

## GUIDELINES FOR TAXONOMIC DESCRIPTIONS OF CEPHALOPOD SPECIES

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### Abstract

This paper presents a format of guidelines considered necessary for the description (or redescription) of species of cephalopods. These guidelines or standards include specific requirements for descriptive characters of species within the Orders Sepioidea, Teuthoidea and Octopoda as well as general information, e.g., synonymy, locality, etc. Standards are given for descriptions, counts of measurements, and illustrations. Appendices list definitions of counts, measurements, and indices; diagrammatically illustrate standard measurements; and give examples from the literature of descriptions that approach these standards.

### General Standards

*Introduction.* The need for minimum standards for the description of species in cephalopod systematics was addressed at the International Workshop on the Biology and Resource Potential of Cephalopods (Roper, 1983) sponsored by the National Museum of Victoria and the Victorian Institute of Marine Sciences and held at the Marine Sciences Laboratory, Queenscliff, Australia, 9-13 March 1981. We are most grateful to a number of the workshop participants who responded to the suggestion that the outline of the proposed standards be begun at the workshop. The discussion that ensued resulted in a significant percentage of the required and secondary characters being listed. So, to that important extent, these standards result from the combined efforts of these colleagues: S. v. Boletzky, R. Hanlon, F. G. Hochberg, C. C. Lu, T. Okutani, and R. E. Young. The authors also wish to thank Michael J. Sweeney for his valuable contribution in compiling notes, verifying and expanding the characters and definitions based on searches in the literature, and overall assistance in preparing the manuscript. The illustrations were prepared by Carolyn Gast, to whom appreciation is expressed. Valuable comments on the manuscript were received from F. M. Bayer, S. D. Cairns, and F. G. Hochberg.

At the outset it is important to point out that international standards exist for the naming of

new zoological species (and other taxa). The naming of any new taxon should adhere to the rules and recommendations of the International Code of Zoological Nomenclature (Stoll *et al.*, 1964).

The following criteria are considered necessary to adequately describe a new species or to redescribe a species inadequately described originally. Ideally, at least five specimens consisting of both males and females should be considered as a prerequisite for describing a new species. Greater numbers, however, are strongly preferred in order to present an indication of the range of variability in various characters with respect to size (age), sex and geographic distribution. It is recognized, of course, that some new species may be represented by fewer than five specimens. While it is advisable to have additional material, unusual circumstances (unquestioned distinctiveness of the species, the high probability that no additional material will be forthcoming soon) may make it necessary to describe the species. This should be done only in very well justified cases. In any new description, all measurements, counts and indices used must adhere to standard definitions or be completely defined in order to facilitate direct comparison with descriptions of other species. Appendix 1 presents a list of definitions for the most commonly used meristic characters. This is based on the definitions given by Voss (1963) but is modified and expanded to reflect changes and

increases in knowledge since that time. Appendix 2 contains diagrammatic illustrations of the more frequently used measurements.

*Definition.* The family and genus into which the species is placed should be defined based on recognized definitions cited from the literature, or they should be redefined. Clear justification must be made for placing the species in a genus; the species must be clearly differentiated from all other species in that genus. If related genera are not well defined, or if their criteria are questionable, the new species should be clearly differentiated from all species in the related genera, as well. The unique or diagnostic features of the new species should be pinpointed. Appendix 3 cites papers which contain examples of adequately described taxa.

*Synonymy.* The synonymy in essence is a summary of the nomenclatural history of a specific entity. If the information presented is either a description of a new species or a redescription of a previously named species, a synonymy giving specific citations should be included. The synonymy serves as an additional source of information as well as a list of identified specimens other than those in the Material Examined section. The synonymy should distinguish between works that describe a single species under more than one taxonomic name and one taxonomic name containing specimens of more than one species.

*Material Examined.* This section of the species description should list all specimens examined by the author. The HOLOTYPE always should be the first specimen listed, followed by any other designated type-material (PARATYPE(S)). The remainder of the specimens examined follows, designated as "other material" or "additional material". Some of the other material could be specimens examined by the author that are listed in the synonymy section from previously published papers. Data for holotype and paratypes must be presented separately for each specimen: sex, ML, etc. Data for all other specimens examined should be presented in the following order: number of specimens (if several are from the identical specimen lot) and sexes, mantle length(s) (minimum and maximum, by sex), collector (e.g., individual, ship) and station

number, locality by place name and latitude and longitude, depth collected, collecting gear or technique, date collected, and museum catalog number. The last element of data, the MUSEUM CATALOG NUMBER, is strongly emphasized as it permits rapid location in the future of individual specimen lots in collections and of additional information.

*Description.* Details are given below under each order; also, see Definitions of Characters.

*Type Designation.* A description of a new species and a redescription of a species with an extant holotype should list the type-specimen (HOLOTYPE), the museum where it is deposited and the museum catalog number for that specimen. If a NEOTYPE or LECTOTYPE is designated in the process of a redescription, it is listed in the same manner as a HOLOTYPE. All type-specimens must be specifically labelled as HOLOTYPE, PARATYPE, LECTOTYPE, etc.

*Type-Locality.* The geographic locality of the primary type and other pertinent data are presented here for quick reference. A general description of the area (i.e., North Atlantic Ocean, off Galapagos Islands, Australia, Southern Ocean, etc.) and the specific latitude and longitude of the collecting point are required. The depth of capture and other pertinent data should also be given.

*Distribution and Habitat.* The limits of the known geographic distribution and areas of concentration of the species should be defined in this section. Areas of apparent absence should be analysed in view of sampling limitations. The range of vertical distribution also should be determined using both discrete (e.g., closing-net, on-site, bottom gear) and non-discrete (e.g., non-closing midwater trawls, deep benthic trawls, etc.) depth records. Habitat information should be presented, as well, if available (e.g., bottom type, habitat type, water mass type).

*Discussion.* Detailed comparisons with other species in the genus are of prime importance in this section. Comparisons should include key characters and address specific similarities and differences. Proper comparisons may necessitate the detailed examination, or even redescription, of related species, if they are in-

sufficiently known. Differences in locality, size, etc. should be noted, but they are not sufficient in themselves to distinguish species. The actual morphological characters must be compared and contrasted. Frequently, graphs and tables are useful for this purpose.

*Definitions of Characters.* The definitions consist of a compilation from several relatively recent systematic works as well as some terms newly formulated for completeness. Also, some of the definitions may be slightly altered from their original form in earlier publications because of increased knowledge about the character or of a possibility for a more broadly applicable definition. Note that all measurements or counts on arms, tentacles and clubs customarily are made on the right-side appendage (or both right and left); if a right-side appendage is damaged or missing, the left-side one may be used, and designated as such. Also note that for each measurement it is possible to calculate an index as a method of comparison against a standard. Usually the standard is mantle length, but occasionally it may be another morphological feature of which the measured character is a part (e.g., gladius width index has the gladius length as the standard).

It is important to point out that not all definitions herein will apply equally well to a specific feature in all species. Because of the possibility (probability) of variation in an atypical taxon, an author is encouraged to define very carefully any deviations from these standards. Also, of course, not all counts, measurements and indices listed here can be applied to each species of cephalopod, i.e., some are specific to octopods, or squids, or cuttlefishes. Furthermore, a new species may have a meristic character not included in this list. If so, that particular character count, measurement, or index must be carefully defined consistent with the standard definitions.

Frequently in the past, authors have presented only raw data, that is, only the measurements of characters. Because indices represent a refinement of raw data against a standard, they permit comparisons of differences caused by growth. The use of indices allows comparisons within a population (collection) of a single species as well as between

populations of two or more species. Thus indices have become a very useful tool in descriptive systematics of cephalopods. It is here very strongly urged that authors of new species or of redescriptions include the indices in addition to the raw data. Also, whenever indices are used (e.g., in tables, graphs, etc.) the mantle length(s), the standard of size in all cephalopods, must be listed. Because the indices are so important and their use is so strongly encouraged, the definitions of measurable characters presented in Appendix I are of the indices rather than the raw measurements. However, the definition of the actual measurement is inherent in the definition of the index; therefore, no confusion should arise should an author wish to use a raw measurement definition.

Additional comments concerning data not covered in other sections are helpful: e.g., behaviour, non-permanent color patterns observed on live specimens, bottom or habitat preference, abundance, prey, predators, etc. Since parasites frequently are host-specific, they should be described and identified to lowest possible taxon; the aid of a specialist is recommended.

The *etymology* of the new name is highly recommended, and the name must conform to the requirements of the International Code of Zoological Nomenclature (Stoll *et al.*, 1964).

#### Ordinal Standards

The different groups ("orders") of cephalopods have somewhat different descriptive requirements because of their different morphologies and characteristics. The three major groups—cuttlefishes, squids, and octopuses—each are discussed separately under sections on description, counts and measurements, and illustrations.

The written description is the most important part of the analysis of a species description. Every effort must be made to choose carefully the words for an accurate, clear, concise species description. The anatomical features listed below for each group must be carefully described to achieve a complete and accurate description. Clearly this paper cannot list every character or variation or modification of

characters that exists for any given species. Nor will each species necessarily possess all characters listed. Every author is responsible for insuring that each character is thoroughly scrutinized and described, regardless of whether that character is listed herein.

A. ORDER SEPIOIDEA—SEPIIDAE  
(CUTTLEFISHES), SEPIOLIDAE, ETC.

*Description.* The following characters are to be included in the description of a new species of Sepioidea:

1. Mantle: shape, thickness, musculature, width, sculpture, pigmentation patterns
2. Cuttlebone (Sepion): shape, sculpture, striations, spine, coloration
3. Gladius (in non-cuttlefish): shape, sculpture, thickness, width, and length of rachis, vane, and conus
4. Arms: arm formula (by decreasing length), number and spacing of longitudinal rows of suckers (basal, medial and distal sections), swimming keel(s), dorsal and ventral protective membranes and trabeculae, attenuation of tips
5. Hectocotylus: arm(s) involved, arrangement of suckers, loss, enlargement, reduction or other modification of suckers, modification of sucker stalks, protective membranes and trabeculae, presence of pits, ridges, or papillae
6. Club and Tentacle: dorsal and ventral protective membranes and whether they are united or separate at base of club; trabeculae; arrangement, size and number of rows of suckers in each section (carpus, manus, dactylus); shape and size (e.g. robustness) of club and tentacular stalk; swimming keel(s); clefts
7. Suckers (arms and clubs): shape, absolute and comparative sizes, dentition of rings, soft rings
8. Buccal Mass: membrane, lappets, connectives, suckers
9. Spermatophore Pad: location, shape, and structure in females
10. Beak: shape, pigmentation, angles, etc. of component parts; several sizes and sexes — (See Clarke, in prep.)
11. Radula: number, shape and relative size of teeth in a transverse, unused row; cusps; lateral plates. (Check several specimens for variation)
12. Reproductive system: all male and female component parts
13. Spermatophores and Eggs: shape, size, number, component parts of spermatophores
14. Integumentary features: permanent color patterns, chromatophores, sculpture, papillation, supplement with observations of live animal if possible
15. Fins: shape, extent, width, attachment
16. Digestive tract: nature of digestive gland, pancreatic tissue, ducts, spiral caecum, stomach, crop, intestine, anus
17. Funnel Organ: shape, sculpture, dorsal and ventral components
18. Funnel-mantle Locking Cartilage: mantle and funnel components, shape, size
19. Photophores: location, type, shape, size, number
20. Parasites (often host-specific): identify group and lowest possible taxon; seek aid of specialist.

*Counts and Measurements.* Counts and measurements in millimetres (mm) (or centimetres (cm) for large species) for sepioids should be presented in a table for the structures listed below. These counts and measurements are a minimum for the description; those given in brackets also should be included for completeness but may not be critical. Most measurements can be given as an index, a direct proportional relationship to the mantle length, the standard length of all cephalopods. The index is determined by the formula:

$$\frac{\text{Character Measurement}}{\text{ML}} \times 100 = \text{Index}$$

e.g., ML=270 mm, HW=33 mm:  $\frac{33}{270} \times 100 = 12.2$

Direct measurements of all characters may appear in the table with indices or in an appendix, if desired. See Appendix 1 for standard definitions and Figure 1. Because some characters are so different between groups, a standard defini-

tion may not apply; in these cases the modified definition is given with the character.

1. Mantle Length (ML); [Total length (TL), Ventral Mantle Length (VML)—use VML only when significant differences exist between dorsal and ventral lengths, as in *Stoloteuthis* or *Nectoteuthis*]
2. Mantle Width Index (MWI)—greatest straight-line width across ventral surface of mantle (excluding fins) as a percentage of mantle length
3. Fin Length Index (FLI)
4. Fin Width Index (FWI)
5. Head Width Index (HWI); [Head Length Index (HLI)]
6. Arm Length Index (ALI); [Arm Formula (AF)]
7. Arm Sucker Index (ASIn for normal, ASIE for enlarged); [Arm Sucker Count (ASC), Sucker Teeth Count (STC)]
8. Club Length Index (CLIL)
9. Club Row Count (CIRC)
10. Club Sucker Index (CISI)
11. Hectocotylus Length Index (HcLI); [Hectocotylized Arm Index (HcAI)]
12. Spermatophore Length Index (SpLI); [Spermatophore Width Index (SpWI)]
13. Egg Length Index (EgLI)
14. Gill Lamellae Count (GiLC)
15. Cuttlebone Length (CbL)
16. Striated Zone Index (StZI)
17. Cuttlebone Width Index (CbWI)
18. [Eye Diameter Index (EDI), Lens Diameter Index (LnDI)]
5. Sucker rings\*, club and arms
6. Hectocotylized arm(s)\*
7. Beak and radula
8. Reproductive system, male and female
9. Spermatophores and eggs
10. Cuttlebone\*, dorsal and ventral views; inner and outer cone, amount of fusion; spine; lateral wings; dorsal and/or ventral keels on spine
11. Stellate ganglion
12. Color photograph of living animal, if possible (to be deposited with holotype)
13. Oral view\*, all arms spread out (divide between arms IV) in both sexes (very important for sepiolids)
14. Photophores\*—if present
15. Gladius\*—if present (in some sepiolids), whole and series of cross section, in detail, not diagrammatic.

B. ORDER TEUTHOIDEA—NERITIC AND OCEANIC SQUIDS

*Description.* The following characters are to be included in the description of a new species of teuthoid squid:

*Illustrations.* Illustrations of the following characters are highly recommended in support of the descriptive section for sepioids. Those designated by an asterisk are especially important. Always include the mantle length of the specimen from which the illustrated character was drawn and the size of the scale unit.

1. Whole animal, dorsal\* and ventral view
2. Funnel organ\*
3. Funnel-mantle locking cartilage\*
4. Club\*, including suckers, membranes, keels, clefts
1. Mantle: shape, thickness, musculature, width, sculpture
2. Gladius: shape, sculpture, thickness, width, and length of rachis, vane, and conus
3. Fins: shape, margins, extent, attachment, tail
4. Funnel: shape, extent, musculature, funnel valve, funnel organ
5. Funnel-Mantle Locking Cartilage: type, shape, size, sculpture
6. Head: shape, eyes, eyelids, olfactory papillae, nuchal folds, nuchal locking-cartilage
7. Arms: arm length in decreasing order (= formula); number of longitudinal sucker and/or hook rows; suckers, sucker rings (chitinous and soft), hooks; keels, membranes, trabeculae, papillation; attenuation, robustness
8. Hectocotylus: arm(s) modified; sucker arrangement, loss or reduction; pits, holes, ridges, papillae, membranes, trabeculae, attenuation

9. Spermatophore Pad or Receptacle (on female): shape, location, sculpture
  10. Tentacle and Club: tentacle—stalk-size, length, cross-section, suckers on stalk; club—carpus, manus and dactylus, number of sucker rows (transverse and longitudinal), suckers, sucker rings, hooks, knobs, keels, membranes, papillation, trabeculae, size, attenuation
  11. Buccal Mass: membrane, lappets, connectives, suckers
  12. Beak: shape, pigmentation, angles, etc.; several sizes and sexes—(See Clarke, in prep.)
  13. Radula: number, relative size, and shape of teeth in a transverse, unused row; cusps; lateral plates (Check several specimens for variation)
  14. Chromatophores: location, color, patterns, densities; supplement with observations of live animal
  15. Photophores (Light Organs): location, type, shape, size, number; internal, external
  16. Spermatophores: shape, size, details of component parts; number
  17. Eggs: shape, size, number
  18. Reproductive System: component parts of mature male and female
  19. "Larval stages": if different from adult
  20. Parasites (often host-specific): identify group and lowest possible taxon; seek aid of specialist
- (GWI), Rachis Length Index (RLI), Rachis Width Index (RWI)]—see Toll, 1982
  4. Fin Length Index (FLI)
  5. Fin Width Index (FWI)
  6. Arm Length Index (ALI); [Arm Formula (AF), Arm Hook Count (AHC), Arm Sucker Count (ASC), Arm Sucker Index (ASIn and ASIe)]
  7. Club Length Index (CLLI); [Club Sucker Index (CISI)]
  8. Club Row Count (CIRC); [Carpal Sucker Count (CSC), Dactylus Sucker Count (DSC), Manus Sucker Count (MaSC), Manus Hook Count (MaHC), Transverse Row Count (TrRC)]
  9. Hectocotylus Length Index (HcLI); [Hectocotylized Arm Index (HcAI)]
  10. Sucker Teeth Count (STC)—for largest suckers on manus, dactylus, arm III and arm IV, especially
  11. Head Length Index (HLI)
  12. Head Width Index (HWI)
  13. Lens Diameter Index (LnDI); [Eye Diameter Index (EDI)]
  14. Lappet Sucker Count (LpSC)
  15. Spermatophore Length Index (SpLI)
  16. Sperm Reservoir Index (SpRI)
  17. Spermatophore Width Index (SpWI)
  18. Gill Lamellae Count (GiLC)
  19. [Egg Length Index (EgLI), Tentacle Length Index (TtLI), Tubercular Ridge Index (TbRI)]

*Counts and Measurements.* Counts and measurements in millimetres (mm) (centimetres (cm) acceptable for very large species) for squids should be presented in a table for the structures listed below. These counts and measurements are a minimum for the description; those that follow in brackets should be included for completeness. Refer to Sepioid section for details on determining indices. See Appendix 1 for standard definitions, and Figures 2 and 3.

1. Mantle Length (ML); [Total Length (TL)]
2. Mantle Width Index (MWI)
3. Gladius Length (GL); [Gladius Length Index (GLI), Gladius Width Index

*Illustrations.* Illustrations of the following characters are highly recommended in support of the description of squids. They should be as detailed as possible and consistent with the description. Always include the mantle length of the specimen from which the illustrated character was drawn and the size of the scale unit.

1. Whole animal, dorsal\* and ventral view
2. Funnel organ\*
3. Funnel-mantle locking cartilage\*, both components
4. Tentacular club\* and tentacular stalk (if bearing armature), including armature, keels, membranes, etc.
5. Hectocotylus\*

6. Largest sucker (with stalk), or a series\*, from arms III and IV (at least) and from manus and dactylus (both inner and outer chitinous rings should be visible, or make 2 drawings if necessary.) (Scanning electron micrographs are an excellent substitute for illustrations of sucker dentition.)
7. Photophores\* and their distribution (very important for many teuthoid species)
8. Beak and radula\*
9. Gladius\*, whole and series of cross-sections
10. Largest hook from tentacular club and arms III and IV; or a series
11. Larval stages, if morphologically different from the adult
12. Reproductive system, male and female
13. Spermatophore and eggs

#### C. ORDER OCTOPODA—BENTHIC AND PELAGIC OCTOPUSES

*Description.* Octopods are subject to changes in morphology due to preservation to a much more pronounced degree than either cuttlefishes or squids. For this reason it is very important that the preserved specimens used for the description are typical of the species as a whole. Live or recently dead specimens should be examined and measured for comparison whenever possible.

Because some benthic octopods have the ability to elongate their mantles and contract back to normal (e.g., *Octopus ornatus*), measurements using mantle length as a standard can be greatly affected. In such cases the author should indicate that the mantle is elongated and thus has distorted the indices (see Voss, 1981 re *O. ornatus*). The normal range of changes in octopods may or may not affect the range of means of indices. In the cirroteuthids, the mantle musculature is very weak and a significant part of the mantle length lies posterior to the shell vestige. This portion is subject of great shrinkage in preservation and in many genera (*Stauroteuthis*, *Cirroteuthis*, etc.) makes indices using mantle length nearly meaningless. Good judgement has to be exercised and several workers have found the in-

terocular width to be less distorted and have used that measurement as a standard. Whichever character is used, it must be clearly stated. Workers are urged to remain aware of these problems and to deal with them on a species-by-species basis.

The anatomical features listed below must be carefully described to achieve a complete and accurate species description.

1. Mantle: shape, thickness; mantle opening
2. Head: shape; eyes, dimensions
3. Funnel: shape, size; funnel opening; funnel organ
4. Arms: arm formula; robustness, attenuation; number of sucker rows, cirri
5. Suckers: number; absolute and comparative sizes; patterns, sculpture; presence and position of enlarged suckers
6. Web: formula; thickness; extent or depth; extension out the side(s) of the arms (state which side)
7. Hectotylus: location (arm number, right or left side), shape, size; ligula, calamus, membrane, sculpture
8. Gills: shape, number of lamellae on each demibranch; example, 9 outer 7 inner
9. Digestive tract: shape, size (salivary glands, crop, stomach, spiral caecum, digestive gland, anus, ink sac); extent of involvement of ink sac in digestive gland (surface, buried or absent)
10. Reproductive system: shape, size (details of all male and female components)
11. Spermatophores and eggs: configurations; sizes, egg maturity (with or without striations)
12. Beak: shape, pigmentation, angles; several sizes and sexes—(see Clarke, in prep.)
13. Radula: number; relative size, and shape of teeth in a transverse unused row; formula (Check several specimens for variation)
14. Integumentary features: permanent color markings or patterns, chromatophores, ocellae, white patches, sculpture, papillae, rugosity, supple-

- ment with observations of live animals if possible
15. Stellate ganglion: configuration; size of fin nerves
  16. Eyes: size
  17. Live animal characteristics: habitat, behavior
  18. Larvae: if planktonic, presence of Kolliker's bristles
  19. Parasites (often host-specific): identify group and lowest possible taxon; seek aid of specialist
  20. Shell vestige (fin cartilage): shape, cross-section; for both sexes (cirrates)
  21. Olfactory organ: presence, size, shape (cirrates)
  22. Optic lobe and "White body": length, width (especially cirrates); types of nerves and bundles
  23. Fins: shape, size (cirrates)

*Counts and Measurements.* Counts and measurements for the octopod structures listed below should be presented in a table. These counts and measurements are considered a minimum for the description; those that follow in brackets should be included for completeness. Refer to sepioid section for details on determining indices. See Appendix 1 for standard definitions and Figure 4.

1. Mantle Length (ML)
2. Mantle Width Index (MWI)
3. Head Width Index (HWI); [Head Length Index (HdLI)]
4. Mantle Arm Index (MAI)
5. Arm Length Index (ALI); [Arm Formula (AF)]
6. Arm Width Index (AWI)
7. Arm Sucker Count (ASC)
8. Arm Sucker Index (ASIn and ASIe).
9. Web Depth Index (WDI); [Web Formula (WF)]
10. Hectocotylus Length Index (HcLI)
11. Opposite Arm Index (OAI); [Hectocotylized Arm Index (HcAI)]
12. Ligula Length Index (LLI)
13. Calamus Length Index (CaLI)
14. Gill Lamellae Count (GiLC)
15. Total Length (TL)
16. Spermatophore Length Index (SpLI);

- [Spermatophore Width Index (SpWI), Penis Length Index (PLI), Penis Diverticulum Length Index (PdLI)]
17. Egg Length Index (EgLI)
  18. Cirrus Length Index (CLI)
  19. Funnel Length Index (FuLI)
  20. Free Funnel Index (FFuI)
  21. Pallial Aperature Index (PAI)
  22. [Eye Diameter Index (EDI), Eye Orifice Index (EOI), Lens Diameter Index (LnDI)]

*Illustrations.* The following illustrations are strongly recommended in support of the descriptive section for octopods. Always include the mantle length of the specimen from which the illustrated character was drawn and the size of scale unit.

1. Whole animal, dorsal\* view; color pattern, ocellae, papillation
2. Lateral and/or ventral view of animal if permanent color pattern or papillation dictates
3. Ventral view of mantle opening and funnel\*
4. Funnel organ\*
5. Oral view\* of portion of arm with unusually enlarged suckers or with cirri
6. Hectocotylus\*—entire and details of calamus and ligula
7. Beak and radula
8. Viscera—ventral view of arrangement of organs in mantle cavity
9. Digestive tract\*—dissected out
10. Male and female genitalia\*—dissected out
11. Spermatophores\* and eggs
12. Stellate ganglion\*
13. Color pattern(s)\*, ocellae\* (drawn from live animal, if possible) and papillation (supplement with color photographs)
14. Oral view\* of arms, cirri, primary and secondary webs of cirrates
15. Fin cartilage\* of cirrates (both sexes)
16. Optic lobe and White body
17. Olfactory organ of cirrates

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### Appendix 1. Definitions of counts, measurements (in mm), and indices of cephalopods.

Refer to the discussion section (p. 51) of the text before applying these definitions, as certain qualifications must be understood.

- Arm Formula—AF: comparative length of arms expressed numerically in decreasing order, e.g., 3.4.2.1., 3.2.4 = 1. or III.IV.II.I. etc.
- Arm Length Index—ALI: length of arm measured from first basal (proximal-most) sucker to tip of arm in squids and cuttlefishes as a percentage of mantle length; measured from beak to tip of arm in octopods. (Arm I, dorsal; II, dorso-lateral; III, ventro-lateral; IV, ventral).
- Arm Hook Count—AHC: number of hooks on basal (proximal) half of each designated arm.
- Arm Sucker Count—ASC: number of suckers on basal half of each designated arm.
- Arm Sucker Index—ASIn: diameter of largest normal arm sucker on each designated arm as a percentage of mantle length. ASle: diameter of largest enlarged arm sucker (state which arm) as a percentage of mantle length. (See illustration in Appendix 2).
- Arm Width Index—AWI: width of stoutest (right) arm at mid-point of arm length as a percentage of mantle length (measurement exclusive of webs and membranes).
- Calamus Length Index—CaLI: in octopods, length of calamus measured from last (distal-most) sucker to its distal tip as a percentage of ligula length. Warning—a better measurement needs a definite starting point.
- Carpal Sucker Count—CSC: number of suckers and knobs on carpus of (right) club, e.g., 7 suckers, 6 knobs.
- Cirrus Length Index—CiLI: length of longest cirrus on each arm as a percentage of the diameter of the largest normal sucker; (alternative: as a percentage of interocular width).
- Club Length Index—CLi: length of designated club as a percentage of mantle length. Club length is measured from proximal base of carpal cluster of proximal-most carpal sucker or knob to distal tip of club or, in those species having no distinct carpal cluster, from proximal-most basal sucker that truly is part of the club.
- Club Row Count—CIRC: number of longitudinal rows of suckers and/or hooks across the width of the club. Define when used—rows may be counted as longitudinal (parallel with the long axis of the club) or oblique for dactylus or manus.
- Club Sucker Index—CISI: diameter of largest sucker on (right) club as a percentage of mantle length.
- Cuttlebone Length—CbL: dorsal length of cuttlebone along midline, including spine.
- Cuttlebone Width Index—CbWI: greatest width of cuttlebone as a percentage of cuttlebone length.
- Dactylus Sucker Count—DSC: number of suckers on dactylus of (right) club.
- Egg Length Index—EgLI: length of (mature) egg as a percentage of mantle length. (Eggs should be taken from the oviduct to ensure greatest degree of maturity, or preferably use spawned eggs if available.)
- Egg Width Index—EgWI: greatest width of (mature) egg as a percentage of mantle length. (Eggs should be taken from the oviduct to ensure greatest degree of maturity, or preferably use spawned eggs if available.)
- Eye Diameter Index—EDI: diameter of eye across bulbus as a percentage of mantle length.
- Eye Orifice Index—EOI: diameter of the opening of the eye as a percentage of mantle length.
- Fin Length Index—FLI: greatest length of fins as a percentage of mantle length. (May or may not include "tail".) (In cirrate octopods—length from midpoint of base of fin to the outer tip as a percentage of head width.)
- Fin Width Index—FWI: greatest width (dorsally) across both fins as a percentage of mantle length. (In cirrate octopods—greatest width across one fin perpendicular to the fin length as a percentage of fin length.)
- Funnel Length Index—FuLI: the length of the funnel from the anterior funnel opening to the posterior border measured along the ventral midline as a percentage of mantle length.
- Free Funnel Index—FFuI: the length of the funnel from the anterior opening to the point of dorsal attachment to the head as a percentage of mantle length.
- Gill Lamellae Count—GiLC: number of lamellae on outer demibranch, and inner demibranch including the terminal lamella(e); e.g., 9 outer, 7 inner.
- Gladius Length—GL: dorsal length of gladius along midline.
- Gladius Length Index—GLI: length of gladius as a percentage of mantle length.
- Gladius Width Index—GWI: greatest width of gladius as a percentage of gladius length.
- Head Length Index—HLI: dorsal length of head measured from point of fusion of dorsal arms to anterior tip of nuchal locking cartilage, or to some definable point if no nuchal locking cartilage exists.
- Head Width Index—HWI: greatest width of head at level of eyes as a percentage of mantle length. (Same as interocular distance in octopods.)
- Hectocotylized Arm Index—HcAI: length of hectocotylized arm measured from proximal-most armature, or

- defined proximal point, to tip as a percentage of mantle length.
- Hectocotylied Length Index—HcLI:** length of modified portion of arm(s) measured from proximal-most modified sucker (or hook) to tip of arm as a percentage of total length of hectocotylied arm (define distal point if modification does not extend to arm tip).
- Lappet Sucker Count—LpSC:** total number of suckers on buccal lappets; may be given as number on individual lappets, then summed.
- Lens Diameter Index—LnDI:** diameter of eye lens as a percentage of mantle length.
- Ligula Length Index—LLI:** in octopods, length of ligula measured from distal-most sucker to tip of arm as a percentage of length of hectocotylied arm.
- Mantle Arm Index—MAI:** in octopods, mantle length as a percentage of longest arm.
- Mantle Length—ML:** dorsal mantle length. In decapods, measured from anterior most point of mantle to posterior apex of mantle or tip of united fins, whichever is longest. In octopods, measured from midpoint between eyes to posterior end of mantle.
- Mantle Width Index—MWI:** greatest straight-line (dorsal) width of mantle as a percentage of mantle length (ventral width is used in sepiids).
- Manus Hook Count—MaHC:** number of hooks on manus of (right) club.
- Manus Sucker Count—MaSC:** number of suckers on manus of (right) club.
- Nuchal Commissure Index—NCI:** width of nuchal commissure as a percentage of mantle length.
- Opposite Arm Index—OAI:** length of hectocotylied arm as a percentage of its fellow arm on opposite side (in octopods).
- Pallial Aperture Index—PAI:** the measurement between the points of attachment of the mantle to the head along the ventral margin of the mantle as a percentage of mantle length. (Same as mantle aperture index.)
- Penis Length Index—PLI:** in octopods, length of penis and diverticulum as a percentage of mantle length.
- Penis Diverticulum Length Index—PdLI:** length of penis diverticulum as a percentage of total penis length.
- Rachis Length Index—RLI:** length of free rachis measured from anterior end of gladius to point where anterior edge of vane joins rachis, as a percentage of gladius length.
- Rachis Width Index—RWI:** width of rachis measured at point where anterior edge of vane meets rachis as a percentage of gladius length.
- Striated Zone Index—StZI:** length of striated zone on ventral surface of cuttlebone as a percentage of cuttlebone length.
- Sucker Diameter Index—SDI:** the diameter measured across the aperture from outer rim to outer rim as a percentage of mantle length.
- Sucker Teeth Count—STC:** number of teeth on chitinous sucker rings.
- Sperm Reservoir Index—SpRI:** length of sperm reservoir as a percentage of total spermatophore length.
- Spermatophore Length Index—SpLI:** length of spermatophore as a percentage of mantle length.
- Spermatophore Width Index—SpWI:** greatest width of spermatophore as a percentage of spermatophore length.
- Tentacle Length Index—TtLI:** total length of tentacular stalk and club as a percentage of mantle length.
- Total Length—TL:** in decapods, measured from tip of club to posterior most point of mantle or tip of united fins, whichever is longest. In octopods, measured from end of longest arm to posterior end of mantle.
- Transverse Row Count—TrRC:** number of transverse (latitudinal) rows of suckers along the club or a portion of the club (e.g., entire club, manus, dactylus). Define proximal and distal points.
- Tubercular Ridge Index—TbRI:** length of tubercular ridge as a percentage of mantle length (in Cranchiidae, Histioteuthidae).
- Ventral Mantle Length—VML:** ventral mantle length measured from anterior border of mantle at ventral midline, to apex of mantle or tip of united fins, whichever is longest.
- Web Depth Index—WDI:** in octopods, measurement of deepest (most extensive) sector of web measured from mouth to midpoint of sector between arms as a percentage of longest arm. (Web sector A, dorsal to dorsal arm; B, dorsal to dorso-lateral; C, dorso-lateral to ventro-lateral; D, ventro-lateral to ventral; E, ventral to ventral.)
- Web Formula—WF:** comparative depth of each web sector measured from mouth to midpoint of sector between arms expressed alphabetically in decreasing order (e.g., B.C.D.=A.E., see Web Depth Index for sector definitions).

## Appendix 2. Diagrammatic illustrations of frequently used measurements in cephalopods.

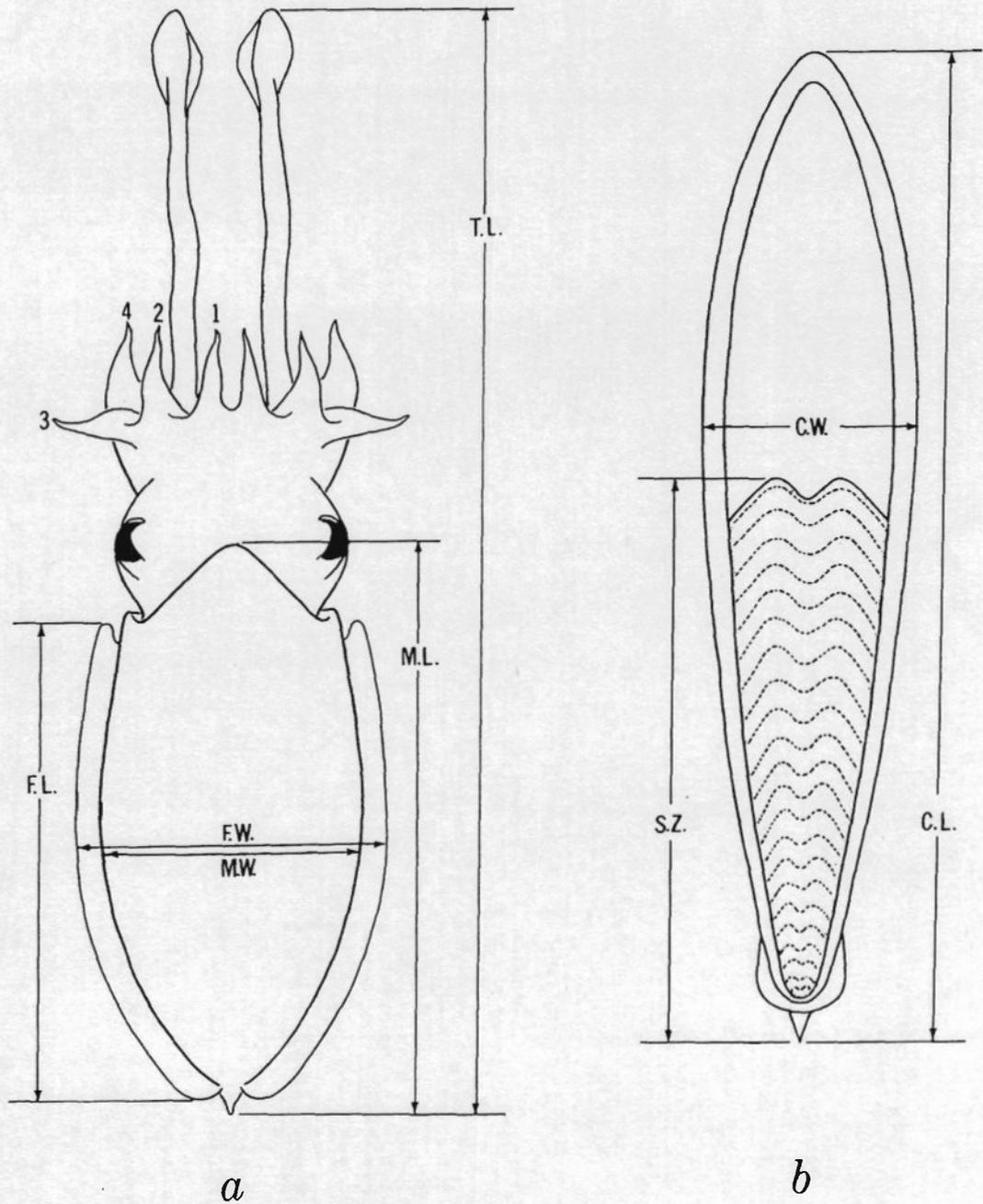
Figure 1. Sepioidea, Sepiidae. a. Dorsal view: FL=Fin Length, FW=Fin Width, ML=Mantle Length (dorsal), MW=Mantle Width, TL=Total Length. b. Cuttlebone, ventral view: CL=Cuttlebone Length, CW=Cuttlebone Width, SZ=Striated Zone.

Figure 2. Teuthoidea. a. Dorsal view, composite diagram. ED=Eye Diameter, FL=Fin Length, FW=Fin Width, HL=Head Length, HW=Head Width, ML=Mantle Length, MW=Mantle Width, TL=Total Length, TtL=Tentacle Length; Left eye=oegopsid eye, Right eye=myopsid eye. b. Gladius, ventral view. GL=Gladius Length, GW=Gladius Width, RL=Rachis Length, RW=Rachis Width.

Figure 3. Teuthoidea. a. Hectocotylied Arm: AL=Arm Length, AW=Arm Width, HL=Hectocotylied Length. b. Tentacle and Club: CL=Club Length, CS=Club Sucker (largest), TtL=Tentacle Length.

4th arm - (L) & (R)

Figure 1



E

Figure 2

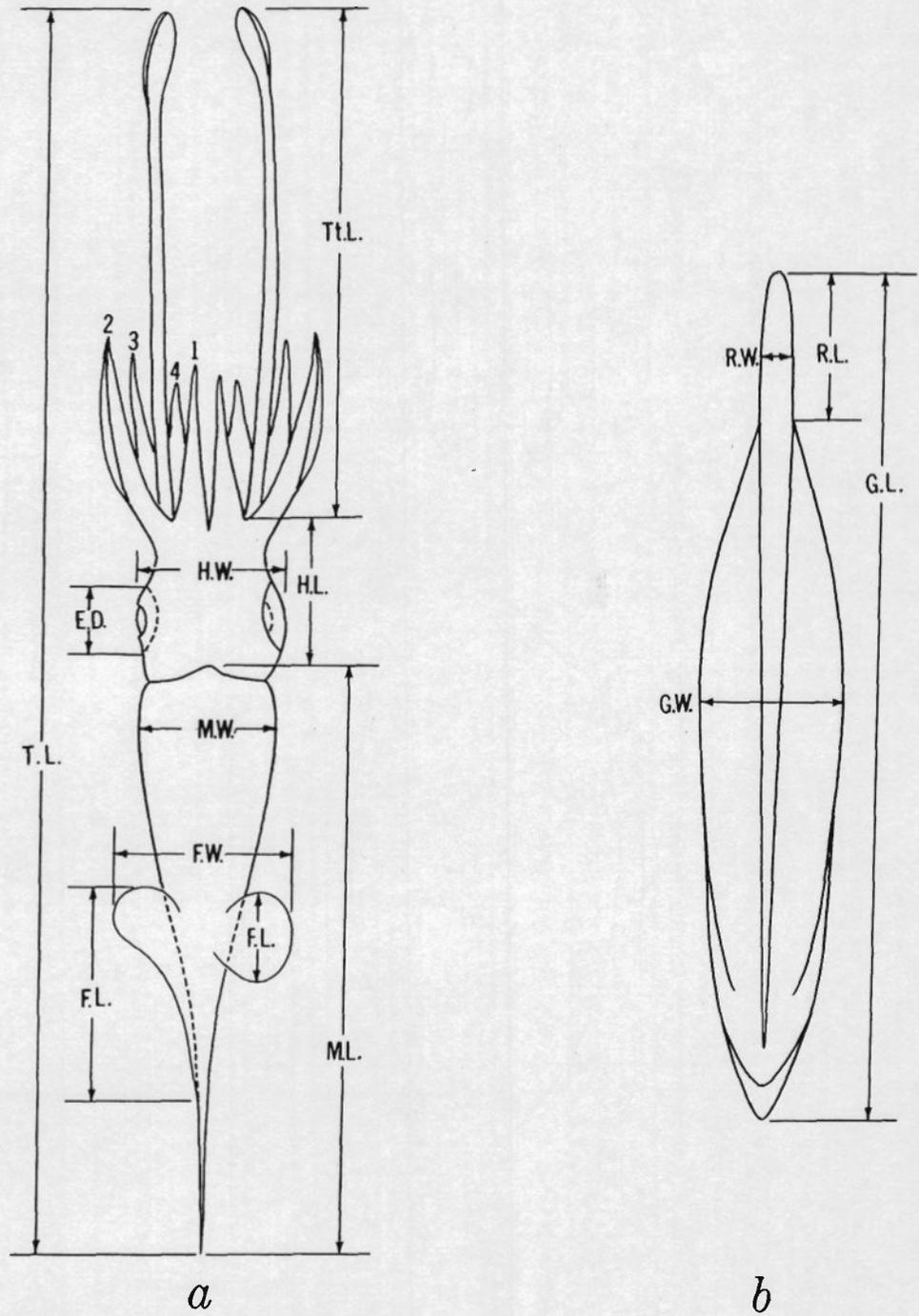


Figure 3

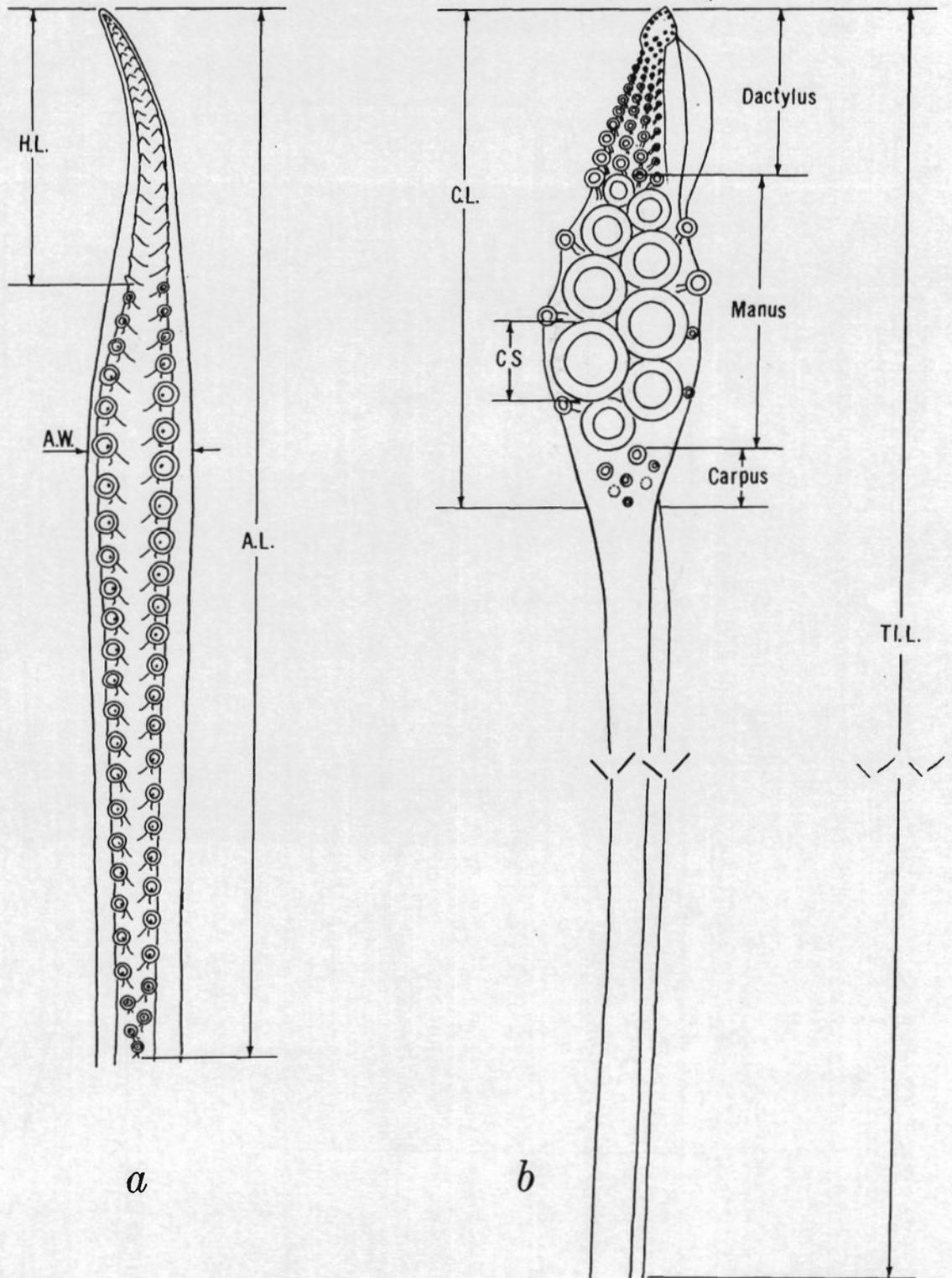
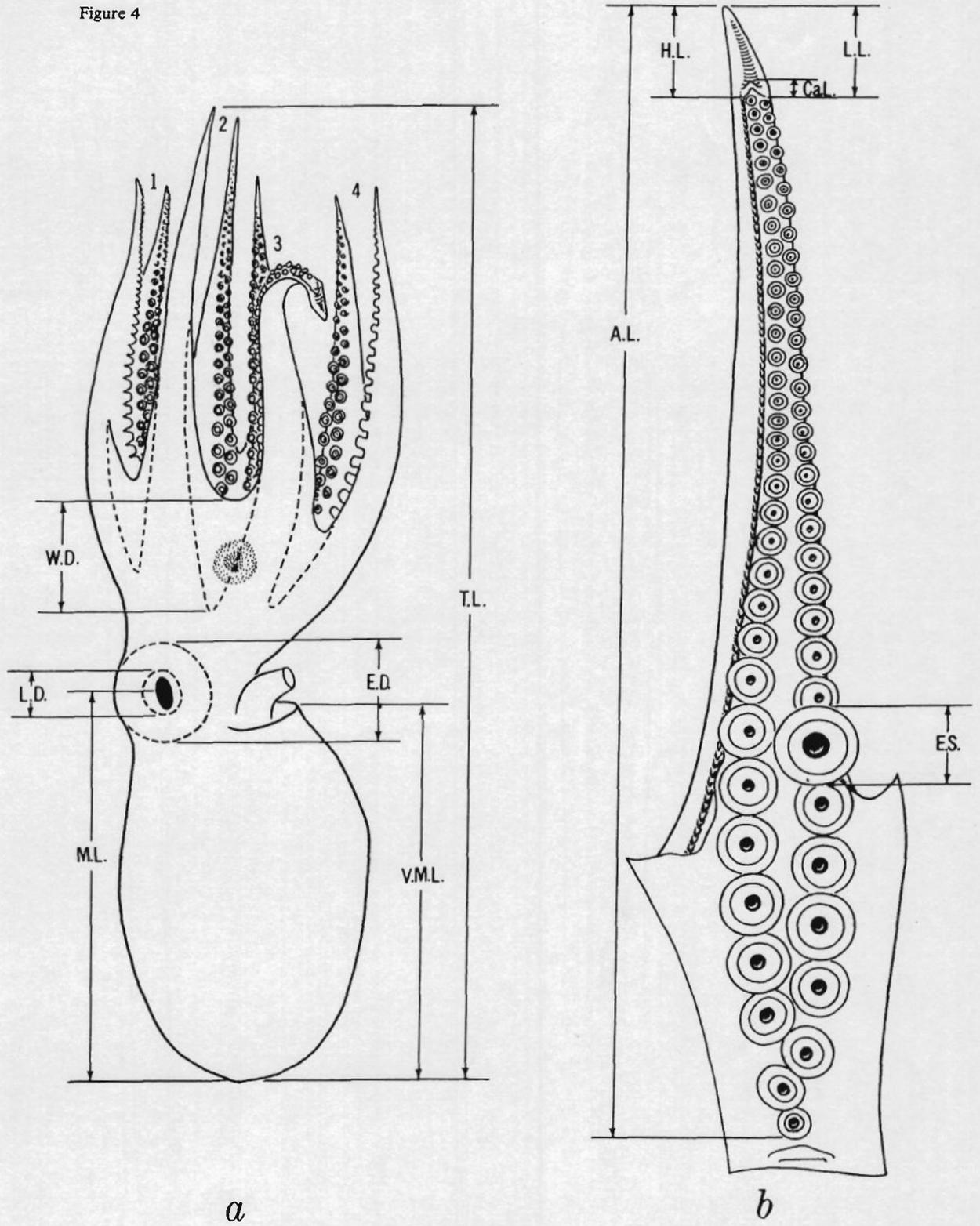


Figure 4



**Appendix 3. Selected references as examples of adequate taxonomic descriptions.**

**SEPIOIDEA (CUTTLEFISH)**

- ROELEVELD, M. A., 1972. A review of the Sepiidae (Cephalopoda) of southern Africa. *Ann. South Afr. Mus.* 59(10): 193-313, 20 figures, 11 plates.

**TEUTHOIDEA (SQUIDS)**

- BURGESS, L. A., 1967. *Loliolus rhomboidalis*, a new species of loliginid squid from the Indian Ocean. *Bull. Mar. Sci.* 17(2): 319-329, 5 figures.
- COHEN, A. C., 1976. The systematics and distribution of *Loligo* (Cephalopoda, Myopsida) in the western North Atlantic, with descriptions of two new species. *Malacologia* 15(2): 299-367, 31 figures.
- KRISTENSEN, T. K., 1981. The genus *Gonatus* Gray, 1849 (Mollusca: Cephalopoda) in the North Atlantic. A revision of the North Atlantic species and description of *Goantus steenstrupi* n. sp. *Steenstrupia*. 7(4): 61-99, 29 figures.
- KUBODERA, T. & OKUTANI, T., 1981. *Gonatus midden-dorffi*, a new species of gonatid squid from the northern North Pacific, with notes on morphological changes with growth and distribution in immature stages (Cephalopoda, Oegopsida). *Bull. Nat. Sci. Mus. Ser. A* 7(1): 7-27, 4 figures, 1 plate.

- ROPER, C. F. E., 1969. Systematics and zoogeography of the worldwide bathypelagic squid *Bathyteuthis* (Cephalopoda: Oegopsida). U.S. Nat. Mus. Bull. 291: 1-210, 74 figures, 12 plates.

- ROPER, C. F. E. & YOUNG, R. E., 1969. A monograph of the Cephalopoda of the North Atlantic: The Family Cycloteuthidae. *Smithson. Contr. Zool.* 5: 1-24, 9 plates.

- YOUNG, R. E., 1972. The systematics and areal distribution of pelagic cephalopods from the seas off southern California. *Smithson. Contr. Zool.* 97: 1-159, 38 plates.

- VOSS, N. A., 1980. A generic revision of the Cranchiidae (Cephalopoda; Oegopsida). *Bull. Mar. Sci.* 30(2): 365-412, 13 figures.

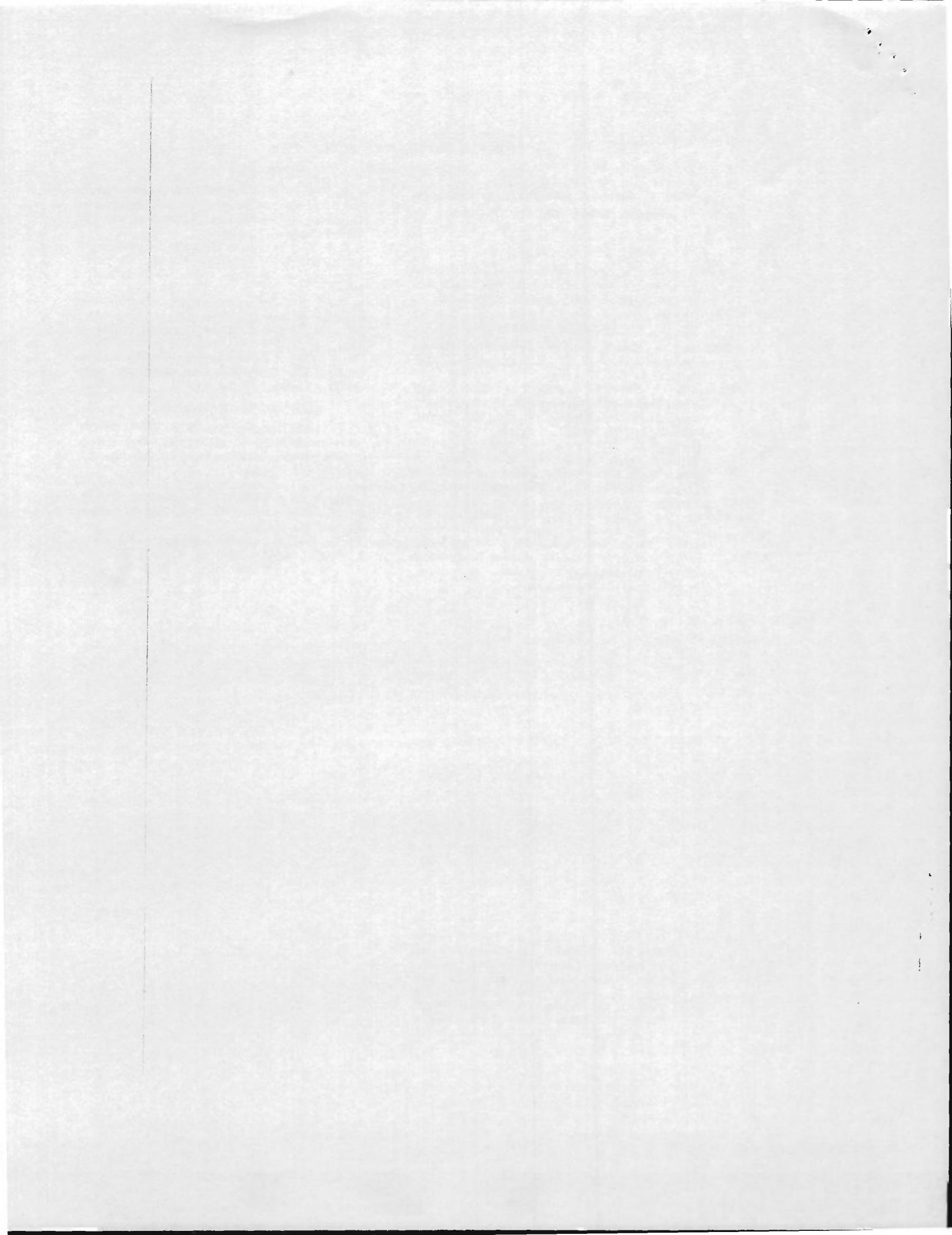
**OCTOPODA (OCTOPUSES)**

- Voss, G. L., 1968. Octopods from the R/V PILLSBURY southwestern Caribbean cruise, 1966, with a description of a new species, *Octopus zonatus*. *Bull. Mar. Sci.* 18(3): 645-659, 4 figures.

- Voss, G. L., 1981. A redescription of *Octopus ornatus* Gould, 1852 (Octopoda: Cephalopoda) and the status of *Callistoctopus* Taki, 1964. *Proc. Biol. Soc. Wash.* 94(2): 525-534, 3 figures.

- Voss, G. L., 1982. *Grimpot euthis bruuni*, a new species of finned octopod (Octopoda: Cirrata) from the southeastern Pacific. *Bull. Mar. Sci.* 32(2): 426-433, 2 figures.

Figure 4. Octopoda, Incirrata. a. Lateral View: ED=Eye Diameter, LD=Lens Diameter, ML=Mantle Length, TL=Total Length, VML=Ventral Mantle Length, WD=Web Depth. b. Hectocotylied Arm: AL=Arm Length, CaL=Calamus Length, ES=Enlarged Sucker, HL=Hectocotylus Length, LL=Ligula Length.



GUIDELINES FOR TAXONOMIC DESCRIPTIONS OF CEPHALOPOD  
SPECIES

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