little is known about the life history of the Leafy seadragon. It has only been since the late 1990s that there has been any success in maintaining this species long-term in an aquarium environment (Powell 1997). Scientific literature pertaining to the life history of seadragons is quite limited. In December 1985, Rudy Kuiter conducted a study on the growth rates of newly hatched Leafy seadragons for Australia's national television station. In that study, the newly hatched dragons measured 35 mm in length. After 21 days in temperatures ranging from 17 degrees C to 21 degrees C, the juveniles attained a length of 85 mm (Kuiter 1988). A similar study was conducted by the staff at Underwater World Perth in late 1992, and early 1993. The growth rates were observed in a number of newly hatched juvenile Leafy seadragons for a period of ten weeks. During that study period the specimens in one of the rearing tanks was found to have a growth rate of approximately 9 mm per week at 18 degrees C (Mackay 1996). Pang Quong of PQ Aquatics reports that typically in the first 10-12 weeks the juvenile Leafy seadragons at his facility grow at a rate of approximately 10 mm per week (Quong 2005). Leafy seadragons mature at length greater than 20 cm usually around two years of age (Kuiter 1988).

An informal survey conducted by Charles Delbeek of the Waikiki Aquarium, Hawaii in 2004, polled members of the Aquatic info and Syngnathidae list serve groups as to the longevity of the Leafy seadragons in their collections. He recorded the results in a table and the incomplete results are listed below. From this anecdotal evidence, and the fact that facilities are, just within the past decade, able to keep Leafy seadragons long- term, the estimated life span of a Leafy seadragon is believed to be approximately ten years (Delbeek 2004). **(See Table 1 below)**

Table 1

Institution	Years in Captivity	Source	Year Hatched
Long Beach	8	PQ	
Shedd Aquarium	8	DWA/PQ	1998
Omaha Henry Doorly Zoo	6	DWA/PQ	Dec. 1998
Toba Aquarium, Japan	9	Wild	?
Dallas World Aquarium	8	Wild	Collected as adult 1996
Waikiki Aquarium	3	PQ	Jan. 2000
Ripley's Aquarium of the Smokies	3	?	
New England Aquarium	5+	DWA/PQ	1997
Seattle Aquarium	4+	DWA/PQ	1999

PQ = Pang Quong, PQ Aquatics
DWA = Dallas World Aquarium
DWA/PQ= Loan from DWA, originally raised by Pang Quong

Habitat Parameters

Providing the proper habitat to house Leafy seadragons is one of the most important elements in their husbandry. Key factors such as system design, water flow, temperature, and lighting are critical to the well being and long term health of the Leafy seadragon (Powell1997).

System Design

The size of the aquarium housing Leafy seadragons is important in several ways. The length and width must be such that the animals have plenty of space in which to swim, without being crowded. Leafy seadragons can easily damage their slender snouts, if accidentally pushed by a tank mate or the current into the sides of the exhibit. In general, the Leafy seadragon also seems to prefer a deep aquarium as opposed to a shallow aquarium, which is also beneficial when displaying the fish in an exhibit with either live or artificial kelp. The depth of the aquarium can also aid the newly acclimated Leafy seadragon in regaining its buoyancy (Groves 1997). It is very common for the Leafy seadragon to experience buoyancy problems during or shortly after collection and transport. In many instances, this tendency to float at the surface can be corrected by the seadragon itself when placed in a deep tank. The inability to correct a buoyancy problem, can ultimately lead to the death of the animal.

Leafy seadragons have been displayed in a variety of exhibits with success in terms of their longevity. Most of the successful exhibits have been at least one meter or more in height and width. Recently, seadragons have also been displayed in cylindrical exhibits (Marshall 2004). **Table 2** is an excerpt from a paper presented at the AZA National Conference in Minneapolis, Minnesota in 1999 describing the size of the exhibit and relation to the observation of breeding behavior in Leafy seadragons. Since 1999, many of these institutions, as well as a number of others have experienced repeated egg production events, without successful transfer of eggs to the male. The reasons for these failures are still unknown. Exhibit design, especially tank depth may eventually prove to be a factor in successful breeding of Leafy seadragons (Powell 1999).

Holding or quarantine systems should be designed to accommodate the animals at various sizes, but especially when the animals are young and quite small.

Water Flow and Temperature

Depending on the size and volume of the exhibit or holding system, the flow should allow the entire volume of the aquarium to be turned over at least 4- 6 times per hour. At The Dallas World Aquarium, we use two ¾ horse power spa pumps to circulate water through a reservoir (sump) and to the exhibit. Too little flow will result in a reduction of activity of the seadragon; too much flow can cause them to "fight" the current, potentially exposing the fish to undue stress as well as injury. In an effort to help prevent piping behavior at the surface of the aquarium, it is best to keep a little flow across the top to disrupt the "mirror" effect that can occur with a lack of flow at the surface (Delbeek 2005).

Water temperatures in the natural range of the Leafy seadragon range from 9 degrees C to 21 degrees C. Generally, seadragons are kept at temperatures between 12 degrees C and 18 degrees C. A number of institutions have been varying their temperatures in order to initiate breeding (Forsgren 2004). A Universal Marine Titanium chiller is used for maintaining water temperature in the seadragon exhibit at The Dallas World Aquarium.

Filtration

Filtration for Leafy seadragon displays can be achieved in a number of different ways. At The Dallas World Aquarium, our seadragon display and holdings are very simple closed systems. Synthetic seawater is made using the city water supply, filtered by reverse osmosis and Instant Ocean salt mix. Biological filtration is achieved using a "modified Berlin" method with live rock as the only biological filter. A large "ETS" style protein skimmer, Baker Hydro mechanical pool filter and Rainbow/Lifeguard UV sterilizer are used for water clarity. Super activated charcoal and Aquarium Pharmaceuticals phosphate remover are used as chemical filter media. Ozone use is not recommended on a Leafy seadragon exhibit.

Water Quality and System Maintenance

In order to ensure that Leafy seadragons remain healthy and disease free, excellent water quality is required. Frequent, small, water changes, with siphoning of the substrate, is recommended. These water changes should be done with a minimum of stress to the dragons, with little or no temperature or salinity change. Removing the dragons to siphon the exhibit is not recommended. Water quality parameters should not vary to any great degree. Below is a description of the acceptable parameters for water quality in the seadragon exhibit at The Dallas World Aquarium.

Salinity: 27 – 35 ppt	Nitrate (NO_3) < 5.0
pH: 8.0-8.3	Phosphate (PO_4): <0.05
Ammonia (NH_3): 0.0	Calcium 250-400 ppm
Nitrite (NO_2): 0.0	

Lighting requirements

Lighting a Leafy seadragon display is one of the most important factors in successfully maintaining the collection. Sudden, dramatic changes in lighting are a source of stress to the

Leafy seadragon. A variety of lights should be used so that the seadragons are exposed to a varying amount of light, gradually increasing throughout the day, and decreasing at night. Paul Groves, formerly of Underwater World, Perth Australia (Groves 1996), discourages the use of intense lighting normally used to light coral reef displays, as this is, in his opinion, too intense for the Leafy seadragon. At The Dallas World Aquarium we now use only one 250 watt metal halide light, and have not observed that this is a problem for the seadragons. One problem that does result from the use of metal halide lighting is the growth of filamentous algae, which can cause the seadragons to become entangled when feeding. The combination of metal halide and fluorescent actinic lighting is very effective for both display and husbandry purposes.

The use of a night light has also been important in the lighting requirements of the Leafy seadragon at The Dallas World Aquarium and many other institutions displaying seadragons. We use a small 20 watt fluorescent tube that is timed to come on just before the main exhibit lights go out for the day, and will go off, just as the main lighting is beginning to come on. We have observed that the seadragons tend to be attracted to external light sources outside of the exhibit and gather near the front of the aquarium when the "night light" is not on above them. They appear more settled, and will group together in a cluster when the light is in use.

Many institutions are varying their light cycles, naturally or intentionally, in order to help initiate breeding. In some instances, this variation coincides with the fluctuations in temperature to simulate the changes in sunlight and water temperatures in their natural environment (Forsgren 2004).

Acclimation

A long acclimation period is recommended when introducing new Leafy seadragons to their exhibit or holding system. Often, if transported from Australia, the fish have been in bags for more than 36 hours, and their water quality and water temperature may be drastically different from the aquarium into which they will be moved. It is not uncommon to have to overcome salinity differences of several points and temperature differences of several degrees.

At The Dallas World Aquarium, our normal acclimating procedure is to trickle water slowly into the transport bags from the exhibit through a small diameter airline tubing that can be "tied closed" to slow down the flow when the temperature, pH, or salinity differences are great. This procedure normally takes from one to three hours. The animals are not transferred into the exhibit until salinity, pH and temperature match exactly.

It is recommended that the "night light" be the only light on in the exhibit when the seadragons are transferred into it. The lights can be turned on gradually after the fish have had a chance to adjust to their new surroundings. The use of a net on the seadragons is discouraged, especially when removing them from the water during transfer into the aquarium. Use of a glass Pyrex bowl or a small bucket is recommended to avoid lifting the snout or gills of the seadragon from the water. It is best if the seadragon remains completely submerged during the transfer. The use of a bowl or bucket also reduces the risk of damage to the fish from getting tangled in the net by their leafy appendages.

In addition, it can be useful to cover the sides of the holding aquarium if it is an area frequented by aquarium staff. This allows the dragons to "settle in" and adjust to their new surroundings without becoming "spooked".

Feeding and nutrition

Perhaps the single most important factor in successfully keeping the Leafy seadragon in a controlled environment is the feeding routine. Leafy seadragons were originally believed to be difficult to feed, and prefer live food, specifically mysid shrimp. Obtaining sufficient shrimp to sustain a collection of seadragons, can be very expensive, and culturing them, in addition to the expense, can be very time consuming. At The Dallas World Aquarium, we have tried both methods. At present, we are receiving weekly shipments of 40,000 live *Mysidopsis bahia*, mysid shrimp. These are wild caught in Florida waters. In addition, we have the option to purchase live cultured mysid shrimp from a toxicology lab in the Dallas area. A backup source for the mysid shrimp is very important. The Leafy seadragon cannot go for extended periods of time without food. The adults on exhibit are fed thoroughly twice per week with the live mysid shrimp. The smaller, younger seadragons are fed mysids three times per week. Before each feeding, the mysid shrimp are fed *Artemia sp.*, brine shrimp nauplii that have been soaked in a nutrient rich supplement known as SELCO for 24 hours. These normally warm water shrimp are then acclimated to the cold water of the exhibit.

Many institutions feed frozen mysis shrimp as the main food source (1-3 times per day) or as a supplemental food source for their dragons. Usually these are freshwater *Mysis relicta*, and are often readily accepted by seadragons, usually young dragons. It is best when planning to feed frozen mysis to offer it to the dragons when they are young (and large enough to eat the frozen mysis which can be quite large compared to live). Every institution tries a little something different in terms of feeding techniques, but the key in the beginning seems to be keeping the mysis suspended so that they look like they are swimming. Eventually, if the dragons accept the frozen mysis, they will learn to pick them up from the bottom.

It should be noted that Leafy seadragons successfully weaned onto frozen mysis shrimp can change their preference without notice. This change can happen for no apparent reason, and has been observed after moving young dragons from quarantine or holding areas the exhibit (Nero 2005). It is always best to have access to a supply of live mysids in the event the dragons choose to refuse the frozen variety.

Two sources for quality frozen *Mysis relicta* are Gamma frozen foods and Piscene Energetics.

Many institutions choose to culture live mysid shrimp to meet the needs of their seadragons. The Toledo Zoo has a successful program for culturing live mysid shrimp, and at one point was feeding their dragons exclusively cultured mysids.(Hemdal, 1999)

The Waikiki Aquarium reports that they feed their dragons live Penaid shrimp, *Penaeus vandemai* (Delbeek 2000).

Behavior and Breeding

The behavior of the Leafy seadragon is fascinating to watch and can be at times surprising. Normally thought of as slow moving animals, drifting in and out of the seaweed, Leafy seadragons are amazingly active. They spend most of their time moving between the blades of artificial kelp in the exhibit, and will occasionally “ride” the current in the aquarium, or “roll” upside down.

As feeding time approaches, the seadragons spend a large part of their time searching the bottom of the exhibit and in between the rocks for food. When cleaning the aquarium glass, or scrubbing the rocks, they often come near the scrub brush or pole and look curiously at it, most likely in the hopes that stirring up the gravel, or scrubbing the algae will uncover a previously undiscovered mysid shrimp. It can potentially be a dangerous curiosity, when cleaning the rocks or kelp could result in a slow moving dragon being trapped under a fallen rock.

Seadragons rarely display aggressive behavior, but in situations where there is a large number, or large- sized individuals in a small space, or where food availability is limited, Leafy seadragons have been observed "shoving" each other around in an effort to remove another individual from the area. This behavior can easily be confused with "dancing" which is described below.

Like other Syngnathids, the male seadragon is responsible for brooding the eggs. Unlike seahorses however, the male Leafy seadragon lacks a brood "pouch", and the eggs are deposited in honeycomb-like indentions under his tail. These indentions develop at some point during the mating season, and will disappear at non-breeding times, making it very difficult to distinguish a male from a female Leafy seadragon. A female seadragon can deposit up to 250 eggs under her mates' tail. The male will fertilize them and hold them for a period of up to eight weeks, at which time they will hatch over a period of a week (Kuiter1988).

One of the most important issues facing public aquariums worldwide is the lack of information regarding the breeding behavior of seadragons. There has been no documented successful reproduction of seadragons in an aquarium environment. Previously, the inability of public institutions to maintain the animals long term has been certainly a contributing factor. Also, due to the difficulty and cost of obtaining the animals, institutions have not obtained large numbers of animals. They have also not experimented a great deal with these animals as they would with other less expensive and readily obtained fish. Another factor that may contribute to the lack of knowledge is that many institutions, with recently obtained animals, have juvenile specimens.

The gender of a seadragon can be difficult to identify, even in adults, but can be near impossible to distinguish in juveniles, making pairing difficult. In adult specimens, it is believed that the female has a deeper abdomen and thinner tail than males (Forsgren 2004). "Scute-like" structures on a female's tail generally appear more pronounced than the male's more rounded appearance. This difference is especially noticeable during breeding season when the male's tail begins to swell to receive eggs. The Seattle Aquarium has been working on a research project that involves collecting fecal samples from juvenile Leafy seadragons and measuring the different hormone levels of these samples for differences based upon sex. It is undetermined whether this method will be a useful way of pairing dragons in the future (Whitney-Robinson 2003).

The behavior classified as "dancing" describes the side- by- side courtship display that is characterized by the dragons swimming in close contact and often in a circular pattern back and forth. This dancing also includes a frequently noted rise to the surface as a pair. Observations of dancing are common among public aquariums displaying dragons, with many of these institutions recording attempted egg transfer.

There have been only a few reports of successful transfer of eggs from female to male Leafy seadragons, and in each of these cases, the eggs have been dropped by the male soon after the transfer without any noticeable development of embryos. In contrast, the Weedy seadragon, *Phyllopteryx taeniolatus,* has successfully reproduced on a number of occasions in public aquariums such as The Aquarium of the Pacific, Long Beach, California and the Tennessee Aquarium, Chattanooga, Tennessee (Forsgren 2004).

It is believed that Leafy seadragons may require a deeper column of water in order to successfully transfer the eggs. In addition, lighting and temperature may also play significant roles.

Disease Prevention, Diagnosis and Treatment

During the past decade prevention, diagnosis and treatment of disease in Leafy seadragons have been some of the greatest challenges in maintaining a successful collection of these animals.

Syngnathids are often sensitive to medications or dosages used to treat other marine teleosts, and often are not subject to the same type of parasitic infestations that commonly plague other marine fish. Prevention of a disease outbreak is the key, and holding the animals off exhibit for observation and quarantine is often the answer.

The Syngnathid Health Management Chapter of the Seahorse Husbandry Manual contains information that has been used by the Shedd Aquarium to quarantine and treat their syngnathid collection (Greenwell 2005). This chapter contains valuable information in terms of disease diagnosis and treatments.

The most common problems reported by institutions displaying Leafy seadragons are ciliated protozoan infestations such as *Uronema spp*., *Mycobacterium spp*. infections, and buoyancy problems related to stress, injury or disease. Infestations of internal parasites such as nematodes and trematodes have been less commonly reported, but do occur.

Good husbandry practices, adequate diet and minimal environmental stress such as temperature or lighting changes can help to prevent the problems described above.

In the event that a disease or parasitic outbreak is suspected, always consult with a veterinarian prior to administering any treatment.

Several institutions have reported success in treating ciliated protozoan infestations with formalin either in a long term bath or as a short dip. Generally the formalin is used in a lower dose than with most teleosts, and for a shorter duration. The Tennessee Aquarium uses formalin in a long term bath at 25 ppm. This is a 24 hour bath for 4-7 days with water changes between doses (Alford 2005). The Shedd Aquarium reports using formalin in a 10 minute dip at 200 ppm (Greenwell 2005).

In addition, hyper-salinity has been used to reduce problems with ciliates. The Tennessee Aquarium keeps the salinity in their seadragon systems at 36-39 ppt (Alford 2005).

Adequate UV sterilization and preventative antibiotic treatment may help in the prevention of *Mycobacteria* infections. The Dallas World Aquarium uses a mixture of rifampin and minocycline antibiotics on a quarterly basis as a food additive to help in the prevention of this disease. The antibiotic is added to a mixture of RO water and live *Artemia* nauplii. The nauplii are allowed to soak in the antibiotics for up to 20 minutes, the entire mixture is then poured into the container with live *Mysidopsis bahia* that are being acclimated to the colder system water. After approximately 30 minutes the mysid shrimp have become "gut loaded" with the medicated nauplii and are fed to the seadragons. The sudden onset of buoyancy related problems in Leafy seadragons can be caused by environmental stress such as aggression, lighting or temperature changes, or extensive breeding behavior. Additionally, intestinal blockages or disease can cause a seadragon to float abnormally at the surface, or sink to the bottom of the aquarium. Generally the problem occurs when the airbladder becomes over or under inflated.

Aquarium veterinarians and biologists have tried a number of different methods to treat these problems. Placing the dragon into a container and sinking it to the deepest part of the exhibit has been successful, on occasion, especially when the problem is due to a sudden stress such as lighting changes or stress during exhibit cleaning.

For suspected intestinal blockages, a low salinity bath (roughly 16 ppt for 10 min – 1 hr) can be used to help the seadragon pass a foreign object such as a rock, or a particularly large fecal mass.

If antibiotics or other medications are chosen to treat a buoyancy problem, the dragon can be weighed by removing it from the water and placing it on a scale directly, or by weighing the dragon in a container with water. (The dry method may be more accurate) (Gomezjurado 2005; Verdugo 2005).

If the buoyancy issue cannot be immediately resolved, a number of institutions report that they have been able to reverse the condition with the use of acetazolamide or ceftazidime via injection. Also, tapping the airbladder and removing the excess air, followed by treatment with an antibiotic such as ceftazidime is also recommended (Greenwell 2002; Verdugo 2005).

If a seadragon is not eating (which is often the case with the conditions mentioned above) tube feeding can be an effective way to keep it from becoming anorexic. A variety of tubing methods and formulas are used. Most institutions report using a mixture of frozen or live mysid shrimp, (or other fish meals) blended with a 2.5% dextrose solution and fed through the snout via a tube into the stomach. A small diameter catheter such as a cat catheter, or butterfly catheter works well. This method is best performed while gently holding the dragon's snout underwater to reduce air intake into the gut. The length of the catheter should be measured prior to the feeding to ensure proper placement into the stomach, which is just past the bend of the neck. Depending on the size of the seadragon, small amounts of the gruel should be given (.02- .25 cc). This procedure can be used daily and can also be an effective way of introducing antibiotics or anti-parasitic medications (Robertson 2005).

The treatment of disease in Leafy seadragons is still very much a process of trial and error. With continued collaboration and communication between institutions displaying Leafy seadragons, the future looks promising.

Collection Management

Following, is a quote from Dr. Rod Connolly, Senior Lecturer in Marine Ecology, School of Environmental and Applied Sciences, Griffith University, Queensland Australia. Rod has been researching the behavior of Leafy seadragons in their natural environment for many years.

"Leafy seadragons are iconic in southern Australian waters, and are a flagship species of conservation programs and the creation of marine protected areas. Their conservation status is unknown because population trends have not been measured. Threats from human activities include incidental catch during commercial trawl fishing and the loss and degradation of habitat from pollution" (Connolly 2005).

Should public aquariums become successful in breeding Leafy seadragons, a collection management plan will become an important tool in future cooperative breeding efforts. It is important at this point that accurate, detailed records of acquisition be maintained. It is unknown if there is a large degree of genetic variation in wild Leafy seadragons due to their limited geographical range and mating habits. Since many institutions begin their collections with young of the year siblings, and collection of specimens from the wild is either entirely prohibited or extremely limited, exchange of adults from different year classes may be necessary in order to maintain genetic strength of captive species.

As aquarium scientists, we have an incredible opportunity to gather information and collaborate with other scientists working with Leafy seadragons around the world. This sharing of information will prove to be invaluable as we endeavor to ensure the survival of seadragon species both in their natural environment and in our aquarium collections.

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Table 2: System Parameters Of Institutions Reporting Leafy Seadragon Breeding Behavior

INSTITUTION	BEHAVIOR/ FREQUENCY	EGG PRODUCTION?/ TRANSFER TO MALE?	SYSTEM SIZE LxWxH(m)/volume (l)	TEMPERATURE/ VARIATION SEASONALLY?	LIGHTING VARIATION SEASONALLY?
Dallas World Aquarium	Dancing often, /Males with swollen tails 3 times	7 times/no transfer to male	2.4 m x 1. 5 m x 1.5 m / 7580 liters	15 -17 C /No variations	No lighting variations
Omaha Henry Doorly Zoo	Dancing often, male with swollen tail once	No egg production to date	1.5 m x 1.2 m x 1.8 m / 22,740 liters , back of tank goes down 3.0 m, 2/3 off exhibit	17 C/ No variations	No lighting variations
Zoo Basel, Switzerland	Possibly observing dancing occasionally	No egg production at this time	Oval shaped /1420 liters	18 -19.5 C normally/ varies seasonally from 16 - 22 C	No lighting variations
Underwater World Perth, Australia	Dancing, males' tails swollen /once a year	3 times/ no transfer to males	1.8 m x 2.1 m x 2.5 m /9500 liters	16 -17 C/No seasonal variation	No lighting variations
Underwater World Singapore	Dancing, frequently, males with swollen tails	3 times/no transfer to male	1.7 m x .75 m x 1.15 m/ 1472 liters 1.7 m x .75 x .65 m/ 832 l	18 C/ No seasonal variation	No lighting variations
Tokyo Sealife Park, Japan	Dancing frequently, males with swollen tails	2 times/ no transfer to male	1.5m x 1.5 m x 1.4 m / 3157 liters	14- 17 C/ Occasional temperature variations	Gradual lighting changes
Toba Aquarium, Japan	Dancing frequently	14 times/ one transfer, dropped eggs	2.0 m x 1.0 m x 1.6 m / 3200 liters	information not available	information not available
Oceanario de Lisboa, Portugal	Males with red tails	3 times/ no transfer to males	Holding: 3m x 1.2m x 1m/4000 liters Exhibit Cylinder 1m D, 2 m H	15 C/ No seasonal variation	Holding exposed to natural light with seasonal variations, exhibit, no variations

<u>Snipefish, *Macrorhamphosus sp.*</u>

2005
Jay Hemdal (Toledo Zoo; jay.hemdal@Toledozoo.org)

Animal Description

The long-nosed schooling fish in the family Macrorhamphosidae are an enigma to taxonomists. There does not seem to be firm agreement as to how many species there actually are. Including the related bellowsfish of the genera *Centriscops* and *Notopogon*, (which do not appear in North American aquariums) there are about 11 species (Nelson 1976). The genus *Macrorhamphosus* contains two or more species, (at the very least, there seems to be two species available to aquarists).

Macroramphosus gracilis, the slender snipefish reported to reach a length of 150mm (FishBase 1999) and is found to depths of 350 m. Due to confusion with other species, the range of this fish is uncertain, but may be found worldwide in deep temperate waters. Reports of a snipefish found on the continental slope of the United States may be this species, although most aquarium specimens originate in Japan. A slender species, the dorsal spine is not very prominent and often held flat against the body. This spine does not extend posterior beyond the soft dorsal fin. Coloration is a finely mottled red on the back, shading to pinkish red on the underside. This species exhibits strong schooling behavior, and with enough specimens, in a large enough aquarium, they tend to orient themselves in a close school. These fish are rather easily shocked by rapid changes in light intensity, and moving them from the dark confines of a shipping box into a brightly lit room may prove fatal. Drape their quarantine tank with dark plastic sheeting, and withdraw that a little each day as they acclimate to normal room light levels. This species is also much more sensitive to the movement of people around their aquarium as are *M. scolopax*. Successfully utilizing this species for public exhibit may require an extended period of social acclimation. One technique that can be tried (after the fish are adapted to normal room light levels) is to attach strips of plastic garbage bags to a support near their tank. Then, direct a fan to blow across these strips, giving them more or less constant motion. The snipefish will soon adapt this movement and will hopefully be much less afraid when people subsequently walk by their aquarium. Public displays of these fish should probably incorporate a second panel, separated by an air space, from the main aquarium viewing panel. This may reduce the stress from people tapping the exhibit window.

Macroramphosus scolopax, the Longspine snipefish is reported to reach 200mm, (FishBase 1999) but long-term captives (5+ years) failed to reach even 80mm in length. The distribution of this species is equally uncertain. Most specimens found in public aquariums probably originated in the Eastern Atlantic or Mediterranean Sea. A heavy bodied species, the dorsal spine is very prominent and if not damaged, can extend beyond a line drawn up through the middle of the caudal fin. This species does not seem to have as strong an affinity for schooling with conspecifics as does *M. gracilis*. At times, although normally peaceful, this species has been seen "jousting" with tankmates by trying to intimidate each other with snout thrusts and raising their dorsal spines. Normally a pink or orange color, when frightened or interacting with other snipefish, they develop a faint blotchy coloration on their flanks.

Husbandry Requirements

The basic husbandry requirements of both species are similar. They prefer dimly lit aquariums held at a typical specific gravity of 1.022, a pH above 8.0 and a water temperature of between 52 and 62 degrees Fahrenheit. As with most skittish fish, they may jump out if frightened, so the aquarium should be fitted with a secure cover. Live adult brine shrimp or even live mysid shrimp may be required to elicit a feeding response in newly captured Macrorhamphosids. Once feeding on these items, it is generally a routine matter to switch them over to feeding on frozen mysids and *Euphasia pacifica* krill.

Relevant Contact Information

The captive breeding programs are overseen by:

North America: George Parsons Head of AZA MFTAG Seahorse sub-committee
John G. Shedd Aquarium, 1200 South Lake Shore Drive, Chicago, IL, 60605, USA
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Fax (+31) 10-443-14-31

AZA MFTAG priority species:	Species coordinator	FAITAG priority species	Species coordinator
H. abdominalis	Pam Eby (sailfish@neb.rr.com)	*H. capensis*	Tania Oudegeest (t.oudegeest@rotterdamzoo.nl) Colin Wells (colin.wells@national-aquarium.co.uk)
H. comes *H. erectus*	Scott A. Greenwald (Sgreenwald@mbayaq.org) Jennifer Rawlings (jrawlings@riverbanks.org)	*H. guttulatus*	Neil Garrick-Maidment (neil.seahorses@tesco.net) Robin James (robinJames@merlin-entertainments.com)
H. ingens	Jorge Gomezjurando (jgomezjurado@aqua.org)	*H. hippocampus*	Neil Garrick-Maidment (neil.seahorses@tesco.net) Robin James (robinJames@merlin-entertainments.com)
H. kuda	Devasmita De (dde@sheddaquarium.org)		
H. reidi	Jorge Gomezjurando (jgomezjurado@aqua.org)		
H. zosterae	Lance Ripley (saltwater@auduboninstitue.org)		
Phyllopteryx taeniolatus	Isabel Koch (Isabel.Koch@wilhelma.de)		
Phycodorus eques	Paula Powell (ppshark@aol.com)		

Colin Grist (c.grist@chesterzoo.org) moderates the Syngnathid Discussion Group.

Appendix 1: 2003 AZA Space Survey for Seahorses and Seadragons

Institution	H. adominalis	H. barbouri	H. capensis	H. comes	H. erectus	H. guttulatus
Audubon Aquarium of the Americas		1 unit	1 unit		1 unit	
Beardley Zoological Gardens						
Belle Isle Aquarium / Detroit Zoo			1 unit			
Buffalo Zoo						
Busch Gardens						
Calvert Marine Museum					2 units	
Cleveland Metroparks Zoo						
Colorado's Ocean Journey					1 unit	
Dallas Aquarium at Fair Park	1 unit			1 unit		
Denver Zoo					1 unit	
El Paso Zoo						
Florida Aquarium	1 unit				1 unit	
Fort Wayne Children's Zoo						
Fort Worth Zoo						
Golden Gate Park						
Happy Hollow Zoo						
Henson Robinson Zoo						
Indianapolis Zoo	1 unit				2 units	
John Ball Zoological Gardens						
Living Desert						
Living Seas (The)						
Long Beach Aquarium of the Pacific						
Los Angeles City Zoo					3.3.150	

Los Angeles Zoo						
Maritime Aquarium at Norwalk, CT						
Memphis Zoo						
Milwaukee County Zoo						
Minnesota Zoo			1 unit			
Monterey Bay Aquarium						
Montgomery Zoo						
Mystic Aquarium	3 units				3 units	
National Aquarium (in D.C.?)						
National Aquarium in Baltimore	1 unit	1 unit		1 unit	1 unit	
New Jersey State Aquarium					1 unit	
New York Aquarium						
Newport Aquarium					2 units	
North Carolina Aquarium at Ft. Fisher					4 units	
Oglebay's Good Zoo						
Palm Beach Zoo						
Philadelphia Zoo						
Point Defiance Zoo & Aquarium					in 2003	
Ripley's Aquarium at Myrtle Beach						
Riverbanks Zoological Park					2 - 3 units	
Rosamond Gifford Zoo at Burnet Park					1 unit	
San Antonio Zoo			we have 2 units		possibly 1 unit	
Santa Ana Zoo						
Seattle Aquarium	2 units	1 unit	2 units		1 unit	

Sequioa Park Zoo						
Shark Reef at Mandalay Bay	1 unit					
Silver Springs						
Six Flags World of Adventure	1 unit (holding)					
St. Paul's Como Zoo					possibly 1 unit	
Staten Island Zoo						
Tennesee Aquarium	2 units	1 unit		2 units	1 unit	
Texas State Aquarium					1 unit	
Toronto Zoo						
Vancouver Aquarium Marine Centre						
Virginia Marine Science Museum					1 unit	
Wonders of Wildlife					1 unit	
Audubon Aquarium of the Americas		1 unit		1 unit	2 units	2 units
Beardley Zoological Gardens						
Belle Isle Aquarium / Detroit Zoo						
Buffalo Zoo						
Busch Gardens						
Calbrillo Marine Aquarium		2 units				
Calvert Marine Museum						
Cleveland Metroparks Zoo				1 unit		
Colorado's Ocean Journey						
Dallas Aquarium at Fair Park						1 unit
Denver Zoo						
El Paso Zoo						

Florida Aquarium					1 unit	1 unit
Fort Wayne Children's Zoo						
Fort Worth Zoo						
Golden Gate Park						
Happy Hollow Zoo						
Henson Robinson Zoo						
Indianapolis Zoo	2 units		2 units			2 units
John Ball Zoological Gardens						
Living Desert						
Living Seas (The)				2 units		
Long Beach Aquarium of the Pacific		10.10.300	4.4.120			6.4.200
Los Angeles City Zoo						
Los Angeles Zoo						
Maritime Aquarium at Norwalk, CT						
Memphis Zoo						
Milwaukee County Zoo						
Minnesota Zoo		1 unit				
Monterey Bay Aquarium						
Montgomery Zoo			1 unit			1 unit
Mystic Aquarium						
National Aquarium (in D.C.?)						
National Aquarium in Baltimore		2 units	2 units	2 units	1 unit	2x800 gal 1weedy/1leafy
New Jersey State Aquarium				1 unit		
New York Aquarium						
Newport Aquarium				1 unit	1 unit	1 unit in a year
North Carolina						

Aquarium at Ft. Fisher						
Oglebay's Good Zoo						
Palm Beach Zoo						
Philadelphia Zoo						
Point Defiance Zoo & Aquarium						
Ripley's Aquarium at Myrtle Beach						
Riverbanks Zoological Park						
Rosamond Gifford Zoo at Burnet Park						
San Antonio Zoo						
Santa Ana Zoo						
Seattle Aquarium	1 unit	1 unit	1 unit	1 unit	2 units	1 unit
Sequioa Park Zoo						
Shark Reef at Mandalay Bay					1 unit	
Silver Springs						
Six Flags World of Adventure						
St. Paul's Como Zoo						
Staten Island Zoo						
Tennesee Aquarium	1 unit	2 units	2 units	1 unit	2 units	2 units (ea.)
Texas State Aquarium					2 units	
Toronto Zoo						
Vancouver Aquarium Marine Centre						
Virginia Marine Science Museum						
Wonders of Wildlife						

Appendix 2: Responses from 2005 International Census of Seahorses in Public Aquariums.

Institution	Country	Contact	Email	Species	No. males	No. females	No. juveniles (or unknown)	Breeding (yes/no)	Rearing * (yes/no)
Albuquerque Aquarium	USA	Brian Dorn	bdorn@cabq.gov	*H. kuda*	6	6		no	no
Albuquerque Aquarium	USA	Brian Dorn	bdorn@cabq.gov	*H. reidi*	3	3	3	yes	no
Anglesey Sea Zoo	UK	Karen Tuson	zooteam@angleseyseazoo.co.uk	*H. guttulatus*	0	1	0	no	no
Anglesey Sea Zoo	UK	Karen Tuson	zooteam@angleseyseazoo.co.uk	*H. hippocampus*	3	3	0	Courting	no
Anglesey Sea Zoo	UK	Karen Tuson	zooteam@angleseyseazoo.co.uk	*H. reidi*	1	2	0	yes	no
Anglesey Sea Zoo	UK	Karen Tuson	zooteam@angleseyseazoo.co.uk	*H. whitei*	0	0	1	no	yes
Antwerp Zoo	Belgium	Philippe Jouk	Philippe.Jouk@zooantwerpen.be	*H. capensis*	20	24	14	yes	yes
Aquarium de San Sebastián	Spain	Dr. Amalia Martínez de Murguía	depinvestigacion@aquariumss.com	*H. guttulatus*	14	14	0	no	no
Artis Zoo	Netherlands	Eugene Bruins	e.bruins@artis.nl	*H. barbouri*			36		
Artis Zoo	Netherlands	Eugene Bruins	e.bruins@artis.nl	*H. comes*			3		

Atlantis, Nassau, Bahamas	Bahamas	Dave Wert	Dave.Wert@kerzner.com	*H. reidi*	3	3		yes	ongoing
Audubon Aquarium of the Americas	USA	Suzy Albes	salbes@AudubonInstitute.org	*H. abdominalis*	6	6	18	yes	no
Audubon Aquarium of the Americas	USA	Suzy Albes	salbes@AudubonInstitute.org	*H. erectus*	5	3		yes	yes
Audubon Aquarium of the Americas	USA	Suzy Albes	salbes@AudubonInstitute.org	*H. zosterae*	2	4	7	yes	yes
Blue Planet Aquarium	UK	George Ablett	georgea@blueplanetaquarium.co.uk	*H. capensis*	12	13	0		
Blue Planet Aquarium	UK	George Ablett	georgea@blueplanetaquarium.co.uk	*H. kuda*	3	2	0		
Brookfield Zoo, Chicago	USA	Michael O'Neill	MiONeill@BrookfieldZoo.org	*H. ingens*	0	2	0	no	no
Burgers' Zoo	Netherlands	Max Janse	M.Janse@burgerszoo.nl	*H. erectus*	2	8		no	just started with this species
Chester Zoo	UK	Mike Crumpler	M.crumpler@chesterzoo.org	*H. capensis*	12	13	0	not at present	yes

Chester Zoo	UK	Mike Crumpler	M.crumpler@chesterzoo.org	*H. fuscus ?*	74	92	266	yes	yes
Chester Zoo	UK	Mike Crumpler	M.crumpler@chesterzoo.org	*H. kuda*	74	97	171	yes	yes
Chester Zoo	UK	Mike Crumpler	M.crumpler@chesterzoo.org	*H. reidi.*	15	15	100	yes	no
Cleveland Metroparks Zoo	USA	Nick Zarlinga	njz@clevelandmetroparks.com	*H. abdominalis*				yes	no
Cleveland Metroparks Zoo	USA	Nick Zarlinga	njz@clevelandmetroparks.com	*H. reidi*				no	no
Columbus Zoo and Aquarium	USA	Ramon Villaverde	ramon.villaverde@columbuszoo.org	*H. abdominalis*	4	3	2	no	
Columbus Zoo and Aquarium	USA	Ramon Villaverde	ramon.villaverde@columbuszoo.org	*H. erectus*	10	18		yes	no
Columbus Zoo and Aquarium	USA	Ramon Villaverde	ramon.villaverde@columbuszoo.org	*H. zosterae*		1			
Dallas World Aquarium	USA	Paula Branshaw	Ppshark@aol.com	*H. reidi*	9	6	0	no	no
Dallas Zoo & Dallas Aquarium at Fair Park	USA	Brian Potvin	dallasaq@airmail.net	*H. abdominalis*	11	6		no	

Dallas Zoo & Dallas Aquarium at Fair Park	USA	Brian Potvin	dallasaq@airmail.net	*H. erectus*	3	1		no	
Dallas Zoo & Dallas Aquarium at Fair Park	USA	Brian Potvin	dallasaq@airmail.net	*H. reidi*	3	4		no	
Dallas Zoo & Dallas Aquarium at Fair Park	USA	Brian Potvin	dallasaq@airmail.net	*H. whitei*	3	6		no	
Deep Sea World	UK	Matt Kane	mattkane@deepseaworld.co.uk	*H. kuda*	3	2	0		
Denver Zoo	USA	Rick Haeffner	RHaeffner@denverzoo.org	*H. erectus*	20	20	50	yes	yes
Haus des Meeres-Vienna	Austria	Daniel Abed-Navandi	daniel.abed@haus-des-meeres.at	*H. barbouri*	0	1	0	no	no
Haus des Meeres-Vienna	Austria	Daniel Abed-Navandi	daniel.abed@haus-des-meeres.at	*H. guttulatus*	1	3	0	no	no
Haus des Meeres-Vienna	Austria	Daniel Abed-Navandi	daniel.abed@haus-des-meeres.at	*H. kuda*	1	2	>200	yes	?
Haus des Meeres-Vienna	Austria	Daniel Abed-Navandi	daniel.abed@haus-des-meeres.at	*H. reidi*	2	5	0	yes	?

Indianapolis Zoo	USA	Karen Imboden	kimboden@indyzoo.com	*H. abdominalis*	7	8	71	yes	yes
Indianapolis Zoo	USA	Karen Imboden	kimboden@indyzoo.com	*H. capensis*	1	1		no	
Indianapolis Zoo	USA	Karen Imboden	kimboden@indyzoo.com	*H. erectus*	12	5	23	yes	yes
Indianapolis Zoo	USA	Karen Imboden	kimboden@indyzoo.com	*H. proserus*	9	6		no	
Indianapolis Zoo	USA	Karen Imboden	kimboden@indyzoo.com	*H. reidi*	10	31	54	yes	no
Indianapolis Zoo	USA	Karen Imboden	kimboden@indyzoo.com	*H. zosterea*	7	8	11	yes	yes
Institut oceanographique Paul Ricard	France	Patrick Lelong	plelong@institut-paul-ricard.org	*H. guttulatus*	4	6	0	yes	no
Institut oceanographique Paul Ricard	France	Patrick Lelong	plelong@institut-paul-ricard.org	*H. hippocampus*	0	1	0	yes	no
Jenkinson's Aquarium	USA	Laura Graziano	jenkinsonsaquarium@comcast.net	*H. erectus*	1	0	0	no	no

Jenkinson's Aquarium	USA	Laura Graziano	jenkinsonsaquarium@comcast.net	*H. kuda*	0	3	0	no	no
Jenkinson's Aquarium	USA	Laura Graziano	jenkinsonsaquarium@comcast.net	*H. reidi*	1	1	6	yes	no
Kingdom of the Seas Aquarium	USA	Bobby Curttright	bob_curttright@yahoo.com	*H. abdominalis*	7	4	approx 40	yes	yes
Kingdom of the Seas Aquarium	USA	Bobby Curttright	bob_curttright@yahoo.com	*H. erectus*	3	5	0	no	no
Kingdom of the Seas Aquarium	USA	Bobby Curttright	bob_curttright@yahoo.com	*H. fuscus*	14	13	0	yes	yes
Kingdom of the Seas Aquarium	USA	Bobby Curttright	bob_curttright@yahoo.com	*H. kuda*	14	2	0	no	no
Kingdom of the Seas Aquarium	USA	Bobby Curttright	bob_curttright@yahoo.com	*H. reidi*	4	2	0	no	no
Melbourne Aquarium	Australia	Nick Kirby (Curator)	alisone@underwaterworld.com.au	*H. abdominalis*	10	2		yes	hundred or so
MN Zoo	USA	Dan Peterson	dpeters@mail.mnzoo.state.mn.us	*H. erectus*	19	6	2	yes	yes
MN Zoo	USA	Dan Peterson	dpeters@mail.mnzoo.state.mn.us	*H. reidi*	0	1		no	no

Monterey Bay Aquarium	USA	Jonelle Verdugo	JVerdugo@mbayaq.org	*H. barbouri*	0	10	0	no	yes
Monterey Bay Aquarium	USA	Jonelle Verdugo	JVerdugo@mbayaq.org	*H. breviceps*	5	15	35	yes	yes
Monterey Bay Aquarium	USA	Jonelle Verdugo	JVerdugo@mbayaq.org	*H. erectus*	29	30	20	yes	yes
Monterey Bay Aquarium	USA	Jonelle Verdugo	JVerdugo@mbayaq.org	*H. whitei*	3	9	9	no	no
Museu Municipal do Funchal (História Natural)	Portugal	Ricardo Araújo	ricardo.araujo@cm-funchal.pt	*None*	0	0	0		
National Aquarium in Baltimore	USA	Jorge Gomezjurado	JGomezjurado@aqua.org	*H. erectus (FL)*	24	25	52	yes	yes
National Aquarium in Baltimore	USA	Jorge Gomezjurado	JGomezjurado@aqua.org	*H. ingens*	1	0	0	no	no
National Aquarium in Baltimore	USA	Jorge Gomezjurado	JGomezjurado@aqua.org	*H. kuda*	3	1	0	no	no
National Aquarium in Baltimore	USA	Jorge Gomezjurado	JGomezjurado@aqua.org	*H. reidi*	537	523	1130	yes	yes

National Marine Aquarium Plymouth	UK	Colin Wells	colin.wells@national-aquarium.co.uk	*H. abdominalis*	5	8	0		
National Marine Aquarium Plymouth	UK	Colin Wells	colin.wells@national-aquarium.co.uk	*H. capensis*	2	3	0		
National Marine Aquarium Plymouth	UK	Colin Wells	colin.wells@national-aquarium.co.uk	*H. erectus*	1	7	0		
National Marine Aquarium Plymouth	UK	Colin Wells	colin.wells@national-aquarium.co.uk	*H. hippocampus*	2	2	0		
National Marine Aquarium Plymouth	UK	Colin Wells	colin.wells@national-aquarium.co.uk	*H. kuda*	6	8	0		
National Marine Aquarium Plymouth	UK	Colin Wells	colin.wells@national-aquarium.co.uk	*H. reidi*	15	18	0		
National Marine Aquarium Plymouth	UK	Colin Wells	colin.wells@national-aquarium.co.uk	*H. zosterae*	2	4	0		
Newport Aquarium	USA	Keri Siegert	kpaddock@newportaquarium.com	*H. erectus*	2	2	0	no	no
Newport Aquarium	USA	Keri Siegert	kpaddock@newportaquarium.com	*H. reidi*	1	1	0	no	no

Oceanário de Lisboa	Portugal	Nuria Baylina	nbaylina@oceanario.pt	*H. abdominalis*	12	12	1	yes	yes
Oceanário de Lisboa	Portugal	Nuria Baylina	nbaylina@oceanario.pt	*H. guttulatus*	0	2	0	yes	no
Oklahoma City Zoo & Botanical Gardens	USA	Brian Aucone	BrianA@OKCZOO.com	*H. erectus*	6	5	0	yes	not yet, just born
Oklahoma City Zoo & Botanical Gardens	USA	Brian Aucone	BrianA@OKCZOO.com	*H. kuda*	5	2	0	no	no
Point Defiance Zoo & Aquarium	USA	Chris Spaulding	cspaulding@pdza.org	*H. abdominalis*	4	4	1	yes	no
Point Defiance Zoo & Aquarium	USA	Chris Spaulding	cspaulding@pdza.org	*H. barbouri*	2	2	0	no	
Point Defiance Zoo & Aquarium	USA	Chris Spaulding	cspaulding@pdza.org	*H. capensis*	1	0	0	no	
Point Defiance Zoo & Aquarium	USA	Chris Spaulding	cspaulding@pdza.org	*H. erectus*	5	4	1	yes	no
Point Defiance Zoo & Aquarium	USA	Chris Spaulding	cspaulding@pdza.org	*H. kuda*	6	6	0	no	
Riverbanks Zoo	USA	Melissa Salmon	msalmon@riverbanks.org	*H. abdominalis*	11	7	0	yes	no

Riverbanks Zoo	USA	Melissa Salmon	msalmon@riverbanks.org	*H. reidi*	6	1	0	yes	no
Sea World Australia	Australia	Marnie Horton	Marnie.Horton@wvtp.com.au	*H. kuda*	0	0	5	No	no
SeaLife Biological Services Weymouth	UK	Robin James	RobinJames@merlin-entertainments.com	*H. abdominalis*	0	0	122	yes	
SeaLife Biological Services Weymouth	UK	Robin James	RobinJames@merlin-entertainments.com	*H. barbouri*	0	0	8	yes	
SeaLife Biological Services Weymouth	UK	Robin James	RobinJames@merlin-entertainments.com	*H. comes*	0	0	8	yes	
SeaLife Biological Services Weymouth	UK	Robin James	RobinJames@merlin-entertainments.com	*H. comes x whitei*	0	0	23	yes	
SeaLife Biological Services Weymouth	UK	Robin James	RobinJames@merlin-entertainments.com	*H. guttulatus*	0	0	149	yes	
SeaLife Biological Services Weymouth	UK	Robin James	RobinJames@merlin-entertainments.com	*H. kuda*	0	0	7	yes	
SeaLife Biological Services Weymouth	UK	Robin James	RobinJames@merlin-entertainments.com	*H. reidi*	0	0	80	yes	

SeaLife Biological Services Weymouth	UK	Robin James	RobinJames@merlin-entertainments.com	*H. whitei*	0	0	10	yes	
SeaQuarium@ West Midland Safari Park	UK	Andrea Redfern	ar@wmsp.co.uk	*H. barbouri*	0	0	3	no	no
SeaQuarium@ West Midland Safari Park	UK	Andrea Redfern	ar@wmsp.co.uk	*H. kuda*	4	0	0	no	no
SeaQuarium@ West Midland Safari Park	UK	Andrea Redfern	ar@wmsp.co.uk	*H. reidi*	3	0	0	no	no
Skansen-Akvariet	Sweden	John Hontalas	john.hontalas@skansen-akvariet.se	*H. kuda*	4	2	0	yes	no
South Carolina Aquarium	USA	David Moyer	dmoyer@scaquarium.org	*H. erectus*	3	3	~350 (<2 cm) + 1 (6 cm)	yes	no
Staten Island Zoo	USA	Ken Kawata	KawataSIZ@aol.com	*H. reidi*	0	0	6	no	no
Steinhart Aquarium	USA	Bart Shepherd	bshepherd@calacademy.org	*H. comes*	0	1	0	no	no
Steinhart Aquarium	USA	Bart Shepherd	bshepherd@calacademy.org	*H. reidi*	3	2	~50	yes	no

Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*H. abdominalis*	0	0	94	yes	yes
Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*H. breviceps*	0	0	1	no	no
Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*H. erectus*	0	0	105	yes	yes
Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*H. kuda*	0	0	40	yes	no
Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*H. procerus*	0	0	75	yes	yes
Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*H. reidi*	0	0	53	yes	yes
Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*H. subelongatus*	0	0	6	yes	no
Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*H. zosterae*	0	0	115	yes	yes
The Aquarium at Moody Gardens	USA	Shawna Reiner	sreiner4@yahoo.com	*H. abdominalis*	7	6	0	no	no
The Aquarium at Moody Gardens	USA	Shawna Reiner	sreiner4@yahoo.com	*H. barbouri*	0	1	0	no	no
The Aquarium at Moody Gardens	USA	Shawna Reiner	sreiner4@yahoo.com	*H. capensis*	0	1	0	no	no

The Aquarium at Moody Gardens	USA	Shawna Reiner	sreiner4@yahoo.com	*H. erectus*	9	4	0	no	no
The Aquarium at Moody Gardens	USA	Shawna Reiner	sreiner4@yahoo.com	*H. kuda*	?	?	12	no	no
The Aquarium at Moody Gardens	USA	Shawna Reiner	sreiner4@yahoo.com	*H. procerus*	0	1	0	no	no
The Aquarium at Moody Gardens	USA	Shawna Reiner	sreiner4@yahoo.com	*H. reidi*	10	5	18	Newly acquired but were breedin g at previous location.	no
The Deep, Hull	UK	Katy Rigby	Katy.Rigby@thedeep.co.uk	*H. fuscus*	2	3	0	no	no
The Deep, Hull	UK	Katy Rigby	Katy.Rigby@thedeep.co.uk	*H. kuda*	1	1	8	yes	yes
The Maritime Aquarium, CT, USA	USA	Kerry Dobson	kdobson@maritimeaquarium.org	*H. erectus*	11	7	20	yes	yes
the National Aquarium of New Zealand	New Zealand	Kerry Hewitt	kerry@national aquarium.co.nz	*H. abdominalis*	6	11	0	No, due to breedin g plan	

Toledo Zoo	USA	Jay Hemdal	jay.hemdal@toledozoo.org	*H. abdominalis (bleekeri?)*	4	2	0	no	no
Toledo Zoo	USA	Jay Hemdal	jay.hemdal@toledozoo.org	*H. erectus*	2	1	0	yes	yes
Tulsa Zoo	USA	Gary Lunsford	AndrewBranson@CityofTulsa.org	*H. erectus*	2	6		no	no
Underwater World Hastings	UK	Dan Davies	curator@discoverhastings.co.uk	*H. barbouri*	1	0	0		
Underwater World Hastings	UK	Dan Davies	curator@discoverhastings.co.uk	*H. erectus*	3	3	0		
Underwater World Hastings	UK	Dan Davies	curator@discoverhastings.co.uk	*H. hippocampus*	2	2	0	yes	no
Vancouver Aquarium Marine Science Centre	Canada	Erika Paradis	Erika.Paradis@vanaqua.org	*H. abdominalis*	12	18	0	yes	yes
Veracruz Aquarium	Mexico	Antonio Martinez	caballitosdemar@acuariodeveracruz.com	*H. erectus*	145	120	0	yes	yes
Wildwalk @Bristol	UK	Marie Orchard	marie.orchard@at-bristol.org.uk	*H. reidi*	0	0	4	no	no
Zoo Vienna	Austria	Ekkerhard Wolf	ewolff@zoovienna.at	*None*	0	0	0		

Zoological Society of London	UK	Heather Koldewey	heather.koldewey@zsl.org	*H. fuscus*	1	9	0	yes	no
Zoological Society of London	UK	Heather Koldewey	heather.koldewey@zsl.org	*H. kuda*	5	5	12	yes	yes
Zoological Society of London	UK	Heather Koldewey	heather.koldewey@zsl.org	*H. reidi*	148	145	0	yes	no
Zoomarine	Portugal	Bernardo Nascimento	aquario@zoomarine.pt	*H. guttulatus*	1	0	0	no	no

*Rearing is defined as offspring reaching reproductive age

Appendix 3: Responses from 2005 International Census of Seadragons in Public Aquariums.

Institution	Country	Contact	Email	Species	No. males	No. females	No. juveniles (or unknown)	Breeding (yes/no)	Rearing* (yes/no)
National Aquarium in Baltimore	USA	Jorge Gomezjurado	JGomezjurado@aqua.org	*Phycodurus eques*	3	6	0	no	no
Toldeo Zoo	USA	Jay Hemdal	jay.hemdal@toledozoo.org	*P. eques*	0	0	4	no	no
Toldeo Zoo	USA	Jay Hemdal	jay.hemdal@toledozoo.org	*Phyllopteryx taeniolatus*	2	0	0	no	no
Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*P. taeniolatus*	0	14	0	yes	yes
Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*P. eques*	0	6	5	no	no
Oceanário de Lisboa	Portugal	Nuria Baylina	nbaylina@oceanario.pt	*P. eques*	0	0	8	no	no
Oceanário de Lisboa	Portugal	Nuria Baylina	nbaylina@oceanario.pt	*P. taeniolatus*	1	1	0	no	no
Point Defiance Zoo & Aquarium	USA	Chris Spaulding	cspaulding@pdza.org	*P. taeniolatus*	0	0	2	no	
Point Defiance Zoo & Aquarium	USA	Chris Spaulding	cspaulding@pdza.org	*P. eques*	0	0	3	no	
Kingdom of the Seas Aquarium	USA	Bobby Curttright	bob_curttright@yahoo.com	*P. eques*	1	0	2	no	no

Kingdom of the Seas Aquarium	USA	Bobby Curttright	bob_curttright@yahoo.com	*P. taeniolatus*	0	0	2	no	no
Melbourne Aquarium	Australia	Nick Kirby	alisone@underwaterworld.com.au	*P. eques*	1	1	5	no	no
Melbourne Aquarium	Australia	Nick Kirby	alisone@underwaterworld.com.au	*P. taeniolatus*	4	4	0	yes	no
Columbus Zoo and Aquarium	USA	Ramon Villaverde	ramon.villaverde@columbuszoo.org	*P. taeniolatus*	0	0	3	no	
Monterey Bay Aquarium	USA	Jonelle Verdugo	JVerdugo@mbayaq.org	*P. eques*	0	0	7	no	no
Audubon Aquarium of the Americas	USA	Suzy Albes	salbes@AudubonInstitute.org	*P. taeniolatus*	0	0	4	no	
Audubon Aquarium of the Americas	USA	Suzy Albes	salbes@AudubonInstitute.org	*P. eques*	0	0	3	no	
Indianapolis Zoo	USA	Karen Imboden	kimboden@indyzoo.com	*P. eques*	0	0	2	no	
Dallas World Aquarium	USA	Paula Branshaw	Ppshark@aol.com	*P. eques*	4		8 juv, 7 unk		
Aquarium of the Americas (being held at Dallas World Aquarium)	USA	Paula Branshaw	Ppshark@aol.com	*P.eques*	0	0	3		

Aquarium of the Americas (being held at Dallas World Aquarium)	USA	Paula Branshaw	Ppshark@aol.com	*P. taeniolatus*	0	0	4		
MN Zoo	USA	Dan Peterson	dpeters@mail.mnzoo.state.mn.us	*P. taeniolatus*			5	no	no

*Rearing is defined as offspring reaching reproductive age

Appendix 4: Responses from 2005 International Census of Other Syngnathids in Public Aquariums.

Institution	Country	Contact	Email	Species	No. males	No. females	No. juveniles (or unknown)	Breeding (yes/no)	Reari * (yes/
Albuquerque Aquarium	USA	Brian Dorn	bdorn@cabq.gov	*Syngnathus scovelli*	1	2	0	no	
Aquarium of the Bay San Francisco CA	USA	Allison Pizel	allisonp@aquariumofthebay.com	*Syngnathus leptorhynchus*	5	11	45	yes	yes
Artis Zoo	Netherlands	Eugene Bruins	e.bruins@artis.nl	*Aeoliscus strigatus*	0	0	17		
Artis Zoo	Netherlands	Eugene Bruins	e.bruins@artis.nl	*Corythoichthys intestinalis*	0	0	1		
Artis Zoo	Netherlands	Eugene Bruins	e.bruins@artis.nl	*Doryichthys boaja*	0	0	25+		
Artis Zoo	Netherlands	Eugene Bruins	e.bruins@artis.nl	*Doryramphus multiannulatus*	0	0	0		
Artis Zoo	Netherlands	Eugene Bruins	e.bruins@artis.nl	*Doryrhamphus excisus*	0	0	1		
Artis Zoo	Netherlands	Eugene Bruins	e.bruins@artis.nl	*Dunkerocampus dactyliophorus*	0	0	1		
Artis Zoo	Netherlands	Eugene Bruins	e.bruins@artis.nl	*Entelurus aequarus*	0	0	1		
Artis Zoo	Netherlands	Eugene Bruins	e.bruins@artis.nl	*Syngnathus acus*	0	0	7		
Audubon Aquarium of the Americas	USA	Suzy Albes	salbes@AudubonInstitute.org	*Doryrhamphus dactyliophorus*	1	1	3	yes	no
Audubon Aquarium of the Americas	USA	Suzy Albes	salbes@AudubonInstitute.org	*Doryrhamphus janssi*	0	0	3		
Audubon Aquarium of the	USA	Suzy Albes	salbes@AudubonInstitute.org	*Doryrhamphus melanopleura*	0	0	3		

Americas									
Audubon Aquarium of the Americas	USA	Suzy Albes	salbes@AudubonInstitute.org	*Doryrhamphus pessuliferus*	0	0	3	no	
Chester Zoo	UK	Mike Crumpler	M.crumpler@chesterzoo.org	*Doryichthys boaja*	1	4	1	yes.	no
Chester Zoo	UK	Mike Crumpler	M.crumpler@chesterzoo.org	*Doryichthys martensii*	0	2	0	no	no
Cleveland Metroparks Zoo	USA	Nick Zarlinga	njz@clevelandmetroparks.com	*Doryrhamphus dactyliophorus*				no	no
Cleveland Metroparks Zoo	USA	Nick Zarlinga	njz@clevelandmetroparks.com	*Doryrhamphus janssi*				no	no
Dallas World Aquarium	USA	Paula Branshaw	Ppshark@aol.com	*Halliichthys taeniophora*	0	1	2		
Dallas Zoo & Dallas Aquarium at Fair Park	USA	Brian Potvin	dallasaq@airmail.net	*Corythoichthys intestinalis*	0	1	0	no	
Dallas Zoo & Dallas Aquarium at Fair Park	USA	Brian Potvin	dallasaq@airmail.net	*Doryrhamphus dactyliophorus*	0	0	1	no	
Dallas Zoo & Dallas Aquarium at Fair Park	USA	Brian Potvin	dallasaq@airmail.net	*Doryrhamphus excisus*	1	1	0	no	
Dallas Zoo & Dallas Aquarium at Fair Park	USA	Brian Potvin	dallasaq@airmail.net	*Syngnthus biaculeatus*	0	0	1	no	
Haus des Meeres-Vienna	Austria	Daniel Abed-Navandi	daniel.abed@haus-des-meeres.at	*Syngnthus biaculeatus*	1	0	0	no	no
Indianapolis Zoo	USA	Karen Imboden	kimboden@indyzoo.com	*Syngnathus scovelli*	6	2	33	yes	yes

Institut oceanographique Paul Ricard	France	Patrick Lelong	plelong@institut-paul-ricard.org	*Syngnathus typhle*	1	3	0	yes	yes
Jenkinson's Aquarium	USA	Laura Graziano	jenkinsonsaquarium@comcast.net	*Syngnathus fuscus*	0	0	4	no	no
L'Oceanogràfic de Valencia	USA	Pablo Areitio	pareitio@oceanografic.org	*A. chinensis*	0	0	1	no	no
Monterey Bay Aquarium	USA	Jonelle Verdugo	JVerdugo@mbayaq.org	*Syngnathus leptorhynchus*	0	0	27	no	no
Monterey Bay Aquarium	USA	Jonelle Verdugo	JVerdugo@mbayaq.org	*Syngnathus scovelli*	0	0	1	no	no
Newport Aquarium	USA	Keri Siegert	kpaddock@newportaquarium.com	*Syngnathus scovelli*	0	0	5		
Oceanário de Lisboa	Portugal	Nuria Baylina	nbaylina@oceanario.pt	*Doryrhamphus janssi*	1	0	0	no	no
Oceanário de Lisboa	Portugal	Nuria Baylina	nbaylina@oceanario.pt	*Doryrhamphus pessuliferus*	2	2	0	no	no
Point Defiance Zoo & Aquarium	USA	Chris Spaulding	cspaulding@pdza.org	*Doryrhamphus pessuliferus*	0	0	1	no	
South Carolina Aquarium	USA	David Moyer	dmoyer@scaquarium.org	*Sygnathus spp.*	0	0	1	no	no
South Carolina Aquarium	USA	David Moyer	dmoyer@scaquarium.org	*Syngnathus fuscus*	0	0	22	no	no
South Carolina Aquarium	USA	David Moyer	dmoyer@scaquarium.org	*Syngnathus pelagicus*	0	0	4	no	no
South Carolina Aquarium	USA	David Moyer	dmoyer@scaquarium.org	*Syngnathus springeri*	0	0	15	no	no
Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*Doryrhamphus dactyliophorus*	0	0	1	no	no
Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*Doryrhamphus excisus*	0	0	2	no	no
Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*Syngnathus fuscus*	0	0	1	no	no

Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*Syngnathus scovelli*	0	0	6	yes	yes
Tennessee Aquarium	USA	Kathlina Alford	katsseahorses@yahoo.com	*Syngnthus biaculeatus*	0	0	6	no	no
The Aquarium at Moody Gardens	USA	Shawna Reiner	sreiner4@yahoo.com	*Corythoichthys haematopterus*	0	0	2	no	no
The Aquarium at Moody Gardens	USA	Shawna Reiner	sreiner4@yahoo.com	*Doryrhamphus excisus*	0	0	2	no	no
The Aquarium at Moody Gardens	USA	Shawna Reiner	sreiner4@yahoo.com	*Syngnathus louisianae*	0	0	1	no	no

*Rearing is defined as offspring reaching reproductive age