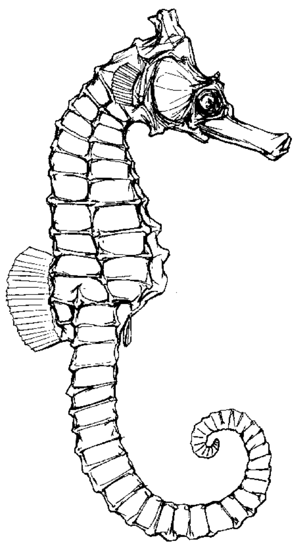
TECHNICAL REPORT SERIES

No. 4

MEASURING SEAHORSES

Sara Lourie



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PROJECT SEAHORSE TECHNICAL REPORT NO. 4: MEASURING SEAHORSES

1. Introduction

Size is a very important biological variable and measuring the sizes of focal organisms is a vital part of studies on growth and reproduction, ecology, behaviour, habitat selection, the effects of tagging or other experimental manipulations, as well as for systematics, population assessments and constructing fisheries models. For studies to be repeatable and comparable it is essential that specimens be measured using standard methods. The unusual shape of seahorses however, creates challenges when it comes to defining a standard method of measuring them (Howe 2002). Furthermore, a protocol for live specimens may not work well with dead ones and vice versa, since seahorses can be moved when alive, but when dead they are often stiff, and curled up to different degrees.

Different studies often need measurements for different reasons. This can affect the level of precision required, and trade-offs between accuracy, precision, and the time taken for the measurements often need to be balanced. In some cases, a single measurement from each animal might be sufficient (e.g. in population assessments, or fisheries models). In others, many measurements need to be taken (e.g. in systematics, or allometry studies). Ideally it would be useful to be able to convert measurements e.g. between live and dried specimens, or from height to standard length to allow for comparisons across a wide range of studies.

In the following report I explore the effects of measurements taken in different ways, and provide recommendations for taking measurements both in the field or lab with live seahorses, and *ex situ* with dead ones, for a wide range of studies. Given the potential confusion arising from the variety of measurements that can be taken and have been taken in the past, it is important when reporting seahorse size to be extremely clear in explaining the exact method used (a diagram may be helpful).

2. Parts of a Seahorse

Seahorses (genus *Hippocampus*) have a very unusual body shape, immediately distinguishable from other fish, but relatively similar across species within the genus. Their head is bent, almost at right angles to their body (but still mobile in a vertical plane), their trunk is inherently curved and their fin-less tail is prehensile (grasping). They have no scales, few fins, no ribs and a thick external skeleton. These features mean that many of the traditional morphometric measurements taken on fish are hard to apply to seahorses. On the other hand, their bony 'external skeleton' provides a wonderful opportunity; dried specimens can be used for investigation since their rigidity ensures that there is only minimal shape/ size change after death. It also allows the possibility of directly comparing live and preserved specimens.

A seahorse's body is covered by bony plates (Ginsburg 1937) that appear externally as a series of ridges (running anterior-posteriorly) and rings (running dorsal-ventrally and laterally) (Figure 1a). The body can also be divided into three main sections: head, trunk, and tail. The head is from the tip of the snout to the cleithral ring. The trunk is from the cleithral ring to the last trunk ring, which can be identified as the last one that extends to the inferior trunk ridge. The tail is the rest of the seahorse, posterior to the last trunk ring, and is four-sided as opposed to the seven-sided trunk. The points where the rings and ridges intersect are often raised to form bumps, tubercles (particularly large rounded bumps) or spines.

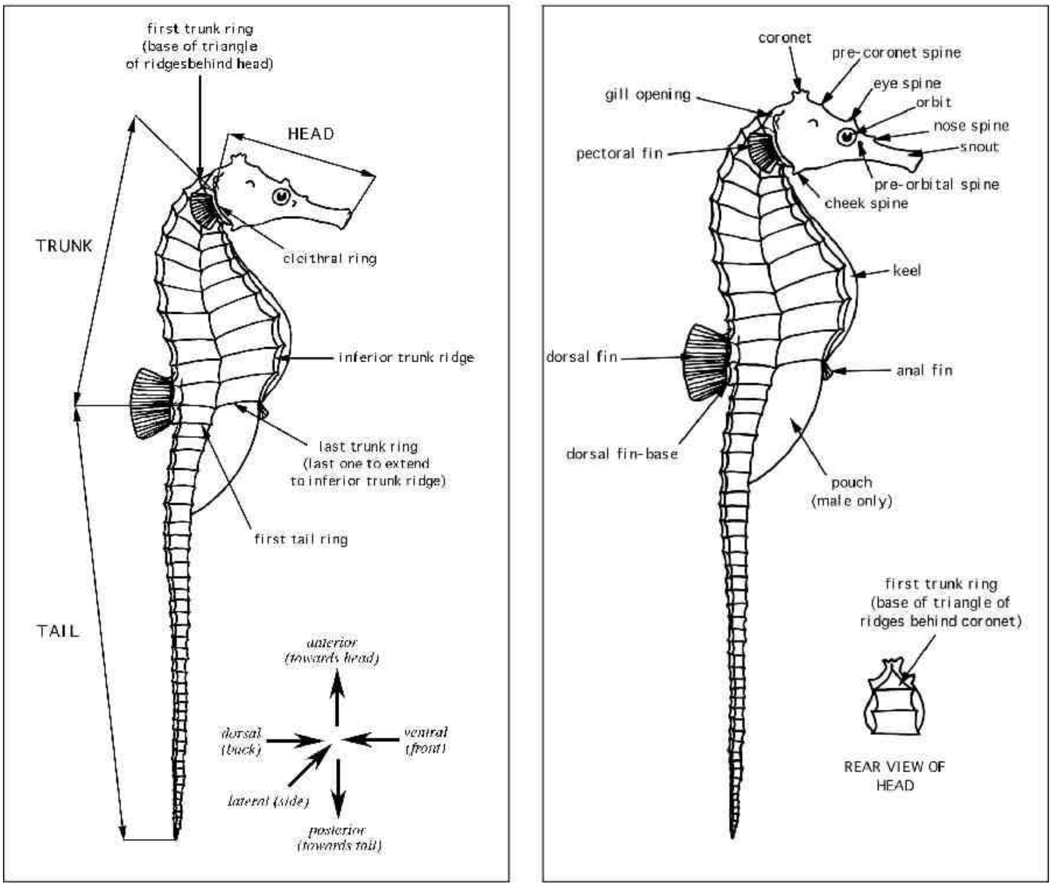

Figure 1a, b. Parts of a seahorse (after Lourie *et al.* 1999).

Other parts of a seahorse that are important to note for identification purposes, and as reference points for measurements (especially for systematic studies on dead specimens) include: snout, nose spine, pre-orbital spine, eye spine, cheek spine, pre-coronet spine, coronet, gill opening, pectoral fin, dorsal fin, dorsal fin base, anal fin, keel, pouch (in males only) (Figure 1b). Definitions of some of these are given below:

Mid-point of cleithral ring: the incomplete bony ring immediately posterior to the operculum (gill cover). The cleithrum is the underlying bone. The approximate mid-point is visible as the junction of the ring with a diagonal ridge that runs from the dorsal spine of the on the first trunk ring.
First trunk ring: the first complete body ring, easily identified as it forms the base of a triangle of ridges on the dorsal surface immediately posterior to the head.
Last trunk ring: the last complete body ring, immediately anterior to the anal fin. It is also the last ring to extend to the inferior trunk ridge, and to bear an inferior trunk spine. The lateral mid-point is the junction of this ring with the lateral trunk ridge.

3. Length Measurements

One of the most commonly reported measurements in fish studies is standard length (SL). Since other body measurements are often reported as a proportion of standard length it is important that SL be measured in an unambiguous and repeatable fashion. SL is usually defined as the tip of the snout to the hypural joint (at the base of the caudal fin) (Howe 2002). In seahorses this definition is hard to apply, because of the right-angled bend between the head and the trunk, and also because of the inherent curvature of the trunk.

Standard length has been defined for seahorses as the sum of the head length (HL) + trunk length (TrL) + tail length (TaL), using a curved measurement of trunk length from the mid-cleithral ring to the last trunk ring (Lourie *et al.* 1999a). Other studies, particularly with live seahorses or in a field situation (e.g. Perante *et al.* 2002), have used the same composite measure for SL. However they tend to use a straight-line measurement between the mid-cleithral ring (with the head held at right angles to the body) and the last trunk ring as trunk length. These two methods will give different values for SL. However, it should be possible to create a regression equation to convert from one to the other for comparative purposes.

Another size measurement commonly applied to seahorses is height (HT), particularly when live or in a field situation. This measurement is defined as the vertical distance from the tip of the coronet, to the tip of the outstretched tail, with the head held at right angles to the body (Lourie *et al.* 1999b). HT is the most intuitive way to represent seahorse size but can be quite imprecise because it is very dependent upon the angle of the head, and is difficult to measure on a dried seahorse that cannot be straightened.

Other workers have used different definitions for length measurements. For example: total length (TL) as a straight-line measurement from the gill opening to the tip of the extended tail (Vari 1982; Gomon 1997), or from the 'curved part of the trunk' [first trunk ring?] to the tip of the outstretched tail (Kuiter 2001), or from the median groove of the coronet to the lowermost part of the curved tail (Ginsburg 1937). The latter two methods I strongly advise against, as they are very dependent upon how curled the seahorse is.

The difference between using the posterior margin of the gill opening (B), the first trunk ring (C) or the mid-point of the cleithral ring, (D), as the anterior-most reference point (Figure 2) for a straight-line measurement of trunk length, total length or part of standard length is negligible in comparison to measurement error (unpublished data), but their accuracy varies widely depending on the angle of the head (unpublished data). The measurement that is least affected by the angle of the head is that which uses the first trunk ring as the anterior-most reference point. However, if it is possible to manipulate the seahorse's head to be as close to right angles to its body, any of these three reference points will give approximately the same results. Overall the measurement that is least affected by different angles of the head is the curved trunk measurement (E) using the mid-point of the cleithral ring as the anterior-most reference point. Thus, this method is the best option when dealing with dried, immobile specimens. The curved measurement is also the most repeatable and precise (unpublished data), but is not practical for working with live animals. As mentioned previously, the curved measurement will result in a significantly different value for trunk length (and therefore standard length) than the straight-line measurement. The median groove of the coronet (A) was included here for completeness. It is used as the anterior-most reference point for height, but is not used for trunk length, standard length or total length.

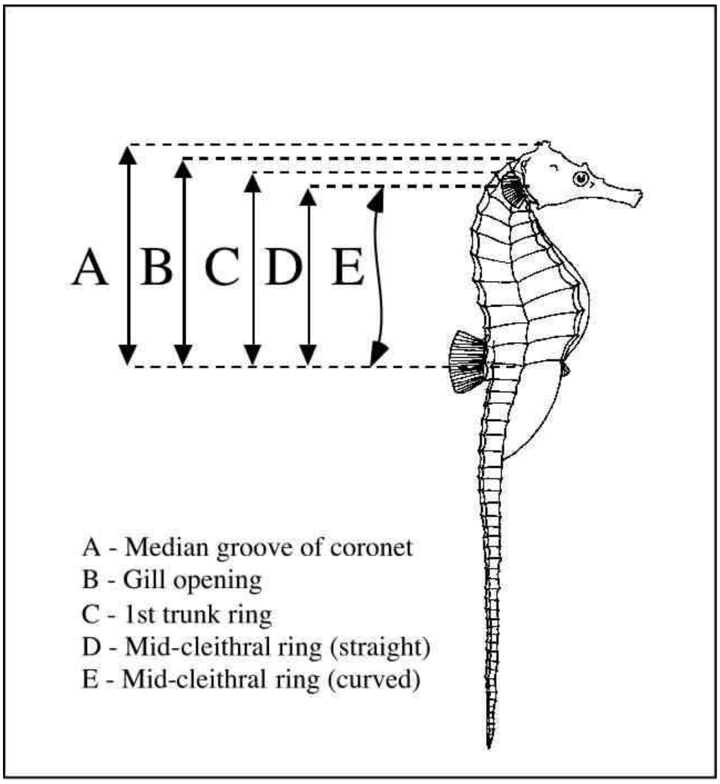

Figure 2. Various trunk length measurements that have been taken on seahorses

Once again, it is very important to understand the differences among the various measurements, and to be extremely clear when reporting length measurements for seahorses. Different studies have different needs and constraints when measuring specimens, thus different methods may be employed but it is important that they are reported in such a way that it is clear precisely which method (e.g. straight-line or curved) and which reference points were used to define the measurements.

4. Measuring Live Seahorses

When measuring live seahorses it is important to try to minimise stress to the animal. Taking only a few measurements will reduce handling time, and keeping the seahorse in the water will also reduce stress. However the goal of the study should be kept in mind, and a balance must be struck between speed and precision. Measurements taken underwater may be less stressful for the seahorse, but they are sometimes more difficult for researchers to execute, especially without SCUBA equipment. If measurements are taken above water, a bucket or large tub can be used to submerge the seahorse in. This is particularly important in hot, sunny weather where a seahorse can dry out in a few minutes. Be sure to change the water frequently to ensure that it remains cool and well aerated.

Most of the measurements outlined in the protocol at the end of this report can be taken on live seahorses as well as dead ones although there may be some loss of precision. In most studies involving live seahorses however, it is not necessary to include all these measurements and many studies use only some combination of head length, trunk length (straight-line) and height. The most important difference between live and dead protocols is the use of a straight-line versus curved trunk measurement, since it is not practical, in terms of excessive handling and time, to take curved trunk measurements on live seahorses.

With a live seahorse it is usually possible to gently move its head so that it is at right angles to its body, and to stretch out its tail. The simplest method to then measure the seahorse is to hold it against a ruler, clipboard or slate with the thumb of one hand, and use the other hand to stretch the seahorse out. The measurements (e.g. HT, HL, TrL (straight-line) or TaL) can either be noted directly from the ruler, or pencil marks can be made on the slate for later measurement with a ruler or callipers. Having a second person can help here with one person holding the seahorse, and the other measuring. Alternatively the seahorse can be held in one hand and measurements (e.g. HL, TrL (straight-line) or TaL) can be made with a clear ruler or callipers. Since many seahorses are larger than a person's hand when fully stretched out, this method can not be easily used for HT. When measuring TaL I have found it helpful to turn the seahorse upside-down and stretch its tail out along my thumb. If seahorses are reluctant to stretch out, tickling their tail can often encourage them to relax. Seahorses in the wild are frequently observed to have damaged tail tips. For these individuals, HT and TaL cannot be taken. For this reason measuring TrL as a matter of course can allow the missing values to be estimated later using a regression analysis.

For researchers who are unused to dealing with lots of pieces of equipment underwater, the ruler, or ruler mounted on a clipboard methods might be simpler to use than callipers. In terms of equipment, plastic callipers are preferable to metal ones for using near water or underwater. Although plastic callipers can be slightly less precise, this loss of precision is usually negligible in comparison to measurement error, and they do not rust. Callipers are more precise than a ruler marked in mm, but again this should be weighed against ease of measuring and the final goal of the study.

Measurements commonly taken on live seahorses:

- **Height (HT)**: vertical distance from the median groove at the tip of the coronet, to the tip of the outstretched tail, with the head held at right angles to body.
- **Head Length (HL)**: distance from the tip of the snout (upper jaw) to the mid-point of the cleithral ring.
- **Trunk Length (TrL-straight line)**: straight-line distance from the mid-point of the cleithral ring to the mid-point of the last trunk ring (that immediately above the anal fin and the last to extend to the inferior trunk ridge) with the head at right angles to the body.
- **Tail Length (TaL)**: distance from the mid-point of the last trunk ring, to the tip of the outstretched tail.
- **Pouch dimensions** (Figure 3):
  Length: diagonal distance from the anal fin to the point where the pouch joins the tail
  Depth: greatest distance from the inferior tail ridge to the midline of the pouch (difficult on non-pregnant specimens)
  Width: greatest distance from one side of the pouch to the other

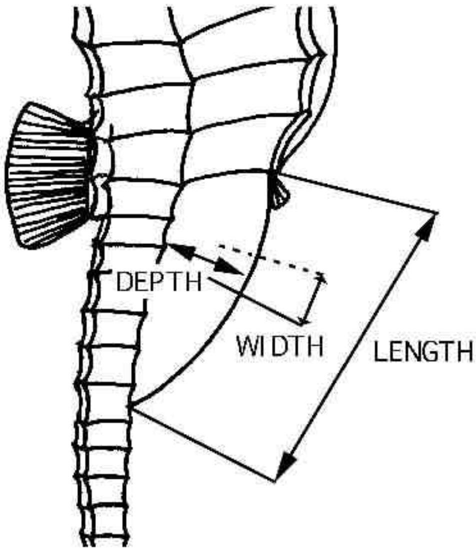

Figure 3. Definitions of pouch dimensions.

- **Reproductive state** (Vincent 1990):
  Male: 0 – just given birth, pouch flabby; 1 – pouch empty, pouch flat; 2 – pregnant, pouch rounded; 3 – about to give birth, pouch extremely rounded and shiny
  Female: 0 – just given away eggs, belly sunken; 1 – no mature eggs, belly flat; 2 - bearing mature eggs, belly slightly raised; 3 – hydrated eggs, belly distended.

5. Measuring Preserved Specimens

Alcohol-preserved specimens are sometimes flexible enough to allow movement of the head so that it can be positioned at right angles to the body, and movement of the tail so that it can be stretched out and measured in a similar way to live specimens. More commonly however, preserved specimens are stiff and inflexible, particularly if they are dried. This requires more creative solutions to achieve consistent measurements among specimens. One solution to account for tails that are curled to different degrees is to use a piece of fine wire (< 0.1mm diameter), or cotton to mould around the curvature of the tail, following as close as possible to the mid-lateral line. It takes some practice to be proficient with these techniques. If cotton is used, pins can be used to hold it in place while pulling it around the curvature of the specimen. The wire or cotton is then straightened out and measured using callipers or a ruler. This method can also be used to measure the trunk length following the lateral trunk ridge from the mid-cleithral ring to the last trunk ring. As mentioned above, this curved measurement of trunk length is the most precise measurement, and the one least affected by changes in head orientation. Thus it is valuable for dealing with a) inflexible specimens and b) for systematic studies where precision is extremely important.

A full protocol for measuring preserved seahorse specimens has been published previously (Lourie *et al.* 1999a, b) and is reiterated here with slight modifications to some of the descriptions for clarity. See 'Parts of a Seahorse' section above for definitions of reference points and Figure 4 for a diagrammatic representation of the measurements.

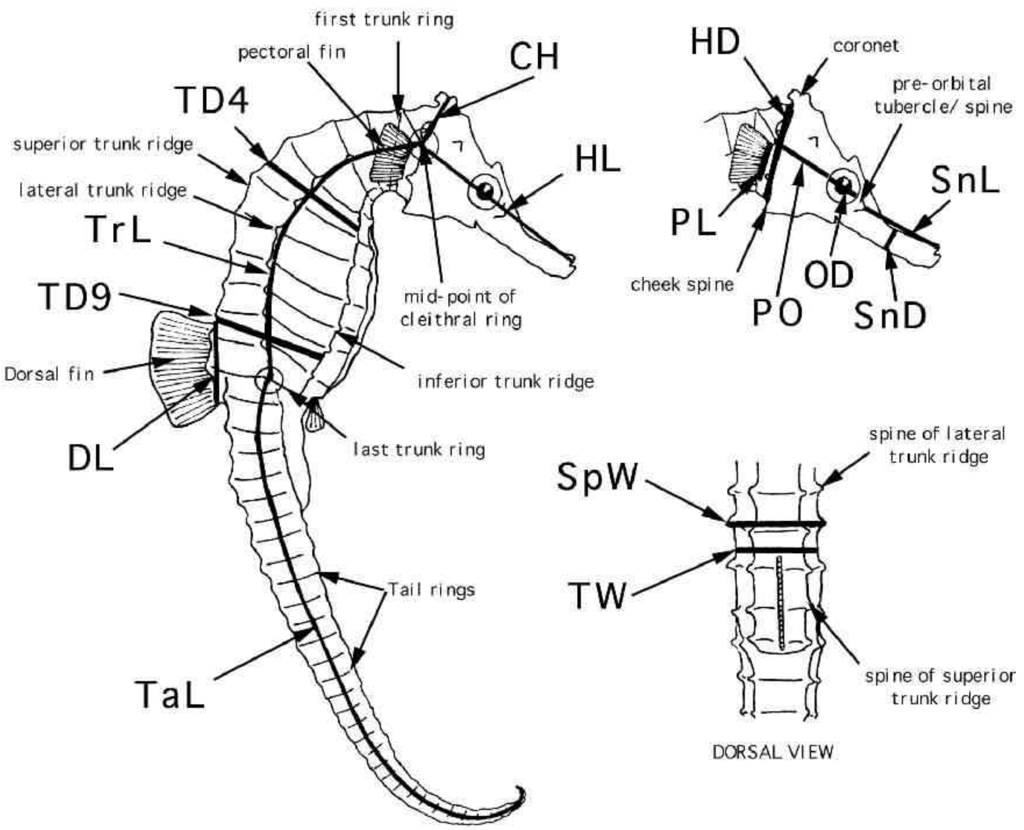

Figure 4. Morphometric measurements of seahorses. See text for abbreviations.

1. **Standard length (SL)**: the sum of head length + trunk length (curved) + tail length, such that it is comparable with this measurement in other fish (i.e. snout tip to hypural joint).
2. **Trunk length (TrL)**: the curved distance from the mid-point of the cleithral ring to the lateral mid-point of the last trunk ring. [note that a curved distance is used here, as opposed to a straight-line distance with live seahorses]
3. **Tail length (TaL)**: the distance from the mid-point of the lateral ridge of the last trunk ring to the tail tip.
4. **Coronet height (CH)**: the diagonal distance from the median groove (central depression) of the coronet to the mid-point of the cleithral ring.
5. **Head length (HL)**: the distance from the tip of the snout (upper jaw) to the mid-point of the cleithral ring.
6. **Snout length (SnL)**: the distance from the tip of the snout (upper jaw) to the anterior side of the tubercle/ spine immediately in front of the orbit (pre-orbital tubercle/ spine).
7. **Snout depth (SD)**: the narrowest distance between the dorsal and ventral surfaces of the snout.
8. **Orbital diameter (OD)**: the distance between the anterior and posterior inside edges of the orbit (eye socket).
9. **Post-orbital length (PO)**: the distance between the posterior edge of the orbit and the mid-point of the cleithral ring.
10. **Head depth (HD)**: the distance from the lowest point of the depression immediately behind the coronet to immediately behind the cheek spine.
11. **Trunk depth between 4th and 5th trunk rings (TD4)**: the narrowest distance between the superior and inferior trunk ridges between the 4th and 5th trunk rings.
12. **Trunk depth between 9th and 10th trunk rings (TD9)**: the narrowest distance between the superior and inferior trunk ridges between the 9th and 10th trunk rings.
13. **Trunk width between 9th and 10th trunk rings (TW)**: the narrowest distance between the left and right lateral trunk ridges between the 9th and 10th trunk rings. (This is most easily measured from the back of the seahorse).
14. **Distance between the 9th trunk ring lateral ridge spine tips (SpW)**: the distance between the tips of the lateral trunk ridge spines of the 9th trunk ring
15. **Pectoral fin length (PL)**: the distance between the dorsal and ventral points of insertion of the fin rays.
16. **Dorsal fin length (DL)**: the distance between the anterior and posterior points of insertion of the fin rays.
17. **Number of trunk rings (TrR)**: the number of external raised bony rings that encircle the body. For the first few it is easiest to identify them on the dorsal surface of the seahorse. See above for how to identify the first and last trunk rings.
18. **Number of tail rings (TaR)**: the number of external raised bony rings that encircle the tail. For the majority it is easiest to identify these on the lateral surface of the seahorse. Towards the tail tip the rings become indistinct and cracks appear on the ventral surface between the rings. These are sometimes easier to count than the rings themselves. See above for how to recognise the first tail ring.

19. **Number of pectoral fin rays (PF)**: the number of bony rods that support the fin membrane.
20. **Number of dorsal fin rays (DF)**: the number of bony rods that support the fin membrane. The last ray sometimes appears double, but is counted as one ray because the two parts are joined at the base.
21. **Keel index (KI)**: a semi-quantitative measure of the depth of the body ventral to the ventral trunk ridge: 1=no ventral keel, 2=ventral keel <1mm deep, 3=ventral keel 1-3mm deep, 4=ventral keel >3mm deep. This appears to be a sexually dimorphic trait, more common in males.
22. **Coronet height index (CI)**: a semi-quantitative measure of the overall height of the coronet in relation to the arc of the neck (Figure 5).
23. **Spikiness index (SI)**: a semi-quantitative measure of how spiny a seahorse is, based on an examination of the first few spines on the dorsal surface of the tail: 1=sum of spine lengths on left + right side ≤ 1/4 dorsal width of that tail segment, 2=length of spines >1/4 but ≤ 3/4 dorsal width, 3=length of spines > 3/4 dorsal width. Where spines run in a definite series of long and short, or non-existent, it may be appropriate to record two indices.
24. **Chin shape index (CSI)**: a qualitative description of the arrangement and form of the cheek spines as viewed from the ventral surface of the head (Figure 6).

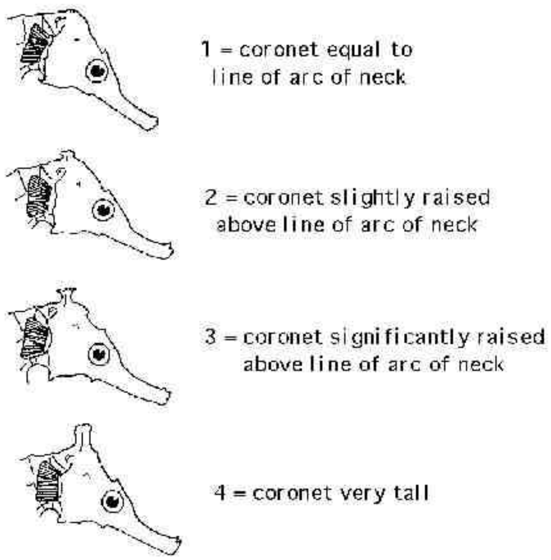

Figure 5. Definitions of coronet height.

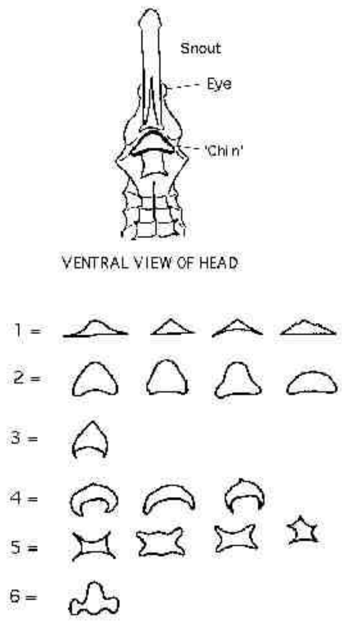

Figure 6. Definitions of chin shape index.

6. Correlations among Measurements

Although it would be ideal to have a single, standardised protocol for measuring all seahorses in all situations, this is clearly not possible. As an interim measure it has been suggested that linear correlations between measurements could be used in order to compare across studies that have used different methods, or to include samples with missing datapoints (e.g. missing height values because of damaged tails). Tight correlations among measurements could also reduce the number of measurements that need to be taken in a study particularly in field-based studies where a single 'size' measurement is often all that is required. Straight-line trunk length, with the head held at right angles to the body, or head length have both been proposed as a proxy for height. Methodologically, it is recommended that a correlation with a free intercept be used (i.e. the correlation is not forced through the origin). However, the intercept will have no biological meaning and the correlation should not generally be extrapolated beyond the range of the original data.

A second use of correlations would be to enable measurements taken on specimens that have been preserved in different ways to be used in the same analysis. Although seahorses have rigid, external skeletons and probably undergo little shape or size change when preserved, there might still be some shrinkage of particular parts. Multivariate analysis can be used to test whether specimens preserved in different ways differ significantly. If they do, correlations between measurements taken on specimens which have been preserved in different ways could provide 'correction factors' and allow the inclusion of a greater number of specimens in a sample set than might be possible if only specimens preserved in a single manner could be used.

Potentially useful correlations include:

- HT vs. TrL (straight)
- HT vs. HL
- SL vs. TrL (straight)
- SL vs. HL
- SL vs. TrL (curved)
- TrL (curved) vs. TrL (straight)
- All of the above comparing within or between modes of preservation
- Principal Component Analysis of live vs. dried vs. alcohol preserved
- Correlations for each measurement in the protocol between different preservation modes

Initial correlations have been generated for some of these measurements (e.g. Figure 7 for HT vs. TrL (straight-line) and are given in Appendix 1.

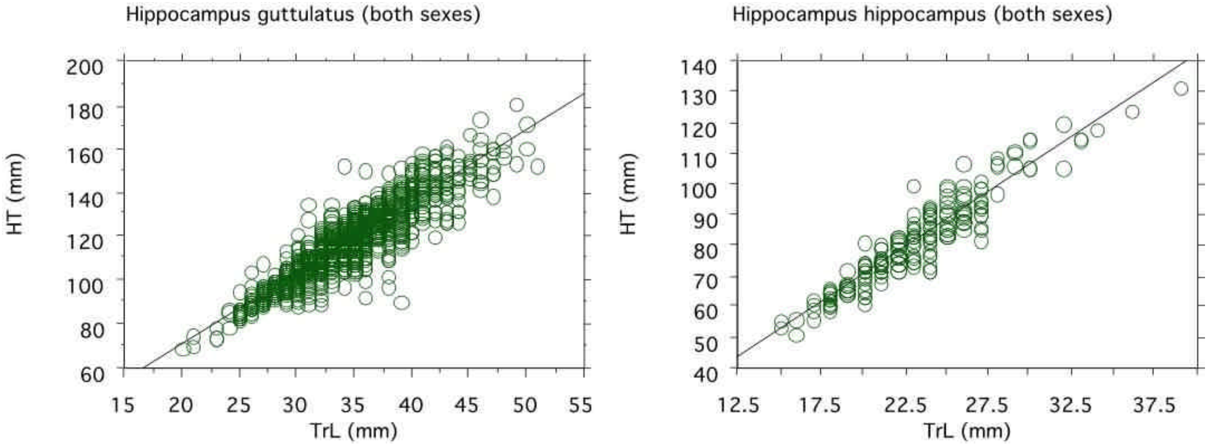

Figure 7. Linear correlations between TrL (straight line from mid-cleithral ring to last trunk ring) and HT for 1759 *H. guttulatus* and 199 *H. hippocampus* (J. Curtis, unpublished data).

Some of the potential confounding factors that might limit the utility of such linear correlations include: allometric differences (i.e. different body parts grow at different rates so that the relationship is not linear); sex differences; species differences; non-linear changes in growth; preservation differences. All of these factors need to be borne in mind when translating from one measurement to another. Ideally a correlation, based on a sample size of at least 30, over as wide a range of sizes as possible, needs to be generated for each specific situation in order to have confidence in the relationship.

7. Conclusion and Recommendations

- Stick to standard protocols
- Practice a lot to ensure measurement consistency
- Ensure that all observers are comfortable with the measurement protocol and are taking measurements in the same way
- Check often against a standard to ensure consistency
- Be very clear when reporting measurements to include all the necessary information (e.g. reference points and modes of preservation)
- Do proper trials of correlations
- Be wary when using correlations and try to control for species, sex and preservation

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Appendix 1. Correlations between morphometric measurements for some seahorse species

Table 1. HT vs. TrL (straight) for live specimens**.** Regression coefficients for the linear correlation HT = a+b(TrL) with TrL measured as a straight line from the mid-cleithral ring to the last trunk ring (J. Curtis, unpublished data for *H. guttulatus*, *H. hippocampus* and S. Lourie, unpublished data for *H. kuda*). Because of possible ontogenetic changes in the relationship between body parts, I do not recommend the extrapolation of these correlations beyond the range given. Measurements are in mm.

Species	Sex	n	R^2	Intercept, a	SE [a]	Slope, b	SE [b]	Range (HT)
H. guttulatus	Both	1759	0.843	6.052	1.150	3.256	0.034	69-181
H. guttulatus	Female	838	0.886	9.024	1.327	3.083	0.038	70-172
H. guttulatus	Male	921	0.874	-1.858	1.513	3.573	0.045	69-181
H. hippocampus	Both	199	0.885	-1.521	2.157	3.590	0.092	51-132
H. hippocampus	Female	95	0.946	0.574	2.017	3.375	0.084	51-132
H. hippocampus	Male	104	0.924	-10.226	2.668	4.098	0.117	56-120
H. kuda	Both	20	0.725	25.061	16.499	2.724	0.396	113-163
H. kuda	Female	9	0.869	18.653	16.982	2.736	0.401	113-152
H. kuda	Male	11	0.856	18.943	16.861	2.993	0.410	113-163

Table 2. HT vs. HL for alcohol preserved specimens**.** Regression coefficients for the linear correlation HT = a+b(HL). Measurements were taken in mm on dead (alcohol-preserved) specimens. I only included species with a sample size of >5. Separate analyses by sex were carried out in cases where the total sample size was >30. (S. Lourie, unpublished data). Because of possible ontogenetic changes in the relationship between body parts, I do not recommend the extrapolation of these correlations beyond the range given. Measurements are in mm.

Species	Sex	n	R^2	Intercept, a	SE [a]	Slope, b	SE [b]	Range (HT)
H. abdominalis	Both	10	0.933	19.069	14.764	5.090	0.481	80-225
H. angustus	Both	51	0.802	3.205	7.303	3.867	0.274	30-155
H. angustus	Female	29	0.800	5.640	8.772	3.583	0.345	30-140
H. angustus	Male	22	0.850	15.243	9.627	3.651	0.343	78-155
H. barbouri	Both	12	0.913	-0.865	9.965	4.256	0.415	60-145
H. borboniensis	Both	12	0.673	9.584	20.038	4.170	0.919	80-140
H. erectus	Both	44	0.883	4.388	5.255	4.416	0.248	30-150
H. erectus	Female	14	0.891	10.545	7.951	3.886	0.391	50-135
H. erectus	Male	27	0.844	12.698	8.130	4.180	0.919	55-150
H. guttulatus	Both	31	0.867	-7.646	8.468	5.223	0.380	47-145
H. guttulatus	Female	15	0.939	-1.992	7.439	4.878	0.345	47-125
H. guttulatus	Male	16	0.759	-17.818	19.824	5.736	0.864	85-145
H. hippocampus	Both	20	0.855	-7.524	9.256	5.957	0.577	55-130
H. histrix	Both	10	0.647	24.252	21.667	2.824	0.737	65-135
H. ingens	Both	15	0.974	-5.447	6.109	5.261	0.237	45-190
H. kuda	Both	45	0.801	2.168	10.204	4.433	0.337	70-260
H. kuda	Female	19	0.719	-15.375	24.866	4.916	0.746	75-260
H. kuda	Male	24	0.710	32.846	13.545	3.437	0.468	70-260
H. reidi	Both	23	0.802	15.819	11.327	3.819	0.414	55-175
H. spinosissimus	Both	15	0.915	-2.536	8.727	4.589	0.387	53-138
H. trimaculatus	Both	16	0.879	-26.912	12.800	5.974	0.591	70-130
H. whitei	Both	25	0.705	7.384	11.925	3.635	0.490	55-137
All species	Both	514	0.856	3.132	1.892	4.362	0.079	13-260
All species	Female	268	0.829	3.944	2.784	4.204	0.117	16-260
All species	Male	237	0.883	4.852	2.575	4.436	0.105	13-240

Table 3. HT vs. HL for dried specimens**.** Regression coefficients for the linear correlation HT = a+b(HL). Measurements were taken in mm on dead (dried) specimens. I only included species with a sample size of >5. Separate analyses by sex were carried out in cases where the total sample size was >30. (S. Lourie, unpublished data). Because of possible ontogenetic changes in the relationship between body parts, I do not recommend the extrapolation of these correlations beyond the range given. Measurements are in mm.

Species	Sex	n	R^2	Intercept, a	SE [a]	Slope, b	SE [b]	Range (HT)
H. abdominalis	Both	5	0.933	32.764	27.373	4.921	0.761	172-280
H. barbouri	Both	15	0.802	13.557	13.261	3.775	0.520	84-141
H. borboniensis	Both	7	0.808	29.538	18.989	3.449	0.751	92-129
H. comes	Both	24	0.632	57.894	11.239	2.345	0.382	107-146
H. erectus	Both	5	0.558	-20.361	83.395	5.444	0.797	105-165
H. guttulatus	Both	7	0.957	-41.644	15.974	6.955	0.661	85-181
H. histrix	Both	9	0.956	-1.750	8.428	3.553	0.287	74-132
H. kelloggi	Both	18	0.956	-9.272	9.802	4.670	0.251	90-250
H. kuda	Both	32	0.793	7.023	11.783	4.210	0.393	84-157
H. kuda	Female	11	0.655	34.251	24.352	3.335	0.806	107-157
H. kuda	Male	21	0.845	-2.785	13.289	4.524	0.445	84-154
H. reidi	Both	15	0.899	1.240	10.940	4.183	0.388	85-150
H. spinosissimus	Both	40	0.776	11.338	9.694	3.934	0.343	78-162
H. spinosissimus	Female	20	0.894	10.807	8.571	3.801	0.308	78-125
H. spinosissimus	Male	20	0.726	17.720	16.028	3.856	0.559	93-162
H. trimaculatus	Both	37	0.643	-1.904	14.350	4.745	0.596	80-149
H. trimaculatus	Female	21	0.693	1.007	16.489	4.428	0.676	80-149
H. trimaculatus	Male	16	0.888	-37.230	14.602	6.486	0.617	92-139
All species	Both	269	0.807	3.605	3.785	4.360	0.130	47-280
All species	Female	139	0.843	2.350	5.677	4.300	0.196	47-280
All species	Male	130	0.833	10.435	4.838	4.184	0.166	49-250