RICHARD EDWARD YOUNG

The Systematics and Areal Distribution of Pelagic Cephalopods from the Seas off Southern California

SMITHSONIAN CONTRIBUTIONS TO ZOOLOGY NUMBER 97

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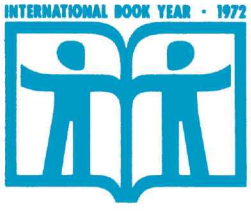

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ABSTRACT

Young, Richard Edward. The Systematics and Areal Distribution of Pelagic Cephalopods from the Seas off Southern California. *Smithsonian Contributions to Zoology,* number 97, 159 pages, 15 figures, 38 plates, 1972.—The mid-water cephalopods from off the coast of southern California and adjacent areas are described and their areal distribution is discussed. Forty-two species of pelagic cephalopods are now known from this area including ten new species. Off southern California the fauna is part of the transitional and subarctic fauna to the north, while primarily tropical species are found off northern Baja California.

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Richard Edward Young

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Introduction

The pelagic cephalopod fauna of the eastern North Pacific is poorly known. The single major paper treating cephalopod systematics of this area (Berry 1912b) dealt with only a small portion of the pelagic species. Material for this study was collected by the University of Southern California over a six-year span from the fall of 1960 to the fall of 1966. During this period, 445 mid-water tows were taken with an Isaacs–Kidd mid-water trawl. This represents an estimated 911 hours of "fishing" at discrete depths from the surface to about 1200 meters. This program yielded over 5,000 specimens of pelagic cephalopods belonging to 40 species of which 33 are described in this report.

The present paper attempts to delineate the pelagic cephalopod fauna occurring in the waters off southern California and to discuss the zoogeographic relationships of this fauna. Subsequent papers will treat the vertical and seasonal distribution of the most abundant species.

Materials and Methods

Specimens were collected with an Isaacs-Kidd mid-water trawl with a mouth 10 feet in diameter. The net was operated from the University of Southern California's R/V VELERO IV. Comparative material was available from the large collections gathered by G. L. Voss at the University of Miami's Institute of Marine and Atmospheric Sciences. The University of Southern California trawling program initially studied the waters over the most accessible inshore basin, the San Pedro Basin, which lies between the mainland and Santa Catalina Island. The program subsequently was extended to include the area of the Santa Caltalina Basin to the west of Santa Catalina Island. The most intensive sampling (over 200 stations) has occurred in this area. While never completely abandoning these two basins, the program was extended to include San Nicolas Basin, San Clemente Basin, the waters just west of the continental slope, and the waters to the south as far as the vicinity of Guadalupe Island. The total area studied is well within a region extending from 28°N to 34°N. While the region sampled is rather small, it lies within a transitional faunal region and, as a result, distinct differences were noted in the species composition between the northern and southern ends of this area. To demonstrate such geographic differences, I have divided the area of study into seven zones (Figure 2) so that each includes a major area of sampling.

In this paper, the following abbreviations are used:

Sta. no. number of station where specimen was captured
M.L. mantle length
M.W. mantle width
P.L. pen length
P.W. greatest width of pen
F.L. fin length

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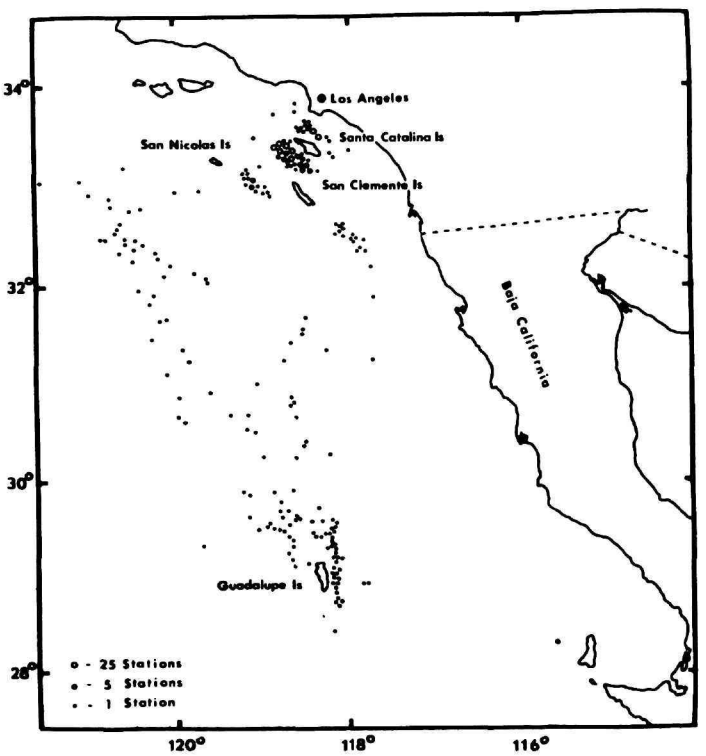

FIGURE 1.—Localities of trawling stations. Dots correspond to the midpoints of the trawling transects.

H.W. head width

H.L. head length measured from the anterior end of the nuchal cartilage of the base of arms I

Tail L. tail length

Arm L. I length of arm I measured from the arm base, between arms I (where the muscular portion of the arms join) to the arm tip

Arm L. II length of arm II measured from the arm base between arms II and III to the arm tip

Arm L. III length of arm III measured from the arm base between arms II and III to the arm tip

Arm L. IV length of arm IV measured from the arm base between arms IV to the arm tip

A.C. I–IV arm count (Total number of suckers and/or hooks on the indicated arm)

½ A.C. I–IV total number of suckers and/or hooks on the proximal 50 percent of the arm length of the indicated arm measured from the basal sucker

A.C. Dist. S. I–IV number of suckers distal to arm hooks on the indicated arm

A.C. Prox. S. I–IV number of suckers proximal to arm hooks on the indicated arm

A.C. Hooks I–IV number of hooks on the indicated arm

Sucker D. diameter of largest arm sucker

\+ accurate count or measurement greater than given figure due to damaged arm.

Club L. length of tentacular club

Club H. number of hooks on club

Club H. F. club hook formula (number of hooks in the dorsal medial row over the number in the ventral medial row)

Club S. number of suckers on club

Club S. D. diameter (long axis) of largest club sucker

Carp. S. number of suckers in carpal cluster

Carp. K. number of knobs in carpal cluster

Carp. F. carpal formula (number of carpal knobs over the number of carpal suckers)

Dact. S. number of suckers on the dactylus of the club

Dact. T.S. number of suckers in the sucker pad at the tip of the dactylus

Tent. L. tentacle length

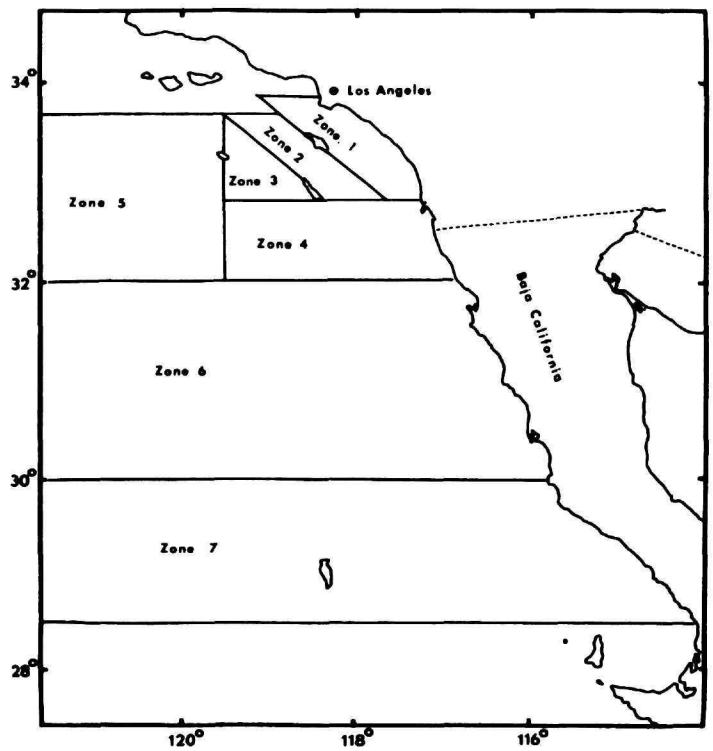

FIGURE 2.—Breakdown of area studied into zones corresponding to major areas of sampling.

Stalk S. number of suckers on the tentacular stalk
D.S.S. number of suckers in the dorsal row on the tentacular stalk
V.S.S. number of suckers in the ventral row on the tentacular stalk
M.S.S. number of suckers in median portion of tentacular stalk
R. right
L. left
Tub. L. length of cartilagenous strip bearing tubercules
Tubercles number of cartilagenous tubercules at funnel–mantle fusion
Gill L. gill length
G.C. gill count (total number of primary gill lamellae)
Gill W. gill width
Lam. L. length of longest lamella
Eye D. eye diameter
Egg D. egg diameter
Ov. G. Diam. diameter of oviducal gland.

Unless otherwise indicated in the tables, measurements and counts of structures on the right and left sides have been averaged to give single figures. Measurements are in mm and have been rounded to the nearest whole number in most cases.

Acknowledgments

I am indebted to many people who assisted me in the present work. J. S. Savage, J. S. Garth, R. Lavenberg, D. Bright, and R. Given associated with the University of Southern California provided specimens and data. F. Hochberg kindly supplied specimens taken by the R/V SWAN. G. Y. Hendrix of the University of Miami provided a considerable amount of help in sorting and caring for the collection and in making preliminary identifications during the early stages of this work. Diane McGinnis helped with sorting when time was becoming a critical factor.

Drs. Garth and Savage also provided funds for a trip to the University of Southern California during the course of the study. I am also indebted to the personnel of the R/V VELERO IV and the students and staff at the University of South-

ern California that participated in the cruises.

This study was accomplished under the supervision of G. L. Voss, whom I thank for his assistance in innumerable ways and for his support, encouragement, and help with the manuscript. The comparative material, which was invaluable to this study, was drawn from the large collections gathered by Dr. Voss at the University of Miami's Institute of Marine and Atmospheric Sciences.

I am grateful to D. DeSylva and R. Hurly for reading the manuscript and offering valuable suggestions.

I am also indebted to C. F. E. Roper for supplying type material and much valuable information concerning specimens in the collections of the National Museum of Natural History. Dr. Roper has added considerably to the present work through numerous discussions on systematic and other biological problems. E. S. McSweeny also provided aid through discussions of many of the problems encountered.

The great majority of the illustrations were done by Mrs. Constance McSweeny. Mrs. McSweeny, a biologist as well as an excellent artist, on many occasions detected important systematic characters that had previously gone unnoticed. I thank Mrs. McSweeny for her excellent illustrations and also for her help with the systematic aspects of the paper. Mrs. McSweeny deserves double thanks for her contribution. After all the plates were completed, they were destroyed in a fire at Miami and had to be redone.

During the course of this study, a number of visits were made to Redlands, California where S. Stillman Berry and I were able to have long discussions on many aspects of cephalopod biology. I thank Dr. Berry for his interest and enthusiasm.

Finally, I wish to thank my wife, Shelia, for assisting with the typing, compiling data, and for supplying ecouragement.

This research was partially supported by grants G–10691 and G–23467 from the National Science Foundation to the University of Southern California, and by grants GM–5729X, GA–0709, and GA–1493 from the National Science Foundation to the Univrsity of Miami, and by the National Geographic Society–University of Miami Deep-Sea Biology Program.

This work was done in partial fulfillment of the Ph.D. degree at the Institute of Marine and Atmospheric Sciences of the University of Miami.

Description of Study Area

The ocean floor off southern California between the shoreline and the continental slope, a distance of 50 to 160 miles, is unusually complex. Shepard and Emery (1941) designated this region the continental borderland to distinguish it from typical continental shelves. This area contains a dozen complete basins ranging from about 500 to 2,100 meters in depth, several troughs, numerous banks, and eight islands. At the western edge of the borderland, the continental slope drops rapidly to a depth of about 3,500 meters.

The waters over the continental borderland are derived from the complex interaction of several water masses. The California Current is the eastern component of the great anticyclonic circulation of the North Pacific and, as such, it is a continuation of the North Pacific Drift (sensu lato). The waters of the northern portion of the California Current are derived largely from the Subarctic water. As this cold current extends southward, it warms through insolation and by increased mixing with waters from Central water to the west. At about 25° N, it begins to turn westward and eventually merges into the North Equatorial Current. Off southern California a nearly permanent eddy is present, creating north-flowing currents between San Clemente and Santa Catalina islands.

The surface waters over the borderland are modified to some extent by upwelling. Prevailing winds along the southern California coast, which are from the north and northwest, are strongest in May and June. Surface waters, under the influence of these winds and the earth's rotation, are driven offshore and replaced by nutrient-rich waters which upwell from below to a maximum depth of 200 to 300 meters. Entrainment of surface water by the California Current over the shallow Santa Rosa–Cortes Ridge may also play a role in the upwelling.

During the winter an inshore surface countercurrent is present along most of the coast from the southern tip of Baja California to at least 45° N. This current seems to be somewhat variable off Baja California and off southern California, but is well defined north of Point Conception where it is known as the Davidson Current.

Below 150 to 200 meters a deep countercurrent of Equatorial Pacific Water flows northward along the coast to at least 40° N. and progressively mixes with the lower layers of the California Current. Off southern California the major flow of the deep countercurrent, which has become transitional in composition at this latitude, occurs just seaward of the continental slope, although portions flow over the borderlands apparently filling the basins and forming the water of the intermediate depths.

Thus, over the borderland, the influence of the California Current, the surface countercurrent, and upwelling predominate in about the upper 200 meters while below 200 to 300 meters the influence of the southern water predominates. (The above discussion is based primarily on Reid, Roden, and Wyllie 1958, and Emery 1960.)

Surface temperature ranges are shown in Figures 3 and 4.

Zoogeography

The present study area lies within an oceanographic and faunistic transitional region. The faunal changes that occur within this area have been demonstrated by a number of authors. The faunal boundries seem to apply equally well to the littoral (Ekman 1953), deep benthic (Parker 1964), epipelagic (McGowan 1968), and mid-water (Brinton 1962, Lavenberg and Ebeling 1967) faunas.

Brinton (1962) gave an excellent account of the distribution of euphausiids in the northeastern Pacific. His chart showing the faunal relationships of euphausiids in this area for a 2-month period (August–September) is reproduced here (Figure 5). A more generalized chart (Figure 6) is given by McGowan (1968) based on the distribution of pteropods and heteropods.

From the limited information available, it appears

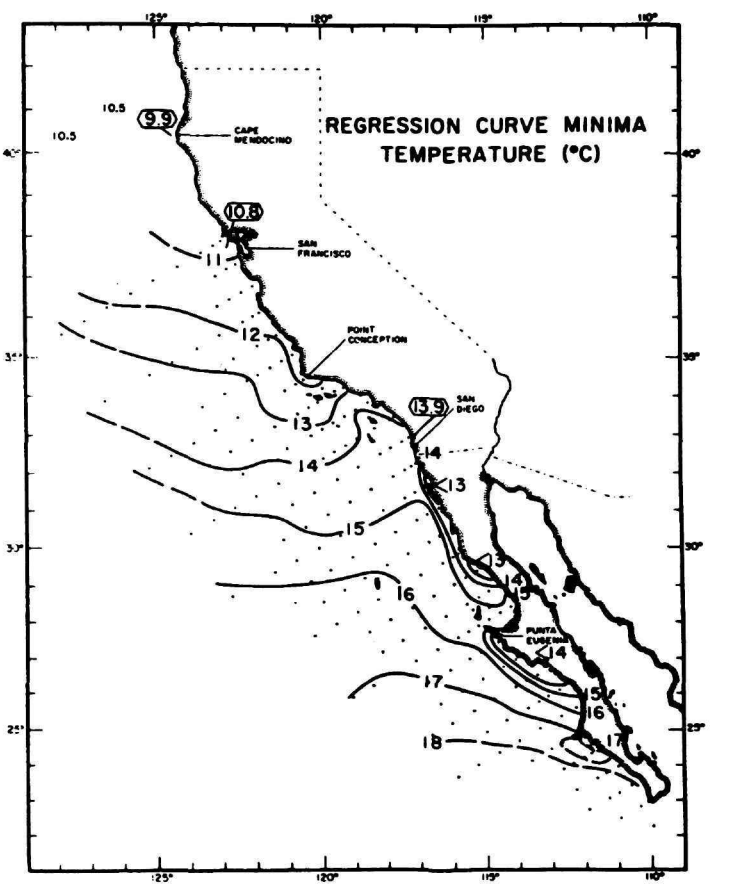

FIGURE 3.—Extremes of temperature regression curves in the study area based on data taken from 1950 to 1962. (Reproduced from R. J. Lynn, 1967.)

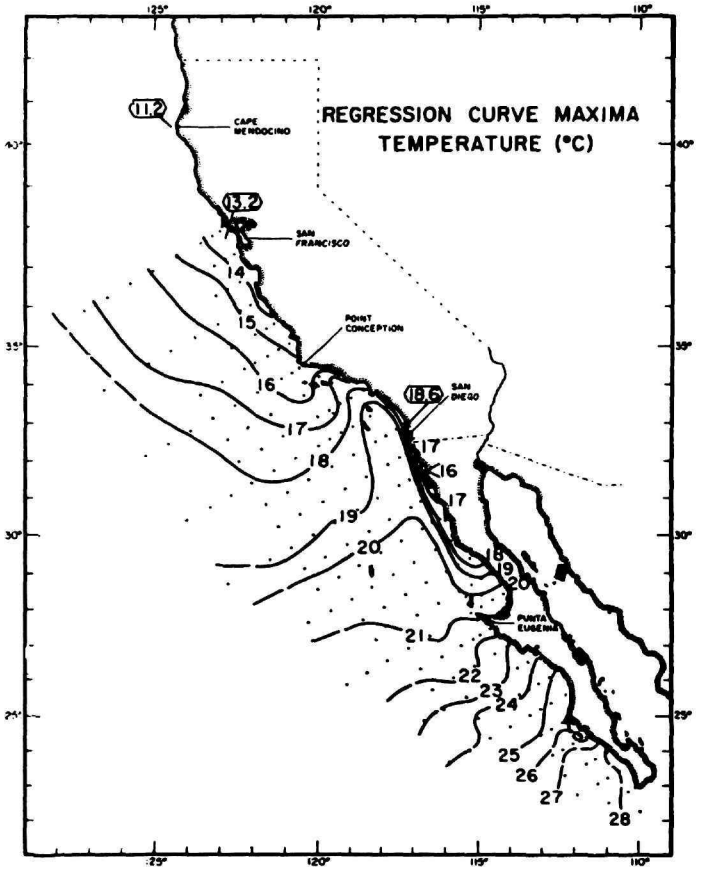

FIGURE 4.—Extremes of temperature regression curves in the study area based on data taken from 1950 to 1962. (Reproduced from R. J. Lynn, 1967.)

that cephalopods in this area exhibit general faunal distributions similar to the euphausiids, pteropods, and heteropods. Many cephalopod species during the period studied were absent or only sparcely represented in the southern zones, but were abundant in the northern zones; the reverse trend was also apparent. In many cases species can be confidently related to the established faunal assemblages of the North Pacific, while for other species only indications of their faunal relationships can be determined.

Subarctic and Transitional species. Due to our present lack of information, it is difficult in many cases to determine whether a species occurs primarily in Subarctic, Transitional, or Subarctic and Transitional waters. Therefore, the placement of certain species within one category or the other must be considered tentative.

Moroteuthis robusta appears to be the species most closely associated with Subarctic water which has been reported off southern California. It has only rarely been collected from these waters (Phillips 1961). It is known from off northern California (Phillips 1966), Oregon (van Hyning and Magill 1964), Canada, the Aleutian Islands, and northern Japan (Clarke 1966).

Two other species, *Berryteuthis magister* and *B. anonychus,* probably are distributed primarily in Subarctic waters and are not known from California. *Berryteuthis magister* (Berry 1913) has been recorded from Japan, Kuril region, coastal waters of the Aleutian Islands, the Gulf of Alaska, Puget Sound, and off Oregon (Clarke 1966). *Berryteuthis anonychus* (Pearcy and Voss 1963) is known only from the coast of Oregon.

Gonatopsis borealis is also known from Subarctic waters, but is more abundant in the southern California waters than *Moroteuthis robusta* and has a southern limit of distribution off northern Baja Cali-

Material Examined

Species	Mantle Length in mm																Total Specimens
	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	121-130	131-140	141-150	150 +	
Abraliopsis falco				6	4												10
Abraliopsis felis	187	395	210	118	20												930
Pyroteuthis addolux	1	18	1														20
Pterygioteuthis gemmata	9	47	99	13													168
Ommastrephes bartramii																5	5
Symplectoteuthis luminosa														1		1	2
Neoteuthis sp.									1								1
Histioteuthis heteropsis	26	128	62	20	3	3	4	3	1	1							251
Histioteuthis dofleini	1	1													1		3
Octopoteuthis deletron	11	12	22	46	9	7	5			2				2			116
Gonatus onyx	—	330+	633	225	88	24	6	1	1		1						1309+
Gonatus berryi	69	123	71	29	10	2		1	1	1				1			308
Gonatus pyros	—	41+	101	41	4												187+
Gonatus californiensis	—	29+	50	25	13	4	1	1	1		1		3				128+
Gonatopsis borealis	6	63	53	12	2											5	141
Onychoteuthis borealijaponicus	31	47	8	3	2		1	1	1	1							95
Mastigoteuthis pyrodes				2		1	3	1	4	3	3	1	1	2	1	5	27
Chiroteuthis calyx		4	19	38	46	24	5			1							137
Valbyteuthis oligobessa		1	6	6	3	1	2										19
Valbyteuthis danae					1												1
Grimalditeuthis bomplandii									1								1
Bathyteuthis berryi	1	11	3		1												16
Cranchia scabra		3	1	1	1		1			1							8
Leachia dislocata	27	65	33	19	19	9	10	7	8	2	7	5	4	7	3		225
Galiteuthis phyllura	14	24	30	37	20	8	3	5	5	6	3	2	3	5	4	13	182
Galiteuthis pacifica				1	1	1	1										4
Helicocranchia pfefferi	5	29	24	25	17	7	8										115
Japetella heathi & *J.* sp.	26	33	26	12	9	1	3	4	1	1							116
Ocythoe tuberculata		2				1		1									4
Alloposus mollis												1					1
Octopus sp.	333+	100+	2														432+
Vampyroteuthis infernalis	14	131	56	40	43	50	16	21	10	6	3						390
Total Specimens																	5,352+

fornia. It has been recorded from California, Oregon, the Bering Sea, Kamchatka, and nothern Japan.

Onychoteuthis borealijaponicus is known from off California, Oregon, Canada, and northern Japan. Probable records also occur in the Bering Sea.

If all northern Pacific *Galiteuthis* (except *G. pacifica*) belong to *G. phyllura,* then this species would be known from the Kurile Islands and the Bering Sea as well as off California and Oregon; it seems likely that this will prove to be the case.

Loligo opalescens may extend as far south as the tip of Baja California and extends north to the southern end of British Columbia (Fields 1965).

A number of additional species are believed to have the southern limit of their distribution off northern Baja California and are known to extend north to the middle Oregon coast. These are: *Gonatus onyx, Chiroteuthis calyx, Octopoteuthis deletron,* and *Abraliopsis felis.* It seems likely that these four species will prove to be distributed primarily in Transitional waters, although *Abraliopsis felis* has tentatively been recorded off Hawaii. *Octopoteuthis deletron* is also known from off northern Peru and may be an antitropical species.

Histioteuthis heteropsis is known from the southern California area north to Monterey Bay. Its southern

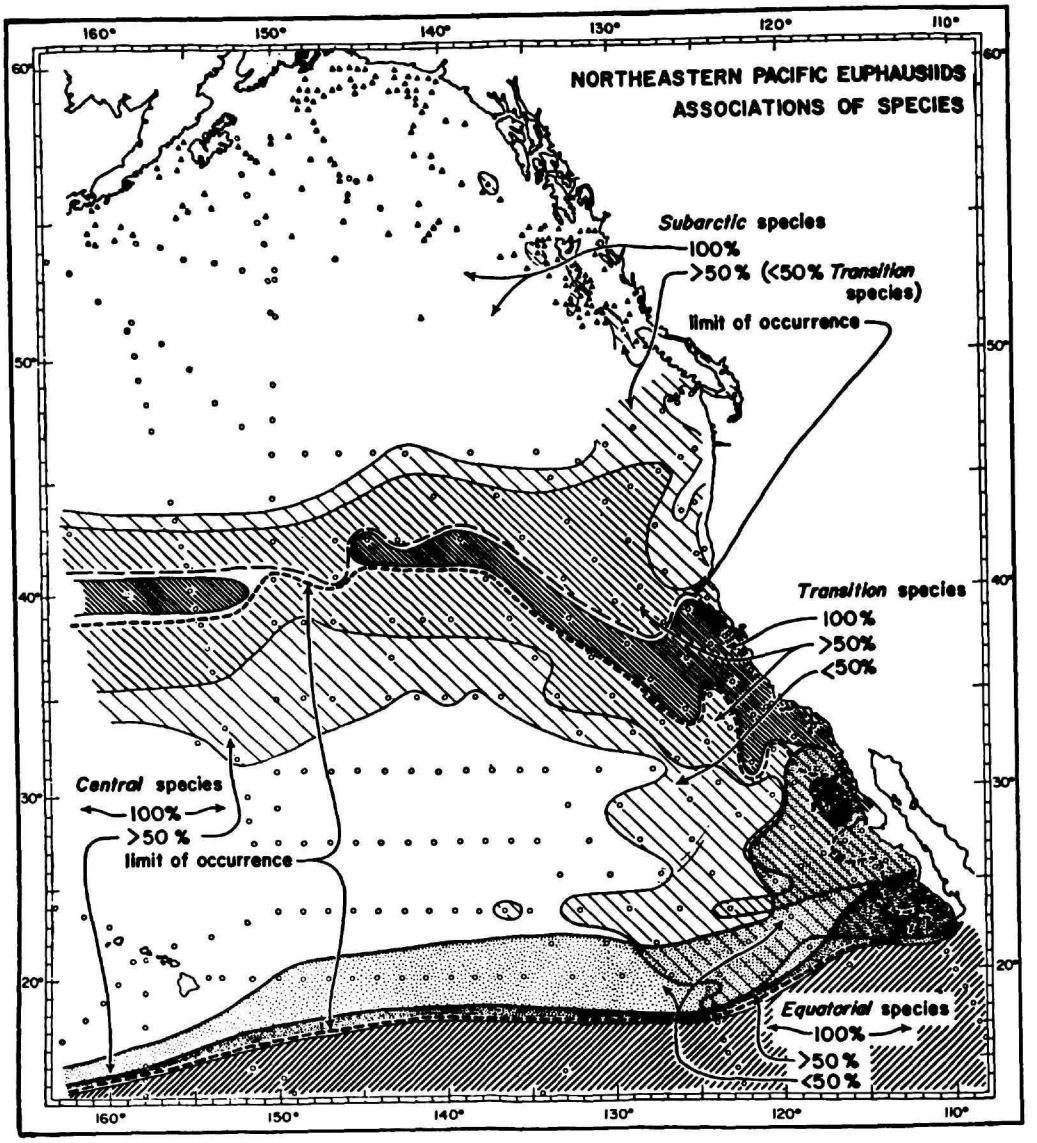

FIGURE 5.—Faunistic zones of the northeastern Pacific based on the distribution of euphausiids. (Reproduced from Brinton, 1962).

limit is thought to lie off northern Baja California. It has also been reported off Chile and is also considered to be antitropical in distribution.

Other species which, at present, are thought to have southern limits off northern Baja California and are known only from Transitional waters are *Gonatus berryi* and *Gonatus pyros*. *Gonatus californiensis* extends somewhat farther south along Baja California, and there is a single record of a larva from the Bay of Panama that apparently belongs to this species. This is, however, considered tentatively to be outside the normal range for this species.

Central species. Two species, *Leachia dislocata* and *Abraliopsis falco*, show definite preference for the southern zones of the study area and have also been found off Hawaii and therefore probably belong

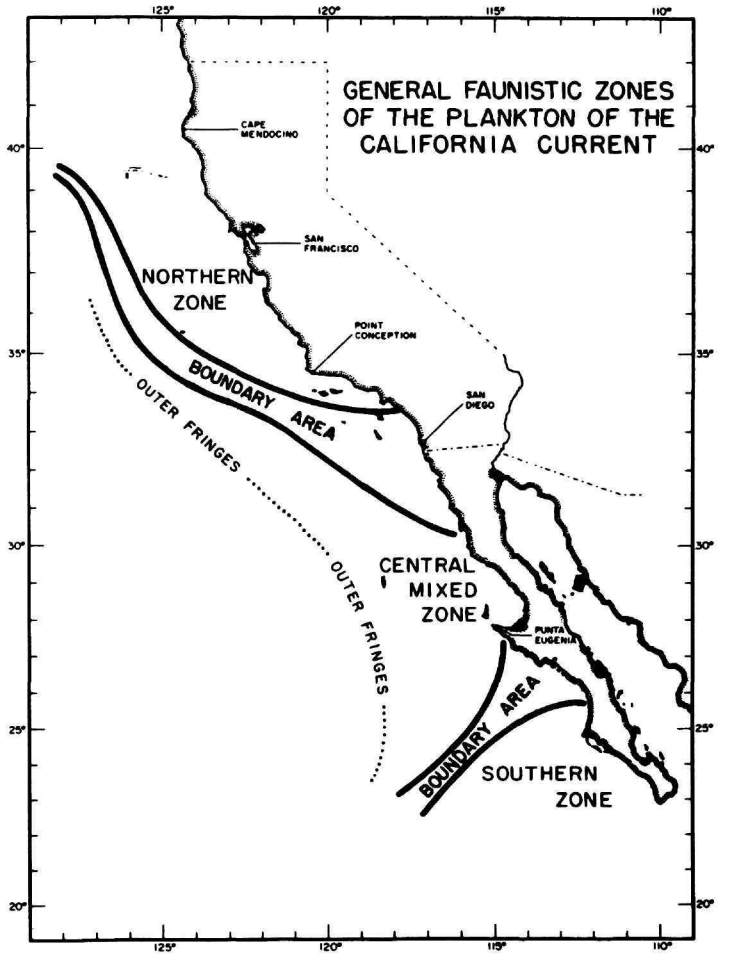

FIGURE 6.—Faunistic zones off California and Baja California based primarily on the distribution of pteropods and heteropods. (Reproduced from McGowan, 1968.)

to the Central Water Mass fauna.

Equatorial species of the eastern Pacific. Two species, *Galiteuthis pacifica* and *Valbyteuthis danae,* are know from the eastern Pacific off Panama where they are thought to be common. Only a few specimens have been taken in the southern California area.

Occasionally, *Dosidicus gigas* is found off southern California. A major invasion of this species took place from 1934 to 1937. This squid first became abundant in 1935 when 12 tons were landed at San Pedro Harbor during August and September. The squid varied from 2 to 2½ feet in length. Many individuals were taken north of Monterey Bay during the fall and winter of 1935 and January of 1936. Most of these specimens were between 3 and 4 feet long. In January 1936, 400 pounds were taken in a purse seine. The individuals averaged close to 4 feet in length (Clark and Phillips 1936). Croker (1937) states that in 1934 and 1935 specimens weighed about 5 pounds, while those caught in the early part of 1937 were averaging over 20 pounds.

This information indicates that *D. gigas* was not breeding in the southern California waters but invaded, grew, and disappeared after 1937. Apparently this species has not been present in any numbers since 1937. Young *D. gigas* are common in the Bay of Panama (personal observation) while only large specimens are known from the coast of Chile, and these disappear during part of the year (P. Garcia-Tello, personal communication). It seems likely that this species is an equatorial form which migrates

away from its spawning grounds into cold water to feed. If this is so, it is strange that this species does not occur more commonly off southern California.

Argonauta pacifica has been reported from the Galápagos Islands to Monterey Bay (Berry 1912b). Its occurrence off southern California seems to be sporadic. On occasion, it has been reported off southern California in considerable numbers (Berry 1912b).

Cosmopolitan tropical and subtropical species. Species known from California that have been recorded as having a cosmopolitan distribution in tropical and subtropical waters are: *Pterygioteuthis gemmata, P. giardi, Ommastrephes bartramii, Alloposus mollis, Ocythoe tuberculata, Histioteuthis dofleini.* Two additional species, *Cranchia scabra* and *Vampyroteuthis infernalis,* have a similar distribution but also occur in somewhat higher latitudes. *Symplectoteuthis luminosa* appears to be broadly distributed within warm waters of the Pacific Ocean only.

Species with insufficient distributional data. Mastigoteuthis pyrodes is found in greater abundance within the southern zones of the study area, but is not known from either the waters off Panama or off Hawaii. *Valbyteuthis obligobessa* and *Bathyteuthis berryi* are known only from the present trawling program and show no preference for the southern or northern latitudes within the study area. *Pyroteuthis addolux* also exhibits no latitudinal preference in the study area, but is clearly more abundant in the more oceanic zones. This species is also known from as far west as longitude 147° W. Systematic problems or insufficient data prevent discussion of the zoogeography of the following species: *Neoteuthis* sp., *Japatella diaphana, Japetella* sp., *Grimalditeuthis bomplandii,* and *Heliocranchia pfefferi.*

Inshore and offshore species. Some species that occur along the coast show preference for inshore waters over the continental borderland, while others show a preference for the more offshore waters seaward of the continental slope. In the present study, *Gonatus onyx,* the most abundant species taken, seemed to prefer near-shore waters as do *G. californiensis* and *G. pryos,* while *Onychoteuthis borealijaponicus* and *Pyroteuthis addolux* showed preference for offshore waters. McGowan and Okutani (1968) found that larvae of *Abraliopsis felis* were taken most frequently in offshore waters. A similar trend was found in the present study in specimens 20 mm M.L. or less, but not in specimens larger than 20 mm. *Valbyteuthis obligobessa* is also more abundant in the offshore zones; this appears to be correlated with its deep-water habitat.

Faunal affinities. It is apparent that in the northern zones off Los Angeles the species with northern affinities (i.e., Transitional and Subarctic species)

TABLE 1.—*Distribution frequencies (specimens per hour of trawling) of most abundant species. Frequencies are corrected for estimated depth of capture and for contamination resulting from the use of open-net trawls.*

Species	*Zones*						
	1	*2*	*3*	*4*	*5*	*6*	*7*
Abraliopsis felis > 20 mm M.L.	0.66	1.13	0.03	0.00	0.50	0.63	0.22
Abraliopsis felis < 21 mm M.L.	0.61	1.07	0.12	0.75	2.93	1.63	0.23
Pterygioteuthis gemmata	0.15	0.08	0.30	0.00	0.13	1.71	1.34
Histioteuthis heteropsis	0.22	0.52	0.37	0.14	0.18	0.31	0.03
Octopoteuthis deletron	0.24	0.18	0.26	0.05	0.36	0.29	0.00
Gonatus onyx	3.12	2.80	1.34	0.05	0.00	0.12	0.00
Gonatus berryi	0.32	0.57	0.59	0.19	0.25	0.45	0.00
Gonatus pyros	0.16	0.24	0.07	0.11	0.03	0.02	0.15
Gonatus californiensis	0.28	0.47	0.16	0.00	0.03	0.00	0.00
Gonatopsis borealis	0.06	0.40	0.05	0.00	0.21	0.08	0.01
Onychoteuthis borealijaponicus	0.05	0.09	0.05	0.00	1.49	3.18	0.18
Chiroteuthis calyx	0.19	0.16	0.26	0.05	0.19	0.52	0.00
Leachia dislocata	0.02	0.07	0.13	0.12	0.31	2.28	1.25
Galiteuthis phyllura	0.11	0.26	0.28	0.04	0.29	0.29	0.02
Helicocranchia pfefferi	0.11	2.28	0.53	0.07	0.04	0.12	1.63
Vampyroteuthis infernalis	0.23	0.57	0.52	0.70	0.89	1.19	0.49
Japetella sp.	0.09	0.15	0.09	0.25	0.22	0.30	0.26

predominated during the study period from 1960–1966. The 14 more abundant species (disregarding *Helicocranchia* and *Japetella* due to systematic complications) taken in this survey give a total frequency of capture (specimens/hour) of 9.41 in zone 2 (Catalina Basin—the most heavily sampled area), of which 8.59 specimens per hour represent species with northern affinities. In zone 7 (the most southernly zone) these same 14 species have a total catch frequency of 3.92 specimens per hour, of which 3.08 specimens per hour represent species with southern affinities (i.e., species of tropical waters including the North Pacific Central waters). These figures also suggest a greater abundance of individuals in zone 2 compared to the more oceanic zone 7.

The predominant affinity with a more northern fauna can be further emphasized by the total counts of individuals. Almost 80% of the total specimens taken in the survey belong to species with northern affinities, while only slightly more than 11% of the total specimens belong to species with southern affiinities. (The remaining 9% represent species whose affinities could not be determined for various reasons.)

Of the 42 species of pelagic cephalopods recorded off southern California and nearby waters 8 are unidentified at the specific level as a result of their damaged condition, larval state, or merely insufficient numbers. Of the remaining 36 species, 10 also occur in the Atlantic Ocean. Available material was sufficient to allow a detailed comparison between Atlantic and Pacific populations of only four of these species: *Pterygioteuthis gemmata, Ommastrephes ·rtramii, Cranchia scabra,* and *Vampyroteuthis in·lis.* All four showed distinct differences between ·o oceans. The differences in local specimens of *P. gemmata* are probably a result of geographical variation. The differences in the local specimens of *O. bartramii, C. scabra,* and *V. infernalis* are presently interpreted as resulting from geographical variation, but this will require confirmation. There was abundant material of a fifth species, *Heliocranchia pfefferi,* available, but comparative material was inadequate; however, a slight difference in eye size was noted between specimens from the different oceans. It is felt that mature specimens as well as more adequate comparative material must be examined before the identification of this species can be confirmed.

Although direct comparisons were made, material of *Alloposus mollis, Ocythoe, tuberculata,* and *Grimalditeuthis bomplandii* was insufficient to allow a careful evaluation of variations in specimens from different oceans.

Comparisons of populations of *Histioteuthis dofleini* have been made by N. Voss. She informs me that this widely distributed species shows considerable geographical variation.

I have not examined specimens of the final cosmopolitan species, *Pterygioteuthis giardi,* which was recently reported from southern Californian waters by McGowan.

It should be emphasized that all ten of these presumed cosmopolitan species are primarily distributed in tropical and subtropical waters and in those species that have been carefully examined, Pacific specimens exhibit distinct differences from those of the Atlantic Ocean.

Of the 26 species known only from the Pacific Ocean, four, *Onychoteuthis borealijaponicus, Moroteuthis robusta, Gonatopsis borealis,* and *Symplectoteuthis luminosa,* are know from the waters around Japan. It is possible, however, that *Octopoteuthis deletron* and *Galiteuthis phyllura* are identical to similar described forms from Japan (i.e., *Octopodoteuthis sicula* and *Galiteuthis armata*).

Only three species, *Leachia dislocata, Abraliopsis falco,* and *Abraliopsis felis,* of the 26 species restricted to the Pacific Ocean have been found off Hawaii, and it seems likely that the juvenile *A. felis* (if this is a correct identification) seen from these waters are outside their area of primary abundance.

Key to the Species Described in this Report

This key is designed for the identification of only adult and subadult specimens. Species (other than *Octopus*) known from southern Californian waters which are not encountered in the present study or only poorly represented in the collections are not included in the key; these are briefly mentioned at the end of this report where they are distinguished from the following species.

1. a. Suckers with chitinous sucker rings 2
   b. Suckers fleshy, without chitinous rings 28
2. a. Hooks present on arms I–III 3

Key to the Species Described in this Report—Continued

b. Only suckers present on arms I–III 12
3. a. Armature in four series on arms 4
b. Armature in two series on arms 8
4. a. Tentacles absent ..... ***Gonatopsis borealis***
b. Tentacles present 5
5. a. A photophore present on ventral surface of each eye ..... ***Gonatus pyros***
b. Eyes without photophores 6
6. a. A median row of suckers and hooks present on tentacular club proximal to large central hook. Single hook present distal to large central hook 7
b. A median row of only suckers present on tentacular club proximal to large central hook. Single hook rarely present distal to large central hook ..... ***Gonatus onyx***
7. a. Oral face of tentacular stalk with numerous suckers between the marginal rows. Median row on tentacular club with hooks at end proximal to large central hook ***Gonatus californiensis***
b. Oral face of tentacular stalk without suckers or with only one or two between marginal rows. Median row on tentacular club with suckers at end proximal to large central hook ..... ***Gonatus berryi***
8. a. Tentacles absent ..... ***Octopoteuthis deletron***
b. Tentacles present 9
9. a. Fins subterminal, with posterior margins convex 10
b. Fins terminal, with posterior margins concave 11
10. a. Tentacular clubs with 3–5 hooks. Arms I–III with hooks in two rows (biserial) ***Pyroteuthis addolux***
b. Tentacular clubs with suckers only. Arms I–III with hooks only in ventral rows ***Pterygioteuthis gemmata***
11. a. Photophores on ventral surface of head randomly dispersed ..... ***Abraliopsis felis***
b. Photophores on head in distinct longitudinal rows ..... ***Abraliopsis falco***
12. a. Mantle fused to the head dorsally 13
b. Mantle articulated with the head dorsally by cartilaginous pads bearing grooves and ridges 17
13. a. Hooks present on tentacular clubs. Fins lanceolate 14
b. Only suckers present on tentacular clubs. Fins not lanceolate 15
14. a. Cartilaginous tubercules present at points of funnel-mantle fusion .... ***Galiteuthis phyllura***
b. Cartilaginous tubercules lacking at points of funnel-mantle fusion .... ***Galiteuthis pacifica***
15. a. Cartilaginous tubercules present over entire surface of mantle ..... ***Cranchia scabra***
b. Cartilaginous tubercles not present over entire surface of mantle 16
16. a. Cartilaginous tubercules extend in a line posterior to each point of funnel-mantle fusion ***Lechia dislocata***
b. Cartilaginous tubercules absent ..... ***Helicocranchia pfefferi***
17. a. Funnel locking-cartilage with an inverted T-shaped groove 18
b. Funnel locking-cartilage without an inverted T-shaped groove 19
18. a. A pair of long luminous strips present on the ventral surface of the mantle ***Symplectoteuthis luminosa***
b. A pair of luminous strips not present on the ventral surface of the mantle ***Ommastrephes bartramii***
19. a. Funnel and mantle locking-cartilages fused. Tentacles absent ***Grimalditeuthis bomplandii***
b. Funnel and mantle locking-cartilages not fused. Tentacles present 20
20. a. Hooks present on tentacular clubs ..... ***Onychoteuthis borealijaponicus***
b. Only suckers present on tentacular clubs 21
21. a. Funnel locking-cartilage with an oval depression bearing one or two inward projecting knobs 22
b. Funnel locking-cartilage with a straight groove and without knobs 25
22. a. Funnel locking-cartilage with only a posterior knob projecting into the oval depression. Funnel valve absent 23
b. Funnel locking-cartilage with a medial knob and with or without a posterior knob projecting into the oval depression. Funnel valve present 24
23. a. Arms IV each with 2–4 suckers ..... ***Valbyteuthis obligobessa***
b. Arms IV each with 13–15 suckers ..... ***Valbyteuthis danae***

24. a. Tentacular clubs whiplike, unexpanded, with 18–22 longitudinal rows of small suckers. No photophores on ink sac ..... ***Mastigoteuthis pyrodes***
    b. Tentacular clubs expanded, with 4 longitudinal rows of suckers. Two photophores present on ink sac ..... ***Chiroteuthis calyx***
25. a. Mantle covered with large photophores 26
    b. Mantle without photophores 27
26. a. Base of arms IV with 8–10 photophores in a transverse series .... ***Histioteuthis heteropsis***
    b. Base of arms IV with 3 photophores in a transverse series ..... ***Histioteuthis dofleini***
27. a. Fins more than ½ of the mantle length. Arm suckers in two series ..... ***Neoteuthis* sp.**
    b. Fins less than ¼ of the mantle length. Arm suckers in 3–4 series on distal half of arms I–III ..... ***Bathyteuthis berryi***
28. a. Fins present. Numerous photophores present ..... ***Vampyroteuthis infernalis***
    b. Fins absent. Photophores absent 29
29. a. Arms with biserial suckers throughout 30
    b. Arms without biserial suckers or with biserial suckers only on distal half of arms 31
30. a. Arms II and III considerably shorter than arms I and IV ..... ***Ocythoe tuberculata***
    b. Arms subequal ..... ***Octopus* sp.**
31. a. Arms with uniserial suckers throughout 32
    b. Arms with uniserial suckers proximally and biserial suckers distally ..... ***Alloposus mollis***
32. a. Eyes and liver with a brilliant, silvery, iridescent layer ..... ***Japetella heathi***
    b. Eyes and liver without a silvery iridescent layer ..... ***Japatella* sp.**

SYSTEMATICS

Class CEPHALOPODA

Order TEUTHOIDEA

Family ENOPLOTEUTHIDAE Pfeffer, 1900

DIAGNOSIS.—Arms with biserial armature (occasionally modified at arm tips) consisting both of hooks and suckers. Tetraserial armature on the tentacular clubs, although marginal rows may be lost with growth in some species. Hooks usually present on clubs. Eight buccal lappets; buccal connectives attach to the dorsal margins of arms IV. Photophores present.

Subfamily ENOPLOTEUTHINAE Pfeffer, 1912

DIAGNOSIS.—Nidamental glands absent. Numerous small photophores present on the surface of the mantle, head, and arms, but not in the tentacles or on the viscera. Posterior margins of fins concave.

Genus *Abraliopsis* Joubin, 1896

DIAGNOSIS.—Arms IV with 2–4 very large photophores at the arm tips. Tentacular clubs with 2 rows of hooks on manus.

TYPE SPECIES.—*Enoploteuthis hoylei* Pfeffer, 1884.

Abraliopsis falco, new species

PLATES 1A,B; 2A–G

DESCRIPTION.—The *mantle* is cylindrical anteriorly and tapers to a blunt point posteriorly. The mantle musculature terminates at the end of the pen which is in advance of the posterior tip of the body. This broad posterior tip appears to be composed of vacuolated connective tissue which continues laterally, for a short distance, up the sides of the muscular portion of the mantle. The anterior margin of the mantle projects slightly in the areas of the dorsal and ventrolateral cartilages. The mantle is moderately thick and muscular.

The large, muscular *fins* are terminal; they are about 70–80% of the mantle in length and about 90–100% in width. Their lateral apex forms a rounded point. The posterior margin is drawn-out along the mantle to its apex. Anterior lobes are free.

The *funnel* is short and muscular. Each funnel locking-cartilage has a straight groove which opposes a straight ridge on the mantle. The dorsal pad of the funnel organ has an inverted V-shape. A large ridge extends diagonally across each lateral limb of the organ and an anterior papilla is present. The ventral pads are oval. A funnel valve is present. The funnel is free laterally.

The *head* bears large eyes that occupy its entire lateral portions. A large sinus is present in the anterior margin of each eyelid, and distinct dorsal and ventral windows lie above and below each eye. A nuchal crest with 4 folds on either side of the head is present; the ventral fold on each side is thick and partially embrances the funnel; the second fold from the funnel bears the "olfactory" organ; the dorsalmost 2 folds join posteriorly on each side forming crescent-shape ridges.

The *arms* are large and muscular; they are considerably longer in the male. The arm formula is: $4=2>3>1$. Arms I–III all have well developed aboral keels and arms IV have well-developed lateral keels. Protective membranes are nearly absent proximally on the dorsal borders of arms I where they are represented primarily by isolated trabeculae; the membranes are very low distally. The dorsal borders of arms II have a few trabeculae proximally, but otherwise lack trabeculae and protective membranes except near the sucker-bearing tip where a trabeculate protective membrane is present. The dorsal borders of arms III show only a trace of a few proximal trabeculae except for a small trabeculate protective membrane near the distal, sucker-bearing tip. The dorsal borders of arms IV have flat, rounded trabeculae with low membranes in females. Arms I–III all have large, trabeculate, protective membranes on their ventral borders. These are present, but not as well developed on arms IV in females.

Each arm I–III possesses a double series of hooks which is replaced by a double row of suckers at the arm tip. The number of distal suckers is difficult to count with certainty. One female had about 34 on each arm I, 23 on each arm II, and 15 on each arm III. The most proximal suckers in this series have broad outer rings; their inner rings have about 10–12 broad teeth which are rounded to truncate on the distal margin. The more distal suckers are globular; they lack outer rings and have reduced apertures without teeth. All suckers are globular and lack outer rings on the dorsal pair of arms in males. Arms IV possess hooks, but lack distal suckers.

The arms in male specimens are longer and have more hooks than do the arms of females. The increased number of hooks in males results from both the greater length of the arms and the smaller size of the hooks. The following chart comparing averages for 4 adult females and 5 adult males demonstrates these relationships.

Both arms IV are *hectocotylized* in the males; however, the left arm is much more highly modified. The trabeculate protective membrane is greatly enlarged on the ventral margin of this arm and is heavily pigmented with dark brownish purple chromatophores. Small conical knobs line the oral margins of the large trabeculae. On the dorsal margin, trabeculae are very prominent proximally but diminish in size distally, while the protective membrane is low and nearly absent proximally; these trabeculae are also lined with conical papillae on their oral margins. The proximal 3–4 hooks on the ventral margin are much larger than the proximal 2–3 hooks on the dorsal margin. The fourth or fifth hook on the ventral margin and the third or fourth hook on the dorsal margin are comparable in size. Distally the hooks on the dorsal margin increase in size, while those of the ventral margin abruptly decrease. Shortly, the hooks of the ventral margin begin to increase in size, while those of the dorsal margin begin a gradual decrease. Approximately the fifteenth hook of the ventral margin approaches in size the adjacent hooks of the dorsal margin. The hooks of the ventral margin then decrease more rapidly in size than those of the dorsal margin up to the end of the series. The fleshy bases from which the hooks arise in the dorsal row bear small conical papillae; there are also a few papillae on some of the hook bases of the ventral row. The oral face of the arm proximal to the first hook also possesses numerous papillae.

The right arm IV shows a lesser degree of modification. On the ventral border, from the second hook to about the middle of the arm, are 4–5 enlarged

Characters	Females *Arms*			
	I	II	III	IV
Arm length/mantle length	0.46	0.55	0.50	0.56
No. of hooks	17	21	19	24
No. of hooks/arm length	0.83	0.89	0.87	0.97

Characters	Males *Arms*			
	I	II	III	IV
Arm length/mantle length	0.63	0.77	0.68	0.79
No. of hooks	27	32	26	42(left) 28(right)
No. of hooks/arms length	1.20	1.17	1.15	1.51(left) 1.02(right)

trabeculae, bearing conical papillae, with a low membrane between them; trabeculae are lacking on the distal half of the arm. Along the distal third of the ventral border, there are two semilunar flaps. The dorsal border has trabeculae that are less prominent, but also bear papillae and have very low protective membranes. A small flap, present distally on the dorsal border, opposes the distal flap on the ventral border. The proximal 3–4 hooks in the dorsal row are considerably smaller than the first 4–5 in the ventral row. Distally the hooks in the ventral row decrease abruptly in size, while those of the dorsal row increase abruptly in size so that the fifth or sixth hook of the ventral margin is much smaller than the fifth one of the dorsal margin. Each series terminates at the proximal end of the distal flaps on each margin. The tips of the ventral arms bear large photophores identical to those of the female. Both modified arms IV are about the same length.

In the male, arms I–III show a slight amount of dimorphism. The trabeculae on the dorsal borders of arms I are considerably larger than in the females. They lack a protective membrane proximally, but one is well developed distally. The oral margins of the trabeculae on both dorsal and ventral borders are lined by conical papillae. In males, papillae are also present to some extent on the trabeculae of arms III and to a lesser degree on arms II. All arms in males generally have 5–20 papillae proximal to the first pair of hooks. In males, the proximal hook on the ventral margin of each arm III is greatly enlarged over the succeeding hook and is approximately equal to (or larger than) the proximal hook of the dorsal margin. The second through fourth hooks of the ventral margin are distinctly smaller than those opposing them on the dorsal margin; farther distally, they are approximately equal in size. Hooks on arms I–III are smaller in males than in females.

The *tentacles* are short and robust. The tentacular club is short and not expanded. The manus bears hooks in 2 rows; those of the ventral row are about twice the height of those in the dorsal row in females, while the difference may be less in males. Hooks of the dorsal row vary from 3–4, while the smaller hooks of the ventral row vary from 2–4. Suckers alternate with the hooks in the ventral row. Only the proximal sucker is present in the dorsal row, and it is occasionally absent. The dactylus has 4 rows of suckers that extend to a circle of suckers at the tip of the tentacle. A random count of 8 clubs shows a variation in dactyl suckers between 48 and 60. A distinct carpal cluster is present which possesses 4 or occasionally 5 suckers and pads. No membrane or flap lies adjacent to the carpus or the manus. A low, thick protective membrane lines the ventral margin of the dactylus. There is no trace of a keel.

Numerous *photophores* of varying sizes are embedded in the mantle in a rather irregular arrangement, although some indication of a pattern is discernible. In the ventral midline, there is a narrow strip that is generally free of photophores; however, this strip is sometimes difficult to detect and often does not extend to the anterior margin or to the posterior end of the mantle. On either side of this strip is a diffuse longitudinal band of photophores. Lateral to these bands, the number of photophores gradually diminishes to only a few scattered organs situated dorsally. Superimposed on this pattern is a single line of photophores that extends from the anterior mantle margin at the projection of the mantle locking-cartilage, posteriorly for about half of the mantle length. Between this series and the midventral strip is another single line of photophores that can be traced about half of the mantle length from the anterior margin. Both series are not always readily apparent.

The funnel has 6 separate groups of photophores, none of which extends to the exhalant opening. One group is located on either side of a clear median strip on the ventral surface of the funnel. A second group is found along each lateral margin of the funnel, and a third group is located on either side of the dorsal surface of the funnel and extends onto the bases of the bridles.

A triangular patch of photophores is located on the ventral surface of the head dorsal to the funnel. This patch continues forward over the ventral surface of the head in the midline as a narrow, well-defined strip to the junction of arms IV where the series divides into a row that runs along the inner margin of each arm IV for about half of the arm length. A second narrow strip on each side of the head runs anteriorly from the first nuchal fold, passes medial to the ventral "window" of the eye, and continues onto the lateral margin of arm IV at the base of the lateral keel. This series continues to the tip of the arm, but is broken at 4–5 spots by short areas that lack photophores. Between these first 2 bands, near the base of

the ventral arms, a few scattered photophores are occasionally present.

A third strip extends anteriorly from each second nuchal fold, passes on either side of the head lateral to the ventral "window" and joins an area of scattered photophores anterior to each "window." Each patch continues onto the margin of the lateral keel of each arm IV as a single row of photophores which extends along the proximal third of the arm. A final series extends around the margin of each eyelid. In the 3 males which allowed accurate counts, the number of photophores in this series varied from 48–54, while in 4 females the number varied from 52–63. This series extends anteriorly on either side onto arm III at the base of the aboral keel and continues the entire length of the arm except for a few breaks in the series in the distal half of the arm.

On the ventral surface of each eye is a series of 5 light organs of which the first and last members are considerably larger than the middle 3.

Distally the tips of arms IV bear 3 large, dark-purple photophores and 2–3 small photophores.

Within the mantle cavity of females on the inner surface of the dorsal mantle wall, immediately anterior to the stellate ganglion, is a highly folded, apparently glandular, pocket. The pleats of this pocket also extend beneath the collar in the nuchal region. Several *sperm reservoirs* (discharged spermatophores) were found attached within the pocket. The pocket has a dark-purple pigmentation which can be seen through the dorsal surface of the mantle beginning about one-eighth of the mantle length from the anterior end of the pen.

The *buccal membrane* has 8 supports and bears numerous long fleshy papillae on its brownish purple oral surface. The buccal membrane connectives attach to the dorsal borders of arms I, II, and IV, and to the ventral borders of arms III.

The specimens are covered with numerous small, reddish brown *chromatophores.*

TYPE LOCALITY.—28°54′ N, 118°08′ W, eastern North Pacific Ocean.

LOCATION OF TYPE.—University of Southern California, U.S.C. Hancock collections, AHF Cephalopod Type No. 1.

DISCUSSION.—The genus *Abraliopsis* has been in an extremely confused state due to many inadequate early descriptions, often based on larvae, followed by numerous misinterpretations by subsequent authors. Fortunately, the genus has been monographed by Voss (in manuscript) and most of the problems have been resolved.

The genus *Abraliopsis* is usually divided into two subgenera: *Abraliopsis,* with a diffuse pattern of photophores on the ventral surface of the head, and *Micrabralia,* with photophores on the ventral surface of the head arranged in distinct rows (Voss 1967). *A. falco* clearly falls into *Micrabralia* which, according to Voss (in manuscript), contains only two other named species: *Abraliopsis affinis* (Pfeffer 1912) and *Abraliopsis gilchristi* (Robson 1924). Pfeffer based *A. affinis* on Hoyle's (1904) description of 4 specimens taken from the eastern tropical Pacific between 2°34′ N, 82°29′ W and 14°46′ N, 98°40′ W. The specimens were only partially described; however, specimens of *A. affinis* in the collections of the Institute of Marine and Atmospheric Sciences which were captured at 7°19′ N, 79°44′ W have allowed adequate comparisons to be made with *A. falco.*

Abraliopsis falco differs most distinctly from *A. affinis* on 2 characters: *A. affinis* has a distinct membrane on the ventral margin of the tentacle that extends from the proximal end of the carpus to the base of the manus; no such membrane is present in *A. falco. A. affinis* has a large keel on the club that extends from the tip of the dactylus to about the midpoint of the manus; a keel is lacking in *A. falco.* The specific value of these features within the genus has been emphasized by Voss (in manuscript). Several other characters are also of value in separating these species. In *A. falco,* the first hook in the ventral row of each arm III in males is usually equal to or larger than the first hook in the dorsal row of the same arm (this feature was valid in 9 out of 10 cases). In *A. affinis* the first hook in this same position in males is distinctly smaller than the first hook in the dorsal row (this feature was valid in 35 out of 36 cases). The midventral strip on the mantle in *A. affinis* which lacks photophores is very broad and generally expands at its posterior termination less than two-thirds of the mantle length from the anterior end. In *A. falco,* this strip is very narrow throughout and seldom reaches either the anterior or posterior end of the mantle. The arms are considerably longer in *A. affinis,* but further study on more material is necessary to quantify this feature. There are a number of other features that seem to show significant differences such as the relative sizes of the

TABLE 2.—*Measurements in mm of* Abraliopsis falco, *new species.*

Characters	*Station Number of VELERO*								
	9899	*9899*	*9899*	*9899*	*10679*	*10679*	*10679*	*10677*	*9901*
Sex	♀	♀	♀	♂	♀	♂	♂ *(Holotype)*	♂	♂
M.L.	43	46	41	35	44	36	37	36	37
M.W.	13	15	12	12	11	10	11	11	12
H.W.	15	—	13	13	15	11	11	14	11
F.L.	31	33	29	25	32	27	29	28	26
F.W.	39	44	37	34	39	34	35	36	37
Arm L. I	20	23	18	22	20	21	22	24	26
II	24	25	21	26	25	26	26	—	32
III	23	23	20	23	22	23	23	27	27
IV	26	25	22	28	25	26	25	30	33
	L R	*L R*	*L R*	*L R*	*L R*	*L R*	*L R*	*L R*	*L R*
A.C. Hooks I	17 18	16 16	16 16	28 27	16 17	29 28	26 26	26 25	27 27
II	22 21	22 23	20 20	30 29	20 21	34 34	32 32	— —	— —
III	19 20	19 19	19 18	24 26	18 19	27 26	26 26	— —	30 —
IV	26 24	26 26	22 22	40 26	21 22	44 31	42 29	39 26	45 29
Tent. L.	50	69	41	45	43	—	38	40	—
Club L.	6	7	5	5	6	—	5	6	—
	L R	*L R*	*L R*	*L R*	*L R*	*L R*	*L R*	*L R*	*L R*
Club H.F.	3/3 3/2	— 3/3	3/4 —	3/4 3/3	3/3 —	—	4/3 3/3	— 3/4	—
Carp. S.	4 4	— 5	4 —	4 4	4 —	—	4 4	4 4	—
Dact. S.	46 55	— 50	54 —	51 —	60 —	—	48 50	— —	—

club hooks and the number of proximal arm papillae; however, the characters listed are sufficient to separate the species.

Since *Abraliopsis falco* appears to be a warm-water species, it is possible that the ranges of *A. falco* and *A. affinis* overlap. Although the original description of *A. affinis* is incomplete, there can be no question of the true identity of this species since a club was illustrated by Hoyle (1904, plate 8, figure 1) that clearly shows the presence of a keel and another illustration (plate 10, figure 1) shows the midventral clear strip on the mantle with the appearance characteristic of specimens discussed in this paper as *A. affinis.*

Abraliopsis gilchristi was described by Robson (1924) from specimens taken off South Africa and has recently been redescribed by Voss (1967). The most obvious feature that separates this species from *A. falco* is the persence of 2 distinctly separate rows of photophores on the midventral surface of the head in *A. gilchristi,* each of which is continuous with the medial series of the nearest arm IV. In *A. falco,* there is only a single series in the midventral line of the head. There are many other features (including the presence of a semicircular membrane on the ventral border of the tentacle between the carpus and manus in *A. gilchristi*) which separates these 2 species, but need not be discussed here.

There is another but unnamed species in the Atlantic Ocean which is treated fully by Voss (in manuscript), and a comparison between this species and *A. falco* will be made in this paper. For the present, it is only necessary to state that they are distinct.

DISTRIBUTION.—The 10 specimens of *A. falco* taken by the VELERO all came from zone 7. An additional specimen (M.L., 20 mm) was taken by the SWAN near Hawaii at approximately 24° N and 151° W. These data indicate that this species is a warm-water form and probably a mid-oceanic species.

Abraliopsis felis McGowan and Okutani, 1968

PLATES 1C–D; 2H–N

Abraliopsis sp., Pearcy, 1965, p.261.
Abraliopsis felis McGowan and Okutani, 1968, p.72.

DESCRIPTION.—The *mantle* is long and slender; its width is about one-fourth of its length. It is cylin-

drical anteriorly, but tapers posteriorly to end in a blunt point. The muscular portion of the mantle terminates at the end of the pen which is in advance of the posterior tip of the body. This broad posterior tip appears to be composed of vacuolated connective tissue which continues for a short distance laterally along the sides of the muscular portion of the mantle. The rhachis of the pen is visible in the dorsal midline. The free margin of the mantle projects in the nuchal region and in the regions of the mantle locking-cartilages.

The *fins* are large, 62–68% of the mantle in length, and broad, 70–83% of the mantle in width. The lateral angles of the fins are rounded. Much of the posterior fin margin forms a nearly straight line at about 45 degrees to the body axis; however, as the edge approaches the mantle, it turns posteriorly and terminates at the tip of the mantle. Anterior lobes are large and free.

The *funnel,* which is free laterally, is small and muscular. The funnel locking-cartilage bears a straight groove. The dorsal pad of the funnel organ has an inverted V-shape and bears an anterior papilla and lateral ridges. The ventral pads are oval. A large funnel valve is present.

The *head* width is approximately equal to the mantle width. The eyes are large and occupy the entire lateral portions of the head. A small but distinct anterior sinus is present on each eyelid. Four large nuchal folds are present on each side of the head, the dorsal 2 of which are joined posteriorly. The second fold from the funnel bears the "olfactory" organ, and the fold nearest the funnel forms the posterolateral edge of the funnel groove and bears photophores on its ventral surface. The nuchal cartilage is elongate and has a prominent median ridge that bears a central groove.

The *arms* are relatively short (arms IV are 55–60% of the mantle in length), and in the order $4>3=2>1$. All arms I–III have well-developed aboral keels; arms IV have large lateral keels. Well-developed trabeculate protective membranes are present on the ventral border of arms I–III, but are absent from the dorsal borders of these arms. Arms IV lack protective membranes on both borders.

Arms I–III each bear 2 alternating rows of hooks which give way abruptly to 2 rows of suckers near the arm tip. Each arm has approximately 15–20 hooks and about 20–26 distal suckers. These suckers have roughly 7–10 slender teeth along the distal half of their inner chitinous rings. Arms IV have 13–15 hooks and lack distal suckers; these hooks are smaller than those of the other arms. The tips of arms IV have usually 3 (sometimes 2 or 4) very large photophores encased in dark-purple pigment followed by 2–4 small photophores of similar appearance.

In the males the right arm IV is *hectocotylized.* It carries 10–12 small hooks and near the distal end of this hook-bearing portion a bilobed membrane, broadest in its proximal half, is present on the ventral border of the arm. Slightly more distal to the hooks, a second membrane arises on the dorsal border. The area beyond the membranes lacks hooks or suckers. McGowan and Okutani (1968) have shown that rarely both ventral arms are hectocotylized. The terminal photophores are the same as in the non-hectocotylized ventral arms.

The *tentacles* are robust and have short unexpanded clubs which lack protective membranes. The manus has from 3–4 hooks (rarely 2) in each of 2 rows, with those of the ventral row being much larger than those of the dorsal row. The latter generally alternate with small marginal suckers, although the full compliment is not always present. The dactylus consists of approximately 14 transverse rows of 4 suckers each. The inner chitinous ring of each of these suckers is nearly smooth, but may have a few irregular teeth on the distal margin of the first few suckers. A distinct carpal cluster is present which has 4–5 suckers and knobs. Membranes are lacking from the clubs and stalks except for a slight indication of a dorsal keel along the distal half of the dactylus. This keel, when detectable, is very low and appears as only a slender ridge.

The *buccal membrane* is purple and 8-parted. The buccal membrane connectives attach to the dorsal borders of arms I, II, and IV and to the ventral borders of arms III.

In females, there is a dark patch on either side of the anterior end of the nuchal cartilage which marks the position of the *spermatophore receptacles.* The inner side of the collar and the outer surface of the body wall adjacent to the nuchal cartilage form a glandular pleated pocket which receives sperm reservoirs. Mature *eggs* are roughly 1.5 mm in diameter. Nidamental glands are absent and the oviducal glands are greatly enlarged.

The mantle is covered with numerous *photophores*

of varying sizes. The light organs have the greatest concentration on the ventral surface, considerably less on the lateral surfaces, and only a few scattered organs are present on the dorsal surface. These organs from a diffuse pattern over the mantle; there is, however, a narrow strip extending the full length of the mantle along the midventral line which lacks photophores, and there is a somewhat regular line of photophores that extends around the ventral two-thirds of the mantle along its free margin. Photophores on either side of the mantle are not strictly bilaterally arranged.

The funnel has 6 separate patches of photophores, none of which extends to the exhalent opening. In fully mature specimens, one patch, located on either side of the midline on the ventral surface of the funnel, has between 16–23 photophores. A second patch is found along each lateral margin of the funnel and usually has 5 or occasionally 6 photophores. The other patches, each of which has about 13–15 photophores, are located on either side of the dorsal surface of the funnel and extend onto the bases of the bridles.

Photophores are abundant on the ventral surface of the head, but have a diffuse pattern with the following exceptions: 2–3 photophores in a single line extend along the medial nuchal fold. From this series, extending dorsally along the posterolateral margin of the head, is a single row of usually 4 photophores (occasionally up to 6) that reaches to a point nearly level with the center of the lens. From usually the second photophore from the ventral end of this series, a single line of broadly separated photophores extends anteriorly along the head (occasionally one or two photophores fall above or below the main line). This series runs lateral to the ventral "window" of the eye. Between this line and the eye opening, there are no photophores except for a line of organs which lie along the margin of the eyelid. The number of photophores in the latter series is relatively constant. A count on 19 eyelids gave 2 with 29 photophores, 3 with 30, 11 with 31, one each with 32, 33, and 34 photophores. There are no photophores over the ventral "window" of the eye. Medial to this area the ventral surface of the head is covered with numerous scattered photophores, diffusely arranged but with a nearly bilaterally symmetrical pattern. Anterior to each "window" there are a few scattered photophores. In the ventral midline, the most posterior photophore lies dorsal to the funnel and immediately in front of the point of attachment of the converging bridles. Immediately anterior to this photophore is a distinct oval area that is usually devoid of photophores.

Arms IV each bear three series of photophores. One series runs along the ventromedial margin of the arm for about two-thirds of the arm length. The middle series runs along the ventrolateral edge of the arm. At the base of the arm this series is arranged in 2–3 irregular rows which shortly converge into a single row that continues to the tip of the arm. Near the arm tip, 2–4 photophores are greatly enlarged and covered with a dark-purple pigment. These are followed by 2–4 small photophores. The final series runs along the edge of the lateral membrane and terminates roughly at the same level as the ventromedial series.

A single row of photophores extends along each arm III at the base of the aboral keel for slightly more than half of the arm length. This series is aligned with 2 photophores of the eyelid series that are situated on the dorsal edge of the eyelid sinus; however, a distant gap separates these 2 series (Plate 1D).

The number of photophores increases with the size of the animal. Therefore, the above discussion applies primarily to mature specimens although many of the features mentioned can also be detected in young specimens.

This squid is covered with numerous reddish brown *chromatophores.*

TYPE LOCALITY.—31°59′ N, 122°24′ W. Eastern North Pacific Ocean.

LOCATION OF TYPE.—U.S. National Museum, catalog number 678792.

DISCUSSION.—*A. felis* belongs to the subgenus *Abraliopsis* which contains only 2 other species: *Abraliopsis (Abraliopsis) pfefferi* Joubin, 1896, from the Mediterranean; and *Abraliopsis (Abraliopsis) hoylei* (Pfeffer 1884), from the Mascarene Islands, Indian Ocean (Voss 1967).

A. pfefferi was originally taken off Villefranche-sur-Mer, but has since been found to be distributed throughout much of the Atlantic Ocean and into the eastern Indian Ocean (Voss 1967). This species is easily distinguished from the Californian species by a number of characters. *A. pfefferi* has a semicircular membrane on the ventral margin of the tentacle that

originates opposite the carpal cluster and extends distally just past the first hook on the manus. This membrane is lacking in *A. felis*. A low, but distinct keel on the club in *A. pfefferi* extends from about the middle of the manus to the dactylus. In *A. felis* an indistinct keel is present only on the distal half of the dactylus. There are usually between 10–12 hooks on the tentacular clubs in *A. pfefferi*, while *A. felis* has usually 6–8. In *A. pfefferi* there are roughly 44–46 photophores surrounding the eyelid, while *A. felis* has usually 30–31 photophores. In *A. pfefferi*, lateral to the ventral "window" of each eye, there is a patch of photophores consisting of at least 4 irregular longitudinal rows. In *A. felis* there is only a single row of photophores in this position. In *A. pfefferi*, the series of photophores surrounding the eyelid continues onto arms III. In *A felis* a distinct gap separates the 2 series. In *A. felis* there is an oval patch devoid of photophores near the midposterior portion of the ventral surface of the head which is lacking in *A. pfefferi*. There are other distinctive characters such as the fin length and the number of arm hooks (see also discussion of *A. hoylei*); however, the features mentioned should be sufficient for the present.

A. hoylei has been the subject of considerable discussion since its original discovery. Hoyle (1904) ascribed several specimens from the Pacific Ocean near Panama to this species. Pfeffer (1912), recognizing the distinctive features of Hoyle's specimens, placed these forms in a new species *A. affinis* (a member of the subgenus *Micrabralia*). Robson (1948) rejected Pfeffer's name and assigned specimens that he examined from Panama to *A. hoylei* which he considered to be a polymorphic species. There can be no doubt, however, that *A. affinis* and *A. hoylei* are distinct species and even belong in separate subgenera (Voss, in manuscript). Both Berry (1913, 1914) and Allan (1945) ascribed specimens from the South Pacific to *A. hoylei*, although with some hesitation. These specimens were either too small or too inadequately described for their identity to be ascertained with certainty; however, it is unlikely that they belong to *A. hoylei*. Therefore, the only valid descriptions of *A. hoylei* are those of the type specimen (Pfeffer 1884, 1912).

A. hoylei is much more difficult to separate from *A. felis* than is *A. pfefferi*. This is not unexpected since one must rely solely on Pfeffer's (1884, 1912) descriptions of the type as the type specimen has been destroyed (Voss, in manscript), and there are no other specimens available. It is, however, possible to detect the following differences: in the single specimen of *A. hoylei*, the fins are 78% of the mantle in length and 95% of the mantle in width; the arms (apparently Pfeffer refers to arms IV which are the longest) are 75% of the mantle length. In *A. felis* the fins are 62–68% of the mantle in length and 70–83% of the mantle in width. Arms IV are 55–60% of the mantle length. The first few distal suckers in *A. hoylei* are stated to have pointed teeth on the inner rings while the rest have smooth rings. In *A. felis* the distal suckers have long slender teeth in at least the first 10 suckers. Pfeffer could not describe the tentacular membranes in *A. hoyei* since the tentacles had undergone some desiccation; however, his illustration (plate 17, figure 9) shows a keel that originates near the middle of the manus. This differs from the previously mentioned conditioned in *A. felis*.

A number of differences can be detected in the light-organ patterns. Pfeffer described a ventral field of photophores on the ventral surface of the mantle which has a median bare strip lacking photophores on the posterior two-thirds of the mantle. The illustration shows this clear band extending somewhat farther anteriorly, but clearly not approaching the anterior margin of the mantle. In *A. felis* this clear band extends to the anterior margin or sometimes is separated from it only by a single line of photophores. The ventral field in *A. hoylei is* bounded laterally by an area which "fast den Eindruck eines leeren Langstreifens macht." Lateral to this zone is another area of more densely packed photophores which Pfeffer called the laterodorsal field. In *A. felis* a relatively clear band separating the laterodorsal field is lacking; instead, the number of photophores gradually diminishes laterally. On the ventral surface of the head, Pfeffer described a row of photophores that corresponds to the row immediately lateral to each ventral "window" of the eye of *A. felis*. Lateral to this row, he describes "eine weitere, unbedeutende kleine Reihe." This additional series is lacking in *A. felis*.

One might be somewhat dubious of the small differences here indicated in the photophore pattern between *A. felis* and *A. Hoylei*; however, *A. pfefferi* differs from *A. felis* in exactly the same features and in the case of *A. pfefferi* there can be no question

concerning the validity of these characters. In fact, the other characters of *A. hoylei* mentioned here, which separate it from *A. felis*, are also shared by *A. pfefferi*. This condition suggests that *A. hoylei* and *A. pfefferi* may be synonymous; however, characters such as the number of hooks on the tentacular clubs and other features make this relationship somewhat uncertain. At any rate, it is possible to separate *A. felis* from both *A. hoylei* and *A. pfefferi* and thus verify the specific status of *A. felis*.

McGowan and Okutani (1968) reduced *Watasenia* to the status of a subgenus of *Abraliopsis* and included in it *Abraliopsis (Watasenia) scintillans* and *Abraliopsis (Watasenia) felis*. In doing this, these authors relied greatly on the sexual modifications of the ventral arms in members of *Watasenia* and *Abraliopsis*.

Descriptions of the males of *A. pfefferi* and *A. hoylei* have never been published; therefore, McGowan and Okutani were unaware of the nature of the hectocotylus in these species. I have examined two males of *A. pfefferi* from the Indian Ocean. The right ventral arm is hectocotylized in each specimen and bears an elongate membrane distally on the ventral margin of the arm. A much smaller membrane is present on the dorsal margin in one specimen, but not the other. The left ventral arm in each specimen is not modified. It is assumed that the very similiar *A. hoylei* would have a comparable condition.

Therefore, within the genera *Abraliopsis* and *Watasenia* all male members seem to have similarly modified right ventral arms although varying slightly between species. In the genus *Abraliopsis* two species, *A. affinis* and *A. falco*, have highly modified trabeculate protective membranes on the left ventral arm in males; a third species, *A. gilchristi* has the left ventral arm slightly modified by the presence of large trabeculae, but with a reduced or absent protective membrane (Voss 1967). These three species are placed in the subgenus Micrabralia. In *A. felis*, *A. pfefferi*, presumably *A. hoylei* (all subgenus *Abraliopsis*), and *W. scintillans* the left ventral is not modified (rarely, in *A. felis* both ventral arms are similarly modified). Therefore, the sexual modification of the ventral arms in *W. scintillans* is simliar to these species of *Abraliopsis;* however, these should not be included in the same subgenus for the following reason: All species of *Abraliopsis* have two rows of hooks on each tentacular club. This is an extremely important feature which is of generic value (all species of *Abralia* have a single row of hooks, all species of *Enoploteuthis* have two rows of hooks). *W. scintillans* has a single row of hooks on each tentacular club and, therefore, is clearly separable from all members of the genus *Abraliopsis*.

The tips of both ventral arms in *W. scintillans* bear several greatly enlarged photophores. This is a highly characteristic feature which is shared by all members

TABLE 3.—*Measurements in mm for* Abraliopsis felis *McGowan and Okutani, 1968.*

Characters	*Station Numbers of the VELERO*								
	8024	*8024*	*9249*	*7280*	*7221*	*7221*	*7221*	*7221*	*7221*
Sex	♀	♂	♂	♀	♀	♀	♂	♂	♂
M.L.	29	31	41	41	42	45	40	40	40
M.W.	8	9	12	13	11	13	11	11	10
F.L.	18	20	28	27	26	28	25	26	26
F.W.	22	22	34	33	34	34	30	28	29
Arm L. I	12	13	18	19	18	18	—	18	18
II	14	17	21	23	21	22	21	19	20
III	13	16	22	22	21	21	21	20	21
IV	17	18	23	23	23	25	24	22	22
A.C. Hooks I	16	17	16	—	16	17	15	—	16
II	16	18	18	—	18	19	17	—	—
III	17	18	17	—	18	18	—	—	—
		L R	*L R*				*L R*	*L R*	*L R*
IV	13	13 11	14 —	—	15	15	15 10	12 10	14 12
Tent. L.	30	36	32	44	48	—	43	37	42
Club L.	6	7	8	9	8	—	—	5	6
Club H.F.	3/3 3/3	3/2 3/3	3/3 3/3	—	3/3 —	—	3/3 3/3	3/3 3/3	3/4 3/3

of *Abraliopsis,* but no other groups. Therefore, at present, the status of *Watasenia* as a separate genus or a subgenus of *Abraliopsis* rests purely on personal preference, but it is clear that *Watasenia scintillans* remains in an isolated position and that *A. felis* belongs in the subgenus *Abraliopsis* of the genus *Abraliopsis.*

DISTRIBUTION.—Specimens of *Abraliopsis felis* over 20 mm M.L. are well represented from zones 1, 2, 5, and 6, having respective frequencies of 0.66, 1.13, 0.50, and 0.63 specimens/hour. In zone 7 the frequence of captures is significantly less, being 0.22 specimens/hour. Specimens less than 20 mm M.L. have a similar occurrence, but have a greater frequency of capture in the more oceanic zones 5 and 6.

McGowan & Okutani (1968) record *A. felis* from about 43° N to about 27° N along the coast of Oregon, California, and Baja California. Apparently, the southern limit for the species is off Baja California. Juvenile specimens taken by the SWAN, which appear to belong to this species, indicate that the species may extend westward to at least 147° W at 26° N.

Subfamily PYROTEUTHINAE Pfeffer, 1912

DIAGNOSIS.—Nidamental glands present. Mantle, head, and arms without photophores. Photophores present on viscera and embedded in tentacular stalks. Posterior margin of fins convex.

Genus *Pyroteuthis* Hoyle, 1904

DIAGNOSIS.—Left oviduct present, but reduced. Hooks present on tentacular clubs.

TYPE SPECIES.—*Enoploteuthis margaritifera* Rüppell, 1844.

Pyroteuthis addolux, new species

PLATES 3B; 4I–Q,S

DESCRIPTION.—The *mantle* is conical and tapers rapidly to a posterior point. The tip of the mantle consists of little more than an integumentary layer which covers the pointed conus of the pen. The mantle wall, for most of its length, is thick and muscular. The free margin projects in the area of the ventral locking-cartilages and in the nuchal region.

The *fins* are separate and each is nearly circular in outline, having broad, free anterior and posterior lobes. The fin length is about 40–50% of the mantle length, and the combined fin width is about 70–80% of the mantle length.

The *funnel* is short; it reaches anteriorly to approximately the level of the midpoint of the lenses. The funnel locking-cartilage has a straight groove. The dorsal pad of the funnel organ has in inverted V-shaped pad which bears median ridges on each of the lateral arms and a very small anterior papilla. The ventral pads are oval and extremely large. A funnel-valve is present.

The *head* is large; its width is greater than that of the mantle. The large eyes occupy the entire lateral sides of the head. A distinct anterior sinus on the eyelid is lacking. A thick "olfactory" papilla is present on either side of the head at the posterior end just lateral to the funnel; the papilla curves forward in an anteromedial direction. A nuchal crest and nuchal folds are lacking. The nuchal cartilage is oval and bears a median ridge with a central groove.

The *arms* are robust; they are about 50–60% of the mantle in length and in the order of $4=3=2>1$. Large trabeculate protective membranes are present on the ventral borders of arms I–III, but are greatly reduced on the dorsal borders. Arms IV have low membranes on their dorsal borders, but none on their ventral borders. Arms I–III all have well-developed aboral keels; arms IV have large, lateral keels. The armature is biserial throughout and consists of hooks over most of the arm length, although there are suckers basally and distally. The hooks of arms IV are considerably smaller than those of the other arms. The hooks have no trace of an aperature and a small secondary cusp is present beneath the major one. This secondary cusp is greatly elaborated in the proximal hooks of the hectocotylus. There appears to be considerable sexual dimorphism in the armature; however, since only a single male was examined, this will need confirmation. The male lacks distal suckers on arms II and III, while females have approximately 4–9 suckers. The male also has a slightly greater number of hooks (21–23 hooks) on arms II and III than do females (14–17) and a lesser number of proximal suckers. The structure of the suckers appears to be similar on all arms except the dorsal pair. The first 2–6 suckers in the distal series of arms I are typical, but the following suckers have lost the outer chitinous ring and are more globular. The first

few of these latter suckers are slightly enlarged over the adjacent typical suckers. The globular suckers have smooth rings. The proximal suckers from arms IV have approximately 10 teeth around the margin of the inner chitinous ring. The teeth of the distal margin are rounded and separate from one another, while those of the proximal margin are truncate and closely adjacent, almost fused to one another.

The right arm IV of the male is *hectocotylized* by the presence of a short semicircular membrane on the ventral border of the arm about one-third of the arm length from the tip of the arm. The 2 rows of hooks proximal to the membrane are more widely separated than in the other arms.

The *tentacles* are moderately long and bear short, unexpanded clubs. The club, on its proximal two-thirds, is bounded by very low, trabeculate, protective membranes. The manus has a single row of 3–5 hooks dorsal to which is a slightly irregular row of relatively large suckers, and ventral to it is a row of small suckers. The remainder of the club distally bears 4 rows of suckers that gradually diminish in size. There is a distinct carpal cluster that consists of 3 suckers and an equal number of pads. The largest suckers of the club each have about 13 broadly separated, blunt teeth around the entire margin of the inner chitinous ring, with those of the proximal margin distinctly larger than those of the distal margin.

There are no *photophores* present on the surface of the mantle; however, a number of light organs are situated on the visceral sac. A large photophore is located on either side of the anus. A transverse series of 3 photophores is located on the midline between the gills; the median member is much the largest. A large round photophore is located at the base of each gill. Posterior to the median, ventral mantle artery lies a single round photophore that is followed farther posteriorly by another median photophore. The latter 2 photophores are often bilobed. There is a final median, round photophore located near the tip of the body at approximately the level of the most posterior edge of the fin.

Twelve photophores are present on the bulbus of the eye: 3 are situated on the anterior margin near the bases of arms II and III, another is immediately posterior to the lens. On the anteroventral margin of the bulbus, there is a series of 5 large photophores that are somewhat staggered in position. The second photophore from the posterior end of the series is the largest. Anteriorly and medially from this photophore is an additional series of 3 very small light-organs.

A series of 7 photophores is imbedded in the tentacular stalk. Near the base of the tentacle, the stalk is bent sharply. This bend is easy to locate and is a permanent feature of all members of the subfamily. At the distal end of this area is a round photophore that is deeply buried in the stalk. Shortly distal to this is a smaller round photophore that lies more superficially near the aboral surface of the stalk. Near the proximal end of the carpal cluster is another round photophore located near the aboral surface of the stalk. Approximately evenly spaced between these proximal and distal photophores are 4 elongate light organs near the aboral surface of the stalk.

The dorsal surface of the mantle, head, and arms is covered with large, reddish brown *chromatophores;* smaller chromatophores of the same color are present on the ventral surfaces. Most chromatophores overlie a silvery, iridescent layer.

The *buccal connectives* attach to the dorsal borders of arm IV.

The *eggs* of the gravid females measure 1.0 mm in in diameter. The *spermatophores* of the male are short, compact, and lack coils in the ejaculatory apparatus.

TYPE LOCALITY.—31°39′ N, 133°16′ W, eastern North Pacific Ocean.

LOCATION OF TYPE.—University of Southern California, U.S.C. Hancock collections, AHF Cephalopod Type No. 2.

DISCUSSION.—In addition to *Pyroteuthis addolux,* there is only one other species, *P. margaritifera* (Rüppell 1844), in the genus. Hoyle (1886) assigned 2 specimens captured in the South Pacific (4°21′S, 129°7′E, and 0°33′S, 151°34′W) to *P. margaritifera.* He did not describe the animal, but merely illustrated the club. Pfeffer (1912) felt that these specimens belonged to a new subspecies, *P. m. oceanica,* since the illustration of the club showed only 3 hooks on the manus and only 2 suckers in the carpal cluster. I examined specimens from the South Pacific which agree with *P. margaritifera* from the Atlantic in the numbers of hooks on the manus and the number of suckers in the carpal cluster and in all other discernable features. The craracters Pfeffer referred to are unusual for *P. margaritifera,* but almost certainly are within the range of variation for this species. There-

fore, it does not seem advisable to retain *P. m. oceanica* as a separate taxon.

Joubin (1924) described a form of *P. margaritifera* from the Atlantic Ocean which he named *P. m. aurantiaca* which supposedly had 2 more occular photophores than does the typical *P. margaritifera*. Joubin's illustration, however, shows only typical photophores. Voss (personal communication) has examined the type which is deposited in the Monaco Museum and informs me that the eyes are indeed normal for the species and that *P. m. aurantiaca* has no taxonomic validity.

The specimens of *P. addolux* are very similar to *P. margaritifera*, but differ in a number of important features. The most distinctive character is the presence of an additional photophore on the tentacular stalk in *P. addolux*, giving a total of 7 photophores compared with 6 in *P. margaritifera*. The long fleshy pad situated on the hectocotylus of *P. margaritifera* is quite different from the shorter, more membranous pad of *P. addolux*. The hooks at the proximal end of the hectoctylus are much larger and of a different shape in *P. margaritifera* (see Plate 4R, s). These hooks are also more numerous in *P. margaritifera*. I have counted the hooks proximal to the pad on 12 males from the Atlantic and South Pacific oceans and find the following variation in *P. margaritifera*:

Number of hooks	13	14	15	16
Number of specimens	1	7	3	1

TABLE 4.—*Measurements in mm for* Pyroteuthis addolux, *new species.*

Characters	*Ships and Station Numbers*							
	SWAN				*VELERO*			
	27A–66		*13A–66*		*8238*		*10838*	
Sex	♂ *(Holotype)*		♀		♀		♀	
M.L.	30		45		20		23	
M.W.	8		14		6		8	
H.W.	10		17		8		8	
F.L.	14		19		9		10	
F.W.	22		34		14		16	
Arm L. I	14		22		10		11	
II	17		26		11		12	
III	17		26		12		12	
IV	16		26		11		12	
Tent. L.	40		59		28		—	
Club L.	5		10		4		—	
	L	*R*	*L*	*R*	*L*	*R*	*L*	*R*
Club H.	3	3	4	5	3	4	—	—
Carp. S.	3	3	3	3	3	3	—	—
A.C. Dist. S. I	10	9	18	22	10+	12	—	—
II	0	0	8	9	5+	3+	5+	7
III	0	0	6	8	3+	4	—	—
IV	12	6	21	22	15	16	—	15
A.C. Prox. S. I	4	4	8	9	11	9	9	10
II	5	5	8	7	9	9	8	7
III	4	3	4	4	5	5	4	—
IV	0	0	2	1	4	3	2	2
A.C. Hooks I	18	18	17	16	15	15	15	14
II	22	21	15	15	15	15	15	14
III	23	22	15	17	16	17	—	—
IV	25	25	20	21	18	19	19	17

the single male of *P. addolux* has only 10 hooks. At the tip of the hectocotylus, *P. addolux* has 6 small suckers while *P. margaritifera* usually has none, although a maximum of 2 small suckers was observed on the 12 males examined. The spermatophores in *P. addolux* also seem to be fairly distinctive, but this cannot be certain until more material can be studied since spermatophores are sometimes subject to considerable variation.

DISTRIBUTION.—Only 20 specimens of *P. addolux* have been taken during the VELERO program. Of these 20, however, only 1 specimen came from the inner 2 basins. Nine specimens were captured in zone 3, 1 specimen in zone 5, 7 specimens in zone 6, and 2 specimens in zone 7. In addition to these, 2 specimens, including the type, were captured by the R/V SWAN between southern California and the Hawaiian Islands at 147° W, 26° N and 133° W, 32° N.

The spotty occurrence off California, the nearly complete absence of *P. addolux* from the inner basins, and the capture of specimens from the Eastern North Pacific Central Water indicates that this species is probably mid-oceanic and is only rarely present in the inshore waters over the continental borderland.

Genus Pterygioteuthis Fischer, 1896

DIAGNOSIS.—Left oviduct absent. Hooks not present on tentacular clubs.

TYPE SPECIES.—*Pterygioteuthis giardi* Fischer, 1896.

Pterygioteuthis gemmata Chun, 1908

PLATES 3A; 4A–H

Pterygioteuthis gemmata Chun, 1908, p.87; 1910 p.108, pl.13, fig.3; pl.14, figs.4,5,9; pl.15, figs.2,3,6–12; pl.16, figs. 1,2,5,7–19.—Pfeffer, 1912, p. 194.—Thiele, 1921.—Voss, 1967.

DESCRIPTION.—The *mantle* is cylindrical anteriorly, but conical posteriorly. The mantle wall is thick and muscular. The pen extends posterior to the fins and terminates in a sharp point. The free margin of the mantle project distinctly in the nuchal region and at the mantle locking-cartilages.

Each *fin* is large and nearly circular in outline and has broad, free anterior and posterior lobes. The fin length is about 40–50% of the mantle length, and the combined width is about 70–80% of the mantle length.

The *funnel* is moderate in size, reaching to the level of the midpoint of the eyes. Each funnel locking-cartilages bears a straight median groove. The dorsal portion of funnel organ is an inverted V-shaped pad with a small anterior papilla and a low ridge on each lateral arm. The ventral pads are roughly oval in shape. A large funnel valve is present.

The *head* is large and has enormous eyes which occupy the entire lateral portions of the head. The eyelid has only a slight indication of an anterior sinus. An "olfactory" papilla is present at the posteroventral edge of each eye as a triangular flap which is swollen at the tip. The olfactory nerve passes along the posterior edge of the flap.

The *arms* are short and robust. The arm formula is 3>4=2>1. Extremely well-developed trabeculate protective membranes are present on the ventral borders of arms I–III and very weakly developed ones are present on the dorsal borders. Arms IV in females have low, fleshy, protective membranes that are particularly thick near the bases of the arms. Large aboral keels are present on arms I–III, but are best developed on arms III. Arms IV have large lateral keels. The arms have biserial armature consisting mostly of suckers, but with 3–7 hooks on the midportion of the ventral row of each arm I–III. Generally there are 2–4 hooks on each arm I, 4–5 on each arm II, and 5–7 on each arm III, although the maximum range is slightly greater than this (Figure 7). The hooks are considerably larger in males. The suckers of arms IV are much smaller than those of the other arms. The proximal suckers are very small but are gradually larger in size over the first two thirds of the arm, then are progressively smaller to the tip. The larger suckers on all arms possess approximately 6–8 long, slender, truncate teeth on the distal margin of the inner chitinous rings. The hooks are low with broad bases and possess a rather large but irregular secondary cusp beneath the primary one. No remnant of the sucker aperture remains.

The left arm IV of the male is *hectocotylized*. It bears 2 large fleshy longitudinal ridges (the distal one is somewhat bilobed) between which is located a pocket with pleated lateral sides that contains a toothed plate. The dentition of this plate is slightly variable, but usually has a proximal portion with 5 cusps, then a large single cusp, and a distal set of

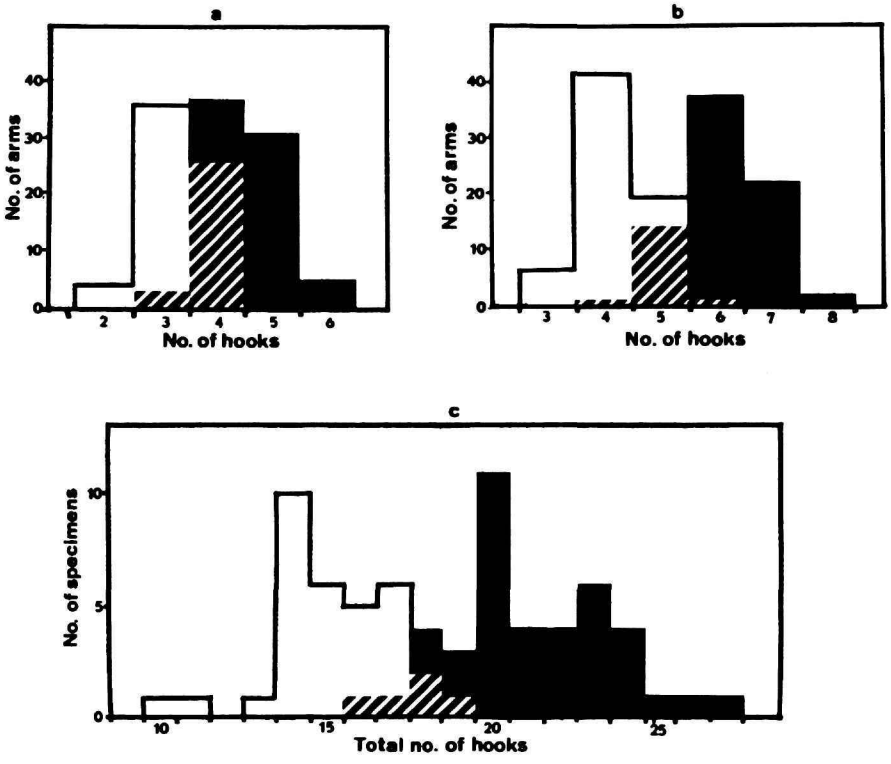

FIGURE 7.—Comparison of numbers of arm hooks between specimens of *Pterygioteuthis gemmata* from the North Atlantic Ocean (white) and from the North Pacific Ocean off California (black). Crosshatched area represents overlap. Comparisons shown: *a*, Arms II; *b*, Arms III; *c*, Arms II and III.

2–3 cusps. The distal one-third of the hectocotylus bears low, protective membranes which embrace small, paired suckers in the last 15–20% of the arm. These suckers are fragile and easily lost during capture and preservation. A large lateral keel is present along the length of the arm.

The *tentacles* are short and the tentacular stalks are naked. The club is only slightly expanded, and possesses moderately developed trabeculate protective membranes; the dorsal membrane is slightly the larger. A distinct keel is lacking. Each carpal cluster consists typically of 3 suckers and 3 pads; occasionally only 2 suckers may be present. Suckers on the manus and dactylus are in 4 rows. The suckers, in a tranverse series on the manus, grade in size from the largest dorsally to the smallest ventrally. The suckers of the ventral row are roughly half the diameter of those of the dorsal row. The suckers of the dactylus are small and equal in size in a transverse series. Dentition of the inner chitinous ring of each of the club suckers consists of approximately 10–14 short, slender, pointed teeth on the distal margin. The proximal margin is smooth or slightly knobby.

The *buccal membrane* is very long, purple, and has 8 lappets. The inner lining of the membrane is produced into numerous, pale, globular papillae. The primary buccal membrane connectives attach to the dorsal borders of arms I, II, and IV, and to the ventral border of arms III. Secondary connectives attach to the ventral borders of arms I and II.

Each eye possesses 14 *photophores* on the surface of the bulbus. On the anterior margin of the eye there is a series of 3 large photophores followed posteriorly by a slightly smaller series of 4 photophores, the third of which has a distinctly different structure. Just posterior to the lens is a rather large, single

photophore. Along the ventral medial margin of the eye are 2 large well-separated light organs and a more anterior medial series of 4 very small light organs. Most light organs on the eyes are spectacular even in preservation, reflecting any color of the rainbow depending on the angle of incident light. Each tentacle contains 4 light organs buried deep in the aboral tissue of the stalk. One of these photophores lies beside the carpal cluster; 2 lie close together about one-third of the tentacle length from its proximal end, and the other organ lies at the base of the tentacle. Several light organs of various sizes lie within the mantle cavity. A large photophore lies on either side of the rectum. A medium-size photophore lies in the midline on the viscera between the bases of the gills, while 2 very large ones lie just posterior to the branchial hearts. Farther posteriorly on the midline, beginning at approximately the level of the midpoint of the fins, there is a series of 3 small photophores of which the anterior 2 are sometimes completely divided into paired organs; however, more often the organs are simply bilobed. The most posterior organ lies near the tip of the pen approximately at the level of the most posterior point on the fins.

Large, paired *nidamental glands* are present. Only the right oviduct, which has a well-developed oviducal gland, is present.

The body, head, and arms are covered by large, reddish brown *chromatophores*. There are distinct silvery iridescent areas on the body and head, although these are rendered nearly invisible by preservation. The sides of the mantle anterior to the fins seem to have been silvery in life although overlain by chromatophores. Similar iridescent spots are present on the posterior-dorsal margin of the head, the posterior–ventral corners of the head, anterior-dorsal corners of the eyes, and the bases of arms II, III and IV and the tentacles.

TYPE LOCALITY.—South Atlantic Ocean.

LOCATION OF TYPE.—Berlin Museum.

DISCUSSION.—At present the following 3 species of *Pterygioteuthis* are established in the literature: *P. giardi* Fischer, 1896; *P. gemmata* Chun, 1908; and *P. microlampas* Berry, 1909. *P. giardi* is very distinctive and easily identified by the presence of hooks in both the dorsal and ventral rows of arms I–III (*P. gemmata* and *P. microlampas* have hooks only in the ventral rows). It can also be separated by the presence of 15 photophores on each eye compared to 14 in the other 2 species, and by the lack of suckers on arms IV.

Pterygioteuthis microlampas poses a problem. It is known from only 2 specimens captured near the Hawaiian Islands, both of which are apparently no longer extant.

In establishing *P. microlampas,* Berry (1914) listed 4 features that distinguished his species from *P gemmata.* The slight difference in the arrangement of the ocular photophores noted by Berry is probably only a result of the slightly damaged condition of his specimens. The small number of hooks on arms II and III (3 on each) which was previously thought to fall outside the range of variation of *P. gemmata* is now known to be well within the limits of the latter species, although it is somewhat unusual for a Pacific Ocean specimen. Berry could not locate suckers on the proximal half of arms IV and considered this a distinctive feature of *P. microlampas;* however, the proximal suckers are often very difficult to observe on *P. gemmata* since they are very small and are frequently covered by the fleshy protective membranes. It seems doubtful that there are any valid differences concerning this feature. The final character concerns the presence of only 2 suckers in the carpal cluster of *P. microlampas.* This feature is unusual, but is also occasionally shared by *P. gemmata.* Therefore, the laterature provides no basis for separating *P. microlampas* from *P. gemmata.* The examination of specimens from Hawaii, however, is necessary before synonymizing the two species.

I examined a number of specimens of *P. gemmata* from the North Atlantic and find that they have fewer hooks on arms II and III than do the California specimens. The total number of hooks on all 4 lateral arms shows almost no overlap (Figure 7c). This is the only feature, however, that seems to differ. I recently examined 17 specimens from the South Pacific and find the hook counts fall somewhat between the specimens from the North Atlantic and North Pacific. The mean number of hooks on arm II is 3.3 for specimens from the North Atlantic, 3.6 for specimens from the South Pacific, and 4.5 for the specimens from the North Pacific. The values for arm III are 4.2, 5.0, and 6.1 for the three areas, and the mean values for the total counts of all 4 lateral arms are 15.2, 17.3, and 21.1. The different hook counts, therefore, seem to reflect geographical variation.

DISTRIBUTION.—*P. gemmata* has previously been

TABLE 5.—*Measurements in mm for* Pterygioteuthis gemmata *Chun, 1908.*

Characters	*Station Numbers of the VELERO*					
	9603	*9603*	*9605*	*9605*	*9602*	*8026*
Sex	♂	♀	♀	♂	♀	♂
M.L.	28	23	30	24	32	25
M.W.	8	7	9	8	9	7
H.W.	10	—	10	8	11	9
F.L.	13	10	14	11	15	9
F.W.	22	18	22	18	24	14
Arm L. I	10	8	10	—	12	9
II	11	9	12	—	13	9
III	13	10	13	—	14	11
IV	12	9	12	9	12	10
Tent. L.	20	22	20	23	19	26
Club L.	4	4	5	4	5	4
	L R	*L R*	*L R*	*L R*	*L R*	*L R*
A.C. Hooks I	3 2	3 3	— 2	2 2	4 4	3 3
II	4 4	5 4	4 4	4 4	5 5	4 4
III	6 6	6 6	6 5	— 5	7 7	6 6

recorded from the equatorial Atlantic (Thiele 1921), from the South Atlantic (Chun 1910; Thiele 1921) from the Indian Ocean (Voss 1967) and off Hawaii (Berry 1914, *P. microlampas*). I have examined numerous specimens captured by the DANA and PILLSBURY from areas throughout much of the north Atlantic and specimens captured by the EL-TANIN in the region of the subtropical convergence in the South Pacific. The species is worldwide in distribution, occurring primarily in warmer waters. For more details concerning the distribution of *P. gemmata* see Voss (in manuscript).

In the present study *P. gemmata* had relatively low frequencies of capture in the more northern zones of the area under study (i.e., 0.15, 0.08, and 0.30 specimens/hour for zones 1, 2, and 3, respectively) and relatively high frequencies of capture in the more southern zones (1.07 and 1.34 specimens/hour for zones 6 and 7, respectively). This species clearly shows a preference for warm water.

Family OMMASTREPHIDAE Steenstrup, 1857

DIAGNOSIS.—Arms with biserial suckers. Tentacular clubs with tetraserial suckers on the manus and usually on the dactylus. Buccal connectives attach to the dorsal borders of arms IV. Funnel locking-cartilage with an inverted T-shaped groove. A muscular bridge anterior to the funnel locking-cartilage passes from the funnel to the ventral surface of the head.

Genus *Ommastrephes* Orbigny, 1835

DIAGNOSIS.—An enlarged tooth present in each quadrant of the largest tentacular suckers. Protective membranes on lateral arms greatly enlarged, particularly on arms III. Arm tips not attenuate; arms containing 50–70 suckers. Funnel and mantle cartilages not fused.

TYPE SPECIES.—*Loligo Bartramii* Lesueur, 1821

Ommastrephes bartramii (Lesueur, 1821)

PLATES 5B, 6C; 7J–R

Loligo Bartramii Lesueur, 1821, p.90, pl.7.

Ommastrephes Bartramii.—Orbigny, 1839, p.347, in Férussac and Orbigny, *Loligo* pl.2; pl.21, fig.5; *Ommastrephes* pl.2, figs.11,12.—Berry, 1912b, p.298; pl.47; pl.50, figs.4–5; text figs. 7–8.

Ommastrephes Bartrami.—Steenstrup, 1880, p.73, fig.2; p.79, fig.3; p.81.

Stenoteuthis bartrami.—Pfeffer, 1912, p.465; pls.35–36; pl.39, figs.1,2.—Sasaki, 1929, p.289, pl.1, fig.8; pl.24, figs. 1–3; text fig.139.

DESCRIPTION.—The *mantle* is long and slender (width about 20% of length). Anteriorly it is nearly cylindrical, but at the level of the anterior edge of the fins, it begins to taper rapidly and terminates in a blunt point. A median ventral keel extends from the level of the conus forward for about 20% of the mantle length. The free anterior margin of the mantle has no distinct projections. The mantle wall is extremely thick and muscular.

The *fins* are about 40%–45% of the mantle in length and about 70%–75% of the mantle in width. They are rather sharply angled laterally and have free anterior lobes.

The *funnel* is very muscular and rather short. The funnel locking-cartilage is complex. The groove has roughly the shape of an inverted T. The dorsal pad of the funnel organ is very large and has an inverted V-shaped appearance. A small anterior papilla can sometimes be detected. The ventral pads are large and oval. A large funnel valve is present. The funnel is fused to the head forward of each locking-cartilage by a muscular bridge.

The *head,* approximately the same width as the mantle, has large eyes which occupy almost its entire lateral sides. Each eyelid has a large anterior sinus. A nuchal crest with 4 folds on each side is present; the most medial folds embrance the funnel. Posteriorly the folds all converge. A low oblique ridge on the posterior extension of the second fold from the funnel is apparently the "olfactory" organ. A small "window" is situated ventral to each eye, but there is only a slight trace of a dorsal "window." The funnel groove contains a large foveola at its anterior end. Seven folds are present within the foveola, and 2–4 side pockets are located lateral to it on either side.

The *arms* are short (30% to 40% of the M.L.) and powerful. Arms I–III all have well-developed aboral swimming keels. In addition, arms I possess accessory lateral keels. Large lateral keels are present on arms IV. All arms have well-developed trabeculate protective membranes. The membranes on the ventral margins of arms I–III are greatly enlarged, but are most extensive on arms III. The elongate trabeculae extend to the margins of the membranes.

The arms have biserial *suckers.* Arms I–III bear from 50–55 suckers while arms IV (excepting the hectocotylus) have about 65 suckers. The dentition of the suckers is somewhat variable. The basal suckers from arms III have about 16–18 pointed teeth (some teeth have irregular shapes) on the distal three-fourths of the ring; the proximal margin is smooth or finely toothed. By the fifth transverse row of suckers from the base of the arm, the teeth are more regularly shaped and the entire ring is clearly lined with about 28–32 teeth. The largest teeth occur on the distal margin; however, these teeth frequently alternate with smaller teeth. The outer ring is made up of roughly 75 elongate slats; each, with only a few exceptions, extends unbroken from the inner to the outer margin of the ring. The slats on the distal portion of the ring bear small knobs at their bases. At the fourteenth row the proximal portion of the inner ring is smooth, and the distal portion bears about 7 large, pointed teeth that may or may not alternate with very small teeth. The largest suckers of arms IV are just slightly smaller than those of the first arms which, in turn, are slightly smaller than those of arms II and III.

The left arm IV is usually *hectocotylized* in males, although occasionally the right arm is modified instead. The largest specimen available (303 mm M.L.) is immature and the hectocotylus is probably only partially formed. All specimens available show some signs of hectocotylus formation which begins with the loss of suckers at the extreme tip of the arm. The largest specimen has 27 suckers on the proximal part of the arm which is followed by a suckerless area which would normally carry 7 suckers. Distal to this is a single row of 6 suckers on the dorsal margin, and the remaining portion of the arm lacks suckers. Distal to the proximal series of suckers, the protective membranes do not appear to have trabeculae. It is likely that this is not a completely mature hectocotylus.

The *tentacles* bear an aboral keel which runs along the tentacular stalk and is continuous with the dorso-aboral keel of the club. Trabeculate protective membranes occur along both margins of the oral face of the tentacular stalk for most of its length; however, the membrane of the dorsal margin is much more extensive. These membranes extend to the tip of the club along the lateral margins. The clubs are expanded and elongate. The suckers of the manus are arranged in 4 longitudinal rows except at the proximal end where they are irregularly aligned and extend onto the tentacular stalk for a short distance. The suckers on the dactylus are arranged in 4 rows which are continuous with those of the manus. The dactylus suckers grade in size from the largest on the

ventral margin to the smallest on the dorsal margin. At the tip of the dactylus, there is a pad of 17 smooth-ringed suckers. At the proximal end of the manus, along the ventral margin, is a row of 2–4 smooth-ringed carpal suckers alternating with 2–4 pads. Proximal to this series lie 5–6 toothed suckers.

The suckers of the medial rows on the manus are nearly 3 times the diameter of the marginal suckers. Numerous fingerlike papillae arise from the fleshy outer edges of these medial suckers. These papillae vary in size and thickness and are often joined at their bases in groups of 4–5, each set looking like a human hand. The papillae are also present on the marginal suckers but are located in only 2 tufts, one on each dorsolateral corner with the biggest tuft nearest the margin of the club. Papillae are not present on the dactylus suckers. On 2 of the largest suckers of the manus 123 and 128 slats were counted in the outer ring. These slats have small knobs at their bases.

The inner rings of the largest suckers of the manus have 4 enlarged teeth, one in each quadrant. Occasionally an additional enlarged tooth may be observed. There are generally 7–10 smaller teeth, which may vary considerably in size, in each quadrant between the large teeth. The marginal suckers have about 25–30 teeth with those of the distal border being much larger than those of the proximal border. Generally, minute teeth may be observed alternating with the distal teeth. The suckers of the dactylus have the same dentition as the marginal suckers on the manus.

The *buccal membrane* has 7 lappets. The buccal connectives attach to the dorsal borders of arms I, II, and IV, and to the ventral borders of arms III.

The animal is speckled with numerous, small, reddish brown *chromatophores*. The ventral surface of the mantle bears an elongate, sharply delineated, silvery strip that extends from the anterior edge of the mantle posteriorly to the level of the anterior edge of the fins. The ventral surface of the head also has a silvery background that extends down arms IV. The dorsal surface of the mantle and the dorsal midportion of the fins have a deep-purple coloration that terminates very abruptly laterally. The dorsal surface of the head is similarly colored, as are the dorsalmost portions of arms I–III and tentacles. The lateral sides of the head and mantle have a silvery, iridescent layer benath the chromatophores.

Numerous *photophores* are imbedded in the musculature near the ventral surface of the mantle. These photophores are not visible in preserved specimens unless the skin is removed, and often it is necessary to chemically macerate the muscle tissue. The photophores are small, closely packed, and extremely irregular in shape. Along the ventral midline of the mantle, there is a strip extending from the conus of the pen to nearly the free margin of the mantle in which the number of photophores is reduced. In the posterior quarter of this strip photophores are lacking.

The concentration of photophores is greatest near the free margin of the mantle. This group of photophores extends along the lateral sides of the mantle margin becoming progressively less numerous. There are no photophores dorsally.

An irregular patch of photogenic tissue is situated on either side of the head at the point of attachment of the muscular bands which pass from the ventral surface of the head to the funnel near the locking-cartilages. At least several photophores are located in the integument and connective tissue immediately anterior to the foveola. Unfortunately, in the specimen examined, the integument was stripped away from most of this area; therefore, there may be more photophores in an intact specimen. Another extremely irregular patch of photogenic tissue is situated on the head near the base of each ventral arm. There is also a long band of photogenic tissue that extends from the base of each ventral arm nearly to the arm tip within the base of the lateral keel.

Within the funnel there is a patch of photophores, clustered approximately into a V-shape, that is located above (dorsal to) the dorsal pad of the funnel organ.

With growth, the patches of photophores on the ventral surface of the head increase in size and change somewhat in shape. The specimen described and illustrated here (Plate 6c) has a M.L. of only 210 mm; therefore, the size of the patches on the head, at least, can be expected to be more extensive in mature specimens.

Discussion.—Three species are presently recognied in the genus *Ommastrephes: O. bartramii* (Lesueur 1821), *O. pteropus* (Steenstrup 1855), and *O. caroli* Furtado, 1887. The latter two are known only from the Atlantic Ocean, whereas *O. bartramii* has been reported from the Atlantic, Pacific, and Indian oceans. The broad distribution of *O. bartramii* indicated that it might possibly represent a species complex. I have carefully compared the present speci-

mens against specimens of *O. bartramii* captured off Florida and find that the eastern Pacific specimens unquestionably differ from those of the Atlantic. The tentacular clubs of the Pacific specimens are distinctly broader than those from the Atlantic. The suckers of the Pacific specimens are about 20% larger than those from the Atlantic specimens of the same mantle length. A specimen of 303 mm M.L. from the Pacific was immature; the hectocotylus was only partially formed and there were no spermatophores present in the genital tract. A specimen of 302 mm M.L. from the Atlantic had a completely formed hectocotylus and spermatophores. There were several minor differences in the structure of the beaks, but it is not known whether these fall within the normal variation for either form.

It is possible that a more complete comparison of all stages of development will reveal additional differences. At present, however, the differences do not seem sufficient to indicate anything more than geographical variation.

There is considerable confusion concerning the relationship between *O. bartramii* and *O. caroli*. It is even possible that they represent different growth stages of the same species. If this is the case, it is curious that the distributions of *O. caroli* and *O. bartramii* do not more closely coincide. *O. bartramii* can be distinguished from *O. pteropus* by the presence of 4–6 suckers on the tentacular stalk proximal to the first knob of the locking apparatus compared to 0–2 suckers in *O. pteropus*. The silvery strip on the ventral surface of the mantle is distinctive of *O. bartramii*, as is the photophore pattern. The photophore pattern in *O. pteropus* was described by Roper (1963) and Clarke (1965). The most obvious distinguishing features of the photophore pattern in this latter species are the presence of a large oval patch composed of densely packed photogenic spherules

TABLE 6.—*Measurements in mm of* Ommastrephes bartramii *(Lesueur, 1821).*

Characters	*Stations*				
	Near Guadalupe Island				*Atlantic off Florida*
Sex	♂	♂	♂	♂	♂
M.L.	211	217	240	303	302
M.W.	44	44	51	65	65
H.W.	42	47	54	—	70
F.L.	91	90	108	137	146
F.W.	158	157	178	220	220
Arm L. I	66	63	77	96	95
II	83	81	96	123	119
III	81	78	96	114	117
IV	78	77	95	*L* *R*	*L* *R*
				117* 121	141* 131
A.C. I	51	50	51	49	51
II	55	54	53	55	57
III	55	57	54	53	58
IV	*L* *R*	*L* *R*	*L* *R*	*L* *R*	*L* *R*
	66* 68	67 51*	48* 66	33* 67	19* 73
Tent. L.	131	123	190	230	200
Club. L.	72	70	92	119	110
Club. S.	143	136	137	131	140
Dact. T.S.	16	16	17	17	17
Carpal F.	*L* *R*	*L* *R*	*L* *R*	*L* *R*	*L* *R*
	2/3 3/2	4/4 3/3	2/2 2/2	2/2 2/2	2/3 3/2

situated on the dorsal surface of the mantle beneath the integument near the nuchal region, and the presence of small, spherical photophores, which are broadly spaced, on the ventral surface of the mantle.

DISTRIBUTION.—There are a number of records of *O. bartramii* from cold water (Pfeffer 1912, Grimpe 1925, Berry 1912b); however, as there has been considerable confusion regarding the identification of this species these records retain an element of doubt. *O. bartramii* is common in tropical and subtropical waters, and I consider that this is the usual habitat for the species, although, being powerful swimmers, it would not be unexpected to find stragglers occasionally in high latitudes. In the present study, 5 specimens were captured at one night-light station off Guadalupe Island.

Genus *Symplectoteuthis* Pfeffer, 1900

DIAGNOSIS.—Funnel locking-cartilage with typical ommastrephid inverted T-shape, but fused in its midportion to the mantle locking-cartilage.

TYPE SPECIES.—*Loligo oualaniensis* Lesson, 1830.

Symplectoteuthis luminosa Sasaki, 1915

PLATES 5A; 6A,B; 7A–I

Symplectoteuthis oualaniensis.—Watase, 1906, p.195.
Symplectoteuthis luminosa Sasaki, 1915, p.144, text fig. 4, pl.4, figs. 7–13; 1916, p.106; 1929, p.293, text fig. 140, pl.24, figs. 4–5.
Eucleoteuthis luminosa.—Berry, 1916, p.60.—Okada, 1927, p.4.

DESCRIPTION.—The *mantle* is long and slender (width 15–20% of length); anterior to the fins it is nearly cylindrical, but posteriorly it tapers to a point. The free margin is only slightly produced near the ventral locking-cartilages and not at all in the nuchal region. The mantle wall is extremely thick and muscular.

The *fins* are about 45–50% of the mantle in length and about 55–60% in total width. They are muscular and attenuate posteriorly. The fins extend to the posterior tip of the mantle. The anterior lobes are free.

The *funnel* is short and muscular. It is fused to the ventroposterior side of the head by a narrow muscular band extending forward anterior to the funnel locking-cartilage. The funnel locking-cartilage has an inverted T-shaped groove which is fused with the mantle locking-cartilage in the posterior portion of the longitudinal groove. The dorsal pad of the funnel organ has an inverted V-shape with only a slight trace of an anterior papilla. The lateral arms are very long and extend onto the funnel retractor muscles. The ventral pads are rather slender and extremely elongate. The anterior and posterior extent of the ventral and dorsal pads coincides. A large funnel valve is present.

The *head* is approximately the same diameter as the mantle. The eyes are large and occupy almost the entire lateral sides of the head. A large anterior sinus is present on each eyelid, and there is a small "window" in the skin above and below each eye. A nuchal crest bears 4 folds which are connected posteriorly. An oblique ridge, the "olfactory" organ, lies on the posterior extension of the second fold from the funnel. A distinct funnel groove is present. The foveola has 8 low ridges on its anterior wall. Only a single, small, side pocket can be found on each side of the foveola. The nuchal cartilage broadens at the anterior end and has a median ridge with a central groove.

The *arms* are short (30–40% of the M.L.) and in the order $2=3=4>1$. Arms I–III all have well-developed aboral keels. An additional keel is present along the lateral side of each arm I. Large lateral keels are present on arms IV.

Trabeculate protective membranes are well developed on all arms. On arms I–III, the membranes on the ventral margins are broader than on the dorsal margins. These are most fully developed on arms III where they are wider than the greatest width of the aboral keel of the same arm. The long, slender, supporting trabeculae extend to the margin of the membrane. The trabeculate membranes of arms IV are equally developed on both margins.

The *suckers* of the arms are biserially arranged and total 43–48 on each of arms I–III and 56–58 on arms IV. The basal few suckers on each arm generally have 3–5 broad, truncate teeth on the upper margin of the chitinous ring and a smooth lower margin. Each broad tooth is the homologue of 2 pointed teeth on the more distal suckers. At rows 5 and 6 on the arms, the teeth have approximately 9–12 sharply pointed teeth on the distal margin that merge with 1–3 broad, generally truncate, teeth on each lateral margin; the proximal margin is smooth. The teeth are more or less of a uniform size, except for an occasional small tooth situated near a larger tooth, al-

though more frequently these are fused, forming a single, somewhat lopsided tooth. The number of teeth is somewhat irregular; some of the large suckers of arms II may have small broadly spaced teeth on the proximal half of the sucker ring. This appears to be a variable feature. Suckers of the seventeenth and eighteenth rows each have 5–6 long pointed teeth on the distal half of their inner rings. The largest suckers of arms IV are roughly half the diameter of the largest suckers of arms II. The largest suckers of arms I and III are only slightly smaller than those of arms II.

The *tentacles* are short and muscular.. An aboral keel extends the full length of the tentacular stalk and onto the club where it is continuous with the dorsoaboral keel of the dactylus. The clubs are only slightly expanded and bear roughly 115–123 suckers. The suckers of the manus are arranged in 4 longitudinal rows except at the proximal end where the number of suckers rapidly diminishes to a few irregularly arranged suckers that extend onto the tentacular stalk. There are no carpal suckers although a single carpal knob was found near the base of the manus close to the dorsal border of both clubs in one specimen, but not in the other. The suckers in the 2 median rows on the manus are greatly enlarged, the largest being 2½ to 3 times the diameter of the marginal suckers. These suckers each bear a single enlarged tooth on the distal margin of the sucker ring. The remaining margin has low jagged edges which form teeth lacking a regular pattern or shape. The dentition becomes more regular on the smaller suckers. The marginal suckers bear about 30–35 teeth around the entire circumference of the chitinous ring. The teeth of the distal margin are slender, pointed, and roughly alternate between long and short sizes. The teeth on the proximal margin are all short and uniform. The dactylus has 4 longitudinal rows of suckers which are continuous with those of the manus. The suckers grade in size in a transverse series from the largest in the ventral row to the smallest in the dorsal row. The sucker dentition is the same as in the marginal suckers of the manus, although the number of teeth decreases as the size of the suckers diminishes near the tip of the dactylus. There is a small pad of about 7–8 smooth ringed suckers at the tip of the dactylus.

The *buccal membrane* has 7 lappets. The buccal connectives attach to the dorsal borders of arms I, II, IV, and to the ventral borders of arms III.

This species has a very distinctive *photophore* pattern. Two broad luminous strips extend almost the full length of the mantle on either side of the ventral midline. Each strip consists of 3 separate parts: a small anterior segment is situated at the free margin of the mantle; a short gap separates this from the second part which extends to approximately the level of the lateral angles of the fins; and this is barely separated from the third portion which continues to approximately the level of the conus of the pen. Near the anterior edge of the mantle are two small patches, one situated on either side of the ventral midline, but medial to the anterior portion of the long strips. Also near the anterior margin, but lateral to each of the long strips, is a medium-size photophore. There is a large photophore on the ventral surface of the head at the base of each arm IV, and another is located on midventral surface of each arm IV.

Many small photophores, generally invisible without dissection, are scattered over the mantle, funnel, head, and arms. These form almost a complete line along the anterodorsal margin of the mantle. They are scattered irregularly over the ventral surface of the mantle, but are absent from its dorsolateral sur-

TABLE 7.—*Measurements in mm of* Sympletocteuthis luminosa *Sasaki, 1915.*

Characters	*Station Numbers of the VELERO*	
	10673	10673
Sex	♀	♀
M.L.	163	136
M.W.	33	26
H.W.	34	30
F.L.	75	67
F.W.	97	79
Arm L. I	49	42
II	61	50
III	57	48
IV	60	48
A.C. I	47	47
II	44	43
III	48	48
IV	56	58
Tent. L.	78	61
Club L.	35	29
Club S.	123	115

face. They are scattered along the dorsal midline from the anterior mantle margin to the fins. The inner surface of the funnel has a single photophore on each dorsolateral side at approximately the level of the emergence of the cephalic vein. There is a photophore at the funnel attachment of each of the 2 bridles and 2 small photophores are imbedded in the funnel valve. On the head, a few photophores are scattered lateral to the base of the funnel. I have found only a single photophore in the integument immediately in front of the foveola; however, since most of the tissue there has been torn away, it is quite likely that at least several others are present in intact specimens. A small distinct photophore is present at the medial base of each ventral arm very near the point where the arms unite. A line of irregularly shaped photophores extends along the lateral edge of each ventral arm at the base of the keel in the proximal half of the arm. There is also a series of small photophores along the surface of the axial nerve of each tentacle.

There can be no assurance that all photophores have been located, since they are extremely difficult to see. For example, Okada (1927) in a histological examination found photophores in the fins, but I have not been able to find them by gross dissection.

The larger specimen examined is a *gravid female* with greatly enlarged nidamental glands. The mature eggs measure just under 1 mm.

The animal is covered with numerous, small, reddish brown *chromatophores*. The dorsal surface is darker than the ventral surface, and the lateral sides of the animal have a distinct silvery appearance.

TYPE LOCALITY.—Off Misaki, Japan.

LOCATION OF TYPE.—In Tokyo Imperial University.

DISCUSSION.—Within the genus *Symplectoteuthis* there are, presently, only 2 recognized species: *S. luminosa Sasaki,* 1915, and *S. oualaniensis* (Lesson 1830). (A third species very similar to *S. oualaniensis* has recently been reported (Clarke 1965), but not described.) The long, luminous strips on the ventral surface of the mantle are present on the former, but not the latter, and easily allow their separation. The present specimens agree with Sasaki's description except for some differences concerning dentition of the arm and club suckers, the number of side pockets in the funnel groove, and the number of carpal knobs. These features, however, are probably all variable. The small photophores buried within and beneath the integument were first reported by Okada (1927).

DISTRIBUTION.—*S. luminosa* is known only from the waters off Japan (Sasaki 1929), as possible record from the Kermadec Islands (Berry 1916), and from the California Current (Okutani 1967). It is here recorded off Guadalupe Island at 29°37′ N, 188°49′ W.

Family NEOTEUTHIDAE Naef, 1921

DIAGNOSIS.—Arms with biserial suckers; tentacular club with 4 rows of suckers on the distal part of the manus and dactylus and numerous small smuckers at the proximal end of the manus. Buccal connectives attach to the dorsal borders of arms IV. Funnel locking-cartilage with a straight, simple groove. Anterior fin lobes lacking; posterior fin lobes free. Photophores absent.

Genus *Neoteuthis* Naef, 1921

DIAGNOSIS.—Fins more than 60% of the mantle length. Club length more than 60% of the mantle length. Most of manus bearing many hundreds of minute suckers.

TYPE SPECIES.—*Neoteuthis thielei* Naef, 1921.

Neoteuthis species

PLATE 8A–C

DESCRIPTION.—The *mantle* is cylindrical anteriorly and gradually tapers to a point posteriorly. The mantle wall is thick and moderately muscular; anteriorly it is produced slightly at the nuchal and funnel locks. The pen is visible in the dorsal midline.

The *fins* are peculiar: they are very elongate (66% of M.L.), but very narrow (29% of M.L.); and they lack anterior lobes, but possess small posterior lobes. The posterior attachment of the fins is slightly in advance of the pointed tip of the mantle. The fins are attached to the lateral sides of the mantle and are, thus, broadly separated from one another in the dorsal midline.

The *funnel* is small: it reaches just past the level of the posterior margin of the eyes. The funnel locking-cartilage has a simple, straight groove which opposes a straight ridge on the mantle. The dorsal pad

of the funnel organ has roughly an inverted V-shape. A small papilla is present near the rounded apex. On each lateral arm of the dorsal pad a ridge is present that slopes from the lateral margin toward the midline, then gradually back to the lateral margin. The lateral arms are very long and extend onto the funnel retractor muscles. The ventral pads are also very large and have a teardrop shape with the more pointed end posterior. The funnel is free from the head laterally.

The *head* is rounded and bears large eyes which occupy almost the entire lateral sides of the head. A sinus is present on the anterior border of each eyelid, but is extremely small. There is no indication of nuchal folds or a nuchal crest. An "olfactory" papilla is present on either side of the head immediately lateral to the funnel. The nuchal cartilage is broader anteriorly and bears a median ridge with a central groove.

The long *arms* (60–80% of M.L.) are rather brittle in preservation, and in the order of 4>3>?2>1. Arms I–III bear low, broad, gelatinous protective membranes with gelatinous trabeculae that project well beyond the membrane. Protective membranes are barely detectable on arms IV. The arms have been rubbed, and no evidence of aboral keels remains. Arms IV have low, gelatinous lateral keels.

All *arms* bear biserial suckers. The suckers are large except for those on the ventral arms, the largest of which is less than half the diameter of the largest suckers of arms III. On arms I–III the suckers are largest in the middle of the arms, but on arms IV the suckers are largest near the base of the arms. Although the sucker rings have almost been destroyed by the fixative, it is still possible to detect about 13–15 apparently semilunar or truncate teeth on the distal two-thirds of each ring; the proximal portion seems to be smooth.

The *tentacles* are long (64% of the M.L.) and bear very large clubs. The clubs are expanded and the manus, which tapers gradually onto the stalk, bears many hundreds of minute suckers arranged in numerous irregular rows. Approximately 35 suckers are present in a transverse series at about two-fifths of the club length from the proximal end. The most distal of the small manus suckers have very broad outer rings. Each inner ring seems to bear triangular teeth around its entire margin, with those of the distal margin enlarged. The suckers in the middle of the manus have teeth which are all nearly equal in size. The suckers decrease in size at the proximal and lateral margins of the manus, but at the distal end the suckers increase abruptly in size, the largest being about 4 times the diameter of the smaller suckers. Except for the area where the manus and dactylus blend together, the dactylus has suckers arranged in 4 longitudinal rows with the suckers of the ventral margin 2 to 3 times as large as the suckers of the dorsal margin. The medial suckers grade in size between the marginal rows. Except for an irregular circle of smooth-ringed suckers at the tip of the dactylus, all suckers of the dactylus have roughly 26–28 sharply pointed teeth around the entire margin of each inner ring. There is a large dorsoaboral keel on the dactylus that extends onto the distal end of the manus.

The *buccal membrane* connectives attach to the dorsal borders of arms I, II, and IV, and to the ventral borders of arms III.

Discussion.—The genus *Neoteuthis* and the family Neoteuthidae were erected by Naef (1921:48). The only diagnosis, given in a footnote, was based on 3 young specimens which were not given a specific name. Later in the same year, Naef named *Neoteuthis thielei* form a description that Thiele (1921) had given of a small squid from Antarctic waters identified as *Octopodoteuthis sp.;* therefore, *Neoteuthis thielei* becomes the type species of the genus by subsequent monotypy. The diagnosis given by Naef and the description given by Thiele greatly lack in detail. Although Naef's diagnosis states the club has 4 rows of suckers, it seems likely that he merely overlooked the manus suckers since in young specimens the tentacles are disproportionately small and the manus suckers are extremely difficult to see. No new information has appeared on this group since Naef's work. Fortunately, at Miami there are specimens captured in Antarctic waters by the USNS ELTANIN that look very similar to Thiele's sketch. Except for this material, it probably would have been impossible to correctly identify the California form.

Although *Neoteuthis* has a very distinctive appearance, it is closely related to the genus *Alluroteuthis,* the sole genus of the family Alluroteuthidae. The similarities are: in both, the buccal membrane connectives attach to the dorsal borders of arms IV. Both genera have very distinctive fins which arise from the lateral sides of the mantle and are broadly separated from one another in the dorsal midline. The fins are also slightly subterminal, lack anterior lobes,

and have free posterior lobes. The fins in the 2 genera are identical, except that they are much longer and more slender in *Neoteuthis*. Likewise, the clubs differ only in degree. *Alluroteuthis* has a cluster of minute suckers at the proximal portion of the manus which corresponds to the much more elaborate manus of *Neoteuthis*. The appearance of a large broad head is similar in both groups as in the armature of the arms, including the occurrence of reduced suckers on the ventral arms.

These features are sufficient to indicate the close relationship between *Neoteuthis* and *Alluroteuthis*. Their families must therefore be considered synonymous, and the more recent family *Alluroteuthidae* Odhner, 1923, must be submerged into the older Neoteuthidae.

The present species is very close to *N. thielei*. The specimens of *N. thielei* that are available for comparison, however, are fragmentary and the original description offers little of specific value. Thus, I am unable to determine whether the present form is conspecific with *N. thielei* and, therefore, must refrain from giving it a specific name.

Data from the single specimen of *Neoteuthis* sp. here described are: Sex, ♂; M.L., 83; M.W., 18; H.W., 23; F.L., 55; F.W., 24; Arms I, 49; II, 56+; III, 64; IV, 68; Tent. L., 118; Club L., 53.

DISTRIBUTION.—The genus *Neoteuthis* has been reported from Antarctic waters (Thiele 1921), and from the Mediterranean Sea (Naef 1921). The specimen described here came from 30°23′ N, 118° 29′ W (VELERO Station 10840). Several specimens are present in the collections at Miami which were taken at the following localities: 3°30′ N, 4°41′ E, Gulf of Guinea (PILLSBURY Station 306); 0°31′ S, 11°02′ W and 13°31′ S, 18°03′ W, South Atlantic (DANA collections); and 46°30′ S, 170°9′ W, South Pacific (ELTANIN collections).

This broad distribution suggests that more than one species may be present in the genus.

Family HISTIOTEUTHIDAE Verrill, 1881

DIAGNOSIS.—Arms with biserial suckers. Tentacular clubs with suckers generally arranged in more than 4 rows. Large, anteriorly directed photophores over the surface of the mantle, head and arms. Left eye considerably the larger. Buccal connectives attach to the dorsal borders of arms IV. Funnel locking-cartilage with an approximately straight, somewhat broad groove.

Genus *Histioteuthis* Orbigny, 1839

DIAGNOSIS.—The characters coincide with those of the family.

TYPE SPECIES.—*Cranchia bonnellii* Férussac, 1835.

Histioteuthis heteropsis (Berry 1913)

PLATES 9A; 10D–G

Melagroteuthis hoylei.—Berry, 1912b, p.305, text figs. 13–16; pl.50, figs. 1–3; pl.51, figs. 1–5; pl.52, figs. 6–7.
Calliteuthis (Meleagroteuthis) heteropsis Berry, 1913, p.75.
Histioteuthis heteropsis.—Voss, 1969, p.815.

DESCRIPTION.—The *mantle* is short and broad; it tapers gradually posteriorly to a blunt tip. The mantle margin projects slightly in the region of the dorsal and ventral locking-cartilages. The mantle wall is very thick, but moderately gelatinous.

The *fins* are short, about 35–40% of the mantle in length and about 50–55% of the mantle in total width. Each fin is roughly semicircular and has free anterior and posterior lobes. Medially, the fins touch one another only at the posterior end where they extend slightly past the tip of the mantle. Anteriorly, the fin insertions are broadly separated from one another.

The *funnel* is short. The funnel locking-cartilage has a broad, simple, generally straight groove that is deepest in the midportion. This structure opposes a straight or slightly curved ridge on the mantle, the anterior end of which is flanked on either side by additional short broad ridges. The dorsal pad of the funnel organ has an inverted V-shape with a small papilla at the anterior apex. The ventral pads are oval. A funnel valve is present.

The *head* is broad and asymmetrical due primarily to the unequal development of the eyes; the left eye has almost 1⅔ the diameter of the right. An anterior sinus is present on each eyelid. A nuchal crest and nuchal folds are not clearly developed. The nuchal cartilage is short and much broader anteriorly than posteriorly.

The *arms* are broad and short, although slightly greater than the mantle in length. Aboral keels are well developed only on the midportion of arms III; they are represented by faint ridges on arms I and II.

The lateral keels are well developed on arms IV. Low, thick, gelatinous protective membranes, lacking distinct trabeculae, are present on all arms. The arms have biserial suckers. The suckers are globular and have relatively narrow outer rings, and inner rings with about 8–10 rounded to truncate teeth on the distal margin. All arms have low inner and outer webs.

The *tentacles* are short and have small (30–40% of M.L.) expanded clubs. The manus has 7 irregular longitudinal rows of suckers. The third and fourth rows from the dorsal margin bear the largest suckers; the remaining suckers become progressively smaller toward the club margins. Sucker rows near the ventral margin of the club extend slightly farther proximally than the others. Proximally, the dactylus has 7–8 irregular longitudinal rows of suckers; however, these are not all continuous with the rows on the manus. At the base of the dactylus, a new row begins along the dorsal margin giving a total of 8 rows for a short distance; however, rows that have continued on from the manus begin terminating, and approximately at the midpoint of the dactylus the number has dropped to 6 rows, then shortly to 5, and finally to 4 rows at the tip of the dactylus. The extreme tip is occupied by a circular pad of small suckers. The largest suckers of the manus have large, pointed or slightly truncated teeth around the entire margin of the inner chitinous ring. The teeth of the distal margin are only slightly larger than those of the proximal margin in large specimens. In smaller specimens, the size difference is much greater. A trabeculate protective membrane extends along the entire ventral margin of their club, but dorsally it disappears about the middle of the dactylus. A dorsoaboral keel is present on the dactylus.

The carpal locking-apparatus begins in an oblique line of 3 suckers with alternating pads along the dorsal–basal part of the manus. Three to 4 suckers follow with alternating pads that extend proximally in a single line along the dorsal margin of the club and onto the tentacular stalk. Medial to the end of this series is a single small suckers and pad aligned longitudinally and situated slightly to the ventral side of the midline. The major series of suckers and pads crosses from the dorsal margin of the stalk to the ventral margin. Elements transversing the stalk may consist either of 2 suckers, or 2 pads, or 2 suckers and 2 pads. Along the ventral margin of the tentacular stalk, the locking-apparatus consists of a single line of pairs of suckers alternating with pairs of pads. There are 2–3 sets of suckers in this series. The last element in the series is a single sucker set some distance proximal to the alternating suckers and pads.

Histioteuthis heteropsis is covered with numerous small, anteriorly directed *photophores*. On the anterior portion of the ventral surface of the mantle, photophores are aligned roughly in closely packed transverse rows. There are approximately 40–45 photophores along the free edge of the mantle. On the posterior portion, the photophores are irregularly distributed. The number of photophores decreases laterally; on the dorsal surface of the mantle they are sparse and smaller in size. Photophores are absent from the ventral surface of the fins, but occur in small numbers on the dorsal surfaces. The funnel lacks photophores. The ventral surface of the head is covered with many irregularly distributed photophores. About 19–21 photophores are situated at the edge of the circular eyelid of the right eye and only a few, small, scattered light organs are present near the eye opening of the right eye and none of these lies on the edge of the eyelid. Large photophores are scattered over the right side of the head, but the left side has smaller and less numerous photophores. The dorsal surface of the head has small, scattered photo-

TABLE 8.—*Measurements in mm of* Histioteuthis heteropsis *(Berry 1913).*

Characters	*Station Numbers of the VELERO*				
	—	8018	8114	8025	10260
Sex	♀	♀	♀	—	—
M.L.	75	65	33	35	22
M.W.	38	32	18	23	13
H.W.	41	—	21	26	15
F.L.	26	—	12	13	9
F.W.	38	—	17	18	12
Arm L. I	88	86	35	42	26
II	94	87	36	45	29
III	97	87	36	43	29
IV	97	87	35	42	28
½ A.C. I	30	29	27	23	27
II	29	29	30	28	29
III	31	32	30	29	28
IV	28	29	28	27	34
Tent. L.	139	158	47	65	45
Club L.	24	23	11	14	9

phores. At the base of the ventral arms there are 8–9 longitudinal rows of light organs. These decrease to 7 about halfway along the arm length. Arms III have 4 rows near the arm base, but only the ventral row extends to the arm tip. Arms I and II each has a distinct row along its ventral border which extends to the arm tip. Other portions of these arms bear small, scattered photophores.

The *buccal membrane* has 7 lappets, and the primary buccal connectives attach to the dorsal borders of arms I, II, and IV and to the ventral border of arms III. An accessory connective attaches to the ventral border of each arm I.

This animal has a uniform purplish red *coloration*.

TYPE LOCALITY.—Monterey Bay, California, eastern North Pacific Ocean.

LOCATION OF TYPES.—United States National Museum and personal collection of S. S. Berry, numbers 108, 110.

DISCUSSION.—*H. heteropsis* can be separated from all other members of he family by the numerous small photophores on the body, head, and arms (i.e., 8–9 rows across the base of each ventral arm), combined with a lack of cartilaginous tubercules on the arms (Voss 1969).

DISTRIBUTION.—*H. heteropsis* is a common species off southern California. The northernmost record is from Monterey Bay (Berry 1912b) while the southernmost record in this area is from off Baja California at 27°34′ N. (Voss 1969). Within the area of the VELERO survey, the highest frequency of capture, 0.52 specimens/hour of trawling, occurred in zone 2 (Santa Catalina Basin). The other major zones also had a relatively high frequency (.22 to .37 specimens/hour) with the exception of zone 7. In this latter zone only 3 specimens were taken, giving the low frequency of 0.03 specimens/hour. Although not entirely convincing, this data suggests that *H. heteropsis* is primarily a cold-water form, and that its southern limit occurs somewhere off Baja California.

Voss (1969) also recorded a specimen, captured by the USNS ELTANIN, belonging to this species from off the west coast of South America at latitude 33° S. Although the data are sparse, it is possible that *H. heteropsis* is an antitropical species with disjunct populations, one in the temperate northeastern Pacific and the other in the temperate southeastern Pacific.

Histioteuthis dofleini (Pfeffer, 1912)

PLATES 9B; 10A–C

Calliteuthis ocellata.—Chun, 1910, p.147; pl.I, figs.1,2; text fig.23a,b.

Stigmatoteuthis Dofleini Pfeffer, 1912, p.288.

Stigmatoteuthis dofleini.—Sasaki, 1929, p.258; text fig.126–127; pl.22, figs.1–3.

Histioteuthis dofleini.—Voss, 1967, p.74; 1969, p.784.

DESCRIPTION.—The *mantle* is thick walled and moderately muscular. It is conical, but tapers to a blunt point. The free margin projects at the locking-cartilages. Beneath the thin outer integument, the mantle is covered with short, broad, wartlike papillae.

The *fins* are short (about one-third of the mantle in length and one-half of the mantle in width). Each fin is nearly semicircular in outline and has small, free anterior and posterior lobes. The papillate tissue of the mantle extends onto the medial portion of the dorsal surface of the fins.

The *funnel* is short, and free from the head laterally. The dorsal pad of the funnel organ has an inverted V-shape with an inverted V-shaped central ridge terminating in a small anterior papilla. The ventral pads are oval. The funnel locking-cartilage has a straight but deep and broad central groove which opposes a large, slightly curved ridge on the mantle.

The *head* is large and broad. The left eye is nearly twice the size of the right. There appears to be 3 nuchal folds rising from the nuchal crest on either side of the head. The second fold bears the "olfactory" organ. The nuchal cartilage is long and slender; it bears a median ridge with a central groove. The head and aboral surfaces of the arms have weltlike papillae beneath the outer epidermis as on the mantle.

The *arms* are very long (over 175% of the M.L.); they are broad at the bases and attenuate at the tips. The arm formula is I=IV>II=III. Rather broad aboral keels are present on the distal half of arms III, but arms I and II have keels that are only slender ridges. Arms IV have thick, fleshy lateral keels. Arms I–III have large trabeculate protective membranes on both the dorsal and ventral margins; these are much less developed on arms IV. Arms I of the single large female examined have suckers arranged in 3 rows at the arm tips (this is not typical of the species according to N. Voss); otherwise, all arms have biserially arranged suckers. The suckers of arms I–III

are much larger than those of arms IV. The inner chitinous rings have been destroyed by the fixative in the largest specimen; however, in the 14 mm M.L. specimen, about 7–10 triangular teeth are present on the distal half of the inner ring; laterally and proximally these diminish to small knobs. An outer web connecting all arms at their bases is relatively well developed, being approximately 20–25% of the mantle in length.

The *tentacles* are long and muscular. The tentacular clubs are slender but expanded, and nearly 40% of the M.L. The suckers of the manus are somewhat irregularly arranged, but can be generally divided into 5 longitudinal series. There is a row of very large suckers in the median portion of the club. Dorsal to this row is a very irregular row of medium-size suckers that alternate somewhat in size. Ventral to the central series is another, more regular row of medium-size suckers. Along both the dorsal and ventral margin is a row of very small suckers. Along the ventral margin, this row may be incomplete. The suckers of the dactylus also appear somewhat irregularly arranged. In a transverse line through the dactylus there are 3–4 suckers. At the tip of the club there is a small flap that carriers 7–9 suckers. The inner rings of the largest suckers of the manus have as many as 60 sharp teeth around the entire margin. A large dorsoaboral keel is present on the dactylus. The carpal locking-mechanism consists of a row of 2 suckers with alternating pads at the base of the manus along the dorsal border. Proximal to the manus there is a median row of 3–4 alternating suckers and knobs. A small sucker is located near the proximal member of this series. Proximal to the median row is a series of 2–3 pairs of suckers alternating with 2–3 pairs of knobs. The first set in this series is situated obliquely on the stalk, but the remaining lie along the ventral margin. This series terminates with a single sucker or knob.

The *buccal connectives* attach to the dorsal borders of arms I, II, and IV and to the ventral borders of arms III.

The ventral surface of the mantle is covered with large, well-separated *photophores*. A somewhat irregular row of smaller photophores extends along the free margin of the mantle. Dorsally the photophores in this series lie somewhat farther from the mantle margin and are very small. There are 22–23 photophores in this series. On the dorsal surface of the mantle, the photophores are small and scattered. I counted a total of 103 photophores on the entire mantle; however, since some are very difficult to locate in the present material, this number may not be exact. The photophores on the ventral surface of the mantle are arranged approximately in diagonal rows.

Photophores are arranged in diagonal rows on the ventral surafce of the head, except for a transverse series that extends along the posterior margin. Seventeen photophores, embedded in the margin of the eyelid, encircle the right eye. Photophores are not so regularly arranged around the enlarged left eye; unfortunately, their exact arrangement cannot be determined in the material available. A few scattered photophores are present on the dorsal surface of the head. In the proximal half of the ventral arms, photophores are arranged in 3 longitudinal rows. On the third quarter, or slightly more, of the arm, photophores are arranged in 2 rows, and on the distal segment only a single row is present.

Arms I–III all have a single row of large photophores, extending the full length of the arms along the ventral margin of the aboral surface. A second row, near the dorsal margin, of very small photophores is also present on all arms. It is possible that other photophores are present, but not detectable in the present material.

This animal has a uniform purplish red *coloration*.

The data for the largest specimen available are: Sex, ♀; M.L., 150 mm; M.W., 65 mm; H.W., 75 mm; F.L., 54 mm; F.W., 77 mm; arm lengths for arms I–IV respectively, 265 mm, 318 mm, 313 mm, 268 mm; Tent. L., 345 mm; Club L., 61 mm.

TYPE LOCALITY.—Sagami Bay, Japan.

LOCATION OF TYPE.—Not traced.

DISCUSSION.—The present material was identified by N. Voss. She informs me that this species can be separated from all others in the family by the presence of paired genitalia in males, and by the papillate skin in some specimens (i.e., this is a variable character). The short, conical mantle and the very long arms and relatively few photophores separates this species, at a glance, from *H. heteropsis*. A third species *Histioteuthis corona*, subspecies *berryi* has been reported once (Voss 1969) near this area (i.e., about 29° N, 126° W). It is superficially simliar to *H. dofleini* except for the somewhat shorter arms. This species can be easily separated from *H. dofleini* by the presence of four longitudinal rows of light organs

along the proximal half of each ventral arm, compared to three rows in *H. dofleini*.

DISTRIBUTION.—*H. dofleini* occurs primarily in tropical and subtropical waters in both the Atlantic and Pacific oceans, although there are a few records from colder waters (Voss 1969). In the present study, only three specimens (M.L., 150 mm, 14 mm, 9 mm) were taken; these were captured in zones 1 and 7 .

Family OCTOPOTEUTHIDAE Berry, 1912

Veranyidae Chun 1910, p. 139. [Family name inadmissable because originally based on a generic name not currently valid. See Roper, Young, and Voss, 1969.]
Octopoteuthidae Berry, 1912a, p. 645.
Octopodoteuthinae Pfeffer, 1912, p.212.

DIAGNOSIS.—Arms with biserial hooks that may be replaced by suckers near the arm tips. Tentacles present only in larvae (rarely in juveniles). Buccal connectives attach to the ventral borders of arms IV. Fins more than 70% of the mantle length. Funnel locking-cartilage with a simple, approximately straight but broad groove.

Genus *Octopoteuthis* Ruppell, 1844

DIAGNOSIS.—Photophores present at the tips of all arms. At M.L., 15–25 mm, all trace of tentacles has been lost.

TYPE SPECIES.—*Octopoteuthis sicula* Rüppell, 1844.

Octopoteuthis deletron, new species

PLATES 10H–M; 11; 12A–D

Octopodoteuthis sp.—McGowan, 1967, p.209.
Octopoteuthis sicula.—Pearcy, 1965, p.261.

DESCRIPTION.—The conical *mantle* gradually tapers to a blunt point posteriorly. The tip of the mantle is almost always contracted and pulled ventrally and anteriorly, giving the posterior end of the body a very blunt appearance. The mantle extends slightly posterior to the fins in the larger specimens, forming a short, broad tail. The tail is not detectable in young specimens, but increases allometrically with growth in specimens larger than about 40 mm M. L. up to maturity when the tail is about 18% of the M.L.

The *fins* are very large and muscular. At their posterior ends, they are reduced to narrow strips that extend along each lateral edge of the tail and join at the apex of the tail. Although their anterior and posterior lateral edges are slightly flattened, the fins are nearly elliptical in outline, except for the posterior attenuation. Their width is 95% of the M.L., and their length (exclusive of the tail) is 86% of the M.L. in the holotype. Small free, anterior lobes are present. The fins fuse at the dorsal midline.

The *funnel* extends approximately to the level of the midpoint of the eyes. It is free from the head laterally. The funnel locking-cartilage is basically of the simple, straight type, although posteriorly the groove curves slightly and flares. The dorsal pad of the funnel organ has roughly an inverted V-shape with a prominent ridge and papilla at the apex and short ridges on the arms; the organ, however, is somewhat variable in appearance. The ventral pads are very large and oval; a funnel valve is present.

The *head* is large and bears large eyes which extend the entire length of the head. A small optic sinus is present at the anterior end of each circular eyelid. Along the posterior margin of each eyelid is a large, broad, crescentshape patch of muscular tissue. The "olfactory" papillae lie at the posterior edge of the head, lateral to the base of the funnel; each consists of a white, flattened terminal bulb with a short, swollen stalk. Both the mantle and head are encased in a thick layer of gelatinous tissue.

The *arms* are long (over 70% of the M.L. in the holotype). The arms are brittle and almost always broken at the tips; in addition, those that can be measured show considerable variation. The arm formula, therefore, is difficult to determine with certainty; in mature specimens they appear approximately subequal. All arms have gelatinous aboral keels. Low, thick, gelatinous protective membranes are present on all arms, but are only apparent in large specimens. These gelatinous ridges are joined across the midline of the arm by membranes which alternate with the hooks; the ridges and membranes form the walls of cup-shape depressions from which the arm hooks arise. The arms bear 2 rows of small hooks which generally are partially or entirely hidden in thick-walled sheaths. Two small, but distinct, accessory cusps occur on each hook. These cusps are relatively more developed in large specimens. The hooks occupy most of the arm lengths, but near the arm tips they abruptly give way to approximately 3–11

pairs of small, globular suckers which have about 6–9 somewhat irregular, pointed teeth, including a large central tooth in each of the more proximal suckers. The number of suckers seems to depend somewhat on size and stage of development, although in the largest specimens they vary from 6–11 pairs. The extreme distal ends of the arms are bare, swell slightly, and have a small bulb at their tips. The swelling and bulb are generally more pigmented than the rest of the arms and are luminescent.

The *tentacles* are completely lacking in adult specimens; however, a specimen with a mantle length of 17 mm has large blunt stubs of the tentacles. Larval forms have small tentacles with a few enlarged suckers at the tips, but no details can be given due to the damaged state of the larvae available.

Octopoteuthis deletron has a considerable number of *photophores;* however, most are inconspicuous. A single large photophore is buried deep in the mantle tissue in the ventral midline near the posterior end of the body. This abdominal photophore is difficult to locate in specimens less than 30 mm M.L., but very careful examination will reveal its presence in specimens somewhat less than 20 mm M.L.

A large photophore is embedded deeply in the gelatinous tissue of the head just posterior to each eye. As described earlier, the tips of all the arms bear elongate photophores. An elongate, obliquely oriented photophore lies inconspicuously near the anterior medial margin of each eye on the ventral portion of the head. These latter photophores do not seem to be developed in specimens less than about 30 mm M.L. A series of photophores lies near the central core of each of the ventral 4 arms interior to the longitudinal muscles, and are often adjacent to the axial nerves. The basal photophore on each arm is larger than the following ones and is somewhat more isolated from the others. The remaining arm photophores, numbering about 25 on each arm IV, are situated at regular intervals up to the level of the distal sucker-bearing zone of the arms where the series ends. Arms II have only the basal photophore and the arms I lack any trace of this series. In preserved specimens, it is necessary to pick away the muscular tissue of the arms to see these light organs. Another pair of photophores lies near the ventral surface of the ink sac. These photophores are overlain by a pair of muscular bands.

In *mature males* the penis is large and appears capable of extending well beyond the opening of the mantle cavity. *Gravid females* have greatly enlarged nidamental and oviducal glands. The mature eggs measure about 2 mm in diameter.

Specimens are covered with reddish brown *chromatophores.* The external layer of chromatophores that lie in the aboral gelatinous tissue on arms III and IV are arranged in a peculiar manner, in that they lie in parallel transverse planes relative to the axes of the arms and are evenly spaced, giving the appearance of a series of lamellae. The mature female has a uniform dark-purple color.

Octopoteuthis deletron undergoes rather drastic developmental changes at a M.L. of about 30–40 mm. This is the change from the *juvenile* to the adult form, although maturity is not reached until a much larger size. The most apparent changes include the great increase in eye size, the thickening of the arms and body, and the acquisition of greater pigmentation. These changes are illustrated in Plate 12A–D.

The *radula* has a tricuspid rachidian and a bicuspid first lateral, unicuspid second and third laterals, and marginal plaques.

The primary *buccal connectives* attach to the ventral margins of arms IV.

TYPE LOCALITY.—33°15′ N, 118°37′ W, eastern North Pacific Ocean.

LOCATION OF TYPE.—University of Southern California, U.S.C. Hancock collections, AHF Cephalopod Type No. 3.

DISCUSSION.—In the genus *Octopoteuthis* there are 7 nominal species: *O. sicula* Rüppell, 1844, near Messina, Mediterranean Sea; *O. megaptera* (Verrill 1885), off east coast of United States, 44 mm M.L.; *O. persica* Naef, 1923, off south tip of Africa, 34°31′ S, 26° 0′ E, 4.7 mm M.L.; *O. indica* Naef, 1923, Gulf of Aden, Indian Ocean, 13°2′ N, 46°41′ E, 3.8 mm M.L.; *O. danae* Joubin, 1931, near Bermuda, 33°15′ N, 68°20′ W, 31 mm M.L.; *O. nielseni* Robson, 1948, near Cocos Island, Pacific Ocean; *O. longiptera* Akimushkin, 1963, from sperm whale stomach, 20° S, 25° W, Atlantic Ocean.

O. persica is based on an illustration in Chun (1910). The specimen shows distinct swellings near the tips of arms II and extremely broad fins. Both features are strongly suggestive of the genus *Taningia,* and I think it safe to transfer this species from *Octopoteuthis* to *Taningia.*

All members of the genus seem to have the same

basic pattern of large photophores, with the exception of the abdominal series which has either 1 median or 2 lateral photophores, depending on the species. Joubin (1931) first noticed the presence of the larger photophores, and this resulted in the establishment of a new species, *O. danae*. *O. danae* seems to agree in almost all respects with *O. sicula;* unfortunately, the arrangement of abdominal photophores in specimens of *O. sicula* from the Mediterranean is unknown. Still, there would be little evidence to prevent synonymizing these 2 forms if an additional, similar species did not occur in the eastern North Atlantic. In contrast to *O. danae* which has 2 abdominal photophores this species has only a single abdominal photophore, and I shall henceforth refer to it as *Octopoteuthis* A.

The other common Atlantic species, *O. megaptera,* from the western north Atlantic and Gulf of Mexico can easily be distinguished by the greater size of its "tail," by the presence of a 2 abdominal photophores, and by large accessory cusps on the arm hooks even in young stages.

O. longiptera was very inadequately described. The only character of possible specific significance is the relative dimensions of the fins; their length is 135% of the width. (This measurement apparently includes the tail.) This feature is probably only a result of the large size of the specimen (590 mm total length). The specimens from California at 30–40 mm M.L. have fins whose lengths (including the tail) are approximately 55%–65% of their widths; at 109 mm M.L. the fin length is 90% of its width. In the 167 mm male (=300 mm total length) the percentage is 105, while in the 148 mm female the percentage is 120. G. Voss informs me that the type of *O. longiptera* is not extant. Since *O. longiptera* cannot be clearly separated from any of the existing species, it must be considered a *species dubia.*

Unfortunately, *O. indica* from the Indian Ocean must be ignored for the present, since its small size prevents adequate comparison to related forms.

Therefore, we are left with at least 3 distinct species in the Atlantic Ocean: *Octopoteuthis* A, *O. danae,* and *O. megaptera.* One of the former 2 species (most likely *O. danae*) must certainly be a synonym of the Mediterranean species *O. sicula.* This problem, however, cannot be resolved with certainty until the photophore pattern of *O. sicula* is determined. In making comparisons with the Californian species, I shall refer only to the 3 Atlantic forms and assume that *O. sicula* is included in one of them.

In the eastern Pacific, at least 2 additional species are present: *O. deletron* from California and possibly Peru (see discussion of distribution), which is characterized by a short tail and a single abdominal photophore, and *O. nielseni* from the region of Pan-

TABLE 9.—*Measurements in mm of* Octopoteuthis deletron, *new species.*

Characters	*Station Numbers of the VELERO*						
	7414	7414	7414	8025	8716	8878	11097
Sex	♂	♂	♀	♀	♂ (Holotype)	♂	♀
M.L.	33	35	38	39	109	167	148
M.W.	13	17	17	12	37	50	50
H.W.	12	14	12	12	33	42	45
F.L.	26	28	28	—	94	124	91
F.W.	39	43	51	—	104	140	107
Tail L.	—	—	—	—	13	22	30
Arm L. I	25	—	—	—	—	—	116
II	—	—	—	45	—	99	105
III	—	30	—	37	84	—	114
IV	—	27	32	33	79	—	115
½ A.C. I	—	27	—	—	—	—	—
II	—	—	—	29	—	—	27
III	—	—	—	28	28	—	—
IV	—	—	27	28	29	—	29

ama. *O. nielseni* was only briefly described by Robson, and the critical abdominal photophore pattern was not given. G. Voss has recently (1962) examined the type in the British Museum and informs me that the specimen is so damaged that it is not possible to determine the photophore pattern. In the DANA collections, there is a specimen which was captured at 6°48′ N, 80°33′ W off Panama. It is probably safe to assume that this species is *O. nielseni*. It is a short-tailed form, as Robson (1948) illustrated, and possesses 2 posteroabdominal photophores. This is a large specimen (M.L., 112 mm) which, surprisingly, has only a slight trace of accessory cusps on the arm hooks. This latter feature would seem clearly to separate *O. nielseni* from *O. danae,* which possess distinct accessory cusps at least in the adult stage (Adam 1952:73, as *O. sicula*), but the value of this character is somewhat uncertain; I examined a small specimen captured off the west coast of Mexico which also appears to be referable to *O. nielseni,* but has distinct cusps. Also specimens of *O. danae* from the Atlantic can be divided into young forms with accessory cusps and young forms without them. Since *O. deletron* is quite consistant in the presence of this feature, it is possible but perhaps unlikely that these different types represent distinct species. The reason for this confusion and difficulty in resolving the specific status of the different forms results from the presence of only a few specific systematic characters within the genus. This condition is partially the result of the almost invariable loss of the arm tips during capture.

If the difficulties concerning the accessory cusps on the hooks can be explained by individual variation, then it becomes very difficult to separate *O. danae* and *O. nielseni*. I believe, however, that *O. nielseni* will prove to be a valid species and, therefore, believe that its name should be retained at least until detailed data are available on all growth stages of both species.

O. deletron is thus separable from all other species except *Octopoteuthis* A by the presence of only a single abdominal photophore. It differs from *Octopoteuthis* A by having a much shorter tail at equivalent mantle lengths and by having well-developed accessory cusps on the arm hooks which are lacking in the latter species.

DISTRIBUTION.—In the present study, *O. deletron* had a fairly uniform frequency of capture in zones 1, 2, 3, 5, and 6 (i.e., fluctuates between 0.18 and 0.36 specimens/hour of trawling). No specimens were captured in zone 7. McGowan (1967) has recorded larvae identified as *Octopodoteuthis* sp, which undoubtedly belong to the present species, from 34° N to 30° N in the southern California area. Pearcy (1965) reported *O. sicula* from off the coast of Oregon; his specimens possess a single abdominal photophore (G. Voss, personal communication) and can, almost certainly, be referred to *O. deletron*. This information suggests that *O. deletron* is a cold-water species with its southern limit somewhere off Baja California; however, the ELTANIN has taken a large specimen of *Octopoteuthis* from 7°45′ S, 81°37′ W off northern Peru that appears to be identical with *O. deletron*. If this is the same species, present evidence would favor the occurrence of two disjunct populations rather than a continuous distribution from Oregon to Peru.

Family GONATIDAE Hoyle, 1886

DIAGNOSIS.—Arms with tetraserial armature; arm tips may be modified. Median 2 rows on arms I–III consist of hooks except at the extreme base and tip of each arm, with the exception of *Berryteuthis anonychus* which lacks hooks except at the bases of arms I–III in females. Funnel locking-cartilage has a simple straight groove which may flare slightly at the posterior end in some species. Buccal connectives attach to the ventral borders of arms IV. Nuchal folds present.

Genus *Gonatus* Gray, 1849

DIAGNOSIS.—Five teeth present in a transverse series on the radula. Tentacular club with a large central hook and generally additional hooks in the median line. Each tentacular club bears a distinctive locking apparatus on the dorsal border of the manus which consists of a series of large, thick, transverse pads with medial alternating oval pads and suckers.

TYPE SPECIES.—*Onychoteuthis? amoena* Møller, 1842.

Gonatus onyx, new species

PLATES 13A; 14A,C–I; 17J

Gonatus fabricii.—Berry, 1912b, [part], p.308, pl.52, fig.4.—? Pearcy, 1965, p.262.

DESCRIPTION.—The *mantle* is long and slender; posteriorly it tapers gradually to a pointed tip. The

muscular portion of the mantle which is moderately thick terminates at the edge of the conus. A muscular cone with a gelatinous core forms a tail that extends posteriorly from the apex of the conus. This structure is not apparent in young specimens, but increases allometrically and becomes prominent in large specimens. The free margin of the mantle projects slightly at the mantle locking-cartilages.

The *fins* have free anterior lobes. The posterior margins are drawn out along the tail in large specimens. The lateral edges of the fins are rounded.

The *funnel* is free from the head laterally and reaches to approximately the level of the lenses of the eyes. Each funnel locking-cartilage bears a straight, simple groove. The dorsal pad of the funnel organ has the shape of an inverted V; the arms are broadest in the posterior portions; the anterior portions each have a median longitudinal ridge that extend to the apex. Near the anterior apex, which is blunt and slightly indented, a slender papilla arises. The ventral pads are oval. A large funnel valve is present.

The *head* is oval and bears large eyes that occupy the entire lateral sides of the head. An anterior sinus is present on each eyelid. Three pairs of nuchal folds are present; the "olfactory" organ arises from the second pair. The nuchal cartilage is elongate and rounded at the anterior end; it has a median ridge with a central groove and marginal ridges.

Arms II and III are very muscular, nearly equal in size, and 50–60% as long as the pen. The ventral arms are the same length or only slightly less than the lateral arms, but are more slender. Arms I are the smallest; they reach about 40–50% of the P.L. Arms I–III all have gelatinous aboral keels which are best developed on arms III. Arms IV have large lateral keels along their entire lengths. Well-developed protective membranes with long, slender trabeculae are present on arms I–III; they are less developed on the arms IV. The armature is in 4 longitudinal series. On arms I–III the median rows consist primarily of large hooks and the marginal rows of small suckers. The suckers arise near the distal ends of the trabeculae. At the extreme tips of the arms, the hooks are replaced by suckers. A total of 25–30 suckers and hooks occur on the proximal half of each arm I–III. Arms IV lack hooks and have 4 series of small suckers. Specimens larger than 40 mm P.L. have 30–37 suckers on the proximal half of arms IV. The arm suckers all have similar dentition. Long, pointed teeth are present on the distal margin, but decrease in size laterally. The proximal border is smooth. The total number of teeth is generally about 12–13. The suckers of the median rows on arms IV are the largest arm suckers, and the marginal suckers of arms I–III are the smallest. The marginal suckers of arms IV are intermediate in size.

The *tentacles* are robust and have small (approximately 20–25% of the P.L.), complex clubs. The manus possesses the 4 sucker-bearing zones typical of the genus: a ventral-marginal zone that extends the length of the manus and terminates behind the large central hook; a locking zone along the proximal half of the dorsal margin; a dorsal–marginal zone which is continuous with the dactylus distally and proximally passes medial to the locking zone; and, finally, a median zone consisting of a single row of suckers, hooks, or both. The ventral–marginal zone in its central part has 4, rarely 5, suckers that arise from each trabecula and are arranged generally in 4 longitudinal rows. The suckers in the medial row are smaller, but not less than half the diameter of the large suckers in the marginal row. Proximally, the rows converge to a single one which is continuous with the sucker row that extends along the ventral margin of the tentacular stalk. The largest suckers of the ventral marginal zone have 10–12 long, pointed teeth distally, which diminish in size laterally. The teeth are more broadly spaced than are those of the arm suckers.

The locking zone consists of 4–6 thick ridges, each with a large smooth-ringed sucker placed at its proximal end. There is usually a sucker at the distal end of the zone without the adjoining ridge. Alternating with the suckers are large rounded knobs. Proximally, this zone ends abruptly and this break is here used to indicate the proximal limit of the club.

The dorsal-marginal zone contains an irregular group of suckers that do not appear to be arranged in definite rows; distally, however, the suckers merge into 3, or occasionally 2, rows which pass lateral to the large central hook and merge with the suckers of the dactylus. Proximally, the number of suckers decreases rapidly and disappears medial to the locking zone.

The median zone bears a large central hook and a proximal row of suckers. These suckers are never transformed into hooks. Usually, there is no member of this zone distal to the large hook; however, occasionally an enlarged sucker lies behind the hook. Sometimes this sucker may bear an enlarged tooth on

the distal margin of the inner ring; and, rarely, this is developed into a small, but completely formed hook. If such a hook is present, it is usually on only one club of the specimen. At the proximal end of the dactylus, suckers are irregularly arranged in 5–6 rows, but quickly decrease in number distally to form 4 regular longitudinal rows. Except for the basal few transverse rows, there is very little difference in size between members of the dorsal and ventral rows. Distally, the dactylus ends in a circle of smooth-ringed suckers at the tip of the club. The suckers from the middle of the dactylus have dentition similar to those of the manus. The total number of suckers on the dactylus (excluding the circle at the tip), the ventral marginal zone, and the dorsal marginal zone varies from 160–200. A well-developed keel is present on the dorso-aboral surface of the dactylus. A narrow, trabeculate protective membrane extends lateral to the suckers along the entire length of the ventral border of the club. On the dorsal margin, a similar membrane terminates in the proximal half of the dactylus.

The tentacular stalk bears a single series of suckers along either margin. Distally, the row along the dorsal margin consists of alternating suckers and pads with adjacent ridges that show faint resemblance to the locking apparatus of the manus; traces of the fleshy ridges accompany only the first few suckers, then disappear. The knobs are displaced medially, relative to the suckers.

The row on the ventral margin is a continuation of the ventral-margin zone on the manus. Most sucker rings in this series have nearly smooth inner rings. The suckers that are situated one-fifth of the tentacle length from the base of the clubs are nearly smooth, but have the distal margin lightly scalloped. Both marginal rows extend almost the entire length of the tentacle. The number of suckers in the ventral row is 70–115% of the number in the dorsal row. A protective membrane, apparently lacking trabeculae, extends along the entire dorsal margin of the tentacular stalk. A trabeculate protective membrane is present distally on the ventral broder. Only a few, generally less than 10 (maximum range is 0–27), suckers are found between the rows on the oral face of the stalk.

The buccal lappets are indistinct. The *buccal membrane* connectives attach to the dorsal borders of arms I and II and to the ventral borders of arms III and IV.

The animal is covered with numerous reddish brown *chromatophores*. This species seems to have a iridescent silver sheen over the lateral surfaces of the head and arms.

Hooks begin to develop on the arms between 26–28 mm P.L. and on the tentacular club between probably 17–24 mm. A spindle-shaped liver set obliquetly to the body axis is present in the *larvae*.

TYPE LOCALITY.—33°19′ N, 118°45′ W, eastern North Pacific Ocean.

LOCATION OF TYPE.—University of Southern California, U.S.C. Hancock collections, AHF Cephalopod Type No. 4.

DISCUSSION.—Berry (1912b) described a number of specimens under the name *Gonatus fabricii*. One of his illustrations (plate LII, figure 4) showing part of a tentacular club probably refers to *G. onyx*.

This species is unique in generally possessing only a single hook on the tentacular clubs. Occasionally, an enlarged sucker is present distal to the large median hook and sometimes this is transformed into a small hook; however, this rarely happens on both clubs of a single specimen. Suckers proximal to the large hook are never transformed into hooks. Other characters also separate it from some of its close relatives. The low number of suckers (usually less than 10) on the tentacular stalk between the marginal rows separates it from all species except *G. berryi*. The size at which the hooks develop on the arms and tentacles separates it from all species except *G. californiensis*. The number of suckers on the tentacular clubs and the number of hooks and suckers on the proximal half of all arms clearly separates it from *G. californiensis*. (See also, discussion of *G. californiensis*.) The unique and distinguishing characters listed for each of the other species of *Gonatus* are found in the following text.

DISTRIBUTION.—*Gonatus onyx* is the most abundant species in the collections. In the area under survey, its distribution is limited almost exclusively to the San Pedro, Santa Catalina, and San Nicolas basins; out of a total of 1,236 specimens only 7 have been captured outside of these 3 basins. It is apparent that the species seldom penetrates to the area of Guadalupe Island since there is not a single record from this area despite an estimated 76 hours of trawling in appropriate depths. The almost complete absence from all of the most oceanic zones (i.e., 5, 6, 7), however, indicates that this is an "inshore" species which may extend farther south in the more in-

TABLE 10.—*Measurements in mm of* Gonatus onyx, *new species.*

Characters	Station Numbers of the VELERO									
	7279	8117	7279	8117	8112	7394	7394	7394	7394	10399
Sex	—	♀	—	—	—	—	—	—	—	—
				(Holotype)						
P.L.	59	98	55	67	72	50	44	34	42	69
M.W.	15	21	12	15	17	11	12	9	11	17
F.L.	25	—	—	25	28	—	21	15	20	28
F.W	42	52	38	41	37	34	31	26	31	47
Arm L. I	26	40	25	29	30	24	20	14	17	34
II	32	47	27	36	36	27	23	16	20	38
III	31	49	31	36	37	27	24	17	21	41
IV	30	47	30	35	35	26	21	15	18	36
½ A.C.II	28	30	26	27	28	25	28	28	28	29
I	30	31	29	28	31	26	29	29	28	31
III	30	30	28	27	31	29	28	31	28	30
IV	35	34	34	32	35	36	32	33	33	34
Tent. L.	41	66	44	67	66	39	35	30	42	47
Club L.	12	16	12	15	13	11	9	7	9	14
Club S.	194	181	184	174	172	171	177	187	165	185
M.S.S.	12	3	1	1	5	2	15	1	2	5
D.S.S.	75	45	65	66	69	61	74	68	67	66
V.S.S.	71	45	60	54	65	48	67	73	64	64

shore waters which were not sampled south of latitude 32° N.

The northern limits of distribution of this species are unknown. There is a probable record by Berry (1912b) from Monterey Bay. I examined several specimens of *Gonatus* collected by Pearcy from off the Oregon coast which were deposited in the Miami collections. These specimens clearly belong to *G. onyx,* and it is probable that the *G. fabricii* listed by Pearcy (1965) belongs to this species, at least in part. Therefore, the known range of *G. onyx* extends from about latitude 30° N to at least 43° N.

Gonatus berryi Naef, 1923

PLATES 15A; 16A,C–I; 17A–C,L

Gonatus fabricii.—Berry, 1912b, [parts], p.308; pl.52, fig.3; pl.55, fig.2.
Gonatus berryi Naef, 1923, p.245.

DESCRIPTION.—The *mantle* is muscular, but thin walled. The mantle margin is produced at the ventral locking-cartilages, but only slightly, if at all, dorsally. The mantle terminates in a point posteriorly; the muscular portion ends at the conus of the pen. A muscular cone with a gelatinous core forms a tail that extends posteriorly from the apex of the conus. The tail is disproportionately small in young specimens.

The *fins* are rounded laterally and have free anterior lobes. Posteriorly the fin becomes attenuate as it extends along the sides of the tail.

The muscular *funnel,* completely free from the head laterally, reaches to the level of the midpoint of the eyes. The funnel locking-cartilage bears a straight groove which flares slightly posteriorly and opposes a straight ridge, which broadens posteriorly, on the mantle. The dorsal pad of the funnel organ has an inverted V-shape with a blunt or slightly indented apex. The arms are strongly angled laterally and bear median ridges that extend anteriorly to the apex. A small papilla is present near the apex. The ventral pads are egg-shape. A large funnel valve is present.

The *head* is oval and bears large eyes that occupy almost the entire lateral sides of the head. Each eyelid has a well-developed anterior sinus. There are 3 pairs of nuchal folds; the second fold from the funnel on either side bears the "olfactory" organ. The nuchal cartilage is elongate, rounded at its anterior end, and bears a median ridge containing a central groove, and lateral ridges.

Arms II and III are moderately long and muscular.

In specimens greater than 35 mm P.L. they vary between 60–70% of the P.L. Arms I are slightly shorter and vary between 50–60% of the P.L. Arms IV are nearly equal to arms II and III in length, but are much thinner.

The presence of aboral keels on arms I–III is uncertain due to damage to the specimens. Well-developed trabeculate protective membranes are present on arms I–III; they are less developed on arms IV. Armature is in 4 series: on arms I–III the 2 median rows have large hooks and the marginal 2 rows have small suckers; at the arm tips the hooks are replaced by suckers. On arms IV, all 4 rows have only suckers. The number of suckers on the proximal half of each arm IV is approximately 40 at a P.L. of 50 mm and 45 at a P.L. of 119 mm. The average number of hooks and suckers on the proximal half of each of arms I–III is about 25 at a P.L. of 50 mm and 33 at a P.L. of 119 mm. The suckers of the arms all have similar dentition. Long, pointed teeth, which diminish in size laterally, are present on the distal margin of the inner sucker ring. The proximal margin is smooth. The total number of teeth varies approximately from 10–14. The largest arm suckers occur in the median rows of arms IV; these are nearly 1½ times larger than the largest marginal suckers of arms III. The marginal suckers of arms IV are intermediate in size.

The *tentacles* are robust; the clubs are moderately large, generally between 30–37% of the mantle length. The ventral-marginal zone of the manus typically consists of 3 longitudinal rows in its broadest part. Occasionally, 1–2 small suckers are present which are the only indication of a fourth row. The suckers of the median row (occasionally rows) are minute and not more than one-fourth the diameter of the large suckers in the marginal 2 rows. The distalmost suckers of this zone are also minute. The largest suckers of the ventral-marginal zone have about 8–9 long, sharp teeth on the distal half of the inner ring which are rather broadly spaced. These diminsh in size laterally and are replaced on the proximal margin by small knobs. These suckers are distinctly larger than those of the median rows on arms IV. The locking zone consists of 5–6 broad, fleshy ridges with a large smooth-ringed sucker at the medial end of each. An additional sucker is commonly present at the distal end of the zone.

The dorsal–marginal zone has relatively few suckers. Distally, it continues past the central hook in 1–2 irregular rows and merges with the suckers of the dactylus. Proximally, the row terminates medial to the locking apparatus. The median zone contains a large central hook followed distally by a small hook and preceded proximally by a single series of suckers and hooks. One or two suckers always lie nearest to the large hook and are followed by 2–4 hooks; the largest hook is never the closest one to the large central hook. At the base of the dactylus along the dorsal border, there are 2 rows of large suckers. Between these rows and the ventral margin are scattered a few minute suckers. The number of rows increases distally to 4 regular series that extend to the tip of the dactylus. The suckers of the ventral row are much smaller than the others. This is most noticeable in the proximal portion of the dactylus and in large specimens. The largest suckers in the middle of the dactylus have similar dentition to the suckers of the manus except that the teeth are disporportionately smaller. At the tip of the dactylus, there is a small circle of smooth-ringed suckers. The total number of suckers on the dactylus (excluding the distal circle), the median zone, and the ventral-marginal zone varies from 159–181. A dorsoaboral keel is present on the dactylus. A small, trabeculate protective membrane is present along the entire ventral margin of the club. A similar membrane is present on the dorsal border of the manus, but ends along the base of the dactylus.

A locking apparatus, consisting of a series of suckers and knobs, extends almost the entire length of the tentacular stalk along its dorsal margin. There is only a slight trace of the fleshy ridges characteristic of the locking apparatus of the manus adjacent to the most distal suckers in the series. The knobs are displaced medially from the suckers. Another series of suckers extends, in a single line, along the ventral margin of the tentacular stalk in its distal half; however, the length is somewhat variable since occasionally scattered suckers extend farther down the stalk. Almost all of these suckers bear pointed teeth along the distal margins of their chitinous rings. Suckers in this series located one-fifth of the tentacle length from the base of the club have 4–6 distinct, pointed teeth on the distal margin of the inner rings. The number of suckers along the ventral margin varies from 38–58% of the number along the dorsal margin. The oral surface of the tentacular stalk between the marginal rows is completely free of suckers except for an occasional

one or two. A low, protective membrane, apparently without trabeculae, is present along almost the entire dorsal margin of the tentacular stalk. A trabecular protective membrane extends along the distal half of the tentacular stalk on the ventral margin.

The *buccal mambrane* bears 7 indistinct buccal lappets. The buccal membrane connectives attach to the dorsal borders of arms I and II and to the ventral borders of arms III and IV.

The *larva* first develops hooks on the arms between 8–10 mm P.L. The large central hook on the club develops at 12–17 mm P.L. The more distal hook develops between P.L. 19–28 mm, while the proximal hooks begin to develop between 25–32 mm. P.L. A spindle-shape, larval liver is never present in this species.

Photophores are absent. Members of this species are covered with numerous, reddish brown *chromatophores*. There is some evidence, at least in younger specimens, of the presence of iridescent silvery tissue on the sides of the head and arms.

TYPE LOCALITY.—Monterey Bay, California, eastern North Pacific Ocean.

LOCATION OF TYPE.—?In personal collection of S. S. Berry, number 98.

DISCUSSION.—Berry (1912b) described a number of specimens of squid which he identified as *Gonatus fabricii*. Naef (1923), noticing that one of the young specimens illustrated by Berry had fins that were unusually large for *G. fabricii*, established for it the new species *G. berryi*. No further information has been published on this species until now. The large size of the club in the type illustration as well as the illustrated details of the club structure make it very easy to connect this name with the second most abundant species of the genus taken in the present study.

G. berryi is very distinct, and there should be no difficulties in its recognition. Among its unique features are the following:

1. In the median zone of the club there are 1–2 suckers which lie near the large central hook. These are followed by several hooks that generally increase in size as the series proceeds away from the central hook. The usual case is the opposite arrangement.
2. The ventral-marginal zone of the club has 2 marginal rows of large suckers and 1–2 rows of minute suckers medially.
3. Suckers in the ventral row on the dactylus are considerably smaller than those of the dorsal row.
4. The tentacular clubs are 30–37% of the pen length.
5. The ventral-marginal row on the tentacular stalk has only about 30–60% of the number of suckers present in the dorsal-marginal row.
6. The larvae develop hooks on the arms when they have a P.L. of only 8–10 mm.

TABLE 11.—*Measurements in mm for* Gonatus berryi *Naef, 1923.*

Characters	*Station Numbers of the VELERO*									
	8117	8117	7394	7394	7394	7343	7279	8112	8018	8795
Sex	—	—	—	—	—	♂	—	—	—	—
P.L.	49	52	42	56	34	119	46	38	33	23
M.W.	17	16	13	14	10	35	16	10	13	9
F.L.	24	24	18	28	14	65	22	—	14	9
F.W.	38	34	29	35	24	72	34	29	26	17
Arm L. I	29	31	22	33	19	65	27	22	18	9
II	35	37	26	37	22	73	31	25	19	11
III	34	37	27	37	23	77	33	26	20	10
IV	32	34	26	36	20	76	32	24	18	9
½ A.C. I	25	25	23	28	23	33	26	23	24	20
II	25	25	24	28	21	34	26	24	24	21
III	25	25	22	29	22	34	24	26	26	20
IV	38	40	35	41	33	45	39	38	33	31
Tent L.	43	57	38	55	30	85	37	35	23	10
Club L.	17	19	13	20	11	30	17	13	10	5
Club S.	173	165	166	162	163	168	162	170	178	158
M.S.S.	1	0	0	0	0	1	0	0	1	1
D.S.S.	86	71	77	74	76	83	74	85	77	—
V.S.S.	32	25	41	26	31	36	33	33	41	—

7. A spindle-shaped larval liver is not present at any stage of the life cycle.

In addition, many features distinguish this species from one or more of its relatives. Among these are the almost complete lack of suckers on the oral face of the tentacular stalk between the marginal rows; toothed suckers along the ventral margin of the tentacular stalk; the relative length of the arms; the arrangement of suckers on the dactylus; the number of suckers on the tentacular club; the number of suckers and hooks on the proximal halves of the arms; and the P.L. at which the hooks on the club develop.

DISTRIBUTION.—This species occurs in all zones except 7. Its frequency of 0.5 specimens/hour of trawling in zone 6 is surprisingly high and compares favorably with its frequency of 0.57 in the Santa Catalina Basin. Its absence from the vicinity of Guadalupe Island, however, is significant and suggests that this area is near the southern limit of the species. The type specimen, which is the only other record of the species, was taken by the ALBATROSS in Monterey Bay. Thus, the known range of this species extends from latitude 30° to 37° N off the coasts of southern California and Baja California.

Gonatus pyros, new species

PLATES 13B; 14B,J–Q; 17G–I,K

DESCRIPTION.—The *mantle* is slender; in almost all specimens examined, it is contracted and tapers gradually from a flaring margin to a posterior point. The mantle margin projects ventrally in the areas of the mantle locking-cartilages, but not dorsally. The mantle wall is moderately thick and muscular.

The *fins* are broad. A posterior "tail" is only slightly developed in the largest specimens. Free anterior lobes are present, and the lateral fin margins are rounded. The fins are very muscular, but are almost always damaged.

The *funnel* is free laterally and extends forward to about the level of the posterior edge of the lens. The funnel locking-cartilage has a long, straight sulcus which opposes a straight ridge on the mantle. The dorsal pad of the funnel organ has roughly the shape of an inverted V; the lateral arms are long and angled laterally. Small, median ridges are present near anterior ends of each of the lateral arms, and a small papilla lies at the blunt anterior apex. The ventral pads are roughly oval in shape.

The *head* is short and rounded. Its width generally exceeds that of the mantle. The eyes are large, and occupy the entire lateral sides of the head; an anterior sinus is present on each eyelid. Each "olfactory" organ is flaplike and located at the posterodorsal end of the second nuchal fold from the funnel. The 3 nuchal folds are very feeble and can be recognized only in the most perfectly preserved specimens. The nuchal cartilage is elongate and rounded at either end. It bears 3 longitudinal ridges; 2 are near the lateral edges of the cartilage, and one is in the median line. The median ridge has a narrow, central sulcus along its midline.

Arms II and III are moderately long and muscular; their length in specimens larger than 35 mm P.L. varies between 60–70% of the P.L. Arms I are shorter and vary between 50–60% of the P.L. Arms I–III appear to have had membranous or gelatinous swimming keels. Arms IV are nearly the same length at the lateral arms, but are more slender. Thin, broad, lateral keels are present along the entire lengths of arms IV. Arms I–III all have well-developed trabeculate, protective membranes; trabeculae and membranes are less developed on arms IV. The armature of the arms is in 4 series. On arms I–III, the marginal rows consist of small suckers that arise near the ends of the trabeculae; the medial 2 rows are composed of large, alternating hooks which are replaced by suckers at the arm tips. Arms IV have suckers instead of hooks in the medial rows. All of the arm suckers have similar dentition. On the distal part of the inner ring are long, pointed teeth that grade into smaller teeth laterally. The proximal margin is smooth. The total number of teeth in each ring varies roughly from 6–9. The marginal suckers of arms I–III are larger than the medial suckers of arms IV, while the marginal suckers of arms IV are smaller than the medial suckers. The usual number of suckers and hooks on the proximal half of arms I–III varies from 29–33, while on arms IV, in specimens larger than P.L. 34 mm, the half-arm count varies from 36–41.

The *tentacles* are long and robust. The tentacular clubs are short, expanded, and very complex. The club length varies from 20–25% of the P.L. The locking zone has 4–6 thick transverse lamellae; adjacent to each at the base of the medial end lies a large, smooth-ringed sucker, and alternating with these are rounded knobs. Proximally, this structure is marked off from the tentacular stalk by a large gap. Distally, the thick lamellae abruptly decrease in size; generally,

the last two are rudimentary, but have typical suckers. Suckers of the dorsal-marginal zone converge into approximately 3 rows which pass around the central hook to merge with the suckers of the dactylus. Suckers in this group usually are absent at the proximal edge of the club, although occasionally they extend onto the stalk. In the median zone, a single, large hook lies near the center of the club and is followed distally by a hook of intermediate size and proximally by 3–4 small hooks. The distal hook is rarely joined by an enlarged sucker with a large median tooth. The small hooks decrease in size proximally and are occasionally preceded by a proximal series of suckers. The ventral–marginal zone consists of 3 or sometimes 4 longitudinal rows of suckers in its midportion, all of which are nearly the same size. This group of suckers continues onto the tentacular stalk not only as the marginal row, but also as a more medial, sligthly irregular series. Distally, this zone terminates opposite the large central hooks.

The largest suckers from the ventral-marginal zone have large, rather broadly separated, pointed teeth on the distal margin of the inner rings which grade into smaller teeth laterally. The proximal border is smooth. The total number of teeth in each ring is roughly 9–10. These suckers are approximately the same diameter as the suckers from the medial rows on arms IV. The suckers of the middle of the dactylus have similar dentition, but with sligthly fewer teeth. The suckers at the proximal end of the dactylus are numerous and not arranged in distinct rows. Slightly distally, they become aligned in 4 longitudinal rows. The suckers in a transverse series are nearly the same size proximally, but distally the suckers of the dorsal row are slightly smaller than those of the ventral row. The tip of the dactylus has a circlet of small, smooth-ringed suckers. The total number of suckers on the dactylus (excluding the circlet), the dorsal-marginal zone, and the ventral-marginal zone varies from 151–184.

The locking apparatus on the manus continues along the dorsal margin of the tentacular stalk proximal to the gap, but much reduced. The large lamellae on the manus are represented by relatively low rounded lobes which soon disappear; but they are much more apparent than in any of the other 3 local species of *Gonatus*. The marginal suckers and alternating knobs decrease in size proximally, and extend along, roughly, three-fourths of the stalk. The suckers along the ventral margins continue for about half the length of the stalk. The suckers in the latter series situated one-fifth of the tentacle length from the base of the club have a few broad, slightly pointed teeth on the distal margin of the inner ring. Almost all specimens have an additional series of suckers on the tentacular stalks which are continuous with the suckers of the ventral-marginal zone of the manus. This series closely parallels the suckers of the ventral margin on the stalk. This series is variable, but usually extends about three-fourths of the length of the marginal row, although it is most clearly present in the distal part. These suckers generally are arranged in a single row, an irregular single row, or occasionally an irregular double row. Sometimes, this series lies very close to the marginal row; more frequently, it is separated from the latter by a distinct gap and rarely contains the only suckers on the tentacular stalks that lie medial to the marginal rows. More commonly, additional suckers are scattered about the oral surface of the stalk. The number of suckers in the ventral row varies between 80–110% of those in the dorsal row. The number of suckers on the stalk between the marginal rows varies betwen approximately 50–125.

The thin *buccal membrane* attaches far up on the bases of the arms. It has 7 lappets and the connectives attach to the dorsal borders of arms I and II and to the ventral borders of arms III and IV.

A single, large, white *photophore* lies on the ventral surface of each eye. Each photophore is somewhat oval and covers the greater portion of the ventral surface of the eye. It is immediately distinguishable from the silver tissue surrounding the eye by its well-defined boundaries and its peculiar surface which seems to have many small pores.

Although the integument is damaged on all specimens, some indication of its *color* remains. The sides of the head and the aboral sides of arms II and III and, to a lesser extent, arms I, are covered by a brilliant silvery layer. This layer extends over the ventral surface of the head, but it is not as well developed there. It is not possible to tell whether or not this layer was present on the lateral surfaces of the mantle. All of the head, arms, fins, and mantle (including the silvery layers) appear to have been covered by brownish red chromatophores. The buccal membrane lacks pigmentation except for a few chromatophores on its outer surface.

Hooks on the arms are present at a P.L. of 17–22

TABLE 12.—*Measurements in mm for* Gonatus pyros, *new species.*

Characters	*Station Numbers of the VELERO*									
	7415	7415	7389	7412	8031	8028	8028	8025	8123	7409
Sex	—	—	—	—	—	—	—	—	—	—
				(Holotype)						
P.L.	35	38	40	39	42	31	33	25	39	38
M.W.	10	10	12	10	11	9	8	—	11	10
H.W.	13	13	15	14	14	12	12	—	14	13
F.L.	15	15	17	14	—	12	12	—	16	—
F.W.	25	29	29	27	30	21	21	—	26	26
Arm L. I	19	20	24	22	23	15	15	9	22	20
II	23	25	27	27	27	17	16	11	26	24
III	22	24	27	26	26	18	17	12	27	24
IV	23	23	26	24	25	18	16	11	25	—
½ A.C. I	31	29	30	29	30	27	29	30	29	31
II	35	31	33	32	34	33	29	32	33	33
III	34	31	31	30	34	31	30	30	32	33
IV	41	38	38	38	38	33	36	35	40	—
Tent. L.	43	44	45	43	67	24	34	—	52	44
Club L.	8	8	10	—	10	7	7	—	10	8
Club S.	170	180	181	168	174	180	175	167	170	159
M.S.S.	104	67	57	85	91	70	58	—	82	79
D.S.S.	86	78	84	73	82	66	77	—	82	77
V.S.S.	74	68	72	68	85	56	69	—	77	73

mm; the distal hook on the club begins to develop at a P.L. of 18–23 mm; the median hook at a P.L. of 15–18 mm; and the proximal hooks at a P.L. of 21–26 mm. A spindle-shape liver lying oblique to the body axis is present in the *larva.*

TYPE LOCALITY.—33°37′ N, 118°26′ W, eastern North Pacific Ocean.

LOCATION OF TYPE.—University of Southern California. U.S.C. Hancock collections, AHF Cephalopod Type No. 5.

DISCUSSION.—*G. pyros* is separated from all other members of the genus by a large photophore on the ventral surface of each eye. Another unique feature is the double series of suckers along the ventral margin of each tentacular stalk. Also among the features which separate *G. pyros* from other species are: size at which the hooks develop; number of suckers and hooks on the proximal half of the arms; number of suckers on the tentacular clubs; and the length of the arms.

DISTRIBUTION.—No specimens of *G. pyros* were taken south of latitude 32° N, and it is assumed that this was the southern limit of the species during the period covered by this survey. In the Santa Catalina zone *G. pyros* is moderately abundant; its frequency is 0.47 specimens/hour of trawling. This species is known only from the present trawling program. The northern extension of the species, therefore, coincides with that of the program.

Gonatus californiensis, new species

PLATES 15B; 16B,J–P; 17D–F

DESCRIPTION.—The *mantle* is long, slender and moderately thick and muscular; it tapers to a point posteriorly. The free edge projects at the ventral, mantle locking-cartilage, but only slightly dorsally. The muscular portion terminates at the conus. Posterior to the conus, a fleshy column continues as a tail which is best developed in large specimens.

The *fins* have free anterior lobes and are attenuate posteriorly along the sides of the tail.

The *funnel* is short and reaches to the level of the lenses of the eyes. The funnel locking-cartilage bears a straight groove that opposes a straight ridge on the mantle. The dorsal pad of the funnel organ has an inverted V-shape. The apex is slightly indented. Each arm is angled on its lateral edge and bears a median ridge on the anterior portion. A slender papilla is present near the apex. The funnel is entirely free from the head laterally.

The *head* is oval. Two large eyes occupy almost the entire lateral surface of the head. A distinct sinus is present on the anterior edge of each eyelid. Three weak nuchal folds are present lateral to the funnel on either side, the second of which bears the "olfactory" organ. The nuchal cartilage is elongate, rounded anteriorly and posteriorly, and has a median ridge with a central groove and marginal ridges.

Arms II and III are muscular and moderately long; generally they are 40–50% of the P.L. Arms IV are approximately the same length as II and III, but are a weaker construction. Arms I are the shortest, being roughly 35–45% of the P.L. Arms I–III bear gelatinous aboral keels. A lateral keel is present on each arm IV and extends the full length of the arm. Well-developed trabeculate protective membranes are present on all arms, but are less developed on arms IV. The armature is in 4 series: arms I–III have 2 medial rows of hooks and 2 marginal rows of small suckers. The suckers arise from the tips of the slender trabeculae. At the arm tips, the hooks are replaced by suckers. Arms IV have 4 rows of suckers only. All arm suckers have similar dentition. Long slender teeth are present on the distal part of the inner ring which grade into smaller teeth on the sides; the proximal margin is smooth. The total number of teeth varies roughly from 9–13. The suckers of the median rows on arms IV are the largest, followed by the marginal suckers of the same arms and finally by the marginal suckers of arms III, but the size differential is not great.

The *tentacles* are moderately long and slender. The tentacular clubs are small (17–24% of the P.L.). The ventral-marginal zone of the club has 4–5 rows of suckers in its central part. Proximally, they blend into a single row which continues onto the tentacular stalk. Suckers of the 3 lateral rows are nearly the same size, while the medial row (or rows) are about half the diameter of the larger suckers. This discrepancy in size only becomes apparent in large specimens and it is somewhat variable in these. The largest suckers from the ventral marginal zone on the manus have roughly 8–10 teeth on the distal two-thirds of the inner ring. The teeth are moderately long and pointed on the distal part of the ring and grade into smaller teeth on the lateral sides. These suckers are clearly smaller than the larger suckers on the arms. The proximal margin appears to be smooth. The suckers of the dactylus have similar dentition, but apparently have slightly fewer teeth. The locking zone has 4–6 large, fleshy ridges with smooth-ringed suckers at their medial ends. Generally a single sucker is present at the distal end of the zone. The suckers alternate with rounded knobs.

The dorsal marginal zone passes lateral to the large median hook in 2–3 irregular rows that blend distally into the suckers of the dactylus. Proximally, the suckers are irregularly arranged and pass medial to the locking zone where they decrease in number until all suckers disappear near the base of the manus.

The median zone contains a very large central hook with a moderately large hook immediately distal to this. Proximal to the central hook are usually 3–5 small hooks followed generally by 1–2 suckers. At the base of the dactylus, suckers are arranged in approximately 7–8 irregular rows, but decrease to 4 rows about halfway out on the dactylus. The suckers of the dactylus are nearly equal in size in a transverse series. The dactylus terminates in a small circle of suckers. A swimming keel is present on the dorsoaboral border of the dactylus. A narrow, trabeculate, protective membrane lies lateral to the suckers along the entire ventral margin of the club. A similar dorsal membrane ends partway out on the dactylus. Both membranes extend down the entire length of the stalks, but are barely visible.

A series of alternating suckers and pads extends along most of the length of the tentacular stalk on its dorsal margin. At the distal end, a few suckers are accompanied by small, fleshy ridges similar to those on the locking apparatus of the manus. A single row of suckers is present along the ventral margin of the stalk for most of its length. The number of suckers in the ventral row varies roughly between 90–120% of the number in the dorsal row. Suckers in this series situated one-fifth of the tentacle length from the base of the club have smooth inner rings. Between these 2 rows there are about 40–80 scattered suckers.

Seven indistinct lappets are present on the *buccal membrane*. The buccal membrane connectives attach to the dorsal borders of arms I and II and to the ventral borders of arms III and IV.

The species has numerous reddish brown *chromatophores*. There is some indication that in life the lateral sides of the head and arms have an underlying silvery iridescent layer.

TYPE LOCALITY.—33°32′ N, 118°24′ W, eastern North Pacific Ocean.

LOCATION OF TYPE.—University of Southern California. U.S.C. Hancock collections, AHF Cephalopod Type No. 6.

DISCUSSION.—*Gonatus berryi* and *Gonatus pyros* have unique features which easily separate them from other members of the genus. *G. onyx* and *G. californiensis* are not as easily separated from one another. The arrangement of hooks on the tentacular clubs of the 2 species differs considerably; in order to demonstrate clearly that these differences are not merely types of variation within a single species, they have been correlated with sucker counts on the tentacles, on the proximal halves of the arms, and in the middle of the tentacular stalks (Figures 8–10). The figures

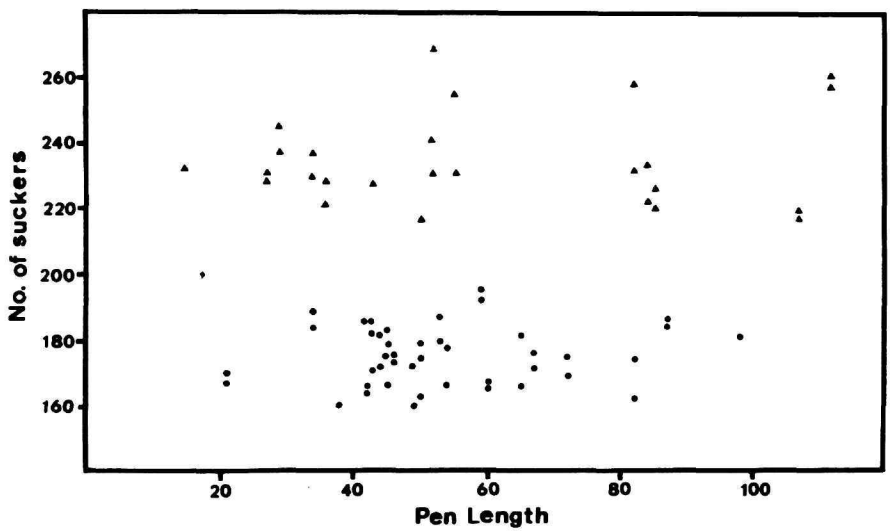

FIGURE 8.—Club-sucker counts, excluding median series and circlet at tip of dactylus, for *Gonatus onyx* (dots) and *Gonatus californiensis* (triangles).

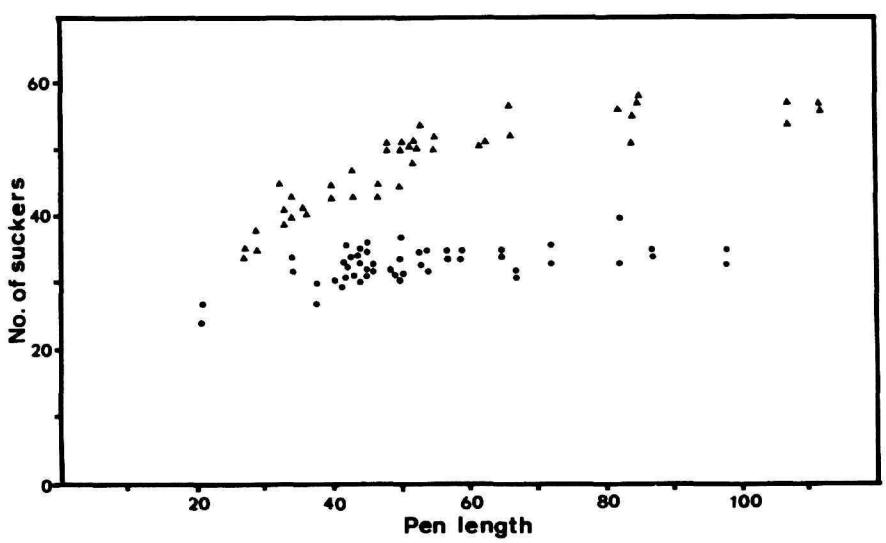

FIGURE 9.—One-half arm counts of arms IV for *Gonatus onyx* (dots) and *Gonatus Californiensis* (triangles).

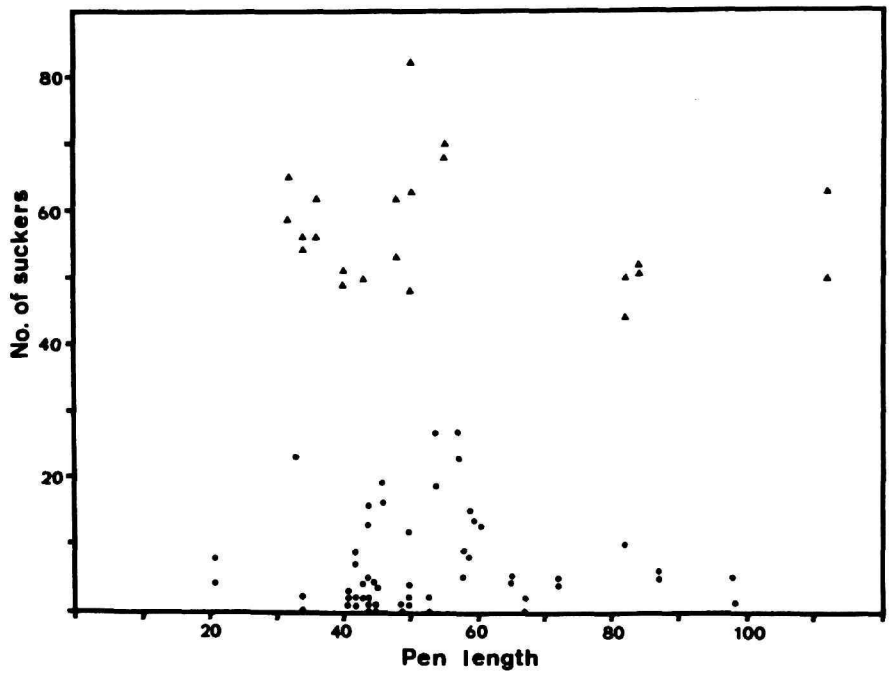

FIGURE 10.—Sucker counts of the medial suckers, excluding suckers of the dorsal and ventral marginal series, on the tentacular stalks for *Gonatus onyx* (dots) and *Gonatus californiensis* (triangles).

also point out several other interesting features of these species. At about a P.L. of 40–45 mm in *G. onyx* and about 60–65 mm in *G. californiensis,* the number of suckers on arms IV no longer increase. Therefore, although the arms will more than double in size as the animal continues to grow (the maximum sizes of these species are not known), the number of suckers will remain constant.

A similar situation occurs with the number of suckers on the tentacular clubs. After the sucker buds have all appeared on the clubs between roughly 10–20 mm P.L., no additional suckers are added. Thus, at almost the first appearance of the definitive clubs the number of suckers is fixed. These features of the arms and tentacles indicate that sucker counts, although little used in the past, can provide excellent taxonomic characters, at least in *Gonatus,* and should be included in all future descriptions of species within this group.

DISTRIBUTION.—*Gonatus californiensis* is the least abundant member of the genus in the collections, yet it is the only species that has been captured in zone 7 around Guadalupe Island. Eleven specimens have been captured there, giving a catch frequency of 0.15 compared to 0.24 specimens/hour of trawling in zone 2. The indication is that this species, although primarily a northern form, extends farther to the south than any of the other species of *Gonatus* of this area. Since all known records of *Gonatus* are primarily from temperate or colder waters, it would be expected that *G. calforniensis* does not extend too much farther south than recorded here, although, McGowan (1967) recorded larvae identified as *Gonatus fabricii* as far south as 25° S off Baja California. Recently, the PILLSBURY captured a larval *Gonatus* (P.L., 17 mm) near the Bay of Panama (7°19′ N, 79°42′ W). This record is extremely surprising and if the specimen belongs to one of the species found off California, as would seem likely, then it can be identified as *G. californiensis.* The small size of the specimen would suggest that it had been spawned in the vicinity of Panama. I cannot adequately account for this rec-

TABLE 13.—*Measurements in mm for* Gonatus californiensis, *new species.*

Characters	*Station Numbers of the VELERO*									
	8114	8116	7411	8114	8114	9960	7157	7157	7410	7221
Sex	—	—	—	—	—	—	—	—	♂	— (Holotype)
P.L.	29	52	48	34	38	46	50	52	107	112
M.W.	9	15	13	11	11	15	13	14	22	21
F.L.	10	20	20	12	13	—	19	21	52	49
F.W.	18	36	30	23	25	32	31	32	58	60
Arm L. I	9	20	20	13	14	19	18	19	43	47
II	12	24	24	16	18	24	23	24	50	56
III	12	25	24	16	18	23	23	24	53	58
IV	10	23	23	14	17	22	22	25	55	62
½ A.C. I	31	30	30	33	31	34	35	35	40	44
II	36	36	35	38	36	37	38	40	40	47
III	38	38	35	36	36	38	39	39	41	45
IV	37	50	44	42	41	48	50	51	56	57
Tent. L.	19	43	47	23	31	37	—	38	97	80
Club L.	6	10	10	8	9	10	10	10	18	19
Club S.	241	269	235	234	225	233	217	236	219	259
M.S.S.	—	45	59	55	59	30	48	22+	40+	57
D.S.S.	—	66	71	68	72	78	65	—	—	82
V.S.S.	—	80	80	75	67	80	67	—	—	90

ord, but believe it unlikely that the normal range of this species extends so far south. This problem can only be resolved by further trawling.

At present *G. californiensis* is definitely known to extend from latitutde 34° N to 28° N off the coasts of California and Baja California.

DISCUSSION OF THE GENUS GONATUS.—Within the genus *Gonatus,* sensu strictu, there was previously considered to be only a single valid species, *G. fabricii* (Lichtenstein 1818), with a worldwide distribution. The discovery of 4 sympatric species of *Gonatus* living off southern California suggests that some of the other forms thought to be synonyms of *G. fabricii* may represent valid species. This is most likely true with *G. antarcticus* (Lönnberg 1899) from Antarctic waters and *G. kamtschatica* (Middendorff 1849) from the northwestern Pacific. It is not known whether or not there is more than a single species in the North Atlantic. Until a study of the latter area is undertaken, the true identity of *G. fabricii* and its accurate characterization must remain in question. Similarly, there is confusion concerning the correct identification of *G. kamtschatica* and *G. antarcticus.* Both have been inadequately described. The collections at the Institute of Marine Sciences indicate that at least 2 species are living in Antarctic waters and at least 2 additional species are living in the Bering Sea. Also, Sasaki (1929) described an adult and a juvenile specimen of *"G. fabricii"* from the northwestern Pacific. From his description and illustrations, it is apparent that Sasaki was dealing with 2 species and that the juvenile, at least, is different from any of the above-mentioned species. The latter form recalls in general appearance a larval gonatid described by Okutani (1966, plate 3: figure 2) called Gonatidae γ. Okutani also considered that these belonged to the same species. Therefore, at least 7 species of *Gonatus* are present in the north Pacific, 2 in the Antarctic and 1 in the Atlantic, with only those from off southern California adequately characterized.

With this unsatisfactory state of the genus, it is nearly impossible to properly compare the California species with those from other areas; however, *G. berryi, G. onyx,* and *G. pyros* each has a number of unique features that allow its separation from other species. *Gonatus californiensis* is very similar to specimens that I have seen from the North Atlantic and Antarctic oceans. It is with some hesitation that I give this species a new name, since it is not possible to separate it clearly from forms in these latter locali-

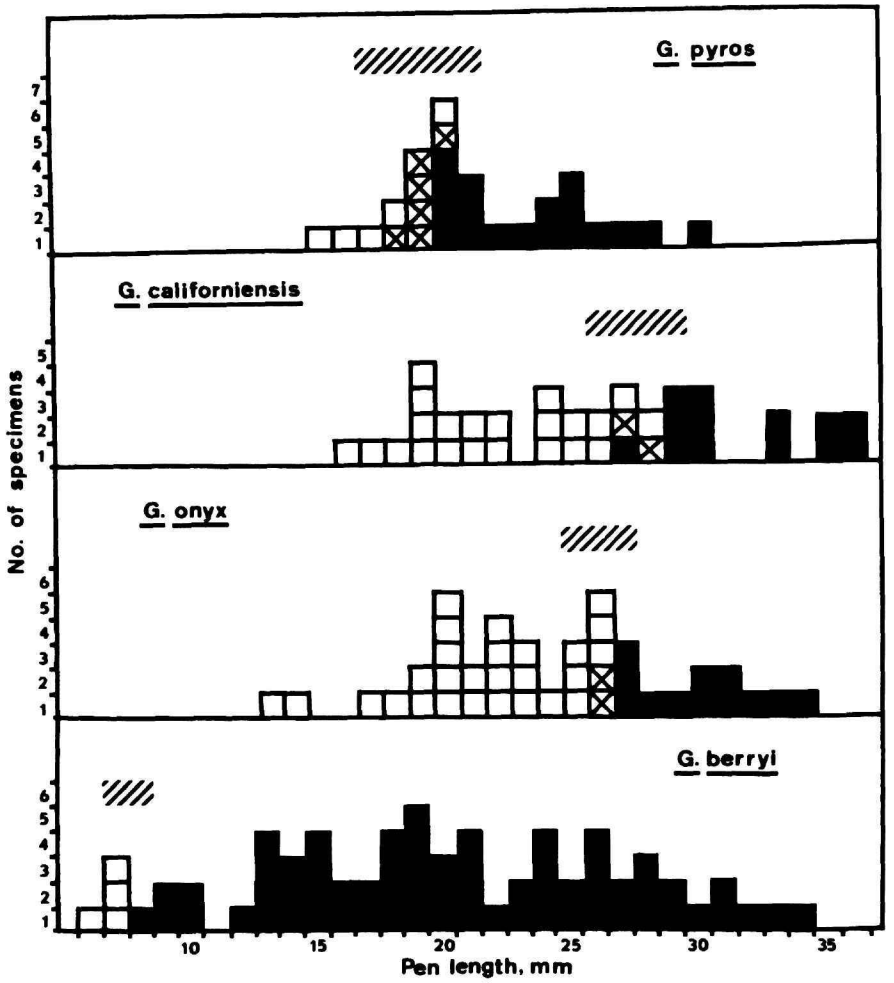

FIGURE 11.—Size at which arm hooks develop for species of *Gonatus*. Empty squares indicate only suckers present. Squares with Xs show intermediate condition (first hint of hook development). Solid squares indicate hooks present including small incompletely formed hooks. Cross-hatched rectangles represent estimated size range over which hooks begin to develop.

ties due to lack of sufficient material. A few differences, however, that substantiate its specific ranking have been noted. The clubs of *Gonatus californiensis* are larger than those of the specimens of *G. "fabricii"* examined from the North Atlantic, but are considerably smaller than those from specimens captured in the Antarctic. There are also differences in the sizes at which the large hooks develop on the tentacular clubs between specimens of *G. "fabricii"* and *Gonatus californiensis*.

Genus *Gonatopsis Sasaki*, 1920

DIAGNOSIS.—Seven teeth present in a transverse series on the radula. Tentacles present only in larvae.

TYPE SPECIES.—Gonatopsis octopedatus Sasaki, 1920.

Gonatopsis borealis Sasaki, 1923

PLATES 18B; 19I–P; 36H

Gonatopsis borealis Sasaki, 1923, p.203, text-fig. p.205; 1929, p.274, pl.30, figs. 3–6.—Okutani, 1966, p.65, pl.II,

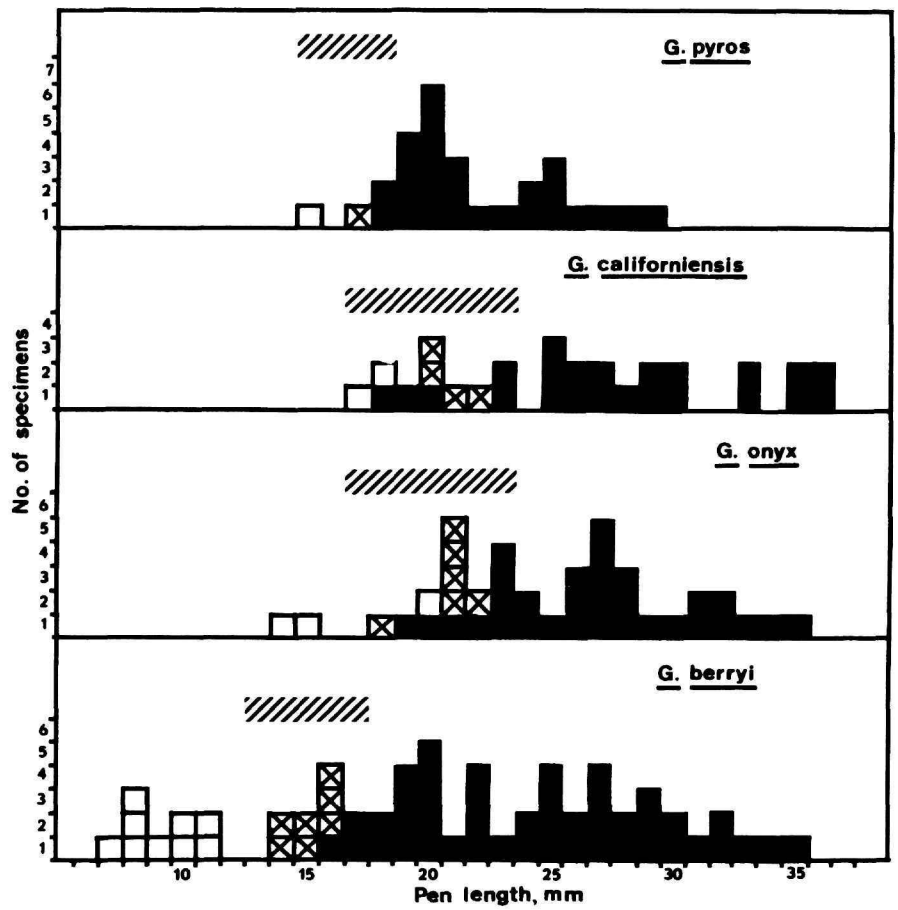

FIGURE 12.—Size at which the central club hook in species of *Gonatus* develops.

figs. 3–4.—Pearcy, 1965, p.261.

DESCRIPTION.*—Anteriorly the *mantle* is cylindrical, but it begins tapering approximately at the level of the anterior margin of the fins and terminates in a blunt point just short of the posterior margin of the fins. The mantle wall is extremely thick and muscular. The free anterior margin of the mantle projects slightly at the funnel and nuchal locking cartilages.

The *fins* are broad (approximately 65–70% of the mantle length), moderately long (over 40% of mantle length), and muscular. The fins are sharply angled at their lateral extremities and taper posteriorly to form a broadly rounded apex where their posterior margins fuse. The anterior lobes are free.

The *funnel* is well developed and powerful. The funnel locking-cartilage has a long straight groove which broadens posteriorly and opposes a long ridge that widens posteriorly on the mantle. The dorsal member of the funnel organ is an inverted V-shaped pad with a small anterior papilla and a low, short ridge near the anterior end of each lateral arm. The lateral arms are long and extend onto the end of the funnel retractor muscles. The ventral pads are large and oval. A funnel valve is present.

The head is cylindrical and has a well-defined, inverted U-shape funnel groove. A nuchal crest is present from which arise 4 nuchal folds on either side of

* K. N. Nesis (1971) has proposed that *G. borealis* be placed in a new subgenus, *Boreoteuthis*. The work of M. Okiyama (1969) and W. Fields and V. Gauley (in press) further indicates that present generic definitions in the Gonatidae are no longer adequate.

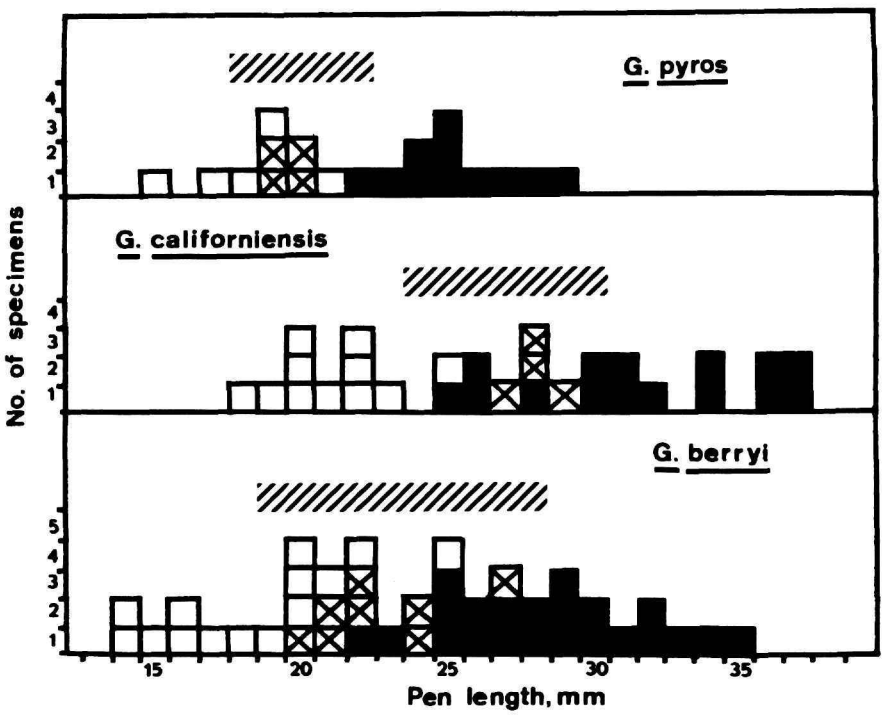

FIGURE 13.—Size at which the distal club hook in species of *Gonatus* develops.

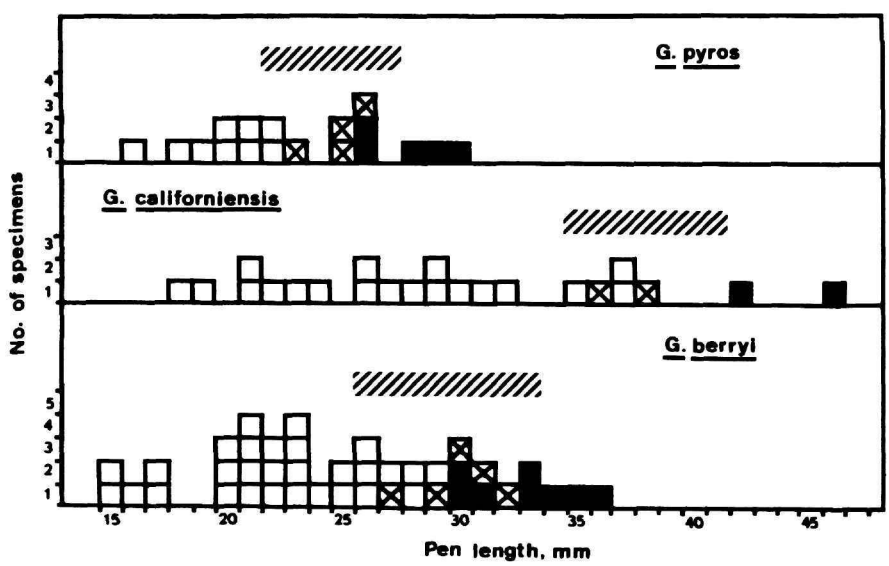

FIGURE 14.—Size at which the first proximal club hook in species of *Gonatus* develops.

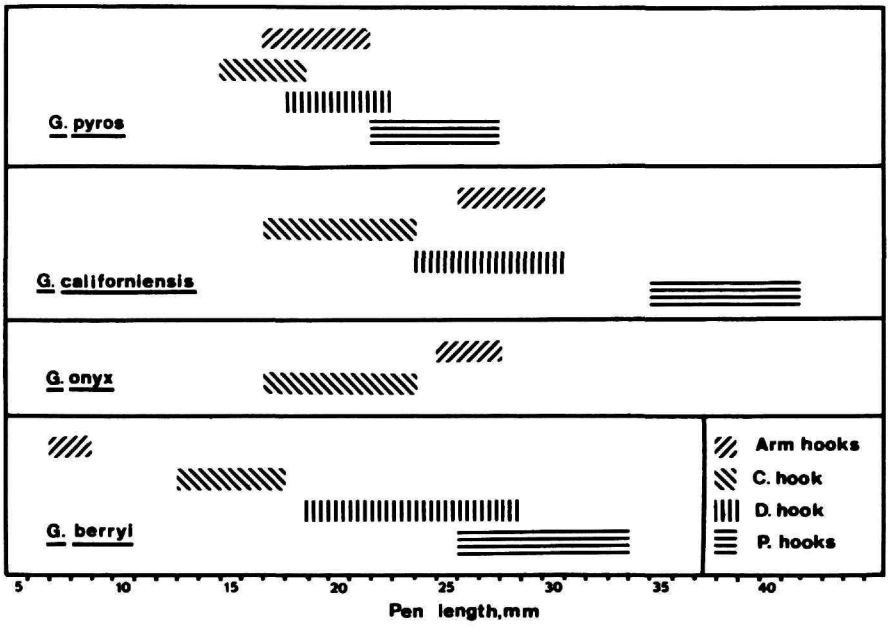

FIGURE 15.—Pattern of hook development for the four Californian species of *Gonatus:* C. hook, central club hook; D. hook, distal hook; and P. hooks, proximal hooks.

the head. The 2 dorsal folds on each side join posteriorly. The second fold from the funnel curves dorsally and bears a small "olfactory" papilla. The ventral-most fold is continuous with the margin of the funnel groove. The eyes are very large and extend nearly the entire length of the head. A large eye sinus is present on the anterior-ventral margin of each eyelid. The nuchal cartilage is large, slightly constricted in the middle of its length and bears a long, straight median ridge with a central groove.

The *arms* are long, muscular, and in the order II= III>I>IV. Arms II and III are roughly 40–50% of the mantle in length. Aboral keels are well developed on arms III, but are less apparent on arms II and form only a small ridge on arms I. Arms IV have well-developed lateral keels. All arms have low, trabeculate protective membranes. Each arm I–III has 39–48 hooks arranged in 2 medial rows and 2 marginal rows of small suckers that arise from the trabeculae of the protective membranes. Near the tips of the arms, the hooks are replaced by large suckers. The 4 rows of suckers thus formed extend to the tips of the arms and usually consist of 56–63 suckers. At the base of the arms, proximal to the hooks are 5–10 suckers. Each arm IV has 4 rows of suckers with 2 median rows somewhat enlarged. All suckers have approximately 12–15 sharply pointed teeth on the distal half of the inner chitinous ring. The proximal margins are generally slightly irregular except on the suckers from the tips of arms III, at least, where the proximal border has distinct small knobs. Peculiarly, in the smaller suckers it is the narrow edge of each tooth which faces the exterior while the broad face lies parallel to the adjacent teeth.

Tentacles are absent except in the larvae.

The largest male, although not fully mature, has a long (95 mm), slender penis that reaches nearly to the mantle opening. There is no evidence of *hectocotylization.* The female has paired oviducts and typical nidamental glands.

There are 7 lappets on the *buccal membrane.* The buccal membrane connectives attach to the dorsal sides of arms I and II and to the ventral sides of arms III and IV.

The *color* in preservation is provided by numerous very small purple-brown chromatophores.

The *juvenile* at 34 mm M.L. is very similar in appearance to the adult; the major exceptions are that only suckers are present on the arms and that the fins are proportionally smaller.

In *larvae* the arms are proportionally shorter, much broader, and bear 4 distinct rows of suckers. Tentacles are present. In the youngest forms they are short and broad, but with pointed tips. The oral face of the tentacle is flattened and bears 3–5 irregular longitudinal rows of suckers. The rows break up proximally and near the base of the tentacle lie 1–3 enlarged suckers. Although differing in the manner in which they arise from the head, the tentacles are very similar to the arms in size and shape.

In the more advanced larva the tentacles are slenderer and much longer than the short arms IV, but only slightly longer than arms III. The enlarged suckers at the base of the club are very prominent. At a later stage, the tentacle is much more slender than any of the arms and is equal in length or slightly shorter than the arms which are roughly subequal at this stage. The enlarged proximal suckers are still prominent. There is considerable variation in the size of the larvae at which these stages of tentacle development occur. At roughly 8–11 mm M.L. the tentacles are lost abruptly.

TYPE LOCALITY.—Kushiro, Hokkaido.

LOCATION OF TYPE.—In Hokkaido Imperial University.

DISCUSSION.—The genus *Gonatopsis* was established by Sasaki (1920) to include a new species *Gonatopsis octopedatus* from the western North Pacific. This gonatid was particularly distinctive in its lack of tentacles and the possession of 8–12 rows of minute suckers on the distal one-third of each arm. In 1923 Sasaki described another member of the genus, *G. borealis,* which also lacked tentacles, but had only 4 rows of suckers at the tips of the arms. Okutani and Nemoto (1964) have described a subspecies of the latter, *Gonatopsis borealis makko,* from specimens taken from the stomachs of sperm whales in the North Pacific. This form differs from *G. b.*

TABLE 14.—*Measurements in mm* of Gonatopsis borealis *Sasaki, 1923.*

Characters	*Station Numbers of the VELERO*									
	10402		8697		10401		10260		8022	
Sex	♂		♀		♂		—		—	
M.L.	200		240		257		34		30	
M.W.	44		61		60		12		10	
H.W.	41		49		—		—		—	
F.L.	85		107		110		13		10	
F.W.	137		155		164		26		22	
Arm L. I	99		104		101		14		11	
II	108		110		113		15		13	
III	107		113		110		14		12	
IV	88		93		99		14		11	
	L	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*
A.C. Hooks I	39	40	45	43	42	40	—	—	—	—
II	39	40	48	44	44	42	—		—	
III	39	39	47	46	44	43	—		—	
A.C. Prox. S. I	7		7		10		—		—	
II	7		6		8		—		—	
III	6		6		8		—		—	
							Total Arm S.		*Total* Arm S.	
A.C. Dist. S. I	57		54		60		129		129	
II	59		61		61		137		139	
III	58		59		57		131		131	
	L	*R*	*L*	*R*	*L*	*R*				
A.C. IV	129	153	139	149	—	177	144		144	

borealis primarily in having a slenderer mantle, longer arms (two-thirds of the M.L. versus two-fifths of the M.L.), a slightly different arm formula, and smaller fins. These differences are sufficient to indicate that *G. b. borealis* and *G. b. makko* should be considered as distinct species and not as subspecies. The distinctness of *G. makko* is further enhanced by the recent description (Okutani 1966: 66, plate III: figure 1) of a larval squid, thought to belong to this species, which differs greatly in shape from the larvae of *G. borealis*.

The present material of *G. borealis* differs from Sasaki's description in the slightly smaller size of arms IV and in the slightly greater number of suckers and hooks on the arms. At best, these differences can only be considered to represent geographical variation.

DISTRIBUTION.—Previously, *G. borealis* has been recorded off California (Rice 1963) from a whale stomach, off Oregon (Pearcy 1965), the Bering Sea, off Kamchatka (55°40′ N, 180°00′ and 49°50′ N, 165°49′ E) (Okutani 1966), and off Japan (Sasaki 1929).

Sasaki's comments (1929) on *G. borealis* are worth repeating:

> Specimens examined have mostly come from Kushiro, but also include those from Nemuro and Tokachi. These localities cover the eastern coast of Hokkaido strongly influenced by a cold current 'Oyashio.' Most of the specimens of Yamaguchi and Shirai referred to were caught on 28th July, 15–30 miles off Kushiro, where the water temperature showed 11.6°C. at the surface and 2.5°C. at the depth of 20 fathoms below the surface. According to the reports of Mr. Yamaguchi and Mr. Shirai who made researches on the habits of the species by angling from the experimental boat "Sangyo-maru" 1922, whenever *Ommastrephes sloani pacificus* [=*Todarodes pacificus*] was abundant, *Gonatopsis borealis* was very rare, the reverse being also the case, or when both the species happened to be met with at the same region of the sea, the latter species was always angled from a much greater depth than the former. All these facts point to the conclusion that *Gonatopsis borealis* is physiologically adapted to much colder water than *Ommastrephes sloani pacificus*, which generally inhabits water above 10°C in temperature. [Spelling has been corrected.]

In the present study the frequency of capture of *G. borealis* in the Santa Catalina Basin was 0.40 specimens/hour of trawling. The adjacent basins (zones 1 and 3) show surprisingly low frequencies (0.06 and 0.05 specimens/hour, respectively). The reason for the discrepancy is uncertain; however, the relatively high frequency of capture in the Santa Catalina Basin, the most intensively studied area, indicates that this species is fairly abundant in the northern sector of the area under study. Only 4 specimens have been taken in zone 6 and only a single one in zone 7 (frequency 0.08 and 0.01 specimens/hour). Although the data is somewhat confusing due to the low frequency of capture in zones 1 and 3, I think that it is safe to assume that zone 7 roughly coincides with the southern limits of this species in the eastern North Pacific.

Family ONYCHOTEUTHIDAE Gray, 1849

DIAGNOSIS.—Arms with biserial suckers. Tentacular clubs with tetraserial armature of which the 2 marginal rows may disappear during growth. Clubs, where known, bear hooks in the medial rows. Buccal connectives attach to the ventral sides of arms IV. Funnel locking-cartilage with a simple, straight groove. Nuchal folds present.

Genus *Onychoteuthis* Lichtenstein, 1818

DIAGNOSIS.—Tentacular clubs with 2 rows of hooks; marginal suckers absent except in early juveniles. Arm suckers with smooth chitinous rings (teeth lacking). Photophores present on viscera and a single photophore present on the ventral bulbus of each eye.

TYPE SPECIES.—*Onychoteuthis bergii* Lichtenstein, 1818.

Onychoteuthis borealijaponicus Okada, 1927

PLATES 18A; 19A–G

Onychoteuthis banksii.—Berry, 1912c, p.83, text figs.44–48; 1913, p.77.—?Pfeffer, 1912, p.79, p.85.—Sasaki, 1916, p.90; 1929, p.228, pl.20, fig.12, pl.30, figs. 1–2.
Onychoteuthis borealijaponicus Okada, 1927, p.4.
Onychoteuthis banksi?—Clarke, 1962, p. 424.—Pearcy, 1965, p.262.

DESCRIPTION.—The *mantle* is long and slender (width 22–27% of length); the anterior half is cylindrical, and the posterior portion tapers to a terminal point. The mantle wall is thick and muscular. The free margin projects in the nuchal region and at the mantle cartilages. The muscular portion of the mantle terminates at the conus. The pen is clearly visible the entire length of the mantle in middorsal line. The rostrum of the pen extends posterior to the conus and is

easily visible in ventral view. The rostrum is surrounded by a cone of gelatinous connective tissue.

The *fins* are 54–60% of the M.L. in length and 70–79% of the M.L. in width. The anterior lobes are free. Posteriorly, the fins terminate at the tip of the mantle.

The *funnel* is small; it extends to the level of the middle of the eyes. The funnel cartilage is pointed anteriorly, flares slightly posteriorly, and bears a straight median groove. The dorsal pad of the funnel organ has an inverted V-shape. The posterior portion of the lateral limbs broaden abruptly; the anterior portion bears a weak lateral ridge. A low, conical papilla is present at the anterior apex. The ventral pads are very large and oval. The funnel is free from the head laterally and contains a large valve.

The *head* is relatively small, being equal to or less than the mantle width. The large eyes occupy the entire lateral sides of the head. Each eyelid has a large anterior sinus. Distinct dorsal and ventral "windows" are present on either side of the head. A funnel groove with well-defined margins is present; in the median anterior line the margin turns forward to form an acute angle. There are 9–10 folds on the nuchal crest on either side of the head; the second bears the "olfactory" papilla. The second to fifth or sixth folds are joined posteriorly. The first fold connects with the midportion of the second. The nuchal cartilage is elongate, constricted slightly laterally, and bears a prominent median ridge with a central groove.

The *arms* are short (longest arms of the largest specimens are 40% of the M.L.) and in the order $2=3=4>1$. Aboral keels are well developed on arms II and III, but are present only on the distal halves of arms I. Lateral keels are present on arms IV. Low trabeculate protective membranes are present on all arms. The armature consists of biserial suckers throughout the length of each arm. The inner chitinous rings of the suckers are smooth; the outer rings are reduced. The suckers of arms IV are distinctly smaller than those of the other arms.

The *tentacles* are short and robust. The tentacular clubs measured to the proximal end of the carpus are 24–27% of the M.L. The club is not clearly divided into manus and dactylus. It bears biserial hooks and no suckers except for a small cluster of 15–16 smooth-ringed suckers at the tip of the club. Marginal rows of small suckers, however, are present on the club in juveniles up to a M.L. of at least 33 mm. The chitinous rings of these suckers are smooth. The first 5 hooks of the ventral row increase gradually in size distally and have symmetrical bases. The following 2–3 hooks increase greatly in size and have asymmetrical bases. The succeeding hooks gradually decrease in size. Each hook distal to the largest hook frequently bears a small knob near the ventral border of its base, although this is somewhat variable. In the dorsal row, the second hook is usually slightly larger than the first. The following hooks gradually decrease in size to the fifth or sixth hook. The succeeding hooks increase slightly in size, then gradually diminish in size. With the possible exception of the first few proximal hooks, the hooks of the dorsal row are much smaller than those of the ventral row. The carpus occupies an oval patch clearly marked off from the surrounding tissue. It contains 8–10 suckers and pads. The tentacular stalk is bare. A protective membrane is present along the full length of the ventral margin of the club. The proximal portion is much more expanded. A low membrane is present along the dorsal border lateral to the 5 proximal hooks. A large dorsoaboral keel is present. An additional separate keel extends along the aboral surface of the tentacular stalk.

The *buccal membrane* bears 7 lappets and the connectives attach to the dorsal border of arms I and II and to the ventral borders of arms III and IV.

A large *photophore* is present over the ventral surface of each eye. An oval photophore is present on the ventral surface of the ink sac and an ill-defined photophore is present on the ventral surface of the ink duct just before the duct enters the intestine. Part of the ink sac and the ink duct between the photophores is covered by a band of tissue with an iridescent gold sheen which Okada thought was also photogenic tissue. *O. banksii*, a closely related form, has a very large and well-defined anal and intestinal photophores with no iridescent tissue between them. The animal is speckled with reddish brown *chromatophores*.

TYPE LOCALITY.—Tokachi, Hokkaido, Japan.

LOCATION OF TYPE.—In the collection of Hokkaido Imperial University.

DISCUSSION.—In recent years *Onychoteuthis banksii* has been considered the only valid member of its genus. Throughout its worldwide distribution it can easily be recognized by its robust appearance,

large hooks on the tentacular clubs, a large photophore under each eye, and 2 photophores next to the intestine. In 1927, Okada described a new species, *O. borealijaponicus,* from Japan based primarily on the slightly different form and structure of the light organs. Sasaki (1929), in his monograph of the Japanese cephalopods, placed this species in the synonymy of *O. banksii* indicating that Okada's distinguishing characters might be a result of developmental or seasonal differences. I have examined specimens from 12–100 mm M.L. and find that the appearance of the photophores can easily separate the 2 species throughout this size range. *O. banksii* also is much more robust than is *O. borealijaponicus.*

I have attempted to find additional characters to separate the 2 species, but have run into difficulties. The "*O. banksii*" from Florida waters clearly fall into 2 separate groups and, therefore, the former worldwide species "*O. banksii*" now seems to consist of at least three species: *O. borealijaponicus* from the North Pacific and 2 species from Florida waters. It seems likely that "*O. banksii*" will eventually be found to consist of a number of additional species, and until this complex can be worked out it will be difficult to completely characterize *O. borealijaponicus. O. borealijaponicus,* however, can be separated from the Florida specimens, by the light organs, and by the tentacular clubs. I have counted the number of hooks on 37 specimens of "*O. banksii*" from off the coast of Florida and the results are as follows:

Number of club hooks	19	20	21	22	23
Number of clubs examined	4	28	28	13	1

Voss (personal communication) has examined the type of *O. banksii* and finds that each club carries 21 hooks. The number of hooks on the clubs of the relatively few large specimens of *O. borealijaponicus* available to me clearly fall outside of this range:

Number of club hooks	25	26	27
Number of clubs examined	2	8	4

In addition, the relative sizes of the fins, arms, and tentacular clubs separate *O. borealijaponicus* from each of the Florida species, but in different ways.

DISTRIBUTION.—*O. borealijaponicus* was taken throughout the area under study, although most records (72 of 95 specimens) came from zones 5 and 6. This species is a powerful swimmer and presumably epipelagic, and is thus ill-suited for capture by the

TABLE 15.—*Measurements in mm of* Onychoteuthis borealijaponicus *Okada, 1927.*

Character	*Station Numbers of the VELERO*								*Pawlson Collection off southern California*	
	8237		8121		8114		8121			
Sex	—		—		—		—		♀	
M.L.	81		63		50		48		100	
M.W.	18		14		11		13		23	
H.W.	18		13		10		11		20	
F.L.	47		35		27		26		60	
F.W.	61		48		36		38		70	
Arm L. I	27		20		15		14		32	
II	32		25		19		17		41	
III	31		23		18		16		39	
IV	32		23		17		16		40	
½ A.C. I	23		19		18		17		23	
II	24		21		23		20		23	
III	21		20		22		18		21	
IV	26		25		26		23		26	
Tent. L.	47		35		32		28		73	
Club L.	20		15		13		13		26	
	L	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*
Club H.	27	27	26	26	27	26	25	25	26	26
Carp S.	9	9	9	10	9	10	9	8	9	10
Carp K.	9	9	10	9	10	9	8	9	10	9

Isaacs–Kidd mid-water trawl. The collection consists primarily of larval forms which probably are taken incidentally when the trawl is being lowered and retrieved. Considering this method of collection, the results are rather difficult to interpret, but they seem to indicate that the young, at least, are more abundant in the more oceanic zones of the study.

Pearcy (1965) recorded *O. banksii* from off Oregon. I have examined one of his specimens now at the Institute of Marine and Atmospheric Sciences, Miami, and find that it can be referred to *O. borealijaponicus*. *O. borealijaponicus* is also known from off the western coast of Canada (Roper, personal communication) and the eastern coast of Hokkaido, Japan. Other records of *O. banksii* from the high latitudes in the North Pacific (Clarke 1966) probably belong to this species. I examined a specimen of a more typical "*O. banksii*" from 16° N, 123° W, and Berry (1914) reported the more typical form from the Hawaiian Islands. It appears that *O. borealijaponicus* replaces "*O. banksii*" in the colder waters of the North Pacific.

Family MASTIGOTEUTHIDAE Verrill, 1881

DIAGNOSIS.—Arms with biserial suckers. Tentacles whiplike, with long unexpanded clubs bearing many thousands of minute suckers. Funnel locking-cartilage with an oval depression, usually bearing 1 or 2 knobs (tragus, antitragus). Buccal connectives attach to the ventral borders of arms IV. Small light organs generally present on the surface of the mantle, head, and arms.

Genus *Mastigoteuthis* Verrill, 1881

DIAGNOSIS.—Cartilaginous tubercules not present on surface of mantle, head, funnel, and arms.

TYPE SPECIES.—*Mastigoteuthis agassizii*. Verrill, 1881b.

Mastigoteuthis pyrodes, new species

PLATES 25; 26I–Q

DESCRIPTION.—The *mantle* is cylindrical for most of its length, but posteriorly it tapers rapidly, and the muscular portion terminates in a blunt point just posterior to the anterior end of the fins. The mantle continues past this point as a narrow cylindrical cord of tissue which merges into the tail. The tail extends for a short distance posterior to the fins, but its exact extent is uncertain since it is invariably damaged. The pen appears to extend to the tip of the tail. Anteriorly, the mantle projects strongly in the nuchal region, but less so in the areas of the mantle locking-cartilages.

The *fins* are large, about 60% (excluding the tail) of the M.L., and nearly circular in outline. The anterior lobes are attached for the most part, but project anteriorly very slightly.

The *funnel* reaches approximately to the level of the posterior edges of the lenses. It contains a large valve and a well-developed funnel organ with an inverted V-shaped dorsal pad bearing a small anterior papilla, and 2 oval ventral pads. The funnel locking-cartilage has an oval depresion with a strong tragus on the medial margin. Occasionally, a low antitragus can be detected; however, it is usually not apparent.

The *head* is slightly broader than long. Its width is nearly equal to the M.W., and its length is approximately 20% of the M.L. The eyes are very large, occupying almost the full length and depth of the head. An eye sinus is not apparent on the eyelid. A crescent-shape patch of tissue borders the posterior margin of the eyelid, and a small "olfactory" papilla is located posterior to each eye.

The *arms* are large, the ventral pair extremely so, being comparable to the mantle in length. The arm formula is IV>II>III>I. Although the arms are generally damaged, they appear to contain rather feeble protective membranes supported by flabby, triangular trabeculae. Arms IV have large lateral keels. It is not possible to determine the presence or absence of swimming keels on the other arms due to damage. The suckers are arranged biserially and have slender stalks arising from large conelike bases which are fused with the lateral trabeculae. The oral face of each arm IV is very narrow and the suckers are forced nearly into a single row, particularly in the distal half of the arm. The number of suckers in the proximal half of each arm in the largest female (165 mm M.L.) is 36, 36, 39, and 38 for arms I through IV, respectively. Each sucker ring bears sharply pointed teeth on the distal margin and truncate teeth on the lateral margins. The total number of teeth varies roughly between 10 and 15. The proximal edge of the chitinous ring is smooth. There is no evidence of hectocotylization in males.

The *tentacles* are very long, over twice the mantle length, and very slender. The club is unexpanded and approximately 50% of the tentacle length. The club possesses a microscopic protective membrane with tiny trabeculae which defines the borders of the sucker-bearing portion of the club. The proximal end of the club is damaged in all specimens, so its exact structure cannot be determined with certainty; however, it appears that the sucker-bearing area tapers rapidly to an abrupt end. Distally, the suckers progressively cover increasingly more of the club surface until they completely surround the tentacle a short distance from its tip. The smallest suckers occur at the tip of the club. The largest suckers occur in a broad area about one-third of the club length from its distal end and are arranged in approximately 18–22 rows. The suckers have long, slender stalks which result in a disorderly arrangement in preservation and makes an exact determination of the number of rows difficult. The club suckers are elongate in the proximal-distal plane. The outer chitinous ring is broad and each lateral margin of its inner edge has 2–3 greatly enlarged, blunt teeth that project into the aperature of the sucker. The inner ring has 3 distinct blunt teeth on the distal margin; the proximal and lateral margins are smooth. The largest suckers on the club measure 0.28–0.32 mm in the long diameter of the holotype (110 mm M.L.). The club in its middle portion has a diameter about 7 times the width of the largest suckers of this portion.

The numerous *photophores* present are almost exclusively in the outer integument and, therefore, are easily lost with only a small amount of abrasion. As a result of such injury to the present specimens, it is impossible to determine the exact distribution of light organs. The ventral surface of the mantle is covered with small photophores which appear to diminish in number laterally. On the ventral surface of each fin, adjacent to the mantle, photophores are lacking, while lateral to this area scattered light organs appear, but gradually diminish toward the lateral margins of the fins. Thus, there appears to be a somewhat narrow patch of photophores down the ventral surface of each fin. Photophores are abundant on the dorsal surface of the fins, particularly on the lateral halves. Both the dorsal and ventral surfaces of the funnel are sprinkled with photophores as are the ventral and lateral surfaces of the head. A large light organ is present deep in the tissue near the anteroventral margin of each eyelid. It is oval in shape and may be completely hidden by an aggregation of dark chromatophores. Numerous light organs are present on the ventral surface of arms IV.

The *buccal membrane* attaches to the dorsal borders of arms I and II and to the ventral borders of arms III and IV.

The *color* in preservation consists of a reddish purple background pigmentation upon which dark reddish purple chromatophores occur in the outer integument.

TYPE LOCALITY.—33°32′ N, 118°23′ W, eastern North Pacific Ocean.

LOCATION OF TYPE.—University of Southern California, U.S.C. Hancock collections, AHF Cephalopod Type No. 7.

DISCUSSION.—It is often impossible to identify with certainty many species of *Mastigoteuthis* because of several factors. These animals are soft and apparently inhabit a rather deep zone in the ocean. As a result, specimens are usually brought to the surface badly damaged; their long tentacles are often lost along with the delicate epidermis that frequently (if not always) is covered with photophores. Although these squid apparently are common inhabitants of the deep sea, only rarely is more than 1 or 2 specimens taken at a time. These difficulties, compounded by the large number of species within the genus, have led to the present systematic jumble. Many species are known only from a single mutilated specimen, and most species are inadequately described.

It is with some hesitation that I add a new name to a group that is in such a state of instability; however, there appears to be no other course available.

In the following brief review of the 15 nominal species, pertinent characters are listed only when they are derived from the type material.

Mastigoteuthis agassizii Verrill, 1881b. Club suckers are armed with 2–3 sharp teeth on one side. Arm suckers have smooth inner rings. Fins are 60–65% of the M.L. in length. The arm formula is IV>III= II>I. At the proximal end of the club, the suckers are in 2 rows. Light organs are distributed over the entire body. Tragus and antitragus are both weakly developed. Type locality: Off east coast of United States (about 34° N; 76° W). I examined the smaller of Verrill's syntypes which unfortunately lacks tentacles, and find that there is an enlarged photophore imbedded in the anteroventral margin of each eyelid.

This species can be easily separated from *M. pyrodes* by the lack of dentition on its arm suckers.

Mastigoteuthis grimaldii (Joubin 1895). Tentacles are not known. Arm suckers have 13 pointed teeth on the distal margin of the inner ring. The fins are 54% of the M.L. in length. The arm formula is IV>III= II>I. Light organs are distributed over the entire body. No antitragus is present. Type locality: Near Azores (39°43′ N; 33°22′ W). This species was described from a juvenile specimen that had a M.L. of approximately 26 mm. Due to its lack of described characters, it cannot be separated with any certainty from 5 of the other species of the genus and, therefore, must be considered a *species dubia.*

Mastigoteuthis levimana Lönnberg, 1896. Tentacles are not known. Arm suckers have broad, truncate teeth around the entire circumference of the inner ring. The fins are 38% of the M.L. The arm formula is IV>III=II>I. Arms IV are more slender than others and almost whiplike. Suckers are present only on the proximal portions of arms IV and are arranged in intervals of 2 to 4 mm. Type locality: North Atlantic (43° N, 24° W). The fragile structure of the ventral arms with their peculiar arrangement of suckers, the small fins, and the sucker dentition, indicate that this species does not belong in *Mastigoteuthis* and is here placed in the genus *Valbyteuthis* (Chiroteuthidae).

Mastigoteuthis dentata Hoyle, 1904. Tentacles are not known. The arm suckers have 13 teeth on distal half of the inner ring. Fins are 43–67% of the M.L. in length. The arm formula is IV>III=II>I. Type locality: Off Cape Mala, Panama (7°21′ N, 79°35′ W), and east of the Galápagos Islands (0°36′ S, 86°46′ W). As can be seen from the preceding diagnosis, Hoyle gave very few characters of specific value in the original description. Also, judging by the great discrepancy in fin length between his 2 specimens, it appears that he probably had 2 species. In order to clarify this situation, I here designate his syntype from off Cape Mala (number 7957, male, 72 mm M.L.) as the lectotype. I examined this specimen which is deposited in the United States National Museum (according to C. F. E. Roper, Associate Curator of Mollusks, United States National Museum, the other syntype has been lost). Although the animal has undergone complete desiccation, it is still possible to determine from bits of integument still clinging to the animal that the entire body is covered with photophores and that an enlarged photophore is imbedded in the anteroventral margin of each eyelid.

Recently the PILLSBURY captured 2 specimens from off Cape Mala which agree in all discernible features with *M. dentata.* From these specimens, which unfortunately were badly damaged, I can add the following characters to the description of this species: the clubs, although badly scraped in places, appear to occupy about half of the tentacular length. The largest suckers occur about one-third of the club length from the distal end. This area of the club bears suckers in roughly 35–40 rows. Suckers near the base of the club are smaller and less thickly spaced, but their precise arrangement cannot be determined. Suckers also decrease in size near the lateral margins of the club. The inner chitinous rings of the club suckers are smooth (Plate 26T). The inner edge of the outer ring has 12–14 small knobs around its entire margin that project slightly into the aperature of the inner ring (Plate 26S). The club suckers are very small. The long diameter across the outer ring of the largest club suckers from a specimen with P.L. of 92 mm was from 0.13–0.16 mm. A minute trabeculate protective membrane is present. The funnel locking-cartilage has a tragus and only a weakly developed antitragus, although the posterior end of the cartilage is well undercut. The 2 specimens had fin lengths of 66% and 67% of the M.L.

I had originally thought that the specimens of *Mastigoteuthis* from southern California belonged to this species; however, after examining the specimens from Panama, there can be no doubt that the 2 forms belong to separate species. The much smaller size of the tentacular suckers as well as the differences in the dentition of the inner and outer chitinous rings clearly verifies their separate status.

Mastigoteuthis talismani (Fischer and Joubin 1906). Arm suckers are smooth (?). The fin is 89% of the M.L. in length. Photophores are present on the fins and probably over the entire body. There is no distinct antitragus. Type locality: South of Azores (34°46′ N, 36°11′ W). The original and only specimen of this species was very badly multilated. The club length is given as about one-tenth of the tentacle length; however, this is almost certainly a misinterpretation resulting from the poor condition of the animal and should not be considered a specific character. The larger size of the fins easily separates this form from *M. pyrodes.*

Mastigoteuthis glaukopis Chun, 1908. The club is seven-tenths of the tentacle length. Club suckers have 10–12 small teeth around the margin of the inner ring. Club suckers measure 0.1 mm in a specimen with a M.L. 37 mm. Arm suckers have 5–7 large teeth on the distal portion of the inner ring and somewhat smaller teeth on the proximal side. The arm formula is IV>II>III>I. The fins are 50% of the M.L. in length. A single photophore is imbedded in the anteroventral border of each eyelid. Other photophores are apparently absent. No distinct antitragus is present. Type locality: Region of the east African coast. Due to the small size of Chun's specimen, it is not certain whether the dentition of the club suckers refers to the inner or outer ring. The dentition of the arm and club suckers, fin size, and possibly some of the other characters separates this species from *M. pyrodes*.

Mastigoteuthis flammea Chun, 1908. Tentacles are not known. Arm suckers have 3–5 teeth on distal margin of inner ring. The arm formula is: IV>II>III≧I. Tragus and antitragus are present. Photophores are distributed over the entire body. Eyes are reduced in size. Fins are 50% of the M.L. Type locality: Gulf of Guinea (0°25′ N, 7°00′ W; 1°14′ N, 2°10′ W. This species can easily be distinguished from all others now known by the small size of the eyes.

Mastigoteuthis cordiformis Chun, 1908. The club is two-thirds of the tentacle length. Club suckers have numerous pointed teeth around the entire margin of the inner ring with those of the distal border being much larger. Diameter of the suckers is 0.5 mm in a specimen of M.L. 83 mm. Arm suckers have about 30, very small, rounded teeth on the distal two-thirds of the inner ring. The fins are 78% of the M.L. in length. A tragus is present and an antitragus is present, but small. The arm formula is: IV>II>III=I. Proximal suckers of the club are arranged in 2 rows. The middle portion of the club has approximately 25 rows of suckers. The whole body is covered with small light organs. Type locality: South of Sumatra (0°15′ N, 98°8′ E). This species is easily separated from *M. pyrodes* by its large fins and by the dentition of the club suckers. Descriptions by Chun (1910), Sasaki (1929), Adam (1954), and Voss (1963) indicates that this species exhibits considerable variation.

Mastigoteuthis famelica (Berry 1909). Tentacles are not known. Arm suckers are "minutely toothed." The arm formula is: IV>II>III≧I. Fins are longer than broad. Type locality: Vicinity of Kauai Island, Hawaii. This species, based on a single specimen of 39 mm M.L., is inadequately known. It differs from California specimens of the same mantle length by having much shorter arms (each arm IV in *M. famelica* is 20 mm; in *M. pyrodes* of the same size each arm IV is 35 mm). A redescription of *M. famelica* is badly needed; unfortunately, the type, which was deposited in the United States National Museum, has been destroyed (Roper, personal communication). Therefore, the further elucidation of this species depends on the capture of new material from the Hawaiian Islands.

Mastigoteuthis magna Joubin, 1913. The club is nine-tenths of the tentacle length. Club suckers are so small that they are invisible to the naked eye. The inner rings of the club suckers are smooth. Arm suckers have smooth inner rings. The fin is 65% of the M.L. The arm formula is IV>II>III=I. The funnel locking-cartilage bears a straight groove anteriorly that enters a bowl-shape depression posteriorly. Photophores are apparently absent. Type locality: Middle of North Atlantic Ocean (31°45′ N, 42°39′ W). This species is very distinctive and can easily be separated from all other species by, among other things, its peculiar funnel locking-cartilage.

Mastigoteuthis hjorti Chun, 1913. Tentacles have suckers of 0.25 mm diameter at the proximal end of the club in a specimen with a mantle length of 95 mm. Tentacular suckers are arranged in 18–20 rows. Arm suckers have 9–10 teeth on the distal half of the inner rings. Fins are equal to the M.L. The arm formula is IV>III>II>I. Two large photophores attached to the bulbus of each eye. Type locality: North Atlantic Ocean (31°24′ N, 34°47′ W). This species is easily separated from all others by its enormous fins and by the presence of photophores on the eyes.

Mastigoteuthis latipinna (Sasaki 1916). The club is three-fifths of the tentacle length. The proximal part of the club is slightly flattened and has broad protective membranes with trabeculae. The proximal suckers of the club are equal to large arm suckers in size and bear 10 blunt, minute teeth on the distal margin of the inner rings. Distally, the suckers become smaller and more extensively toothed. The arm suckers have smooth inner rings. The arm formula is IV>II>III>I. The tragus and antitragus

are very faint. The fins are 84% of the M.L. The left eye is much the larger. Type locality: Sagami Sea. This species is very distinctive and can be distinguished from *M. pyrodes* by almost any of the characters mentioned above.

Mastigoteuthis schmidti Degner, 1925. The club is three-fifths of the tentacular length. The club suckers have smooth inner rings and lack inward projecting knobs on the outer rings. Arm suckers have 13–14 slender teeth on the distal border and 11–12 blunt teeth on the proximal border. The arm formula is IV>III=II>I. The fin is 65% of the M.L. Tragus and antitragus are present. Photophores are distributed over the entire body. From 20–23 suckers are present in transverse series in the distal third of the club. Type locality: Eastern North Atlantic (46°30′ N, 7°00′ W). This species can be easily separated from *M. pyrodes* by the dentition of the inner and outer rings of the tentacular suckers.

Mastigoteuthis atlantica Joubin, 1933. Tentacular suckers have 2 or 3 elongate knobs that project inward from the inner edge of the chitinous ring. The inner chitinous ring is apparently smooth. Sucker diameter is 0.36 mm in a specimen with a mantle length of 112 mm. Arm suckers have about 11 sharply pointed teeth on the distal border of the inner ring; proximal borders are smooth except for a possible cleft in the median proximal line. The arm formula is IV>II>III>I. A photophore is embedded in the anteroventral margin of each eyelid. No antitragus is present. Fin is 71% of the mantle length. Type locality: Near Bay of Biscay (46°28′ N, 8°01′ W). Joubin's measurements state that the club is 31% of the tentacle length; however, his illustration indicates that it is much longer. Joubin originally placed this form as a subspecies of *M. glaukopis*, owing to the presence of a large photophore embedded in each eyelid in both forms. It is now apparent that this feature is widespread throughout the genus and that *M. glaukopis atlantica* cannot remain at the subspecific level; it is here elevated to specific status. The differences in sucker dentition and possibly fin size are sufficient to verify that *M. atlantica* and *M. glaukopis* require separate specific status. This species is very close to *M. pyrodes*, but differs primarily in the dentition of the inner rings of the tentacular suckers and in its locality.

Mastigoteuthis iselini MacDonald and Clench, 1934. Tentacles are not known. Arm suckers have 13 pointed teeth on the distal margin of the inner ring

TABLE 16.—*Measurements in mm for* Mastigoteuthis pyrodes, *new species.*

Characters	*Station Numbers of the VELERO*								
	7279	8934	10841 or 10844	11181	10844	11225	9905	9905	9905
Sex	♂ (Holotype)	♂	—	♀	♀	♂	♂	—	♂
M.L.	110	65	35	165	148	86	94	77	84
M.W.	27	17	—	—	34	—	20	16	18
F.L.*	64	36	18	89	89	50	55	44	47
F.W.	61	37	18	96	90	50	58	45	45
Arm L. I	42	23	6	70	62	33	—	29	26
II	55	30	14	85	78	47	52	41	37+
III	52	26	8	79	74	44	41	31	31
IV	99	56	35	126	120	79	85	70	70+
Tent. L.	233	—	—	—	378	188	—	—	—
Club L.	121	—	—	—	150	90	—	—	—
Eye D.	15	—	5.5	22	21	14	15	12	13
Tail L.	17+	7	3	20+	20+	12+	—	7+	13
Club S.D.	.28–.32	—	—	—	.30–.35	.24–.26	—	—	—

*Excluding tail length

which are replaced by 6 blunt teeth on each side of the ring. The median proximal portion is slightly crenulated. There is no antitragus. Fins are 67% of the mantle length. The arm formula is IV>III≧ II>I.

Type locality: 39°04′ N, 71°29′ W. This form is inadequately described and cannot be distinguished with certainty from *M. atlantica, M. dentata* or *M. schmidti* and must be considered a *species dubia.*

DISTRIBUTION.—*M. pyrodes* is known only from the present trawling program. One specimen each was taken from zones 1 and 2, none from zones 3 and 4, 4 from zone 5, 5 from zone 6, and 16 from zone 7. Apparently this species is more abundant in the offshore zones and, in particular, the more southern zones.

Family CHIROTEUTHIDAE Gray, 1849

DIAGNOSIS.—Arms with biserial suckers except occasionally at the arm tips. Tentacular clubs with tetraserial suckers. Funnel locking–cartilage oval and with 1 or 2 distinct knobs (tragus, antitragus) projecting toward the center of the cavity. Buccal connectives attach to the ventral borders of arms IV.

Genus *Chiroteuthis* Orbigny, 1845

DIAGNOSIS.—Arms IV greatly enlarged. Photophores present at least on eyes and arms IV. Funnel locking–cartilage generally with both tragus and antitragus. Tentacles greatly elongated and with secondary clubs (larval clubs) lost.

TYPE SPECIES.—*Loligopsis veranyi* Férussac, 1835.

Chiroteuthis calyx, new species

PLATES 20; 21A,B; 22A–K,N–Q

Chiroteuthis veranyi.—Berry, 1963, p.128, text figs. 1–6.—Pearcy, 1965, p.262.

DESCRIPTION.—The *mantle* is short and conical; its musculature is weak and terminates in a rounded point just past the anterior end of the fins. The pen continues posterior to the fins, but has been broken off in all specimens so that its full length is unknown. The mantle margin protrudes in the middorsal line and very slightly near the mantle locking–cartilages.

The *fins* are nearly circular in outline, 55–65% of the M.L. in length, and have free anterior lobes. On the posterior margin of the fins, where the pen emerges, there is a slight indentation of the musculature covered by a transparent membrane.

The *funnel* is moderate in size, and is free from the head laterally. The funnel locking–cartilage is oval and bears both a tragus and an antitragus. The dorsal pad of the funnel organ has an inverted V-shape with short, wide diverging arms and a prominant anterior papilla. The ventral pads are oval. A small, delicate valve is present.

The *head* is elongate and cylindrical, although swollen slightly in the region of the eyes. Nuchal folds are lacking. The "olfactory" papillae which arise from the ventral surface of the head lateral to the exhalant opening of the funnel have long stalks and a bumpy, terminal swelling. Each eye is large and the eyelid bears only a slight indication of an anterior sinus. The posterior margin of the eyelid consists of a large muscular patch of tissue.

The *arms* are very large and in the order of IV> III>II>I. Arms IV are extremely long, over 1½ times the mantle length, and broad. Arms I–III have low protective membranes supported by fleshy trabeculae which fuse with the broad bases of the sucker stalks. Protective membranes and trabeculae are absent from arms IV. Arms I–III possess thick, low, keels. Arms IV have usually broad, lateral keels which exceed the arm diameter in width. The suckers on each arms I–III are biserial except at the arm tip. The arm tip (i.e., approximately one-tenth of the M.L. on each arm) bears small, closely packed suckers in 3 longitudinal rows. The suckers on each arm IV are broadly separated and arranged in 2 alternating series which tend to converge distally into nearly a single line at the arm tip. Very large globular suckers occur on the middle third of arms I and II, but are somewhat more distally situated on arms III. The suckers on arms IV are largest at the base of the arms, then gradually diminish in size distally.

The enlarged suckers of arms I–III have nearly smooth rings, but may show regular indentations in the margin indicating that they have been formed by the fusion of broad, truncate teeth. On the arm proximal to the enlarged suckers, the inner rings have roughly 18–20 broad, truncate teeth which are separate from one another on the distal two-thirds of the sucker margin; the proximal one-third is smooth. On the arm distal to the enlarged suckers, individual teeth on the suckers also can be recognized. Near the

tip of the arms, the suckers have relatively longer and slenderer truncate teeth on the distal margins and nearly smooth but slightly irregular proximal margins. Distinct truncate teeth also occur on all suckers of the ventral arms. The largest suckers of arms III are more than twice the diameter of the basal suckers of arms IV and are more than 3 times the diameter of the adjacent suckers on arms IV.

The *tentacles* are extremely long, as much as 5–6 times the mantle length; however, their length depends greatly on their state of contraction at the time of fixation. The right and left tentacles in one specimen at hand differ in length by 10 cm, while those of the holotype differ by 6 cm. Thick oval pads are loosely adherent along the length of the tentacle stalks, except near the club where they become embedded in the stalk and decrease in size. It is impossible to get an accurate count of their numbers since many are invariably lost during capture and preservation. It is estimated, however, that there are over 50 of these organs on each tentacle in specimens of about 60 mm M.L.

The *club* is long (55–65% of the M.L.) and bordered by protective membranes with large broad trabeculae. The membrane is divided into a proximal and a distal portion of nearly equal lengths by a slight decrease in width and by a change in the structure of the trabeculae. Each proximal trabecula is split into 2 or 3 parts in its outer half, except for the small trabeculae in the initial 10% of the club. Each proximal trabecula is separated by a small gap from its neighbors. The trabeculae of the distal portion of the club are undivided and broadly separated from one another at their bases. The club is not differentiated into a dactylus, manus, and carpus. The suckers of the club are arranged in 4 longitudinal rows. Each sucker is set on a long stalk composed of 2 portions. A rather broad cylindrical basal portion terminates in a dark purple, pleated "skirt" from which arises the slender distal portion of the stalk that bears the sucker. The basal portions of the marginal stalks are nearly twice the size of the medial ones and each has a narrow, transparent keel along its lateral edge which runs onto the protective membrane between the trabeculae. The number of suckers varies from 134–142 on the adult clubs in specimens examined. The inner chitinous ring of each sucker bears a large recurved median tooth on its distal margin along with approximately 10–12 smaller lateral teeth. The proximal margin is smooth.

Two large *photophores* lie embedded in the ink sac, one to either side of the intestine. The ventral surface of each eye is provided with 2 longitudinal strips of luminous tissue which parallel each other on the inner and outer eye margins. Lying between these strips at either end is an oval luminous patch. An additional small luminous organ is situated between the 4 other organs and slightly in front of the posterior patch (Plate 22N). The large pads on the tentacular stalks may be photogenic. The tip of the club is occupied by a very large photophore which faces aborally. Large spherical photophores, each covered by a layer of dark-brown chromatophores, line the lateral–oral edges of arms IV along the base of the lateral membrane.

The *buccal membrane* attaches to the dorsal borders of arms I and II, and to the ventral borders of arms III and IV.

In preservation *C. calyx* is speckled with numerous red-brown *chromatophores.*

Apparently all members of the genus possess a *larval stage* that attains an unusually large size. *C. calyx* is no exception; its larval form (it is a "doratopsis" larva) has a maximum size of about 60 mm M.L. This larva has recently been described by Berry (1963), and it is necessary to mention here only the following points. The late doratopsis stage has enlarged suckers on the arms, the largest of which have many closely set, slender, truncate teeth. The full compliment of adult club suckers is present proximal to the larval club. The larval club has approximately 63–65 suckers, tetraserially arranged and set on short stalks. The suckers of the ventral row are considerably larger than those of the other rows. At the tip of the club is a small lobe which carries 5 suckers.

TYPE LOCALITY.—Santa Catalina Basin?, eastern North Pacific Ocean.

LOCATION OF TYPE.—University of Southern California. U.S.C. Hancock collections, AHF Cephalopod Type No. 8.

DISCUSSION.—Presently, there are 8 recognized species belonging to the genus *Chiroteuthis* in addition to *C. calyx*. Three species, *C. imperator* Chun, 1910; *C. picteti* Joubin, 1894; and *C. macrosoma* Goodrich, 1896, are easily distinguished from *C. calyx* by the presence of 3 rows of oval photophores on the ventral surface of each eye (many other characters separate them equally well). *C. capensis* Voss, 1967,

seems more closely related to the above 3 species although the eye photophore pattern, which is imperfectly known, seems to be more similar to the pattern in *C. calyx*. At any rate, it can easily be separated from the California species by the dentition of the suckers (8–10 long, slender, sharp teeth on the upper edge of the ring and about 20 low, blunt teeth on the lower edge of the sucker ring), by the lack of photophores on the viscera, by the lack of a striped "skirt" on the stalks of the club suckers, and by the different proportional lengths of the arms, mantle, and clubs.

C. atlanticus (MacDonald and Clench 1934) is known only from a single mutilated specimen; however, its elongate mantle clearly indicates its relationship to the above-mentioned species. *C. joubini* Voss, 1967, can easily be distinguished by the unique photophore pattern on the eye (10 oval photophores in 2 series) and by the presnce of a single, median visceral photophore.

The remaining 2 species, *C. lacertosa* Verrill, 1881, and *C. veranyi* (Férussac 1835), are much more closely related to *C. calyx* than are the other 6 species. *C. lacertosa* was considered a subspecies of *C. veranyi* by Pfeffer (1912). These 2 forms are unquestionably very close and even the validity of *C. lacertosa* still has not been definitely established. The 2 forms differ in the shape of the fins (they are round in *C. veranyi*, but elongated—60 mm long by 40 mm wide—in *C. lacertosa*); otherwise, the animals closely agree in most characters. Unfortunately, the holotype of *C. lacertosa* lacks tentacular clubs; however, if the clubs found by Verrill on other occasions belong to this species, as Verrill believed, then it would appear that the species is more similar to the California species, particularly regarding the arrangement of the lateral trabeculae on the club, and that *C. lacertosa* is certainly a valid species. It is, however, necessary to examine more material from the type locality of *C. lacertosa* (i.e., Brown's Bank off Nova Scotia) before its relationships can be unquestionably resolved. At present, *C. calyx* can be separated from *C. lacertosa* by the differences in sucker dentition (sharply pointed teeth in *C. lacertosa* and truncate or fused teeth in *C. calyx*, different shape of the fins (circular in *C. calyx*, elongate in *C. lacertosa*), and by the greater size of the enlarged suckers on arms I–III in *C. calyx*.

Of the clearly established species, *C. calyx* is most closely related to *C. veranyi*. Relative to the latter species, the suckers in the middle section of arms I–III in *C. calyx* are considerably enlarged, while the

TABLE 17.—*Measurements in mm for* Chiroteuthis calyx, *new species.*

Characters	*Station Numbers of the VELERO*				
	9890	8292	10260	7280	9349?
Sex	Larva	Larva	—	—	— (Holotype)
M.L.	49	56	55	60	60
M.W.	7	12	17	—	17
H.L.	28	24	21	25	23
H.W.	6	9	16	20	20
F.L.	18	22	23	24	25
F.W.	19	23	28	29	28
Arm L. I	7	14	38	61	48
II	11	20	51	74	61
III	14	26	62	91	69
IV	33	49	87	126	100
Tent. L.	46	51	190	—	215
Club L.	12	18	30	40	34
	Adult Larval	*Adult Laval*			
Club S.	142 53	140 63	137	142	134
Eye D.	4	7	11	13	14

suckers of arms IV are relatively reduced in size. The ratio of the diameter of suckers at the midsection of arms III to adjacent suckers on arms IV is greater than 3:1 in *C. calyx*, while it is less than 2:1 in *C. veranyi* (Plate 22B, I, L, M). This difference between the 2 species is large enough that it can be detected at a glance. In *C. calyx*, the sucker rings have distinctly truncated teeth on the distal margin, which on the largest arm suckers may all fuse giving a completely smooth ring. In *C. veranyi*, the suckers have many sharply pointed teeth on the distal half of the ring.

The final major differences between the 2 species concern the protective membranes of the tentacular club. In *C. veranyi*, the proximal portion of the membrane is much broader than in *C. calyx*. Also, in *C. veranyi*, the individual supporting trabeculae in this membrane can be distinguished only at their bases since they are subdivided for most of their length; these subdivisions are all closely aligned making it impossible to separate the subdivisions of one trabecula from those of its neighbors (Plate 21c). In *C. calyx*, the trabeculae are subdivided only in their distal half and the trabeculae remain separated from their neighbors by a distinct gap (Plate 21B).

It is worth noting that the arrangement of photophores is identical in *C. veranyi*, *C. lacertosa*, and *C. calyx*.

DISTRIBUTION.—I examined a specimen of *C. calyx* taken by Pearcy off Oregon at 44°40′ N and 125°16′ W, and his record of *C. veranyi* (1965) from Oregon certainly can be referred to this species. The only other record of *C. calyx* is from off southern California (Berry 1963, as *C. veranyi*).

In the present study, the frequency of capture was fairly even in zones 1, 2, 3, and 5 (i.e., 0.16–0.26 specimens/hour). The highest frequency of 0.52 specimens/hour occurred in zone 6; however, this high figure is largely the result of a single, unusual trawl capture that yielded 15 larvae. If this trawl was ignored, the catch frquency for zone 6 would be 0.24 specimens/hour. No specimens were captured in zone 7.

Although the data are somewhat contradictory, the complete lack of specimens from zone 7 coupled with the records from Oregon suggests that this is a cold-water species with a southern limit of distribution off Baja California.

Genus *Valbyteuthis* Joubin, 1931

DIAGNOSIS.—Funnel locking-cartilage oval. Antitragus present, tragus absent. Tentacular club short, compact and with suckers in 4 rows. Club suckers on short stalks. Fins subterminal. Photophores absent. Funnel valve absent.

TYPE SPECIES.—*Valbyteuthis dana* Joubin, 1931.

Valbyteuthis oligobessa, new species

PLATES 23A,B; 24H–N,Q,R

DESCRIPTION.—The thin, delicate *mantle* is saclike, except posteriorly where it tapers to a point. The anterior mantle margin is broad and only loosely surrounds the head and funnel.

The *fins* are small, about 23–33% of the M.L. in length. Each is roughly semicircular and has only slightly projecting anterior and posterior lobes. The broad, tubular conus of the pen projects posteriorly past the fins. It has been broken in all specimens so that its full extent is unknown. The fins join in the dorsal midline.

The *funnel* is very large; it reaches anteriorly to the level of the anterior margins of the eyes in mature specimens, but is smaller in immature forms. The funnel locking-cartilage is distinctive of the genus; the cartilage has an oval depression that deepens posteriorly where it is overhung by a small antitragus. The opposing mantle cartilage has the appearance of a human nose with a single nostril; the "nostril" locks with the antitragus. The dorsal member of the funnel organ is very small relative to the large size of the funnel. The organ is approximately shield-shape with a rough or papillate surface and an anterior papilla. This papilla, at its base, is slender, but distally it broadens in the transverse plane and is slightly cupped. The ventral pads are somewhat variable, but generally are elongate and oval and slant obliquely toward the midline. There is no funnel valve.

The *head* is elongate and cylindrical. The eyes are small; in all specimens, they have been damaged. The paired bridles and cephalic vein are prominent along the ventral surface of the head beneath the funnel. "Olfactory" papillae are present lateral to the funnel and considerably posterior to the eyes. Each consists of a very elongate stalk with a terminal swelling. The nuchal cartilage is straight, slender, and elongate. A

central ridge with a median groove is barely detectable on its anterior half.

The *arms* are short, extremely delicate, and in the order IV>III>II>I. In young specimens, arms IV are greatly elongate (up to 130% of the M.L.), but in the mature animal they are less than the length of the mantle and only slightly longer than arms III. There is only a slight indication of protective membranes, and keels appear to be lacking from arms I–III, although lateral keels are present on arms IV. The suckers on the arms are biserially arranged along the entire length of each arm I–III. On arms IV, the suckers are broadly separated and arranged in apparent single file. These are preset only on the proximal end of the arms and number only 2–4 on each arm.

The outer chitinous ring of each arm sucker consists of an outer row of parallel scales followed medially by 3–4 rows of scales with generally square bases. The latter bear large knobs which have enlarged, flattened ends in the most medial series of the distal half of the ring. On the proximal side of the ring, the knobs are replaced by hollow cylinders that have a portion of one side missing (Plate 24R). The inner chitinous ring has about 25–35 small, blunt teeth around the distal three-fourths of the margin. The proximal portion is nearly smooth.

The *tentacles* are relatively robust and long. Each tentacular club is short, only slightly expanded, and is not differentiated into a manus and a dactylus. Low, protective membranes are present on both borders. The suckers are arranged in 4 regular longitudinal rows over most of the club, but become slightly irregular at the tip and at the base of the club. The suckers of the ventral row are the largest. The suckers become progressively smaller in a transverse series, although the suckers of the dorsal row are still only slightly smaller than those of the ventral rows. Five or six suckers, arranged in 2 alternating rows, are present in the carpus. The larger of these is sligthly larger than the suckers of the club.

The *buccal membrane* connectives attach to the dorsal borders of arms I and II and to the ventral borders of arms III and IV.

No photophores could be found. This animal is covered with numerous reddish brown chromatophores.

The holotype is a *gravid female*. The mantle cavity is occupied almost entirely by a large mass of mature eggs and large nidamental glands. The ripe eggs are about 1.5 mm in diameter. Several large sperm reservoirs can be found in the enlarged ovary and, surprisingly, one can be seen protruding through each nephridiopore. Paired oviducts are present with en-

TABLE 18.—*Measurements in mm for* Valbyteuthis oligobessa, *new species.*

Characters	*Station Numbers of the VELERO*						
	10265	11101	10976	10265	10973	11181	10976
Sex	—	—	—	—	—	♀	♀ (Holotype)
M.L.	23	33	34	34	36	70	76
M.W.	9	11	11	11	13	23	28
F.L.	7	—	7	8	9	14	14
F.W.	15	—	12	—	—	—	—
Arm L. I	9	—	12	11	10	17	19
II	11	—	15	15	14	20	27
III	14	—	18	16	—	23	29
IV	24+	—	46	41	45	—	30
Tent. L.	—	87	67	55	—	—	—
Club L.*	—	6	6	4	—	—	—
	L *R*		*L* *R*	*L* *R*	*L* *R*		*L* *R*
Arm S. IV	2 3	—	3 -	3 2	3 3	—	2 3

*Does not include carpus

larged oviducal glands. This is the first record of a mature specimen in the genus.

TYPE LOCALITY.—32°17′ N, 120°12′ W, eastern North Pacific Ocean.

LOCATION OF TYPE.—University of Southern California. U.S.C. Hancock collections, AHF Cephalopod Type No. 9.

DISCUSSION.—In addition to *Valbyteuthis oligobessa* there are, presently, only 2 other described species in the genus: *V. danae* Joubin 1931, from the Pacific Ocean off Panama and *V. levimana* Lönnberg, 1896, from the North Atlantic; however, at least 2 undescribed species are also present in the Atlantic. It seems that this genus will eventually prove to be rather speciose. *V. oligobessa* differs from *V. danae* in a numbr of respects. The most obvious distinguishing feature is the much smaller size of the fins in *V. oligobessa* (23–33% of the M.L. versus 50–55% of the M.L. in *V. danae*). Other characters include the number of suckers on the ventral arms (2–4 in *V. oligobessa* and at least 12–15 in *V. danae*), the nnumber and shape of teeth on the inner chitous rings of each arm sucker (25–35 narrow teeth in *V. oligobessa* and 7–10 broad teeth in *V. danae*), the relative size of the tentacular club suckers compared to the size of the largest suckers of each arm (Plate 24B–F, H–L) and the size of the sucker orifice (Plate 24B–F, H–L). This latter character is particularly noticeable on the distal half of each arm in *V. danae* where the size of the orifice relative to the size of the sucker rapidly decreases, whereas the sucker orifice in *V. oligobessa* show very little relative reduction. In addition, the suckers of the ventral row on the tentacular clubs of *V. oligobessa* are slightly larger than those of the dorsal row. In *V. danae* both rows have equal-size suckers.

It is more difficult to separate the Californian species from *V. levimana,* since the latter is known only from the type description which was based on two mutilated specimens. The only definite characters of specific value are the greater number of suckers (6–8) on each arm IV in *V. levimana* and the dentition of the arm suckers, which is described in *V. levimana* as consisting of broad, truncate teeth around the entire aperture.

DISTRIBUTION.—*V. oligobessa* is known only from the present trawling program. Four specimens were taken in zone 2, 1 in zone 4, 5 in zone 5, 3 in zone 6, and 5 in zone 7. If the number of trawling hours in each zone is considered, it is apparent that this species is most abundant in the offshore zones. This distribution probably results from the circumstance that *Valbyteuthis* is one of the "deepest living" species taken in the program.

Valbyteuthis danae Joubin, 1931

PLATES 23C; 24A–G

Valbyteuthis danae Joubin, 1931, p.188.—Roper and Young, 1967, p.1.

DESCRIPTION.—The *mantle* is cylindrical anteriorly, but tapers rapidly posteriorly; the muscular portion terminates at roughly the midpoint of the fins. The pen is broken at the posterior end of the fins, so its full length is unknown. The free margin projects slightly at the nuchal and ventral mantle locks.

The *fins* are large (52% of the M.L. in length) and muscular. Each is nearly semicircular and has free anterior and posterior lobes.

The *funnel* reaches to approximately the level of the middle of the eyes. The funnel locking-cartilage has an oval depression and a distinct antitragus. This opposes a cartilage on the mantle that is shaped like a human nose with a single nostril; the latter locks with the antitragus. The dorsal pad of the funnel organ is nearly triangular, but has a slight posterior indentation. The ventral pads are oval and very large. There is no funnel valve.

The *head* is elongate and broadest posteriorly. The bridles and cephalic vein are prominent on the ventral surface of the head up to the level of the middle of the eyes. The head has been damaged; no other details can be ascertained.

The *arms* are slender and delicate. The arm formula appears to be IV>III>II>I; however, all arms have been damaged and it is impossible to get accurate measurments. All of the arms have low trabeculate protective membranes and biserial suckers. On arms I–III, the suckers near each arm base have relatively larger aperatures than the more distal suckers. Near the arm tips the suckers become globular and have reduced aperatures and reduced outer chitinous rings. Suckers are present only on the proximal portions of arms IV. These suckers are distinctly biserial and number 12 on the left arm and 13 on the right arm. The inner chitinous rings of the arm suckers have about 7–9 broad, truncate teeth on the distal margin; the proximal margin is smooth.

The *tentacles* are long and relatively robust; the clubs are short and compact. Suckers are arranged tetraserially and possess broad outer rings and inner rings with narrow aperatures and smooth margins. The club is not divided into a manus and dactylus. The carpus has 6 suckers arranged in 2 alternating rows. A thick protective membrane lines either side of the club.

The *buccal connectives* attach to the dorsal borders of arms I and II and to the ventral borders of arms III and IV.

TYPE LOCALITY.—Off Panama, 7°30′ N, 79°19′ W.

LOCATION OF TYPE.—Copenhagen Museum.

DISCUSSION.—The above description is based on a single, damaged specimen (♂, 44 mm M.L.). It agrees in all respects with specimens of *V. danae* captured at the type locality off Panama. The illustrations used in this report are taken from Roper and Young (1967) and are based on specimens taken from the eastern tropical Pacific Ocean. For comparisons with the other species presently known, see discussion of *Valbyteuthis oligobessa.*

DISTRIBUTION.—*V. danae* was previously known only from the Pacific Ocean off Panama at about latitude 7° N and off Peru at about latitude 8° S. Within the Panamanian region, however, this species appears to be fairly common. The single specimen described here was taken in the Santa Catalina Basin (VELERO Station 8120) at 32°20′ N, 118°43′ W. There seems to be little doubt that this specimen is a straggler from farther south.

Family GRIMALDITEUTHIDAE Pfeffer, 1900

DIAGNOSIS.—Arms with biserial suckers. Tentacles absent. Buccal connectives attach to the ventral borders of arm IV. Funnel and mantle locking-cartilages fused. Nuchal articulation free.

Genus *Grimalditeuthis* Joubin, 1898

DIAGNOSIS.—The characters coincide with those of the family.

TYPE SPECIES.—*Grimalditeuthis richardi* Joubin, 1898.

Grimalditeuthis bomplandii (Vérany, 1837)

PLATES 27B; 24O,P

Loligopsis Bomplandii Vérany, 1837, p.99, pl.1a.

Chiroteuthis Bonplandii.—Férussac and d'Orbigny, 1839, p. 326.—Gray 1849, p.44.

Grimalditeuthis Richardi Joubin, 1898a, p.101, figs. 1–2; 1899, p.71; 1900, p.79, pl.4, figs. 1–2, pl.5, figs. 1–13, pl.10, figs. 1–2.

Grimalditeuthis Bonplandii.—Pfeffer, 1900, p.188.—Chun, 1910, p.217; 1913, p.8.

Grimalditeuthis bonplandii.—Voss, 1956, p.151, text fig.13b.

DESCRIPTION.—The soft, gelatinous *mantle* is slender (width is 16% of M.L.) and tapers gradually toward the posterior end. Near the level of the anterior edges of the fin, the muscular layers of the mantle diminish. The gelatinous portion of the mantle continues as a thick cylindrical mass of tissue which is divided internally into a number of compartments giving the appearance of a honeycomb.

The funnel and mantle locking-cartilages are fused to one another and thus form a permanent union between the mantle and funnel. The mantle is free in the nuchal region.

The *fin* is large (46% of the M.L. in length and 61% of the M.L. in width) and relatively muscular. It is subcircular in outline. The anterior lobes are almost completely attached. Posterior to the fins, the mantle and pen have been broken off. At this point, the pen is very broad and undoubtedly continues for some distance in the intact animal. Joubin (1900) had an intact specimen in which the pen and mantle continued posteriorly to support a second pair of fins.

The *funnel* is very small. No trace remains of a funnel organ or funnel valve due to damage.

The *head* is cylindrical, elongate, and bears a pair of small, lateral eyes. A pair of "olfactory" papillae is present at the posterior edge of the head. Each papilla lies immediately lateral to the funnel and consists of a terminal swollen bulb set on a slender stalk.

The arms are long and slender; arms IV have exceptionally attenuate tips. All arms lack protective membranes, trabeculae, and swimming membranes. Each sucker stalk arises from a large base from which project 3 conical papillae. The largest suckers on arms I–III occur at roughly two-thirds the distance along the arm from its base. On arms IV, the largest suckers are very near the base of the arm and are smaller than the largest suckers of the other arms. Near the arm bases, the suckers are globular and have very small apertures. Distally, the apertures become relatively much larger. The suckers have about 12–13 slender, pointed teeth on the distal two-thirds

of the inner chitinous rings. The proximal margin is smooth. The tips of all the arms are bare; however, the length of these tips are longer in the ventral arms than any of the others. The tips show no evidence of being photogenic. A large sucker from the right arm III has 13 sharply pointed teeth.

Tentacles are apparently lacking in this species. They are represented by minute stubs located between arms III and IV.

The *buccal membrane* has 7 lappets which attach to the dorsal borders of arms I and II, and to the ventral borders of arms III and IV.

The preserved specimen lacks *pigmentation* except for a few small, scattered, brown chromatophores.

The data for the single specimen from off California are: Sex, ♀; M.L., 89 mm; M.W., 14 mm; H.L., 23 mm; H.W., 16 mm; F.L., 41 mm; FW., 54 mm; Arm L. for arms I–IV respectively, 54 mm, 59 mm, 56 mm, 54 mm; ½ A.C. for arms I–IV respectively, 40, 40, 42, 39.

TYPE LOCALITY.—29° N, 39° W, North Atlantic Ocean.

LOCATION OF TYPE.—Not traced.

DISCUSSION.—Pfeffer (1912) synonymized the 2 nominal species in the family. *Grimalditeuthis bomplandii* (Vérany, 1837) and *Grimalditeuthis richardi* Joubin, 1898a. There has been some doubt concerning the validity of this action, since only *G. richardi* is known to have photophores at the tips of the arms. Judging from the present specimen, it seems likely that this difference represents merely an ontogenetic change. The VELERO specimen lacks photophores at the tips of the arms, but all of the arm tips are free of suckers. This condition is peculiar, but could be easily explained if one assumed that the arm tips were developing into photophores. I compared the VELERO specimens with Atlantic material, but have not been able to detect any differences.

This species is believed to be without tentacles; however, delicate stubs of tentacles are present on all specimens available to me from both oceans which comprise a rather large size range. This indicates that either extremely weak tentacles are present, but are always lost during capture or, that the stubs represent rudimentary tentacles which persist, probably due to their retention of some function which is perhaps sensory. In this regard, it should be emphasized that in other species that lack tentacles (i.e., *Octopoteuthis, Gonatopsis*) the stubs are present in young forms, but are quickly lost with growth.

DISTRIBUTION.—This species is know only from a very small number of specimens. It has been reported from the north Atlantic at 29° N, 39° W (Vérany 1837), 34°51′ N, 33°1′ W (Chun 1913), 38°55′ N, 23°39′ W (Joubin 1898a), from the Gulf of Mexico (Voss 1956), and from the South Atlantic at 28° S, 28° W (Pfeffer 1912). The VELERO specimen was taken from the Santa Catalina Basin at 33°13′ N, 118°28′ W.

Family BATHYTEUTHIDAE Pfeffer, 1900

DIAGNOSIS.—Suckers on arms arranged in 2 rows proximally, increasing to 4 irregular rows distally. Tentacular clubs with minute suckers in approximately 8–10 rows. Minute suckers present on buccal lappets. Fins small and separate with convex posterior margins. Buccal connectives attach to dorsal borders of arms IV.

Genus *Bathyteuthis* Hoyle, 1885

DIAGNOSIS.—The characters coincide with those of the family.

TYPE SPECIES.—*Bathyteuthis abyssicola* Hoyle, 1885.

Bathyteuthis berryi Roper, 1968

PLATES 26A–H; 27A

Bathyteuthis berryi Roper, 1968, p.169.

DESCRIPTION.—(Paraphrased from a manuscript by C.F.E. Roper which was based on VELERO specimens). The *mantle* is very plump and robust; its width is 50% of its length. The mantle remains broad for much of its length, then tapers and terminates posteriorly in a broad, bluntly rounded tip.

The *fins* are short, rounded, and widely separated from one another. Anterior and posterior fin lobes are free.

The *funnel* is large; it extends to the level of the anterior borders of the eyes. The posterior part of the funnel is bound to the posteroventral surface of the head with integument and gelatinous tissue. A small pore lies in the ventral midline of the head near the area where the funnel fuses with the head. The funnel locking-cartilage has a simple, elongate median sulcus. The dorsal member of the funnel

organ is an inverted, approximately Y-shape pad with short, broad limbs. A spatulate papilla is present at the anterior tip of the organ. The ventral pads are approximately oval, but slightly pointed anteriorly. A funnel valve is present.

The *head* is long and narrow. The eyes are large and directed anterolaterally. The eyelids lack an optic sinus. Small, stubby "olfactory" papillae are present. Nuchal folds and crests are absent. The nuchal cartilage is long and narrow and bears a median and 2 lateral grooves.

The *arms* are short, but have attenuate tips. All arms are subequal in length, giving the formula IV= III=II=I. A moderately deep web joins the bases of all arms except the 2 arms IV. The depth of the web decreases from the dorsal to the ventral arms. Low aboral keels are present on arms I–III; lateral keels are present on arms IV. Protective membranes occur on all arms. They are particularly well developed at the basal portion of the arms where they are thick, fleshy, and ruffle-like. The thickened ruffles quickly diminish distal to the bases of the arms, and the protective membranes extend distally as low, even keels. Protective membranes on arms IV are considerably less developed than on arms I–III. No distinct or separate trabeculae support the protective membranes.

The arms bear numerous, small suckers. Proximally, the suckers originate in a single row, but soon become biserial. About one-third of the way out on the arms, the suckers become more closely packed and the rows become irregularly arranged so that occasionally 3–4 suckers occur in a transverse series. On the distal one-third to one-fourth of the arms, the suckers become very closely packed and are exceedingly numerous. On arms IV, the sucker rows do not become as irregular and the suckers are less numerous than on arms I–III. Suckers extend to the extreme distal tips of all arms. The suckers are largest proximally and gradually become smaller distally. About 275 suckers occur on each arm I–III of the holotype. Arms I may have very slightly fewer, and each arm IV has around 150 suckers. The inner sucker rings from the arms bear 10–14 very low, small, rounded or subtriangular, knob-like teeth. There is no *hectocotylization*.

A *tentacle* is known only from a single juvenile (19 mm M.L.). This tentacle is long and robust. The club is short, unexpanded, and simple; no keels or membranes are present and no discrete divisions into manus, carpus, or dactylus exist. About 7 or 8 rows of very small suckers are distributed across the distal half of the club; fewer rows occur proximally. Between 150 and 200 suckers are present at this stage. The extreme distal portion of the club is reduced to a small, papilla-like tip with a few minute bumps that are probably precursors of future suckers. Dentition on the inner rings varies from being nearly smooth or slightly scalloped to having a few minute, low, subtriangular teeth as shown in Plate 26H, although the figure may exaggerate the size of the teeth.

The 7 buccal lappets of the *buccal membrane* are long and bear 4–6 small suckers; the inner chitinous rings of these suckers have about 10 small, low, papilla-like teeth. The buccal membrane attaches to the dorsal margin of arms I, II, and III, and to the ventral margins of arms IV.

Most of the *pigmentation* is bleached out of the holotype, but the smaller specimens exhibit the maroon coloration typical of *Bathyteuthis*.

A single, small, simple *photophore* is embedded in the subcutaneous tisssue at the base of each arm I–III. The photophores in the holotype are not easily seen, but the photophores in the juvenile and larval specimens contrast more with the background pigmentation, are slightly raised, and are more readily seen.

The largest specimen known, the holotype, has a mantle length of 49 mm.

TYPE LOCALITY.—33°18′ N, 118°40′ W, eastern North Pacific Ocean.

LOCATION OF TYPE.—University of Southern California. U.S.C. Hancock collections, AHF Cephalopod Type No. 10.

DISCUSSION.—According to Roper (1968) the genus *Bathyteuthis* includes 3 species: *B. abyssicola* Hoyle, 1885, *B. bacidifera* Roper, 1968, and *B. berryi* Roper, 1968. *B. berryi* can be separated from the other 2 species by the much larger number of arm suckers (i.e., over 250 compared to 150 in *B. bacidifera* and 100 in *B. abyssicola*). It can further be separated from *B. bacidifera* by the lack of free trabeculae at the bases of the arms, and from *B. abyssicola* by the greater size of the grills.

DISTRIBUTION.—This species is known only from the present trawling program. Eight specimens were taken in zone 2, 1 each in zones 3 and 4, 3 in zone 5, 1 in zone 6, and 2 in zone 7.

Family CRANCHIIDAE *Prosch*, 1847

DIAGNOSIS.—Mantle fused to head in nuchal region and to lateral corners of funnel. Buccal connectives attach to ventral borders of arms IV. Armature of clubs generally in 4 longitudinal rows. Arms generally with biserial suckers.

Subfamily CRANCHIINAE Pfeffer, 1912

DIAGNOSIS.—Cartilaginous strips bearing tubercules extend posteriorly on the mantle from the points of the funnel–mantle fusions. Funnel fused laterally to ventral surface of head in the adult stage.

Genus *Cranchia* Leach, 1817

DIAGNOSIS.—Mantle and fins covered with complex cartilaginous tubercules. Fins separate, each nearly circular in outline.

TYPE SPECIES.—*Cranchia scabra* Leach, 1817.

Cranchia scabra Leach, 1817

PLATES 28B; 29J,Q

Cranchia scabra Leach, 1817, p.140.—Hoyle, 1904, p.43, pl.10, fig.11.—Pfeffer, 1912, p.679, pl.48, figs. 22–28.—Sasaki, 929, p.329, pl.26, figs. 13–15, text figs. 151–153.—Voss, 1963, p.142, text fig. 31.—Pearcy, 1965, p.261.
Cranchia tenuitentaculata Pfeffer, 1884, p.26, pl.3, fig. 36.
Cranchia hispida Pfeffer, 1884, p.27, pl.3, fig.37.

DESCRIPTION.—The *mantle* is saclike, although it tapers abruptly to a point posteriorly. The mantle wall is very thin, but muscular. The anterior edge of the mantle is fused to the head in the nuchal region and to lateral corners of the funnel. From each of the latter points of fusion, two, short cartilaginous strips diverge to form a V-pattern. The entire surface of the mantle is covered with cartilaginous tubercules. The tubercules are somewhat variable, but generally have 3–4 well-separated cusps whose tips are usually subdivided into 2–3 additional cusps.

The *fins* are small and terminal (15–20% of the M.L. in length and 25–30% of the M.L. in total width). Each is nearly circular in outline and has free anterior and posterior lobes. The dorsal surface of the fins is covered with cartilaginous tubercules, but the ventral surface appears to have only small, rounded papillae.

The *funnel* reaches slightly past the bases of the arms. The dorsal pad of the funnel organ has roughly an inverted V-shape with a slender median ridge that is larger in its posterior portion; a flap occurs at the lateral edge of each diverging arm. The ventral pads are large and kidney-shaped, with the concave margin facing anteriorly. The surface of the funnel is covered with simple papillae; those on the ventral surface, immediately anterior to the mantle, are interconnected by low, narrow ridges that give a reticulated pattern. A funnel valve is present. The funnel is fused laterally to the head.

The *head* is short but broad and bears very large eyes that occupy the entire lateral sides of the head. Each eyelid has a small anterior sinus. Small, short "olfactory" papillae are present on either side of the head just lateral to the base of the funnel. Small, low papillae are scattered over the surface of the head.

The *arms* are short and in the order of III>IV= II>I. Arms I–III are joined basally by a web. The arms all have broad, trabeculate protective membranes on both dorsal and ventral borders. Well-developed aboral keels occur on arms III, but are barely detectable on arms I and II. Large lateral keels are present on arms IV. The arms have biserially arranged suckers except near the tips of arms III in males and on the hectocotylus. The suckers in the proximal halves of the arms each have about 5–7 low, rounded, irregular teeth on the distal portion of the inner chitinous ring. Distally, the broad teeth become more regular in arrangement and distinctly truncate. The teeth of the inner sucker rings in females seem to be more regularly arranged throughout the arm length, but are particularly so in the more distal suckers which have slender truncate teeth. Each arm III in males has the distal fifth modified by an increase to 4–5 slightly irregular longitudinal rows of suckers and by an abrupt decrease in the size of the suckers. The suckers become biserial again at the extreme tips of these arms.

The right arm IV is *hectocotylized* in males. It is considerably shorter than the left arm, and its tip is swollen and curled laterally. Proximally, the suckers of the hectocotylus are biserially arranged, but become tetraserial near the base of the curved tip. The curved tip has biserial suckers which are considerably enlarged proximally. Trabeculate protective membranes are present, but diminish on the curved portion. A large lateral keel extends to the tip of the arm. Each sucker on the proximal segment of the

hectocotylus has about 6–7 broad truncate teeth on the distal margins of the inner chitinous ring. The largest suckers of the distal segment (curved portion) each have about 13–15 rounded teeth around the entire margin of the inner chitinous ring; the teeth on the distal margin are the largest.

The *tentacles* are short and carry small, compact clubs. Four longitudinal rows of suckers on the manus grade into 4 rows on the dactylus. Suckers of both manus and dactylus have a uniform size in a transverse series. There are 4–7 small, smooth-ringed suckers at the tip of the dactylus. The dentition of the inner rings of the manal suckers varies with the location of the sucker. The proximal suckers have 6–7 slender, pointed teeth on the distal half of the inner ring. On the more distal suckers, the number progressively increases and smaller teeth also develop on the proximal margin of the ring. At the distal end of the manus, the number of teeth per ring approaches 30. Pairs of alternating suckers and pads extend down the tentacular stalk for about two-thirds of its length; the total number of suckers varies from 33–36 in the 2 specimens in which accurate counts were possible.

The *buccal membrane* attaches to the dorsal borders of arms I and II and to the ventral borders of arms III and IV.

In preservation, the specimens have small, brown *chromatophores* scattered over the body, head, and arms. In life, with chromatophores expanded and head contracted into the mantle, the animal looks like a large orange.

Photophores are present only on the surface of the eyes. There is a proximal row consisting of 8 photophores in a U-shaped series passing from the anterior to the medial section to the posterior surface of the eye. A distal series of photophores lies near the lens and has 4 photophores in a cescent-shape row ventral to the lens and 2 photophores dorsal to the lens. The eye, therefore, carries a total of 14 photophores.

TYPE LOCALITY.—Off West Africa.

LOCATION OF TYPE.—British Museum (Natural History).

DISCUSSION.—There is a single species, *Cranchia scabra* Leach, 1817, presently recognized in the genus. Distinct but minor differences exist in the pattern of tuberculation in different specimens of *C. scabra*. Pfeffer (1912) considerd *C. scabra* to consist of 2 subspecies, *C. s. tenuitentaculata* and *C. s. hispida* which he separated primarily by the greater density of tuberculation in the former. I have carefully compared the few specimens available from off California with material from the Gulf of Mexico and find that there is a distinct, but difficult to define, difference in tuberculation between these forms. The Gulf form has a greater number of large tubercules that gives the mantle a rougher appearance than the California form. The Atlantic specimens also have a much thicker mantle wall. I also examined a specimen of *C. scabra* from the Pacific Ocean off Panama that has a thick mantle wall, but which has tuberculation that is clearly less dense than the California or the Gulf specimens. In other features, the specimens coincide rather closely.

It will not be surprising if eventually *C. scabra* is shown to consist of a complex of species. An extensive series of specimens from each locality will be required to get necessary measurements, sucker counts, and other data needed to establish the distinctness of the forms since the differences will be small.

TABLE 19.—*Measurements in mm for* Cranchia scabra *Leach, 1817.*

Characters	*Station Numbers of the VELERO*		
	8025	10897	10259
Sex	♂	♀	♀
M.L.	107	78	53
M.W.	39	38	28
H.W.	30	18	10
F.L.	18	15	7
F.W.	30	24	13
Arm L. I	15	9	7
II	24	14	9
III	34	19	12
	L *R**		
IV	25 15	15	7
Tent. L.	50	31	28
Club L.	12	9	7
	L *R*	*L* *R*	
Club S.	92 96	94 91	—
Stalk S.	36 36	34 33	—
A.C. I	65	56	—
II	89	78	—
III	162	98	—
	L *R*		
IV	88 98*	66	—

*hectocotylus

DISTRIBUTION.—*C. scabra* has been reported primarily from warm waters of the Atlantic, Pacific, and Indian oceans between about 35° N and 37° S (Clarke 1966). Pearcy (1965), however, recorded *C. scabra* from off Oregon at about 44° N. Seven VELERO specimens were taken from the Santa Catalina Basin at 33° N and one from zone 6 at 31°42′ N.

Genus *Leachia* Lesueur, 1821

DIAGNOSIS.—A single cartilagenous strip, bearing tubercules, extends posteriorly from the point of each funnel–mantle fusion. Arms are not attenuate. Arms III of adult males have less than 100 suckers each. (The latter two features separate *Leachia* from the closely related *Drechselia* which has attenuate arms with more than 200 suckers on each arm III. These generic characters are only tentative at present, since the adult stage is not known for most species of *Leachia*.)

TYPE SPECIES.—*Leachia cyclura* Lesueur, 1821.

Leachia dislocata, new species

PLATES 30B; 31; 32

DESCRIPTION.—The *mantle* is long and slender with an extremely thin but muscular wall. The pen is clearly visible in the dorsal midline throughout the length of the mantle and often separates from the mantle during capture. The mantle is fused to the head at the lateral sides of the funnel and in the nuchal region. A line of cartilaginous tubercules, 13–18% of the M.L. in length, extends from each funnel–mantle fusion posteriorly along the ventral surface of the mantle. The tubercules arise from a single continous, cartilaginous band and are somewhat variable in form and arrangement; several basic patterns are apparent. At the extreme anterior end of the cartilaginous strip (i.e., the edge of the mantle), there is a large, complex tubrcule of variable appearance. Closely posterior to this is another large, complex tubercule also variable in appearance, but clearly displaced toward the median line of the mantle. The position of this latter tubercule is invariable and can easily be seen in all specimens beginning at a mantle length of roughly 15 mm. Posterior to the displaced tubercule, large, complex tubercules are generally separated from each other by 2–3 small tubercules usually with a single cusp. Generally, the complex tubercules in the middle section of the strip have a tripartite construction. The middle section has 3 cusps aligned in a row paralleling the body axis with small additional cusps scattered sometimes at various places. The lateral sections are distinctly separated from the middle section and are quite variable in form. In the simplest cases, each appears as a very large single cusp perpendicular to the median complex. More commonly, the tip of this lateral section is formed into 2–4 small cusps. Generally 4–7 of these complex, tripartite tubercules are found posterior to the displaced tubercule.

In the nuchal region, there is a cartilagenous pad which overlies the anterior end of the pen. Two small rounded tubercules arise from the anterior end of the pad, one on either side, which project slightly past the nuchal fusion. Often a low, flattened tubercle is present lateral to each of these tubercles, and occasionally a small, median cusp may be present.

The *fins* are transversely oval in outline; they are about 20–25% of the M.L. in length and about 30–35% of the M.L. in width. Small, free anterior lobes are present. The posterior margin of the fins is nearly flat.

The *funnel* reaches approximately to the level of the anterior end of the eyes. The funnel is fused to the head laterally by narrow strips of tissue. The funnel organ has roughly an inverted U-shape dorsal pad with a median ridge terminating in a long, slender papilla. At each posterolateral corner, there is a long, flattened papilla. Immediately anterior to each of these there may or may not be a similar, but smaller papilla. Sometimes one of these latter papillae will be present on one side of the pad, but not on the other. The ventral pads are elongate and often have an extended narrow anterior end. There is no funnel valve.

The *head* is broad and short. The eyes are large, each occupying almost the entire lateral sides of the head, and sessile in adults. A small anterior sinus is present on each eyelid. An "olfactory" papilla is situated on each side of the head, although the swollen tip of each barely rises above the surface of the head.

The *arms* are short and stout. The arm formula is III>II=IV>I. Arms III are extremely enlarged, being approximately twice the size of arms II and IV. All the arms bear short, broad trabeculae with low protective membranes on both dorsal and ventral

borders, but there is no trace of aboral keels. All arms have biserially arranged suckers. In males, the suckers of the midportions of all the arms (except the hectocotylus) have enlarged suckers with very small apertures; in females, the suckers are smaller and the apertures broader. The arm tips are not modified except for arms III in females and the hectocotylus in males. The inner chitinous rings have approximately 10–14 pointed teeth on the distal margin in both sexes. In mature and nearly mature females (i.e., about 130–135 mm M.L.) the tips of arms III become modified by the loss of suckers and by the enlargement of the trabeculate protective membranes into a spoonlike structure, generally with the edges folded inward. The membranes are dark purple. The oral surface bears a thick layer of highly convoluted tissue that appears glandular. The modified arms III have from 40–45 suckers. In males, arms III have about 60–70 suckers in the large specimens.

The right arm IV is *hectocotylized* in males. No mature males have been collected, and the hectocotylus described here from the holotype is probably not completely developed. The tip of the arm is expanded and bears enlarged suckers with small apertures along the ventral margin and reduced suckers along the dorsal margin. In the type, there is only a slight indication of dentition in the distal suckers of the ventral margin; in a slightly larger specimen these suckers are distinctly toothed around their entire margins. A keel is present along the aboral surface of the arm. The right arm shows only very slight hectocotylization at a M.L. of 110 mm and probably cannot be detected at a smaller size.

The tentacular *club* is short, slightly expanded, and bears suckers in 4 longitudinal rows. The suckers of the median 2 rows on the manus are greatly enlarged. The width of the inner chitinous ring is about 3 times that of the marginal suckers. The larger suckers have about 30 teeth around the entire circumference of the inner ring. Those of the distal margin are longer and may be pointed; the others are all truncate. In the middle of the dactylus, the suckers are largest in the ventral row, and grade in size to the smallest in the dorsal row. There is a small ring of suckers at the tip of the dactylus. Alternating suckers and knobs in 2 rows extend down the tentacular stalk for about half of the tentacle length. The suckers number about 10–13.

The *gravid females* have undergone considerable alternation in appearance. The funnel is enlarged and extremely flaccid. All muscular tissue in the animal appears to be more gelatinous than in nongravid specimens, and the silvery iridescent tissue around the eye has largely disappeared. The mature eggs are approximately 1.2–1.4 mm in diameter.

In the adult animal 8 *photophores* are aligned in a proximal series extending from the anterior end of the eye and passing ventrally and medially along the bulbus to the posterior margin. A second series of photophores more closely encircles the lens. The ventral portion of this distal series consists of 3 large, oval photophores with 2 interspersed small photophores giving the sequence; large, small, large, small, large. The dorsal portion consists of 2 small photophores. There are no photophores on the viscera. It is possible that the modified tips of arms III in females are photogenic.

The *buccal membrane* attaches to the dorsal borders of arms I and II, and to the ventral borders of arms III and IV.

The largest specimens appear to have been covered by numerous, small brown *chromatophores.* The young stages seem to lack chromatophores. At 5 mm M.L., there is no trace of the cartilaginous tubercules on the mantle; but at 10 mm M.L., they are present. In some specimens of this size, it is possible to locate the displaced tubercle. At 16 mm M.L., 2–3 dark patches appear on the proximal face of the rostrum of the eye, which are the first indications of developing photophores. The first 3 photophores seem to develop nearly simultaneously. At this size, the displaced tubercle is clearly present. At 22 mm M.L., the first 3 photophores are well developed. At 25 mm M.L., the eyes have 4 photophores on the proximal face of the rostrum. At 35 mm M.L., the fifth photophore has developed and the photophores on the distal face of the rostrum are beginning to form. The sixth photophore of the proximal series is present at 44 mm M.L., and the seventh at 64 mm M.L. At this latter size, the 3 large photophores of the distal series are well developed. At 86 mm M.L., the eyes are still borne on the long stalks as they have been throughout the *larval development,* but by 110 mm M.L. the eyes have become sessile and an eighth photophore (the most posterior and last member of this series) has developed in the proximal series. This photophore does not fall in perfect sequence with the other members of the series since it is somewhat more distantly

placed. Also, at about 110 mm M.L., the right arm IV in males begins to show the first evidence of modification into a hectocotylus. By 125 mm M.L., traces of the small photophores of the distal series can be detected. At 143 mm M.L., full maturity has been reached, females are gravid, and the photophore pattern is completley developed.

TYPE LOCALITY.—32°35′ N, 118°06′ W, eastern North Pacific Ocean.

LOCATION OF TYPE.—University of Southern California, U.S.C. Hancock collections, AHF Cephalopod Type No. 11.

DISCUSSION.—The differences between the genera *Leachia* and *Pyrogopsis* depend almost entirely on the size and position (i.e., stalked or sessile) of the eyes and on the ocular photophore pattern. Because specimens of *Pyrgopsis* generally have a small size compared with those of *Leachia,* there has resulted considerable debate concerning whether or not the genus *Pyropsis* is based upon growth stages of members in the genus *Leachia* (Naef 1923; Adam 1960; Voss 1967). The problem was not a simple one since at least one adult *Leachia* has been recorded (Voss 1960) that is smaller than some specimens of *Pyrogopsis.*

For the first time a complete series of growth stages of a single species within this complex has been available for study. This material indicates that the genus *Pyrgopsis* Rochebrune, 1884, can no longer be maintained and must be placed in the synonymy of the older genus *Leachia* Lesueur, 1821. Specimens in the present series from 10–35 mm M.L. exhibit all the characters of the genus *Pyrgopsis.* Specimens from 35 to at least 86 mm M.L. have some features of both genera, and specimens at 110 mm M.L. have all the features of the genus *Leachia.* The fully mature females have features (i.e., photophore pattern) that supersede *Leachia* and approach the genus *Drechselia.* The latter group, however, is sufficiently distinct to retain its generic standing pending information on the fully developed hectocotylus of *Leachia dislocata.*

By synonymizing these two genera, I do not necessairly indicate that any of the present species of *"Pyrgopsis"* are necessarily the young of one of the known species of *Leachia.* After examining many collections of specimens belonging to this group, I am convinced that it will prove to be very speciose. Therefore, it is possible that all of the presently recognized species could be valid; however, since many species are very inadequately described, it may prove impossible to incorporate their names into the future classification of the group.

The genus *Leachia* as now constituted contains, in addition to *Leachia dislocata,* the following species: *Leachia cyclura* Lesueur 1821, south Indian Ocean (37° S, 33° E); *Leachia eschscholtzii* (Rathke 1835), south Indian Ocean (28° S, 310° W); *Leachia zygaena* (Vérany 1851), near Messina, Mediterranean Sea; *Leachia rhynchophorus* (Rochebrune 1884), near Island of St. Paul, equatorial Atlantic Ocean; *Leachia schneehagenii* (Pfeffer 1884) off Chile; *Leachia pacificus* (Issel 1908) south Pacific Ocean (14°32′ S, 167°43′ E); *Leachia lemur* (Berry 1920), east of Cape Hatteras (35°27′ N, 73°14′ W); *Leachia atlantica* (Degner 1925), eastern North Atlantic (36°13′ N, 9°44′ W).

There is probably no genus in the Oegopsida that is more systematically confused. Of the 8 species previously recognized, none can be presently identified with any certainty. *L. zygaena* and *L. rhynchophorus* are known only from very young specimens, 22 mm M.L. and 17 mm M.L., respectively. Both species lack enlarged arms III and have suckers extending along the entire length of the tentacular stalks. Neither of these features can be attributed to the small size of the animals. If these features have been correctly described, then there should be no difficulty in separating them from the remaining members in the genus; however, it seems unlikely that arms III are as described. Both Pfeffer (1912) and Naef (1923) have considered these 2 species as possible synonyms. Eventually, both of these forms may have to be considered as *species dubia. L. schneehagenii, L. pacificus,* and *L. lemur* were all described from specimens with a M.L. less than 35 mm and *L. atlantica* with a 50 mm M.L. In defining these species Naef, Berry and Degner put considerable importance on the shape of the fin. This character is of doubtful value due to the very delicate nature of the fin and particularly its anterior edge. I can find no valid characters to separate these 4 species other than differences in their type localities.

Leachia cyclura and *Leachia eschscholtzii* are known from mature or nearly mature specimens. These 2 species cannot be separated from the preceding 4 species since any differences could be ascribed

TABLE 20.—*Measurements in mm for* Leachia dislocata, *new species.*

Characters	*Station Numbers of the VELERO*											
	10840	9905	9905	9905	10985	11100	8025	8025	8116	8024	8881	8028
Sex	♀	♀	♀	♀	♂	♂ (Holotype)	♀	♀	♀	♀	♂?	♂
M.L.	148	140	136	130	137	125	87+	112	76	58	50	110
F.L.	38	29	30	30	30	30	26	27	19	12	11	23
F.W.	54	39	41	45	42	42	35	34	25	—	15	31
Arm L. I	19	16	14	15	15	15	9	7	3	2	2	7
II	27	21	19	21	24	23	13	11	6	3	2	11
III	49	46	42	36	48	47	29	24	17	9	9	25
					L R	*L R*						
IV	25	21	21	19	20 16*	19 19*	12	11	5	3	3	10
Tent. L.	—	—	47	—	—	42	48	45	36	30	23	34
Club L.	—	—	7	—	—	7	7	7	5	4	3	6
Tub. L.	21	21	20	18	18	19	20	17	12	8	7	19

*hectocotylus

to growth. Their type localities are, however, very different.

Pfeffer (1912) identified a specimen captured off the coast of Argentina (39° S, 53° W) as *L. eschscholtzii.* This specimen has an extremely long series of cartilaginous tubercles which extend about half of the M.L. This form probably does not belong to *L. eschscholtzii* due to the differences in the lengths of the tubercular strips. This identification rests almost solely on the common occurrence of 3 light organs in the distal series of the eye, a feature that is not unique.

L. cyclura and *L. eschscholtzii* can be separated from each other by the presence of a single photophore in the former species in the distal series near the lens compared with 3 phorophores in this series in the latter species. It appears now (personal observation) that a number of species which share these photophore patterns have been lumped under these 2 specific names. It would appear that only a major revision of the genus will stabilize this very confusing group. It should also be mentioned that L. Boone (1933) described a specimen identified as *Pyrgopsis schneehageni* from the Pacific Ocean near Panama that seems to have distinctive dentition on the tentacular clubs; however, if I am correct in assuming that this has resulted from confusing the enlarged third arms with the tentacles (this is possible if the description was taken from the illustrations), then it seems likely that the specimen may belong to *Drechselia danae.*

It would be nearly impossible to describe a new species in this genus if it did not possess some extremely distinctive features. Fortunately, the California species has these. The displaced tubercle near the anterior end of the cartilagenous strip on the ventral surface of the mantle separates *L. dislocata* from all other known species. In adult specimens, the number of photophores in both the proximal and the distal series is greater than in any other member of the genus.

DISTRIBUTION.—*L. dislocata* is represented by 225 specimens from the present trawling program. The frequencies of capture are lowest (0.02 and 0.07 specimens/hour) in the San Pedro and Santa Catalina basins and highest (2.28 and 1.25 specimens/hour) in zones 6 and 7, respectively. Recently, the SWAN captured a small specimen (17 mm M.L.(off the Hawaiian Islands at approximately 22° N, 156° W.

The low occurrence of capture in the inshore basins under study combined with the high occurrence in warmer water, more oceanic zones, and its presence off Hawaii indicates that *L. dislocata* may be primarily an inhabitant of the eastern North Pacific Central Waters.

Subfamily TAONIINAE Pfeffer, 1912

DIAGNOSIS.—Cartilagenous strips not present on mantle. Funnel free from the head laterally in adults.

Genus *Galiteuthis* Joubin, 1898

DIAGNOSIS.—Larval forms have tetraserial suckers on the tentacular clubs; the medial 2 series convert into hooks in the juvenile stage. Fins are terminal and lanceolate. Arms have biserial suckers throughout.

TYPE SPECIES.—*Galiteuthis armata* Joubin, 1898

Galiteuthis phyllura Berry, 1911

PLATES 33; 34A,B,D–I,L

Galiteuthis phyllura Berry, 1911, p.592; 1912, p.315, text-figs. 17–18, pl.46, figs. 1–3, pl.54, figs. 5–6, pl.56.
Galiteuthis armata [parts].—Pfeffer, 1912, p.731.—Pearcy, 1965, p.262.

DESCRIPTION.—The *mantle* is long and slender; its muscular portion tapers to a point just past the anterior ends of the fins. The very thin but muscular mantle is fused to the head at the nuchal region and to the lateral corners of the funnel. Each of the latter 2 areas is marked by a flat cartilaginous pad with 2–4 small tuebrcules at its anterior end.

The *fins* are lanceolate, extremely long (41–47% of the M.L. in specimens greater than 100 mm M.L.), and slender (width 28–35% of the M.L. in specimens greater than 100 mm M.L.), and lack anterior or posterior lobes. The fins become very antenuate posteriorly, but extend to the tip of the pen.

The *funnel* is moderate in size, reaching approximately to the level of the midpoint of the eyes. The dorsal pad of the funnel organ has an inverted U-shape with rounded lateral arms. Three large, slightly flattened papillae are present, one on each lateral arm and one on the anterior midline. The dorsal pads are nearly oval in shape. There is no funnel valve. The funnel is free from the head laterally.

The *head* consists almost entirely of 2 very large, bulging eyes which are directed slightly forward. The eyes nearly touch each other in the ventral midline. In specimens up to about 60–65 mm M.L., the eyes are set on stalks. The eye opening is rather small and has an anterior sinus. From the skin over the mid-posterior surface of each eye arises an "olfactory" papilla which has a cup-shape terminal portion set on a swollen stalk.

The *arms* are relatively short, but muscular. The arm formula is IV>III>II>I. All arms possess large trabeculate protective membranes which are better developed on the ventral border of each arm. Arms I–III appear to have low, gelatinous aboral keels. Narrow lateral keels are present throughout the length of arms IV. Arm suckers are biserially arranged.

The suckers are globular, but have rather large apertures. The largest suckers of arms IV occur in the middle of the arms. The chitinous rings are smooth. In the larger of the males, the tips of arms I–II narrow abruptly and possess very small suckers in 2 rows. This distal area gives the impression that the arm tips have been lost and are in a state of regeneration; however, these tips are affected identically among opposite membrs of arms I and II and in all of the larger males (3 specimens). An Atlantic specimen of *G. armata* (also a male) shows the same feature. Therefore, it appears that this modification of the arm tips is a type of hectocotylization. A low web is present which is most noticeable between arms I–II.

The *tentacles* are short and muscular. The clubs are only slightly expanded and have narrow, potective membranes which extend the full length of the club along both margins and contain very broad trabeculae. A minute keel is present at the extreme tip of the club. The manus bears 2 rows of large hooks with 1–2 suckers in each marginal series at the proximal end. In young specimens, the marginal series are complete. Hooks first develop at approximately 40–50 mm M.L. The dactylus is short and bears from 22–32 small suckers arranged in 4 longitudinal rows. The inner chitinous rings of the dactyl suckers have generally 4 slender, widely separated truncate teeth on the distal margin, with 1–2 smaller teeth on each lateral margin. The proximal margin is slightly irregular, but lacks definite teeth. A distinct carpal cluster consists of 7–10 suckers and pads. Suckers are arranged in pairs along about the distal 70% of each tentacular stalk on the oral surface; the number of these suckers varies generally from 36–44. The suckers alternate with low, indistinct knobs.

The *buccal membrane* connectives attach to the dorsal borders of arms I and II and to the ventral borders of arms III and IV.

There are 2 photophores on each eye. The more distal organ lies just ventral to the lens and is approximately bar-shape, but may curve slightly and is divided into 2 sections. The larger photophore occupies almost the entire medial ventral surface of the eye. It has a broad, crescent shape and is thickened on its medial side.

In preservation, *G. phyllura* has many reddish brown *chromatophores* distributed over the head, arms, tentacles, and dorsal surface of the fins. The mantle has only a few large scattered chromatophores of the same color.

All specimens examined are immature.

TYPE LOCALITY.—Off Point Pinos, Monterey Bay, California.

LOCATION OF TYPE.—United States National Museum 214325.

DISCUSSION.—Joubin, 1898b, established the genus *Galiteuthis* based upon a new species, *G. armata* taken from the Mediterranean Sea. Berry (1911) briefly described a second species, *Galiteuthis phyllura,* from Monterey Bay, California, and subsequently (Berry 1912b) gave a more detailed description of the species; however, his species was already relegated, apparently unknown to Berry, to the status of a junior synonym of *G. armata* by Pfeffer in his monograph of oegopsid cephalopods and has remained in that position ever since.

I directly compared this species to several specimens from the North Atlantic and believe that the Californian form deserves the specific status that Berry originally gave it.

My comparative material is inadequate to give good morphometric comparisons. There appears, however, to be a difference in the length of the "tail" (i.e., longer in *G. armata*), although this feature is difficult to use since it is apparently somewhat variable and is subject ot considerable alteration due to damage. The specimens of *G. armata* available to me have damaged eyes, and it is impossible to determine their size. The literature indicates that the eyes of *G. armata* are considerably smaller than those of *G. phyllura.* This is readily apparent when one compares my figure (pl. 33A) with Chun's illustrations from the VALDIVIA reports (1910, plate 59, figures 1, 2) which show animals of nearly identical ' ly lengths.

TABLE 21.—*Measurements in mm for* Galiteuthis phyllura *Berry, 1911.*

Characters	*Station Numbers of the VELERO*																			
	8030		9056		10265		8030		10259		10265		9661		10265		11183		10265	
Sex	♀		♂		♂		—		—		—		—		—		♂		—	
M.L	173		211		254		85		60		108		45		60		359		65	
H.W	23		30		42		12		S.E.*		16		S.E.*		S.E.*		61		10	
F.L	76		91		119		31		19		44		12		18		164		21	
F.W	21		32		38		10		7		13		7		6		46		9	
Arm L. I	18		25		38		8		5		12		4		5		52		5	
II	23		30		45		11		7		14		5		7		71		8	
III	28		38		55		14		9		18		6		8		82		10	
IV	35		43		63		16		11		23		7		10		87		12	
Tent. L	78		79		105		43		35		55		26		33		137		39	
Club L	11		14		19		7		7		9		5		5		21		6	
Tail L	14		28		17		8		5		14		—		5		40		6	
Eye D	14		18		23		6		5		9		—		—		33		—	
	L	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*
Club H	11	11	13	13	13	13	10	10	7	8	12	—	7	6	9	7	14	14	9	8
Carp. S	10	10	8	8	8	8	8	8	8	7	9	8	7	8	8	7	8	8	8	7
Stalk S	36	39	44	43	39	37	36	36	40	42	35	38	42	40	42	42	36	36	38	38
Dact. S	22	26	23	25	26	24	30	27	32	—	—	—	27	32	32	29	21	21	27	26
Tubercles	3	2	4	4	3	3	3	3	2	2	2	4	—	—	2	3	4	3	3	3

*S.E., stalked eyes.

The holotype of *G. armata* described by Joubin (1898b) has a head width of 20 mm. The specimen of *G. phyllura* of the same body length has a head width of 30 mm. There also appears to be differences in arm length, fin lengths, fin widths, sucker sizes, and hook sizes. These differences, however, require verification through the study of a large series of specimens which are not presently available.

The features mentioned here are not sufficient to prove the separation of *G. armata* and *G. phyllura*. I feel that when more material becomes available for study, the differences between these species will be substantiated; and I therefore retain the name *G. phyllura* for the California specimens.

DISTRIBUTION.—*G. phyllura* has previously been recorded only from Monterey Bay (Berry 1912). I examined a specimen captured off Oregon by Pearcy that belongs to this species as does, presumably, *G. armata* listed by Pearcy (1965).

The frequency of capture in the present study is almost constant for zones 2, 3, 5, and 6 (i.e., 0.26 to 0.29 specimens/hour). Zone 7, however, with over 120 hours of trawling has yielded only 2 specimens. It seems likely that zone 7 is near the southern limit for this species. *Galiteuthis phyllura,* therefore, has a distribution that extends from approximately latitude 28° N to at least 44° N along the western coast of North America. Sasaki (1929) recorded *G. armata* from Japan; it is not certain whether his specimens belong to *G. phyllura.*

Galiteuthis pacifica (Robson, 1948)

PLATES 30A; 34C,J–K,M

Taonidium pacificum Robson, 1948, p.130.

DESCRIPTION.—The slender *mantle,* broadest in the anterior half, tapers to a point posteriorly and has an extremely thin but muscular wall. The mantle margin is fused to the nuchal region and at the lateral edges of the funnel. Cartilaginous tubercles are lacking at all of these points.

The *fins* are small and lanceolate; they are about 25% of the M.L. in length and 20% of the M.L. in width. There are no anterior or posterior lobes. The pen, which is visible along the middorsal line, extends slightly posterior to the fins, but this may be an artifact of preservation.

The *funnel* is small, but reaches nearly to the anterior margin of the eyes. The funnel is free from the head laterally. The dorsal pad of the funnel organ has roughly an inverted U-shape. Usually a small papilla arises from the center of the anterior portion of the pad. The ventral pads are small and oval. There is no funnel valve.

The *head* is short and the eyes are relatively small. The eyes are not clearly talked in any of the available specimens since they lack extended optic tracts, although the eyes project at a 45° angle to the body axis. A small olfactory papilla arises posterior to each eye.

The *arms* are short and muscular. Low gelatinous swimming keels are present on the distal portions of arms I–III, and lateral keels are present on arms IV. Low, trabeculate, protective membranes are present on all of the arms. A low, interbrachial web exists between arms I–II. The arm formula is IV>III> II>I. The suckers are arranged biserially on each arm. On the midportions of the arm, the suckers are large, and the inner chitinous rings are smooth and have broad apertures.

The *tentacles* are short and have only slightly expanded clubs. An ill-defined carpal locking-apparatus is present at the base of the manus which seems to include 7–9 suckers; the knobs are indistinct. Proximally, the carpal suckers merge with paired suckers that extend along more than two-thirds of the tentacular stalk. These suckers alternate with indistinct knobs and can therefore be considered as an extension of the carpal cluster. There are 48–74 suckers on the tentacular stalk. The median 2 rows on the manus consist of apparently 5 hooks each, although the clubs have been damaged so that the exact number is uncertain. Lateral to the hooks on either side is a marginal series of suckers. The dactylus is very short and appears to have from 14–24 suckers. The inner chitinous rings of the marginal and carpal suckers each have a few short, truncate, and broadly separated teeth around the entire margin; those of the distal margin are the largest.

On the ventral surface of each eye is a U-shaped *photophore* that extends from the posterior margin along the medial edge to the antrior margin of the eye. A crescent-shape patch of tissue which is limited medially by the photogenic band just described is apparently part of this photophore, although distinctly different in appearance. In the largest specimen, the more distal photophores, characteristic of most members of the subfamily, is just beginning to develop.

This photophore is also composed of 2 parts: a short distal bar and a proximal oval patch. Combined, these have a circular outline.

The specimens have scattered reddish brown chromatophores.

The *buccal connectives* attach to the dorsal borders of arm I and II and to the ventral borders of arms III and IV.

TYPE LOCALITY.—Off Cocos Island, eastern tropical Pacific.

LOCATION OF TYPE.—Numbers 1948.7.8.1 and 2. British Museum (Natural History).

DISCUSSION.—*Galiteuthis pacifica* can easily be separated from the other 2 members of the genus, *G. phyllura* and *G. armata,* by 2 distinctive features: the points of the funnel–mantle fusions are smooth and the distal photophore on each eye is oval. (This latter feature can be observed only in specimens larger than about 60–65 mm M.L.) Both *G. phyllura* and *G. armata* have complex tubercles at each funnel–mantle fusion and a bar–shape, distal photophore on each eye. There are other, less obvious, features concerning the shape and position of the fins, the stalked or sessile condition of the larval eye at a given M.L., and the dentition of the dactyl suckers that also distinguish the species described here.

I examined a large specimen of *Galiteuthis* captured by the DANA and a small specimen taken by the PILLSBURY from the tropical Pacific off Panama. Both specimens closely agree with those from California and are certainly conspecific with them.

Robson (1948) described *Taonidium pacificum* from 2 small specimens taken near Panama. The specimens, due to their small size (the largest had a M.L. of 29 mm), lacked hooks on the tentacular clubs and therefore, their affinity to *Galiteuthis* was not recognized. I here transfer Robson's species to the genus *Galiteuthis*. The late Dr. W. J. Rees, formerly Curator of Coelenterates at the British Museum, kindly examined the types of *G. pacifica* for me and found that the funnel–mantle fusions definitely lack tubercules. Therefore, there can be no doubt that *Galiteuthis pacifica* (Robson) is indentical with specimens here examined from off Panama and southern California.

DISTRIBUTION.—*G. pacifica* was previously known only from the type specimens captured off Cocos Island. The VELERO material was taken between 29° 12′ N and 33°20′ N. PILLSBURY and DANA have provided specimens from 7°19′ N, 79°42′ W and 6°40′ N, 80°47′ W. *G. pacifica* is very rare in California waters, being represented in the collections by only 4 specimens. Since an equal number of specimens are now known free from the Panama area from only minimal trawling, it is safe to assume that the species is common to these waters and only occasionally ranges as far north as the California area.

TABLE 22.—*Measurements in mm of* Galiteuthis pacifica *(Robson, 1948).*

Characters	*Staton Numbers of the VELERO*			
	8243	8018	11022	10906
Sex	—	—	—	—
M.L.	36	42	52	65
M.W.	11	12	15	—
F.L.	9	10	13	17
F.W.	7	8	11	11
Arms I	4	4	6	8
II	6	6	8	10
III	6	7	10	12
IV	7	8	11	13
Tent. L.	28	25	24	—
Club L.	5	4	5	—
Stalk S.	72	56	49	—

Genus *Helicocranchia* Massy, 1907

DIAGNOSIS.—Funnel–mantle without cartilaginous pad. The mantle terminates in a blunt point, and the pen rises free from the mantle shortly in advance of the mantle tip. Fins pedunculate and attach to the free pen except at their extreme anterior ends. Funnel large.

TYPE SPECIES.—*Helicocranchia pfefferi* Massy, 1907.

Helicocranchia pfefferi Massy, 1907

PLATES 28A; 29A–I

Helicocranchia pfefferi Massy, 1907, p.382; 1909, p.34, pl.3, figs. 1–3.—Robson, 1948, p.130.

Teuthowenia (Helicocranchia) pfefferi.—Pfeffer, 1912, p. 740.—Grimpe, 1922, p.98.—Massy, 1928, p.36.

Desmoteuthis megalops [parts], Muus, 1956, p.9; 1962 p.9.

Megalocranchia (Helicocranchia) pfefferi.—Voss, 1960, p. 433.

DESCRIPTION.—The *mantle* is broadest in the mid-portion; posteriorly, it tapers to a blunt point. The

mantle wall is thin but muscular and often has a leathery texture. It is fused to the head in the nuchal region and to the lateral edges of the funnel; no cartilaginous tubercules or pads are present at these points.

The *fins* are separate, paddlelike in shape, and have large posterior lobes. Except at the extreme anterior ends, the fins are supported exclusively by the pen which projects dorsally above the mantle. The small posterior tip of the mantle, therefore, not only extends beneath fins without being attached to them, but also lacks the supporting tip of the pen.

The *funnel* is extremely large; it extends well past the bases of the arms and is very broad. The dorsal pad of the funnel organ has roughly the shape of an inverted V. A slender papilla arises from the mid-anterior portion of each lateral arm and also from the midportion of the apical region. Each ventral pad has an L-shaped appearance with the transverse limb shorter and much broader than the longitudinal one. A funnel valve is not present, and the funnel is free from the head laterally.

The *head* is short and narrow. The eyes, small relative to the size of the body, project from the head and point forward at roughly a 45° angle to the body axis. Each eye has a well-formed ventral rostrum with an ill-defined photophore on its proximal face. A small "olfactory" papilla arises from the tissue covering the lateral surface of each eye.

The *arms* are very small and slender. The arm formula is III>II>I=IV. All arms have low, protective membranes without apparent trabeculae on both the dorsal and ventral margins. Narrow aboral keels are present on arms I–III, and lateral keels are present on arms IV. All arms have biserial suckers over their entire lengths except for arms I and II of males. Each inner chitinous ring has about 7–10 low, rounded, or sometimes pointed teeth on the distal margin; the proximal margin is smooth. These teeth are very difficult to see under the microscope.

In *males,* approximately the distal one-fourth to one-third of arms I and II are modified. On each arm I, the size of the suckers and the diameter of the arms decrease abruptly and the number of sucker rows increases to about 4. On each arm II, the tips are similarly modified except that the number of rows increases to 8–9. These suckers have inner rings that are disproportionally small and apparently lack teeth.

The *tentacles* are long and moderately robust. The tentacular clubs are small but expanded and bear suckers in 4 series. At the proximal end of the manus, the suckers of the median rows are slightly enlarged over those of the marginal rows. On the dactylus, the suckers in a transverse series grade in size from the largest in the ventral row to the smallest in the dorsal row. At the tip of the dactylus, a small lobe bearing 3–4 tiny suckers is present. On the manus, the inner chitinous rings of the suckers have about 8–10 slender, pointed teeth on the distal half of the margin. Laterally, the teeth diminish rapidly in size and form only small pointed knobs proximally. The proximal 2 suckers in the dorsal row of the manus are distinctly reduced in size. A broad, trabeculate protective membrane is present along the entire ventral margin of the club, but the dorsal membrane terminates along the base of the dactylus. A short dorsoaboral keel is present on the dactylus. About 13–17 pairs of small suckers alternating with knobs extend along almost the full length of the tentacular stalk. *Buccal connectives* attach to the ventral borders of arms IV.

H. pfefferi has a characteristic *color* pattern. The mid-dorsal surface of the mantle has scattered elongate chromatophores. A strip of chromatophores extends along each dorsolateral side of the anterior two-thirds of the mantle. The lateral sides have a series of short, transverse bars, while the ventral surface has scattered chromatophores with a small concentration in the anterior midline.

TYPE LOCALITY.—Near Ireland, 51°54′ N; 11°57′ W.

LOCATION OF TYPE.—British Museum (Natural History).

DISCUSSION.—*Helicocranchia* was established by Massy 1907 for *H. pfefferi.* Subsequently, there has been considerable question concerning the validity of the genus (Grimpe 1922; Massy 1928; Muus 1956, 1962; Voss 1960). The group is very distinctive, however, and it is hoped that the above description will remove all doubts concerning its independent status. Presently, the genus contains 2 additional species, *H. beebei* Robson, 1948, from the region of Cocos Island and the Galápagos Islands, and *H. papillata* (Voss 1960) from 32°05′ N, 64°38′ W in the North Atlantic. *H. papillata* can easily be separated from the others by the presence of small, sharp papillae over the surface of the funnel and mantle. *H. beebei* is very similar to *H. pfefferi,* and it is possible that they are synonymous. Some time ago, I examined

TABLE 23.—*Measurements in mm for* Helicocranchia pfefferi *Massy, 1907.*

Characters	*Station Numbers of the VELERO*				
	9249	8030	8111	8111	8027
Sex	♂	♂	♀	♂	♀
M.L.	52	56	60	65	79
M.W.	20	18	22	22	23
F.L.	8	5	4	4	8
F.W.	14	10	10	9	17
Arm L. I	9	9	8	11	13
II	12	11	11	14	16
III	13	12	14	15	19
IV	8	8	8	11	12
Tent. L.	43	37	37	—	69
Club L.	6	5	6	—	7
	L R	*L R*	*L R*	*L R*	*L R*
Stalk S.	34 32	32 31	—	—	29 26

the type of *H. beebei* which is deposited in the British Museum. The arms of the largest specimen were considerably thicker and fleshier than the California and Atlantic material of the same size. It seems likely that *H. beebei* will prove to be a valid species. If this is so, it places the identification of the California material somewhat in doubt, since it indicates a rather peculiar geographical distribution for *H. pfefferi.* Unfortunately, the only difference that I have been able to detect between specimens of *H. pfefferi* from the Atlantic Ocean and from off California is the distinctly larger eyes in the Atlantic forms. This feature is, of course, insufficient by itself to require separate status for the California specimens.

The California specimens, therefore, show slight differences from *H. pfefferi* and *H. beebei,* but these differences are small and since the validity of *H. beebei* is in doubt, there is no recourse but to call the California specimens *H. pfefferi.* Perhaps when mature animals of all 3 forms become available for study, it will be possible to determine their relationships more satisfactorly.

Voss (1962) described a new cranchiid genus, *Ascocranchia,* based on a specimen with a number of peculiar features, the most important of which is the presence of 3 small oval photophores on the eye combined with the absence of cartilaginous strips and tubercules on the mantle. This combination of characters cuts across formerly designated subfamilial boundaries within the Cranchiidae and placed *Ascocranchia* in an uncertain position. I recently examined several damaged females belonging to this genus that were captured by the PILLSBURY in the Gulf of Guinea. The tentacles are missing, and the eyes have been damaged in all of the specimens. They exhibit, however, the basic features of *Helicocranchia* in having a large funnel and paddlelike fins that are supported by the tip of the pen which rises dorsally from the surface of the mantle. The type was a male and shows at least an indication of the peculiar hectocotylization seen in *H. pfefferi* and *H. beebei,* although it occurs on the arms III instead of arms I and II. The light-organ pattern on the eyes of the species in *Helicocranchia* are certainly not typical for the subfamily. In addition, the photophores are known only on the rostrum of the eye in juvenile specimens. It is likely that the rostrum is absent in mature specimens, and that there will be a corresponding alteration in the photophore pattern. Therefore, the light-organ pattern in *Ascocoranchia* may not be as significant as it was thought at first. Until the photophore pattern in mature specimens of *Helicocranchia* is known, the ultimate fate of *Ascocranchia* as an independent genus cannot be resolved with certainty.

DISTRIBUTION.—In the present study, *H. pfefferi* showed the greatest abundance in the northern zone 2 (2.28 specimens/hour), while the second highest concentration (1.63 specimens/hour), occurred in the most southernly zone, zone 7.

Order OCTOPODA

Suborder INCIRRATA

Family BOLITAENIDAE, Chun 1911

DIAGNOSIS.—Rachidian and lateral teeth of radula multicuspidate. Suckers uniserial. Mantle opening broad. Liver and stomach in "normal" position.

Genus *Japetella* Hoyle, 1885

DIAGNOSIS.—Eyes are large. Right arm III in males with many slightly enlarged suckers on the distal two-thirds of the arm.

TYPE SPECIES.—*Japetella prismatica* Hoyle, 1885.

Japetella heathi (Berry, 1911)

PLATES 35B; 36D

Eledonella heathi Berry, 1911, p.589; 1912, p.276, pl.32, fig. 4, pl.33, figs. 2–4.
Japetella heathi.—Robson, 1932, p.335.—Thore, 1949, p. 7.—Pearcy, 1965, p.262.

DESCRIPTION.—The *mantle* is soft and sacular with a gelatinous consistancy. The mantle opening is broad, extending to at least the level of the midpoint of the eyes.

The *funnel* is large and embedded for most of its length in the gelatinous tissue on the ventral surface of the head. The tip of the funnel extends approximately to the level of the anterior edge of the eyes. The funnel organ is an inverted V-shaped pad.

The broad *head* is encased in gelatinous tissue. The eyes are large (13 mm in a specimen of 78 mm M.L.) and elliptical in outline with the longest diameter transverse to the body axis. The ventral–lateral surface of each eye has a strong silvery sheen. This silvery patch also loops above the lens although it may, in this area, be partially covered by reddish brown chromatophores. The dorsal surfaces of the eyes are black with a slight bluish iridescence. The brain is about 4–5 mm in width while the optic stalk is about 8 mm long in a specimen with a mantle length of 71 mm. The peduncle lobe complex lies 3 mm from the optic lobe. A small "olfactory" papilla is present posterior to each eye on the collar.

The *arms* are moderately long and each bears globular suckers arranged in a single row. The suckers are so closely packed that each is in contact with its neighbor. The arms are thick but fragile, and their tips are frequently broken off. The arms are arranged in order of III>IV=II=I. The suckers are deeply embedded in the gelatinous tissue which surrounds the arms; this is particularly so near the bases of the arms.

The web, although easily damaged or distorted, appears to be in the order of A>D>B=C>E. The right arm III in males is modified by an increase in sucker size and perhaps a slight increase in length. Usually the fifth sucker from the base of the arm is the first enlarged sucker; the size of the enlarged suckers decreases gradually to the tip of the arm.

The *liver* is usually oval and very large, although its size varies greatly. Its ventral and lateral sides are covered by a brilliant silvery tissue that extends over the lateral sides of the crop. At its posterior end, the liver laterally embraces the spiral caecum and the anterior part of the stomach. The dorsal surface of the liver is slightly concave where the large crop presses against it. The crop in this species is very capacious and is almost always in the expanded condition even if it is nearly empty. The crop is formed by a large outpocketing of the esophagus. The crop lies primarily to the left side of the esophagus. Large posterior salivary glands lie on the right side of the crop. The pancreas lies embedded in the dorsoposterior portion of the liver. It is slightly bilobed since it follows the contours of this part of the liver. There are 16–22 primarily gill lamellae. The ink sac is small and embedded in the liver at the anterior end of the pancreas.

The *radula* is ctenoglossan. The rachidian has a large central cusp with 3–4 assymmetrically placed cusps on either side. The admedian has 5–7 cusps, the more medial of which is the largest. The second lateral has 6–7 cusps with the medial cusp slightly enlarged. The third laterals have a single elongate cusp. Broad marginal plaques are present.

The *eggs* of the largest female (M.L., 90 mm) are elongate and slightly swollen in the distal half. The length is between 1.2 and 1.3 mm and the greatest width is between 0.3 and 0.4 mm.

Data for 2 of the largest specimens are: from the VELERO 8933, sex, ♂; M.L., 78 mm; M.W., 42 mm; H.W., 38 mm; Arm L., I–IV, respectively, 55 mm, 60 mm, 77 mm, 60 mm; and from the VELERO 8715, sex, ♂; M.L., 72 mm; M.W., 45

mm; H.W., 36 mm; Arm L., I–IV, respectively, 39 mm, 42 mm, 57 mm, 40 mm.

TYPE LOCALITY.—Off Santa Catalina Island, California.

LOCATION OF TYPE.— United States National Museum 214318.

DISCUSSION.—At present only 2 species are recognized in the genus, *J. diaphana,* Hoyle, 1885 (type locality, 0°42′ S, 147° E) and *J. heathi* (Berry 1912b). The original description of *J. heathi* reveals no definite features which could unquestionably relate this name to one of the 2 species present in these waters. Berry's (1912b) statement that the eyes are nearly black would seem to identify it with the species referred to in this paper as *Japetella* sp.; however, it seems more likely that the eyes had lost their silvery iridescence due to preservation. The type, unfortunately, has been destroyed. I think the only solution is to assume the most abundant species in this area is *J. heathi.*

I compared specimens of *J. heathi* with specimens of *J. "diaphana"* from the Atlantic Ocean off Florida and find that there is little to separate these forms; however, considering the great similarity of the sympatric species which occurs off California (see discussion of next species) which allows the separation only of large specimens, one must be careful in discussing worldwide relationships. For the present, I think it best to retain the name *J. heathi,* at least until we have a better understanding of speciation within the genus.

DISTRIBUTION.—Since *J. heathi* has been imperfectly separated from *Japetella* sp. (see following section), the distribution of the 2 species is considered together. It should be emphasized, however, that the vast majority of the specimens belong to *J. heathi. Japetella* is well represented throughout most of the area studied, but did show a slight increase in frequency of capture in the southern zones. Zone 2 had a capture frequency of 0.15 specimens/hour while zone 6 and 7 had a frequency of 0.30 and 0.26 specimens/hour, respectively. *J. heathi* has also been reported from off the coast of Oregon (Pearcy 1965).

Japetella species

PLATE 36A–C

DESCRIPTION.—The *mantle* is saclike and gelatinous. The mantle opening is broad and extends on either side to at least the level of the midpoint of the eye.

The *funnel* is well developed and reaches approximately the level of the anterior edge of the eyes. The funnel organ is an inverted V-shaped pad situated on the inner dorsal surface of the funnel. The funnel is embedded in the gelatinous tissue of the head for most of its length.

The *head* is broad and enveloped in gelatinous tissue. The large eyes, nearly circular in outline, are black although in live specimens they have a greenish hue on the ventral half. The pupils of the eyes are slitlike and oriented at approximately right angles to the body axis. Each optic stalk, on a specimen with a mantle length of 72 mm, is 8–9 mm long, while the width of the brain is approximately 5 mm. The peduncle lobe complex is situated 4 mm from the optic ganglion. A small "olfactory" papilla is present posterior to each eye on the collar.

The *arms* are moderately long and each bears a single row of large, globular suckers. The suckers are closely packed so that each is in contact with its neighbor. The arm formula is III>IV=I=?II. The suckers are very deeply embedded in the gelatinous tissue that surrounds the arms. The right arm III of males is hectocotylized. It is slightly longer than the corresponding left arm and possesses enlarged suckers beginning abruptly with usually the sixth sucker from the base of the arm. The enlarged suckers decrease gradually in size distally to the tip of the arm. The web formula cannot be determined in the available material.

The *liver* is small and slender. The intestine extends along the ventral surface of the liver well past its anterior end. Posteriorly, the intestine passes ventral to the pancreas, between the hepatic ducts, and enters the caecum. The bilobed pancreas is embedded in the ventral–posterior surface of the liver; two large hepatic ducts arise from the pancreas, then join to form a single duct before entering the caecum. The caecum is embraced by the posteriorly directed projections of the liver. The crop is a saclike outpocketing of the esophagus. Dorsal and lateral to the crop on either side lies a posterior salivary gland. These organs, although rather variable, are generally the same size as the liver. The ink sac lies embedded in the ventral surface of the liver at the anterior end of the pancreas. There are about 18 primary *gill* lamellae.

The *radula* is ctenoglossan. The rachidian has a large central cusp with 3–4 asymmetrically placed cusps on either side. The admedian has 5–7 cusps, the most medial of which is the largest. The second lateral has 5–7 cusps with the medial cusp slightly enlarged. The third laterals have a single elongate cusp. Broad marginal plaques are present.

The *measurements* for the largest specimen available are: M.L., 72 mm; M.W., 46 mm; H.W., 40 mm; Arm L., I–IV, respectively, 62 mm, 48+ mm, 76 mm, 55 mm; length of posterior salivary gland, 16 mm; length of liver, 21 mm; width of liver, 6 mm; eye diameter, 14 mm; height of largest sucker of hectocotylus, 6 mm.

DISCUSSION.—This species is very closely related to *J. heathi,* but differs in several significant features. The most apparent character is the lack of the brilliant silvery layer present on the eyes and liver of *J. heathi.* This is very obvious in fresh material and usually Formalin–preserved material, although the iridescence in *J. heathi* may be lost in some specimens after preservation. This characters is difficult to use in material preserved in alcohol. The testis and the male reproductive tract are much larger than in *J. heathi* at equivalent mantle lengths. Also, the viscera, although showing considerable variation, are much larger in *J. heathi.* In large fresh specimens these differences are readily seen, but I have been unable to separate small specimens.

Although clearly different from *J. heathi* and *J. diaphana,* it would be unwise to give this species a name when it is only imperfectly separable from other species. This must wait until better material is available for study and more detailed comparisons can be made. Such a study, comparing this species with *J. heathi,* would be extremely worthwhile for it could set guidelines for the study of speciation within the genus. Such guidelines are badly needed in this group which at present seems to be a very confused state, contrary to the conclusions of Thore (1949).

DISTRIBUTION.—See distribution for *J. heathi.*

Family OCYTHOIDAE Gray, 1849

DIAGNOSIS.—Web almost entirely absent. Right arm III is hectocotylized and retained in a sac until mature. Ventral surface of mantle covered with tubercules and interconnecting ridges. Arms II and III much shorter than arms I and IV. Arm suckers biserial.

Genus *Ocythoe,* Rafinsque, 1814

DIAGNOSIS.—The characters of the genus are the same as those of the family.

TYPE SPECIES.—*Ocythoe tuberculata* Rafinesque, 1814.

Ocythoe tuberculata Rafinesque, 1814

PLATE 37

Ocythoe tuberculata Rafinesque, 1814, p.29.—Berry, 1916, p.1, fig. 1; 1955, p.177, fig. 1.—Naef, 1923, p.749, text figs. 447–454.—Sasaki, 1929, p.26, pl.3, figs. 13,14, pl.8, figs. 12–16, text fig.8.—Robson, 1932, p.201, text fig.27.

DESCRIPTION.—The thick, muscular *mantle* is short and broad. The free edge extends to the level of the dorsal margin of each eye. The ventral surface of the mantle is covered with tubercules and inner connecting ridges in females. The tubercules are more closely spaced at the posterior end of the mantle, along the ventral mantle margin, and along the lateral sides.

The *funnel* is very large; it reaches anteriorly well past the bases of the arms. Laterally, the basal portion is fused to the head; the tubular portion is long and free. Between the base of each arm IV and the funnel is a large pore. The funnel organ is very large; the dorsal pad has the shape of an inverted V. The 2 ventral pads are separate and elongate. The locking-apparatus on the funnel consists of a knob with an anterior flaring lip that lies above a deep pit. The structure locks with a corresponding groove and ridge on the mantle. The "olfactory" organ consists of a flattened pad which may either protrude from the body surface or reside in a shallow pit and is located near the dorsoposterior edge of each eye. The eyes are moderately large. The arms have the characteristic formula I=IV>II=III. There is no web connecting the bases of the arms. The suckers, which are biserial and project well above the surface of each arm, are connected along either margin by a muscular membrane. The arms lack keels or at most are merely angled aborally.

The males are much the smaller. The only male in the present collections has a M.L. of 15 mm, but is immature. The right arm III is hectocotylized and enrolled in a membranous sac. This arm has 2 well-separated rows of flattened suckers. The inner aperatures of the suckers are small and displaced toward the medial end of the transversely oval sucking disk.

TABLE 24.—*Measurements in mm for* Ocythoe tuberculata *Rafinesque, 1814.*

Characters	*Catalina Island*		*Station numbers of VELERO*	
			8242	8238
Sex	♀	♀	♀	♂
M.L.	60	80	12	14
M.W.	45	38	12	13
H.W.	27	28	11	11
Arm L. I	123	148	35	38
II	83	97	18	19
				L *R*
III	80	90	16	18 12*
IV	132	141	38	41

*hectocotylus

The lateral margin of the suckers is fused to a marginal membrane which extends along both sides of the arm. There are 66 of these large suckers on the arm. The arm narrows abruptly at the distal end of the sucker-bearing portion and continues as a slender and attenuate filament which appears to be considerably longer than the sucker-bearing portion of the arm. The proximal portion of the filament is enrolled in a separate sac which forms a bulb at the tip of the sucker-bearing portion of the arm. There are 2 small pads that appear to be reduced suckers on the surface of this sac.

Females have approximately 34 gill filaments, and the only male specimen has 21.

The radula has a tricuspid rachidian tooth, tricuspid first lateral, bicuspid second laterals, unicuspid third laterals, and marginal plaques.

DISCUSSION.—At present only a single species, *Ocythoe tuberculata,* is recognized in the family Ocythoidae; however, there seems to be considerable variation between described specimens. The number of gill filaments varies approximately between 33 and 48. Most authors (Jatta 1896, Robson 1932) described the radula approximately as in the present specimens, but Naef (1921, 1923) stated the second lateral tooth is unicuspid. Both Sasaki (1929) and Jatta (1896) indicate that the hectocotylus has about 100 suckers, but the California specimen has only 66. Also, the California specimens lack the rather large aboral keels of arms I and IV described by Naef (1923) and Robson (1932), although this may be an ontogenetic difference. At present, these variations are assumed to be of little significance, but clearly warrant a more detailed study.

DISTRIBUTION.—Only four specimens have been avaiable for this study. The smaller two animals were captured in the mid-water trawl in zone 2. The two large specimens, collected by Dorothy Petersen, washed ashore at the isthmus on Catalina Island on two successive days (16, 17 January 1967).

Family ALLOPOSIDAE Verrill, 1882

DIAGNOSIS.—Rachidian tricuspid and without seriation. Right arm III in males hectocotylized and coiled in a pocket in front of the right eye. Suckers uniserial proximally and biserialy distally. Other than hectocotylization, sexual dimorphism lacking. A funnel-mantle locking mechanism present.

Genus *Alloposus* Verrill, 1880

DIAGNOSIS.—Characters are the same as those of the family.

TYPE SPECIES.—*Alloposus mollis* Verrill, 1880

Alloposus mollis Verrill, 1880

PLATE 38B

DESCRIPTION.—The *mantle* is short, gelatinous, and broad (length is nearly equal to width). The mantle opening is wide and reaches roughly to the level of the dorsal edge of the eyes. On the inner surface of the mantle, just medial to the gills and lateral to the median pallial adductor muscle is a distinct transverse fold of the mantle which forms a deep groove. This is the mantle component of the funnel-mantle locking mechanism.

The *funnel* is very large. It extends far past the eyes and past bases of the ventral arms. Except for a short free tip, it is completely embedded in the gelatinous tissue of the head. The funnel organ is large and W-shape. The posterior lateral edges of the funnel, near the point of attachment of the funnel retractor muscles, fold sharply forward to form the funnel component of the funnel-mantle locking mechanism.

The *head* is broad and bears large eyes. There is no lateral or dorsal constriction between the mantle and head. Posterior to each eye lies a low, flattened knob which is the "olfactory" organ.

The *arms* are very large, but gelatinous. They are in the order of I>II>III>IV. The suckers begin in a single but slightly irregular series near the base of each arm and gradually become biserially arranged proximal to the edge of the web.

The gills are huge and bear 18 lamellae, each of which is robust and highly folded. The body wall which covers the ventral surface of the viscera is surprisingly tough and opaque. Very small nephridial papillae project from near the base of the gills. Posterior and lateral to the large median pallial adductor muscle, a pair of oviducts opens through prominent papillae. Each papilla is extremely large and muscular. The largest eggs in the ovary are about 1.5 mm long by 0.5 mm wide. The viscera are essentially as illustrated by Thore (1949). The kidneys are very large and extend to the posterior end of the visceral mass. The crop is situated dorsal to the liver, and the stomach and caecum are dorsal and partially posterior to the liver. The entire dorsal surface of the visceral mass is free from the overlying mantle. The space between the visceral mass and the mantle communicates with the ventral mantle cavity laterally around the visceral mass anterior to the funnel-retractor muscles.

The rachidian tooth of the radula is tricuspid; the first lateral is small and bicuspid, and the second and third laterals are unicuspid. The marginals are simple and broad.

The data for the single specimen captured are: Sex, ♀; M.L., 115 mm; M.W., 126 mm; H.W., 120 mm; Arm L., I–IV, respectively, 360 mm, 260 mm, 240 mm, 200 mm; Eye D., 38 mm.

TYPE LOCALITY.—South of Newport, Rhode Island, western north Atlantic.

LOCATION OF TYPE.—United States National Museum.

DISCUSSION.—Thore (1949) concluded that there is only a single species in the Alloposidae. I have compared my large, but rather poorly preserved, specimen with material from the Atlantic Ocean and can find no noticeable difference.

DISTRIBUTION.—The single specimen, captured in August by the VELERO, came from the Santa Catalina Basin (33°23′ N, 118°49′ W). Thore (1949) reviewed the distribution of *A. mollis* and has shown that it is restricted to tropical and subtropical waters throughout the world.

Family OCTOPODIDAE Orbigny, 1845

DIAGNOSIS.—Benthic octopods with simple lateral radular teeth and without a detachable hectocotylus. Stomach and caecum posterior to liver.

Octopus Lamarck, 1798

DIAGNOSIS.—Arms with biserial suckers. Ink sac normal, web moderate. Third right arm hectocotylized. Single penial diverticle. Without velar pouches or finlike membranes. Mantle aperature wide.

TYPE SPECIES.—*Octopus vulgaris* Lamarck, 1798.

Octopus species

PLATE 38A

DESCRIPTION.—The *mantle* is short and broad; its width is roughly 80–85% of its length. The mantle opening extends to the ventral margin of the eyes. The head is narrower than the mantle, and there is only a slight constriction between them. The eyes are small. The integument over the mantle and head appears to contain a definite pattern of papilla in the larger specimens which is rather inconspicuous when retracted. There is a simple median papilla on the dorsal surface of the head at the level of the anterior edge of the eyes. Dorsal to the posterior portion of each eye, there is a complex occular cirrus. On the mantle immediately posterior to each eye is a simple papilla. Just slightly posterior to these, in the dorsal midline is a single median papilla. At about 40% of the mantle length from the anterior edge of the mantle is a pair of simple papillae; each member is situated on a dorsolateral edge of the mantle. At about 25% of the M.L. from its posterior end a similar pair of simple papillae is situated on the dorsolateral areas of the mantle, but slightly ventral to the more anterior pair. There are other papillae that are smaller and often difficult to locate.

The entire surface of the mantle in the larger specimens is slightly granular.

The *funnel* extends to the level of the anterior edges of the eyes. The funnel organ is W-shaped, with the lateral arms at least as long as the median ones.

The *arms* are short and robust. The arm formula is somewhat variable, but in general the arms are subequal. The right arm III of the largest male is

hectocotylized. The ligula is short and broad and incompletely formed; it is about 2% of the arm length. A calamus is not present. Suckers are arranged in 2 rows on the arms, and there are no especially enlarged suckers. The web formula is somewhat irregular, but appears to be B=C=D>A=E. The gills are large and have approximately 23–26 primary lamellae.

Numerous reddish brown *chromatophores* are scattered over the animal, but are more concentrated on the dorsal surface. In life the ventral surface has a silvery, iridescent sheen.

Discussion.—There are numerous specimens of pelagic larval *Octopus* in the collections which appear to belong primarily to one species. Specimens range from less than 2 mm M.L. up to 25 mm M.L. This description refers to the larger specimens only. The following survey briefly discusses possible relationship of the large specimens to the known species of this area.

There are currently 9 species of *Octopus* recognized from southern California and adjacent shores. These are: *O. bimaculatus* Verrill, 1883; *O. bimaculoides* Pickford and McConnaughey, 1949; *O. leioderma* (Berry 1911); *O. californicus* (Berry 1911); *O. rubescens* Berry, 1953; *O. dofleini* (Wülker 1910); *O. pricei* (Berry 1913); *O. micropyrsus* Berry, 1953; and *O. penicillifer* Berry, 1954.

Octopus bimaculatus and *O. bimaculoides* are sibling species that are easily distinguished from the others by the presence of a pair of ocelli near the bases of arms II and III. *O. bimaculoides* has a well-developed ocellus at a mantle length of 9 mm and does not have a pelagic larval stage. *O. bimaculatus* has small eggs and presumably pelagic larvae. Type localities: *O. bimaculatus,* San Diego, California; *O. bimaculoides,* Devil's Slide, La Jolla, California. There are no ocelli present in the pelagic juveniles of VELERO collections; also, the number of primary gill lameallae (23–26) falls outside the maximum range (14–20) for *O. bimaculatus.* This latter feature is sufficient to eliminate the inclusion of the VELERO specimens in *O. bimaculatus.*

The adults of *O. leioderma* have a short, squat body, smooth integument, a lateral keel-like fold around the mantle, and large eyes. Also the dorsal arms are longer than the other pairs. The smallest specimens overlap the VELERO material in size which, according to Berry, exhibit all characteristics of the adults. Type locality: Shelikof Strait, Alaska; also recorded by Berry (1912b) from Monterey Bay. The arm formula, the keel on the mantle, the smooth integument and the large eyes would seem to eliminate the VELERO specimens from this species.

O. californicus can be distinguished by the presence of two, norrowly separated V-shaped funnel organs. In addition, the juveniles which overlap the VELERO specimens in size have enormous eyes. Clearly, the VELERO juveniles do not belong to this species. Type locality: Vicinity of San Diego, California.

Berry (1953) states that *O. rubescens* seems to be the commonest small offshore species of *Octopus* in the waters of southern California and Baja California. In addition, he states the eggs are minute (1.3 mm), and from this it may be assumed that the larvae are pelagic. Berry described the integument as "superficially smooth but under a lens seems to be raised in a tessellate pattern of low blister-like welts, with a few symmetrically disposed, rather small, papillae-like cirri on the dorsum and sides." In the largest of the VELERO specimens, there is some indication of "blister-like welts" and the papillae seem similar to those in the present larvae. The holotype of this species is a male with a body length (32 mm) only slightly larger than the largest VELERO specimen. The much longer arms, long ligula, and a few enlarged suckers on the arms indicated that this species may be separate from the VELERO species, although it is quite possible that these differences would be resolved after the pelagic larvae adopt a benthic habitat. Unfortunately, the gill count is un-

Table 25.—*Measurements in mm of* Octopus *sp.*

Characters	*Station Numbers of the VELERO*			
	7393	7387	7412	7414
M.L.	15	17	18	25
M.W.	11	13	13	18
H.W.	9	11	10	15
Arms I	27	35	39	48
II	29	38	43	54
III	30	33	40	50
IV	29	29	41	48
Eye D	4	4.5	4	5
Gill F	24	25	26	25
Sucker D	1.5	1.7	1.5	2.0

known. Type locality: 7–17 fathoms off South Coronado Island, Baja California, Mexico.

Pickford (1964) referred the giant octopus of California to *Octopus dofleini*. The gap in size between described specimens of this species and the VELERO specimens is great; however, *O. dofleini* has eggs that are 6–8 mm long and, therefore, are probably not pelagic. Also the number of primary lamellae on the gills varies from 40–60. The number of gill lamellae, at least in some species (Burgess 1966) do not seem to vary with the mantle length. Although it is possible that the gill lamellae increase in numbers upon settling, at our present state of knowledge the great number of lamellae in *O. dofleini* must be considered as evidence against relationship. Other differences concern the greater length of the arms and the very elongate ligula in *O. dofleini*. Both features could be due to growth. The weight of evidence appears, however, to be against aligning the VELERO specimens with *O. dofleini*. Type locality: Hokkaido, Japan.

O. pricei has been described from specimens considerably smaller (18 mm M.L.) than the larger VELERO specimens. Berry (1913) stated that this species has very large eyes; this feature alone is enough to separate it from the VELERO specimens, which possess small eyes. Type locality: From stomach of *Onchorhynchus tschawytscha* taken off Point Pinos, Monterey Bay, California.

O. micropyrsus is considerably smaller (10 mm M.L.) than larger VELERO specimens. It has more slender arms, larger eyes, a few enlarged suckers, and an enormous calamus which clearly separate it from the VELERO specimens. Type locality: Off La Jolla, California.

O. veligero is also a small species, although specimens have not been recorded which overlap VELERO specimens in size. Its tripartite funnel organ, fewer gill lamellae and the velumlike prolongations of the web along the ventral margins of the arms separate it from the VELERO *Octopus*. Type locailty: 50 fathoms off San Juanico, Baja California, Mexico.

The unfortunate conclusion resulting from this brief survey is that the VELERO specimens are not clearly referable to any of the known species. This is a somewhat surprising result considering the great abundance of these larvae in the plankton. Part of the difficulty in identification results from the inadequate descriptions of known species. Certainly much of the difficulty is due to their possession of larval characteristics, in spite of their rather large size, and that only after settling and subsequent metamorphosis will it be possible to definitely determine their identity. The problem remains an interesting one for future workers.

Order VAMPYROMORPHA

Family VAMPYROTEUTHIDAE Thiele, 1915

DIAGNOSIS.—Oral crown consists of 8 arms and 2 retractile, sensory filaments. Mantle fused to the head. Fins are present. Suckers are arranged in single series on the arms and lack chitinous rings. Photophores are present.

Genus *Vampyroteuthis* Chun, 1903

DIAGNOSIS.—Characters are the same as those of the family.

Vampyroteuthis infernalis Chun, 1903

PLATES 35A; 36E–G

Vampyroteuthis infernalis Chun, 1903, p.88, text fig. [no number].—Thiele, 1915, p.534, text figs. 67–70, pl.40, pl.41, figs. 1–5.—Robson, 1932, p.90.—Pickford, 1946, p.1; 1949, p.1, pl.1–9.

Cirroteuthis macrope.—Berry, 1912b, p.2733, text fig.1, pl. 32, figs. 1–3.

DESCRIPTION.—The short, broad *mantle* is extensively fused ot the head dorsally. The mantle wall is thick, but very gelatinous. The *fins* which arise subterminally are large and paddlelike. The large *funnel* is embedded in the gelatinous tissue of the head for almost its entire length. The funnel organ consists of only 2 small, oval pads. A funnel valve is present.

The *head* is broad and bears very large eyes. There is no anterior sinus on the circular eyelid. A small "olfactory" papilla is present posterior to each eye. The animal has 8 *arms*, each of which bears a single row of suckers. The suckers, which lack chitinous rings, alternate with lateral cirri along most of the arm length except basally, where the arms are bare. About 12–18 primary cirri occur proximal to the first sucker on each arm. The suckers disappear on the very attenuate arm tips and only the conical sucker bases re-

TABLE 26.—*Measurements in mm for* Vampyroteuthis infernalis *Chun, 1903.*

Characters	California								Africa							
	Station Numbers of the VELERO								*Station Numbers of the PILLSBURY*							
	8796		10259		10259				308		308		308		308	
Sex	♀		♂		♂		♂		♀		♀		♀		♂	
P.L.	74		58		79		60		78		64		56		49	
P.W.	31		28		34		26		38		35		29		25	
Egg Diam.	0.9		—		—		—		4.0		2.8		—		—	
Sucker D.	1.5		1.2		1.7		1.4		2.6		2.2		1.7		1.7	
	L	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*
Gill L.	21	22	21	21	21	22	15	16	17	16	13	12	12	—	10	—
Gill W.	11	11	9	8	8	10	7	8	7	7	5	6	4	—	4	—
Filament L.	12	11	9	8	10	10	7	8	7	7	7	7	4	—	5	—
Ov. G. Diam.	2	2	—	—	—	—	—	—	6	6	5.5	6	—	—	—	—

main; also the lateral cirri fuse together to form a membrane along each distal margin. The arms are joined by an extensive web that extends approximately to the point where the lateral cirri fuse, but not quite to the point where the suckers terminate. The web is equally developed between all arms. Between arms I and II on either side, a slender, retractile filament extends from a pocket on the dorsal surface of the web. The filament is frequently completely retracted within this pocket and may be difficult to locate.

There is no *buccal membrane.*

Numerous small *photophores* are scattered over the surface of the head, mantle, fins, and arms, but are more abundant on the ventral surfaces of the animal. Photophores are lacking on the oral surface of the arms and web and from the aboral surface of the web. A single large photophore is located just posterior to each fin. An oval patch of thickly packed small photophores is located on the dorsolateral surface of the body at the level of the mantle opening.

In *females* there is a flask-shape vesicle imbedded anterior to each eye which functions as a spermatophore receptacle. Eggs are about 3 mm in diameter at maturity. Nidamental glands are lacking. The oral face of the arms and web is *jetblack.* The aboral surfaces, including the fins and mantle, are also nearly black, but seem to have a slight purple tint in the living specimens.

In the specimens counted, the *gills* each had from 28–31 filaments.

Larval specimens have a single posterior pair of fins. With increased size an anterior pair begins to develop that eventually surpasses the larval fin in size. The larval fin degenerates and is represented in adult specimens by a small pocket behind the adult fins.

TYPE LOCALITY.—Region of the Cape Verde Islands.

LOCATION OF TYPE.—Berlin Museum, Berlin, Germany.

DISCUSSION.—A single species, *V. infernalis,* is presently recognized in the order. I compared specimens from the Gulf of Guinea which is not far from the type locality, with specimens from California and find that there are a number of differences. The most apparent difference is the great discrepancy in beak size which can be seen by the illustrations on Plate 36. In addition, the suckers are smaller in the California specimens, the gills are much larger, the females mature at a much larger size, and the eggs at maturity seem to be smaller. Most of these features are somewhat variable and must be used with caution. There can be, however, no doubt that the California and African specimens are significantly different. At present, these differences are interpreted as representing geographical variation; however, a more intensive study of the problem is warranted.

DISTRIBUTION.—Pickford (1946) has demonstrated that *Vampyroteuthis infernalis* has a worldwide distribution primarily within the tropical and subtropical oceans, but with northern and southern

limits near the fortieth parallels of latitude. This species has previously been known to occur off the coast of southern California (Berry 1912) and has recently been reported off the coast of Oregon (Pearcy 1965) at a latitude of approximately 44° N. In the present study, *Vampyroteuthis* was found to be relatively abundant in all the areas sampled. The highest frequency of capture (1.19 specimens/hour) occurred in zone 6 and lowest (0.23 specimens/hour) occurred in zone 1 (San Pedro Basin).

Records of Additional Pelagic Species from off Southern California

A number of other species of pelagic cephalopods occur in the southern California area, but were not included in this study since material was either lacking or inadequate for proper treatment. These species consist of the following: *Dosidicus gigas, Moroteuthis robusta, Loligo opalescens, Thelidioteuthis* sp., *Pterygioteuthis giardi, Argonauta pacifica, Branchioteuthis* sp., *Taonius* sp., *Liocranchia* sp., and *Eledonella* sp.

Dosidicus gigas commonly occurs off the western coasts of Central and South America and Mexico. Occasionally, it is found in the waters off California and has been reported as far north as Monterey Bay. In the years 1934–1937, it was particularly abundant in local waters. Croker (1937) in recording its occurrence stated: "The plague of jumbo squid has been worse in 1937. Set line, net and troll commercial fishermen are still bothered by them, and in addition sport fishermen have been harassed all spring. No sooner does a pleasure boat start to fish than a horde of squid appears on the scene to crowd the game fish away and seize all the baits. When one is hooked, it proceeds to shower boat and fishermen with ink and water, and then delights in biting its captor with its parrot-like beak. Several fishermen have been seriously bitten this year. Although squid fishing is hilarious sport for a few minutes, it becomes too much of a good thing day after day." *Dosidicus gigas* attains considerable size: 4½ feet (Classic 1949) and a weight of more than 30 pounds (Croker 1937) have been recorded for specimens off California, but much larger specimens have been reported off South America. Specimens of *D. gigas* can easily be distinguished from other local ommastrephids by their attenuate arm tips bearing many small suckers which increases the total sucker count to well over 200 suckers per arm. This is more than three times the sucker count of other local ommastrephids.

Moroteuthis robusta has been captured off the west coast of north America, along the Aleutian Islands, and off northern Japan. Although this species has been recorded a number of times from California, only one record (Croker 1934) occurs as far south as the present study area. This species attains a mantle length of at least 7½ feet (Berry 1912b:315). Although the I.K.M.T. (Isaacs-Kidd Midwater Trawl) is perhaps not well suited for capturing specimens of *M. robusta,* it is somewhat surprising that no larvae were taken. It seems probable that southern California is at the extreme limit of its distribution. *M. robusta* can easily be distinguished from *Onychoteuthis borealijaponicus,* the other local onychoteuthid, by the relatively greater length of the arms, by the larger number of hooks on the tentacular clubs (about 36 in *M. robusta* and 25–27 on *O. borealijaponicus*), and by the lack of photophores.

Loligo opalescens is probably the most abundant cephalopod species occurring off the California coast. This species is epipelagic and fast moving, and therefore difficult to capture with an I.K.M.T. Over 80 specimens, however, were taken during the present study, but most were larval forms under 10 mm M.L. Fields (1965) did a detailed study of the biology of this species, and nothing could be added from the present collection. *L. opalescens* is fished commercially off California, primarily at Monterey. Over the past 17 years, the average catch has been approximately 6,500 tons per year; the maximum catch of 19,000 tons occurred in 1946 (Fields 1965).

L. opalescens is the only member of the sub-order Myopsida occurring off California. It can be easily separated from all other squid of this area by the presence of a cornea covering the lens of each eye.

The several specimens of *Taonius* sp. taken during the present program were too badly damaged to treat systematically. *Taonius* has also been reported from off Oregon (Pearcy 1965). This cranchiid appears very similar to *Galiteuthis,* but instead of the central club suckers being modified into hooks, each looks like a set of claws (i.e., a number of elongate teeth on each sucker).

Berry (1912b) recorded a small, finned octopod captured off San Diego, California as "? *Stauroteuthis* sp." The identity of this form is still uncertain, since no additional material has been taken. Judging, how-

ever, from the small size of the fins and the large size of the eyes, it is possible that this is a juvenile specimen of *Opisthoteuthis californiana* Berry, 1949.

Argonauta pacifica has been reported from off California on a number of occasions (see Berry 1912b). It is not yet certain whether this form is specificially distinct from the Atlantic *Argonauta argo*. Several larval specimens of the "paper nautilus" are present in the VELERO collections from off Baja California, but can only be referred to *Argonauta* sp. Specimens of *Argonauta* can easily be recognized. The tips of the dorsal arms in females are each provided with an extensive flaglike web which is responsible for secreting the paper-thin shell that serves both as a broad chamber and a flotation device. Males are dwarfed and lack the modifications of the dorsal arms; however, the third *left* arm is hectocotylized, and enrolled in a sac; this feature distinguishes *Argonauta* from all other cephalopods.

Recntly McGowan (1967) has indicated the presence of *Pterygioteuthis giardi* in the southern California area. This species is very similar to *P. gemmata,* but can easily be separated by the presence of biserial hooks in the middle of the arms. Apparently, this warm-water species occurs off southern California only during certain years.

Other species taken in the present study include larval specimens of *Liocranchia* sp., *Thelidioteuthis* sp. from zone 7, *Brachioteuthis* sp. from zone 6, and one damaged specimen of *Eledonella* sp. from zone 3.

Checklist of Cephalopods Definitely Known to Occur in Southern Californian or Neighboring Waters

Order Sepioidea
- Family Sepiolidae
  - *Rossia pacifica* Berry, 1911 †

Order Teuthoidea
- Suborder Myopsida
  - Family Loliginidae
    - *Loligo opalescens* Berry, 1911
- Suborder Oegopsida
  - Family Enoploteuthidae
    - *Abraliopsis falco,* new species*
    - *Abraliopsis felis* McGowan and Okutani, 1968 *
    - *Pyroteuthis addolux,* new species *
    - *Pterygioteuthis gemmata* Chun, 1908 *
    - *Pterygioteuthis giardi* Fischer, 1895
    - *Thelidioteuthis* sp.
  - Family Ommastrephidae
    - *Dosidicus gigas* d'Orbigny, 1835
    - *Ommastrephes bartramii* (Lesueur, 1821) *
    - *Symplectoteuthis luminosa* Sasaki, 1915 *
  - Family Neoteuthidae
    - *Neoteuthis* sp.*
  - Family Histioteuthidae
    - *Histioteuthis heteropsis* (Berry, 1913) *
    - *Histioteuthis dofleini* (Pfeffer, 1912) *
    - *Histioteuthis corona berryi* Voss, 1969
  - Family Octopoteuthidae
    - *Octopoteuthis deletron,* new species *
  - Family Gonatidae
    - *Gonatus onyx,* new species *
    - *Gonatus berryi* Naef, 1923 *
    - *Gonatus pyros,* new species *
    - *Gonatus californiensis,* new species *
    - *Gonatopsis borealis* Sasaki, 1923 *
  - Family Onychoteuthidae
    - *Onychoteuthis borealijaponicus* Okada, 1927 *
    - *Moroteuthis robusta* Verrill, 1876
  - Family Brachioteuthidae
    - *Brachioteuthis* sp.
  - Family Mastigoteuthidae
    - *Mastigoteuthis pyrodes,* new species *
  - Family Chiroteuthidae
    - *Chiroteuthis calyx,* new species *
    - *Valbyteuthis oligobessa,* new species *
    - *Valbyteuthis danae* Joubin, 1931 *
  - Family Grimalditeuthidae
    - *Grimalditeuthis bomplandii* (Vérany, 1837) *
  - Family Bathyteuthidae
    - *Bathyteuthis berryi* Roper, 1968 *
  - Family Cranchiidae
    - *Cranchia scabra* Leach, 1817 *
    - *Leachia dislocata,* new species *
    - *Galiteuthis phyllura* Berry, 1911 *
    - *Galiteuthis pacifica* Robson, 1948 *
    - *Helicocranchia pfefferi* Massy, 1907 *
    - *Taonius* sp.
    - *Liocranchia* sp.

Order Octopoda
- Suborder Cirrata
  - Family Opisthoteuthidae
    - *Opisthoteuthis californiana* Berry, 1949
- Suborder Incirrata
  - Family Bolitaendiae
    - *Japetella heathi* (Berry, 1911) *

Japetella sp.*
Eledonella sp.
Family Ocythoidae
Ocythoe tuberculata Rafinesque, 1814*
Family Alloposidae
Alloposus mollis Verrill, 1880 *
Family Argonautidae
Argonauta pacifica
Family Octopodiae
Octopus bimaculatus (Verrill, 1883)
Octopus bimaculoides Pickford and McConnaughey, 1949
Octopus leioderma (Berry, 1911)
Octopus californicus (Berry, 1911)
Octopus rubescens Berry, 1953
Octopus micropyrsus Berry, 1953
Octopus dofleini (Wülker, 1910)
Octopus penicillifer Berry, 1954
Octopus pricei Berry, 1913
Order Vampyromorpha
Family Vampyroteuthidae
Vampyroteuthis infernalis Chun, 1903 *

† Berry has divided *R. pacifica*, a benthic sepiolid, into two subspecies: *R. p. pacifica* and *R. p. diegensis*.
* Species described in this report.

For a complete review of the early work done along the Pacific coast of North America, the reader is referred to the excellent paper of Berry (1912b).

Summary

Systematics

1. Thirty-three species of pelagic cephalopods and the pelagic larval stage of a benthic octopus are described, and a key to their identification is presented.

2. The following 10 species are described as new to science: *Abraliopsis falco, Pyroteuthis addolux, Octopoteuthis deletron, Gonatus onyx, Gonatus pyros, Gonatus californiensis, Chiroteuthis calyx, Valbyteuthis oligobessa, Mastigoteuthis pyrodes,* and *Leachia dislocata.*

3. It is demonstrated that *Abraliopsis felis* and *Watasenia scintillans* do not belong in the same subgenus.

4. *Pyroteuthis margaritifera oceanica, Pyroteuthis margaritifera aurantiaca* are considered to be invalid subspecies.

5. *Pterygroteuthis gemmata* is shown to undergo considerable geographical variation in the number of arm hooks.

6. The photophore patterns of *Ommastrephes bartramii* and *Symplectoteuthis luminosa* are described.

7. The genus *Neoteuthis* is delineated and the family Alluroteuthidae is synonymized with the family Neoteuthidae.

8. *Octopoteuthis longiptera* is declared a doubtful species. It is suggested that all identifications of *Octopoteuthis sicula* from the Atlantic Ocean must be held in question until the photophore pattern of specimens from the type locality in the Mediterranean is determined. *Octopodoteuthopsis* is submerged for the second time into *Octopoteuthis.*

9. The formerly monotypic genus *Gonatus* is shown to consist of at least 10 species, 4 of which live sympatrically off California. The number of arm and club suckers in members of the genus are shown to become fixed at a very early stage and constitute an important systematic character. Each species off California is shown to have a distinctive pattern at the time when various arm and club hooks appear.

10. Larval *Gonatopsis borealis* are shown to possess tentacles which are lost abruptly at 8–11 mm M.L. *Gonatopsis borealis makko* is elevated to specific status.

11. *Onychoteuthis borealijaponicus* is shown to be a valid species. It is further suggested that *"O. banksii"* represents a complex of species.

12. The formerly monotypic genus *Valbyteuthis* is shown to consist of at least 5 species, 2 of which are undescribed.

13. The enlarged photophore embedded in the eyelid of certain *Mastigoteuthis* is shown to be a widespread feature in the genus. *M. grimaldii* and *M. iselini* are declared doubtful species. *M. levimana* is transferred to the genus *Valbyteuthis. Mastigoteuthis glaukopis atlantica* is elevated to specific status. *M. dentata* is briefly redescribed from material taken at the type locality off Panama.

14. *Pyrgopsis* is shown to represent a larval stage of *Leachia.*

15. *Galiteuthis phyllura* is considered to be a valid species, although evidence for its separation from *G. armata* is not conclusive. *Taonidium pacificum* is shown to be a larval *Galiteuthis* and a valid species.

16. *Helicocranchia* is demonstrated to be a valid and distinctive genus. The enigmatical genus *Ascocranchia* is shown to be a close relative of *Helicocran-*

chia. The identification of *Helicocranchia pfefferi* off California needs confirmation through the comparison of adults from the Atlantic and Pacific oceans.

17. Two sympatric species of *Japetella* are shown to occur off California, but their taxonomic separation has been incomplete.

18. The abundant octopus larvae appear to belong predominantly to one species, but it has not been identified.

19. It is suggested that Berry's *Stauroteuthis* sp. may be the young of *Opisthoteutnis californiana.*

20. Species known to occur off California, but not encountered in the present trawling program, are briefly distinguished from those described in this paper.

Distribution

1. Northern zones within the area studied have predominantly Subarctic and Transitional water species.

2. Southern zones have predominantly tropical species. The two most numerous of which appear to be associated with the north Pacific central water.

3. Forty-two species of pelagic cephalopods are now known from the waters off southern California, of which 36 have been identified to the specific level. Only 10 of these species appear to be cosmopolitan; however, in only 4 of the 10 species were detailed comparisons with Atlantic specimens possible. All 4 showed marked geographical variation.

4. All 10 apparently cosmopolitan species are associated primarily with tropical and subtropical waters.

5. It is suggested that *Histioteuthis heteropsis* and *Octopoteuthis deletron* are antitropical species.

6. *Gonatus onyx, G. californiensis,* and *G. pyros* appear to occur primarily in the inshore waters over the Continental borderland while *Onychoteuthis borealijaponicus,* larval *Abraliopsis felis,* and *Pyroteuthis addolux* showed preference for more oceanic waters.

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Appendix 1

After the present manuscript was completed, a paper by Okutani and McGowan (1969) on the systematics and distribution of larval squid from the California current was published. Fourteen species of larval squid are described and information is presented on spawning and distribution of some of these. The authors attempted to identify the larvae by tracing successive developmental stages to the identifiable adult (page 7). This is a difficult task under the best circumstances; however, it becomes doubly difficult when the systematics of the adults is in an unstable state as it was when these authors undertook their project. Laboring under these handicaps, it is inevitable that errors will be made; however, as long as the following emendations are considered, little information will be lost from their paper because of systematic difficulties.

1. Specimens identified as *Octopodoteuthopsis* sp. almost certainly belong to *Octopoteuthis deletron.*

2. *Onychoteuthis banksii* should read *Onychoteuthis borealijaponicus.* Their illustration (figure 9*c*) shows a tentacular club with 26 hooks, a feature distinctive of this latter species. Their records of this species are shown to extend far south to the tip of Baja California. The most southernly records possible belong to a member of the *"O. banksii"* complex. This is somewhat suggested by the shape of the individual in figure 9*h* (no locality data are given for this figure); however, even if this proves to be the case, it will not significantly effect the conclusions reached by Okutani and McGowan.

3. The larvae identified as *Gonatus fabricii* probably belong to the most dominant species in the genus off California, *Gonatus onyx,* and this is attested to by their figure of a club belonging to this species (page 28, figure 10*a*). Larvae of *G. pyros* and *G. californiensis* are extremely close to those of *G. onyx* and since these species are quite common, I suspect some of their specimens belong to these species also. The authors mention that 10 larvae had more slender and opaque mantles. I suspect that these are larvae of *Gonatopsis borealis* and not *Berryteuthis magister* as is suggested. Okutani and McGowan state that this latter animal is known from the California coast. I have not been able to find this record, but its occasional occurrence here would not be surprising since it has been reported from Oregon. Even if the species gets as far south as southern California, I doubt that it breeds here as no larvae or juveniles have been taken in the University of Southern California's trawling program.

4. Juveniles identified as *Meleagroteuthis heteropsis* consist of two species: *Histioteuthis heteropsis* (figure 12*c*) and *H. dofleini* (figure 12*d*).

5. The specific identification of their *Ctenopteryx* must be held in question. The genus is in a systematic

jumble at present.

6. Larvae identified as *Chiroteuthis veranyi* almost certainly belong to *C. calyx*.

7. Species identified as *Pyrogopsis pacificus* belong to *Leachia dislocata* as evidenced by figure 16*b* which shows the displaced tubercle characteristic of the species.

8. Species identified as *Teuthowenia megalops* almost certainly belong to *Galiteuthis phyllura*.

These authors add two species to those now known from southern Californian and adjacent waters. These are *Liguriella* sp. from 28°17′ N, 118°58′ W and 29°12′ N, 115°38′ W, and *Ctenopteryx* sp. from 27°33′ N and 115°53′ W.

Appendix 2

Stations Cited

VELERO Station Number	*Date*	*Midpoint Latitude and Longitude*	*Wire Out (meters)*
7157	30 September 1960	33°36′ N 118°28′ W	1845
7221	9 December 1960	33°32′ N 118°24′ W	1385
7279	2 February 1961	33°32′ N 118°23′ W	2000
7280	2 February 1961	33°29′ N 118°20′ W	925
7343	7 April 1961	33°33′ N 118°24′ W	2300
7387	15 August 1961	33°31′ N 118°18′ W	1075
7389	15 August 1961	33°29′ N 118°20′ W	1690
7393	16 August 1961	33°30′ N 118°22′ W	770
7394	16 August 1961	33°33′ N 118°22′ W	2300
7409	6 September 1961	33°36′ N 118°24′ W	1690
7410	6 September 1961	33°30′ N 118°18′ W	2000
7411	6 September 1961	33°29′ N 118°19′ W	2300
7412	6 September 1961	33°37′ N 118°24′ W	2300
7414	7 September 1961	33°28′ N 118°19′ W	1690
7415	7 September 1961	33°32′ N 118°26′ W	2000
8018	19 July 1962	33°18′ N 118°40′ W	3090
8022	20 July 1962	33°19′ N 118°42′ W	3090
8024	7 August 1962	33°21′ N 118°46′ W	1385
8025	7 August 1962	33°16′ N 118°38′ W	1690
8026	8 August 1962	33°22′ N 118°43′ W	1385

Stations Cited

VELERO Station Number	*Date*	*Midpoint Latitude and Longitude*	*Wire Out (meters)*
8027	8 August 1962	33°22′ N 118°43′ W	1690
8028	8 August 1962	33°15′ N 118°32′ W	2000
8030	9 August 1962	33°09′ N 118°23′ W	1690
8031	9 August 1962	33°10′ N 118°22′ W	1385
8111	21 August 1962	33°21′ N 118°45′ W	2300
8112	22 August 1962	33°21′ N 118°44′ W	2300
8114	22 August 1962	33°15′ N 118°31′ W	2000
8116	23 August 1962	33°19′ N 118°44′ W	1385
8117	23 August 1962	33°19′ N 118°45′ W	2000
8120	5 September 1962	33°20′ N 118°43′ W	3090
8121	5 September 1962	33°12′ N 118°32′ W	770
8123	5 September 1962	33°15′ N 118°35′ W	770
8237	22 October 1962	33°15′ N 118°25′ W	2300
8238	25 October 1962	33°23′ N 118°48′ W	3380
8243	26 October 1962	33°20′ N 118°45′ W	1540
8292	8 November 1962	33°22′ N 118°45′ W	770
8697	23 May 1963	33°22′ N 118°46′ W	3695
8716	7 June 1963	33°15′ N 118°37′ W	925
8795	18 July 1963	33°21′ N 118°46′ W	2460
8796	July 1963	33°22′ N 118°44′ W	1845

Stations Cited (continued)

VELERO Station Number	*Date*	*Midpoint Latitude and Longitude*	*Wire Out (meters)*
8878	20 August 1963	33°01′ N 119° 04′ W	3090
8881	21 August 1963	33°03′ N 119°00′ W	925
8934	18 September 1963	33°11′ N 118°28′ W	1540
9056	14 November 1963	33°18′ N 118°42′ W	3380
9249	25 January 1964	33°19′ N 118°38′ W	1540
9349?		Catalina Basin?	
9602	16 April 1964	33°17′ N 118°40′ W	1540
9603	17 April 1964	33°22′ N 118°54′ W	1075
9605	17 April 1964	33°20′ N 118°37′ W	770
9661	14 May 1964	32°59′ N 119°02′ W	3090
9890	5 August 1964	32°48′ N 120°56′ W	310
9899	7 August 1964	29°58′ N 119°12′ W	1845
9901	7 August 1964	29°33′ N 118°59′ W	310
9905	8 August 1964	29°19′ N 119°21′ W	2460
9960	September 1964	Catalina Basin	1845
10259	13 January 1965	33°19′ N 118°41′ W	2125
10260	13 January 1965	33°18′ N 118°42′ W	1075
10265	14 January 1965	33°17′ N 118°40′ W	3370
10399	7 March 1965	33°04′ N 119°08′ W	1385
10401	8 March 1965	32°59′ N 119°01′ W	1845

Stations Cited (continued)

VELERO Station Number	*Date*	*Midpoint Latitude and Longitude*	*Wire Out (meters)*
10402	8 March 1965	33°08′ N 119°13′ W	925
10673	27 August 1965	29°37′ N 118°33′ W	Surface
10677	28 August 1965	29°05′ N 118°06′ W	1230
10679	28 August 1965	28°54′ N 118°08′ W	93
10838	24 November 1965	31°14′ N 118°45′ W	1230
10840	25 November 1965	30°23′ N 118°29′ W	4000
10841	25 November 1965	30°00′ N 118°26′ W	3090
10844	26 November 1965	28°54′ N 117°49′ W	4000
10897	5 January 1966	31°42′ N 118°30′ W	1230
10906	6 January 1966	29°12′ N 118°09′ W	3090
10973	16 February 1966	32°45′ N 120°31′ W	3090
10976	17 February 1966	32°27′ N 120°27′ W	4000
10985	18 February 1966	31°18′ N 117°22′ W	3090
11022?		No data	
11097	14 April 1966	32°33′ N 118°04′ W	1385
11100	14 April 1966	32°35′ N 118°06′ W	40
11101	14 April 1966	32°29′ W 118°01′ W	4000
11181	2 August 1966	29°40′ N 118°48′ W	4000
11183	2 August 1966	29°36′ N 118°35′ W	3090
11225	30 August 1966	30°18′ N 118°53′ W	3090

PLATES 1–38

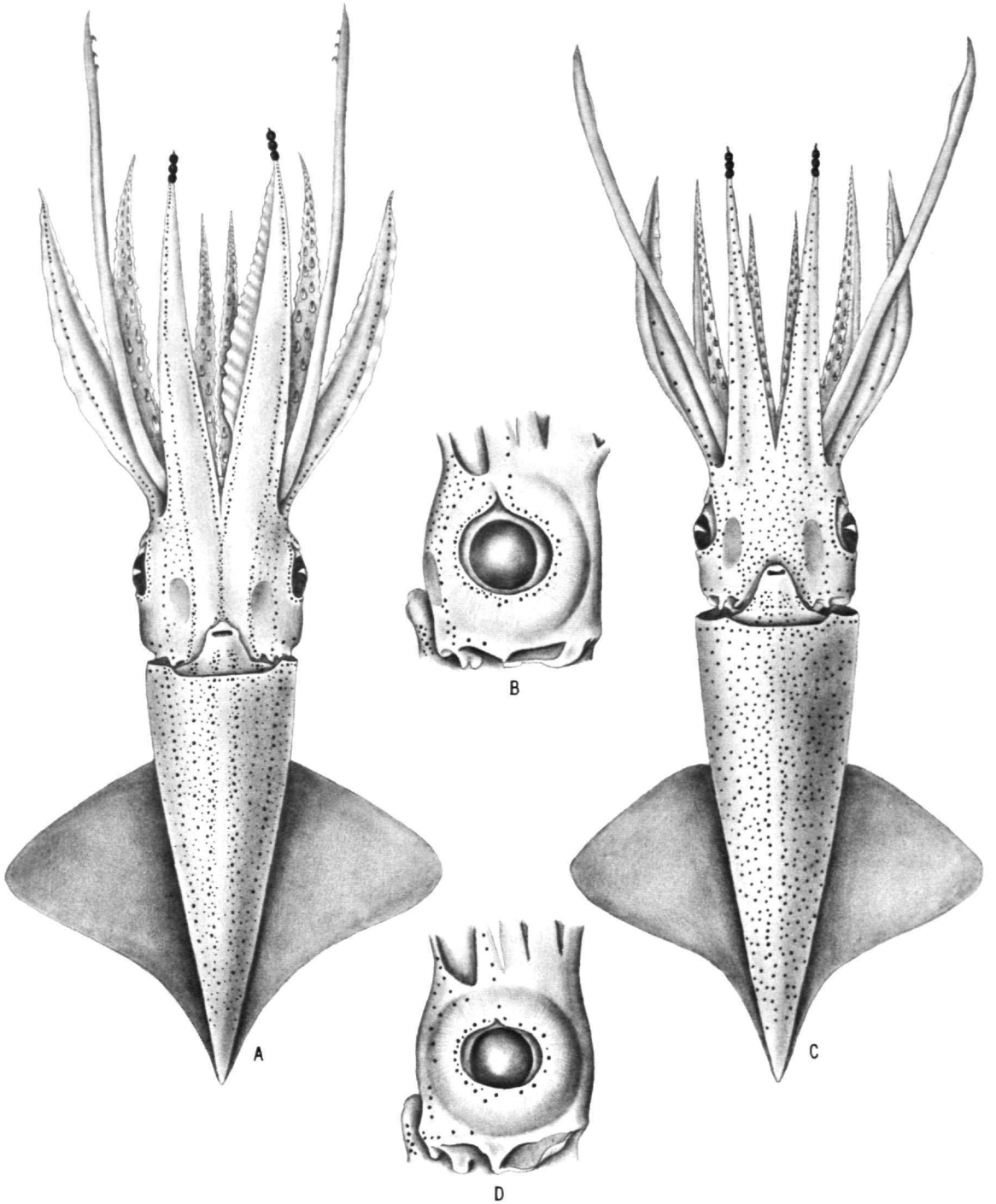


PLATE 1.—A, *Abraliopsis falco*, ventral view, male, M.L. 37 mm; B, same specimen, left side of head; C, *Abraliopsis felis*, ventral view, male, M.L. 41 mm; D, same specimen, left side of head.

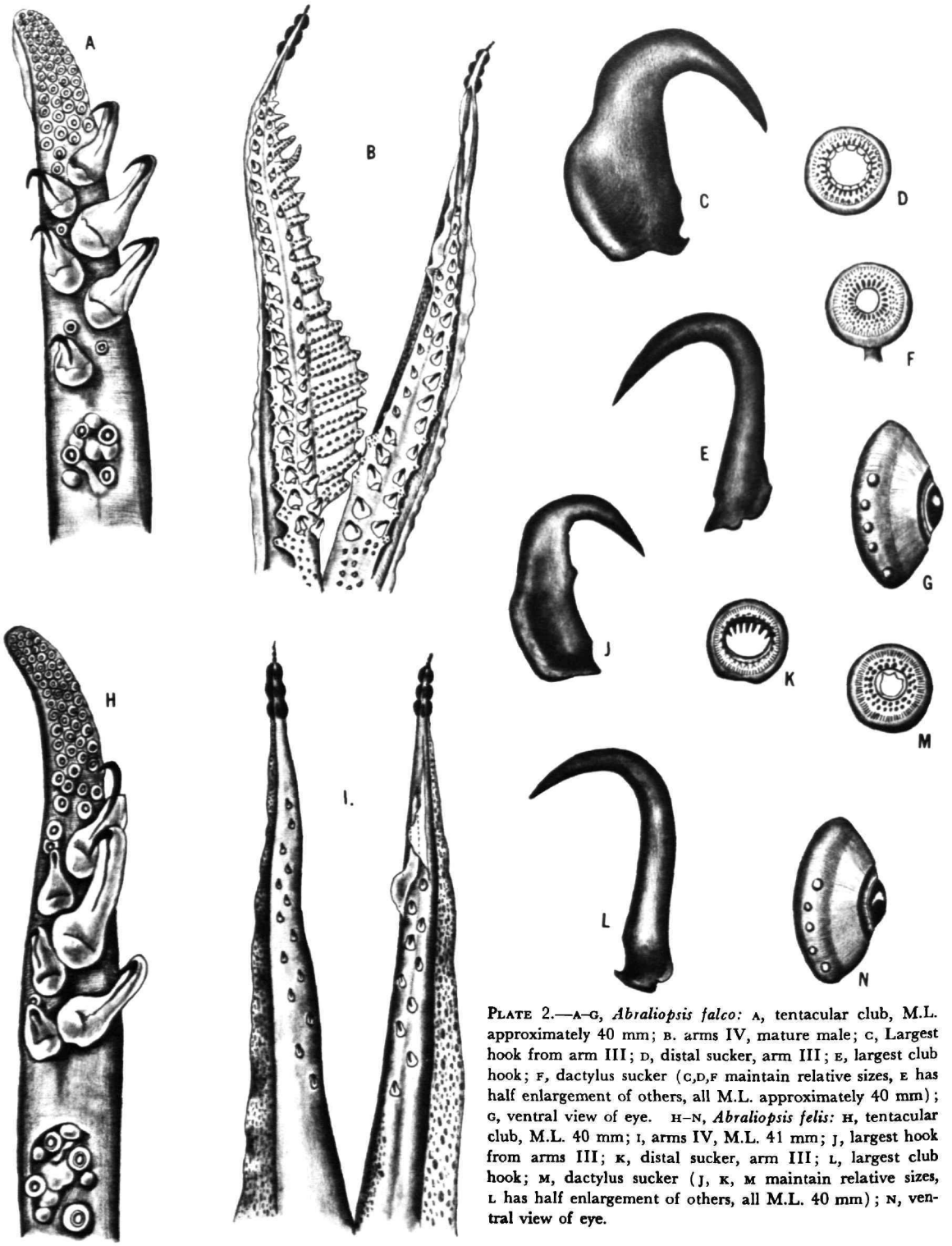


PLATE 2.—A–G, *Abraliopsis falco:* A, tentacular club, M.L. approximately 40 mm; B. arms IV, mature male; C, Largest hook from arm III; D, distal sucker, arm III; E, largest club hook; F, dactylus sucker (C,D,F maintain relative sizes, E has half enlargement of others, all M.L. approximately 40 mm); G, ventral view of eye. H–N, *Abraliopsis felis:* H, tentacular club, M.L. 40 mm; I, arms IV, M.L. 41 mm; J, largest hook from arms III; K, distal sucker, arm III; L, largest club hook; M, dactylus sucker (J, K, M maintain relative sizes, L has half enlargement of others, all M.L. 40 mm); N, ventral view of eye.

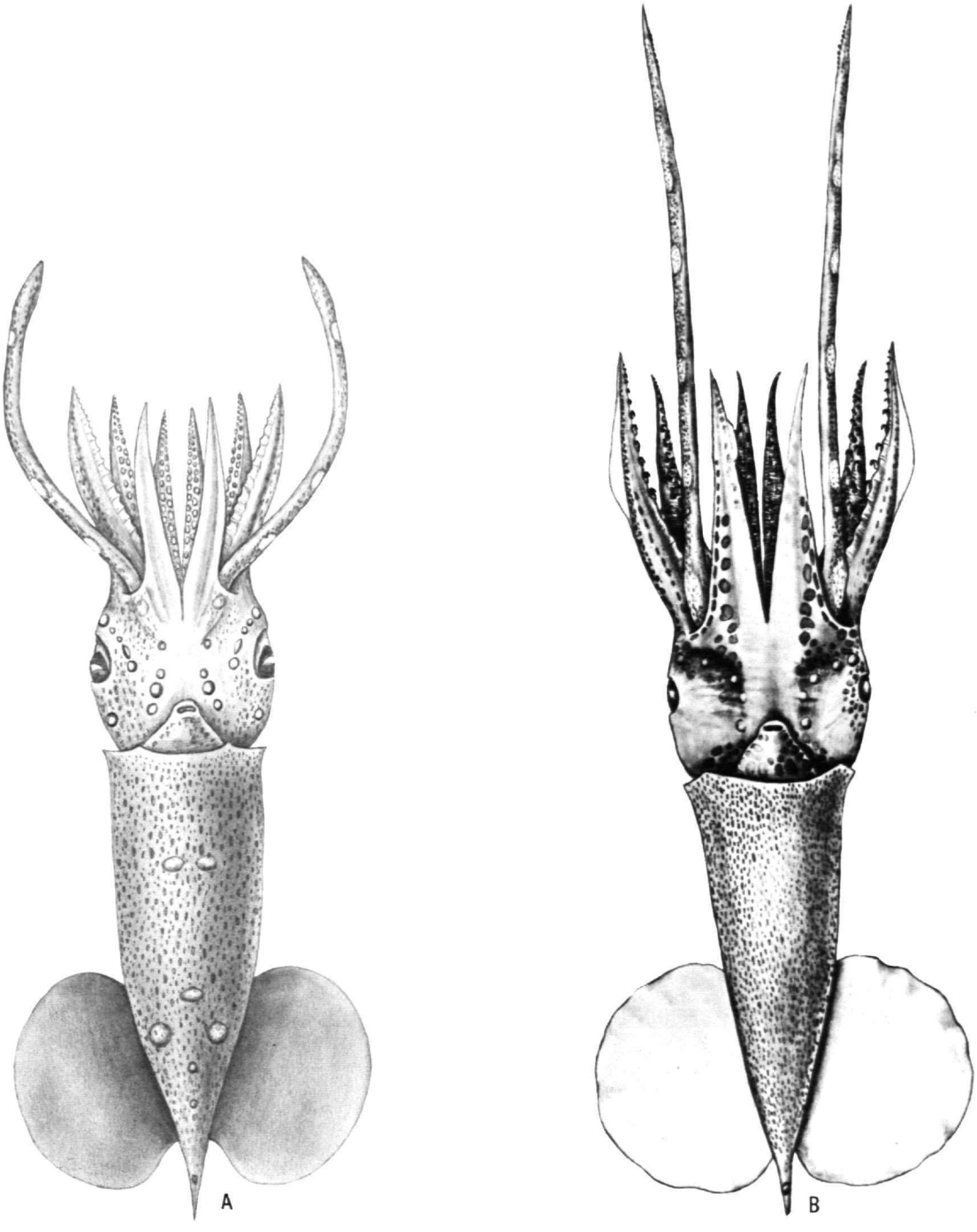
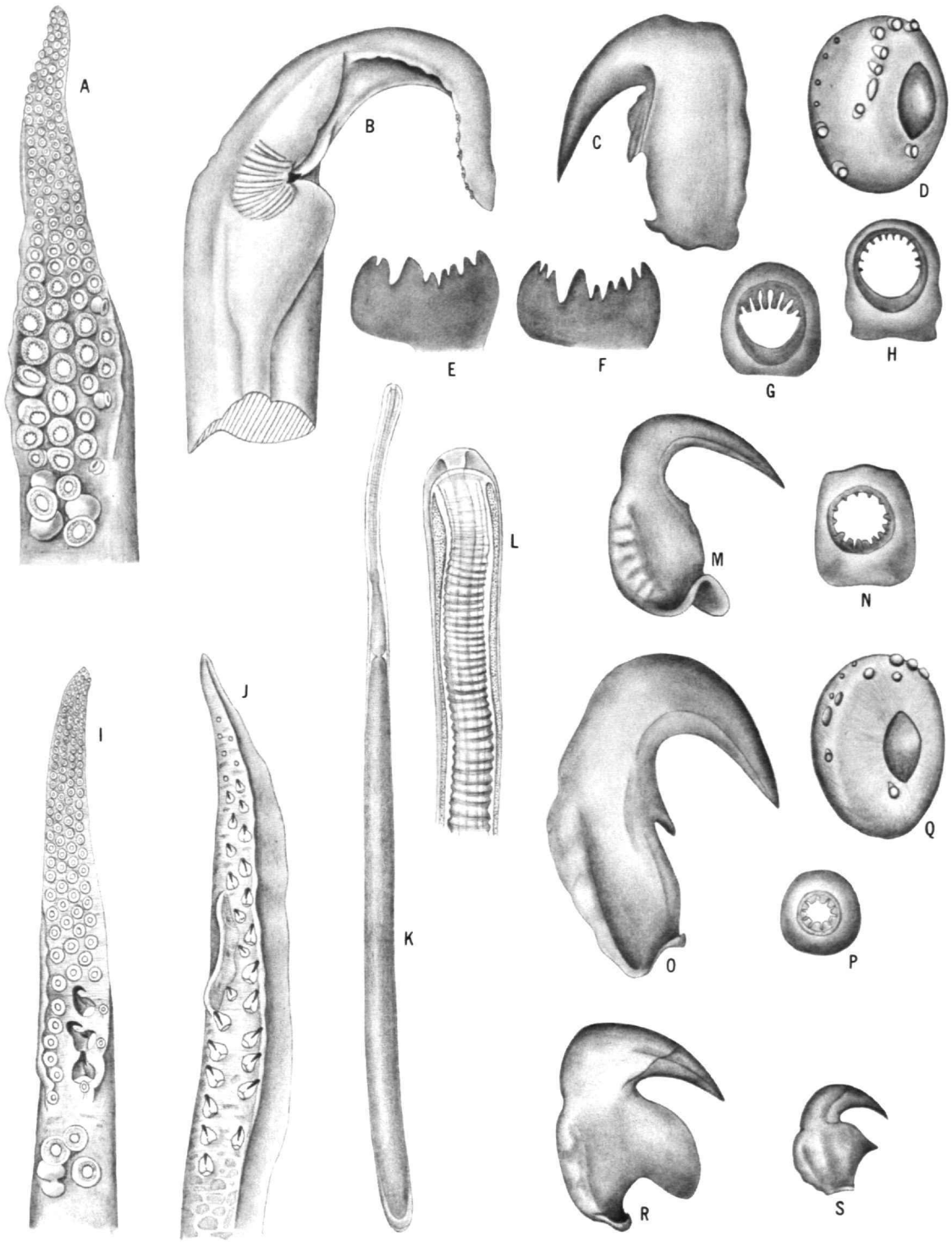


PLATE 3.—A, *Pterygioteuthis gemmata*, ventral view, M.L. 23 mm; B, *Pyroteuthis addolux*, ventral view, holotype, M.L. 30 mm.

PLATE 4.—A–H, *Pterygioteuthis gemmata:* A, tentacular club, M.L. 28 mm; B, medial view, hectocotylus, M.L. 27 mm; C, largest hook, arm III; D, ventral view of eye; E, chitinous plate from hectocotylus, M.L. 24 mm; F. chitinous plate from hectocotylus, M.L. 27 mm; G, inner ring from largest sucker, arm III; H, inner ring, largest sucker, manus (C, G, H maintain relative sizes, M.L. 23 mm). I–Q, *Pyroteuthis addolux:* I, tentacular club, holotype; J, hectocotylus, holotype; K, spermatophore, holotype; L, enlargement of tip of ejaculatory apparatus, holotype; M, largest club hook, tentacular club; N, inner ring of largest club sucker; O, largest hook, arm III; P, inner ring, second proximal sucker, arm IV, (M–P maintains relative size, M.L. 45 mm); Q, ventral view of eye. R. *Pyroteuthis margaritifera,* second hook proximal to pad on ventral row of hectocotylus, Gulf of Mexico specimen, M.L. 28 mm; S. *Pyroteuthis addolux,* second hook proximal to pad on ventral row of hectocotylus, holotype, M.L. 30 mm.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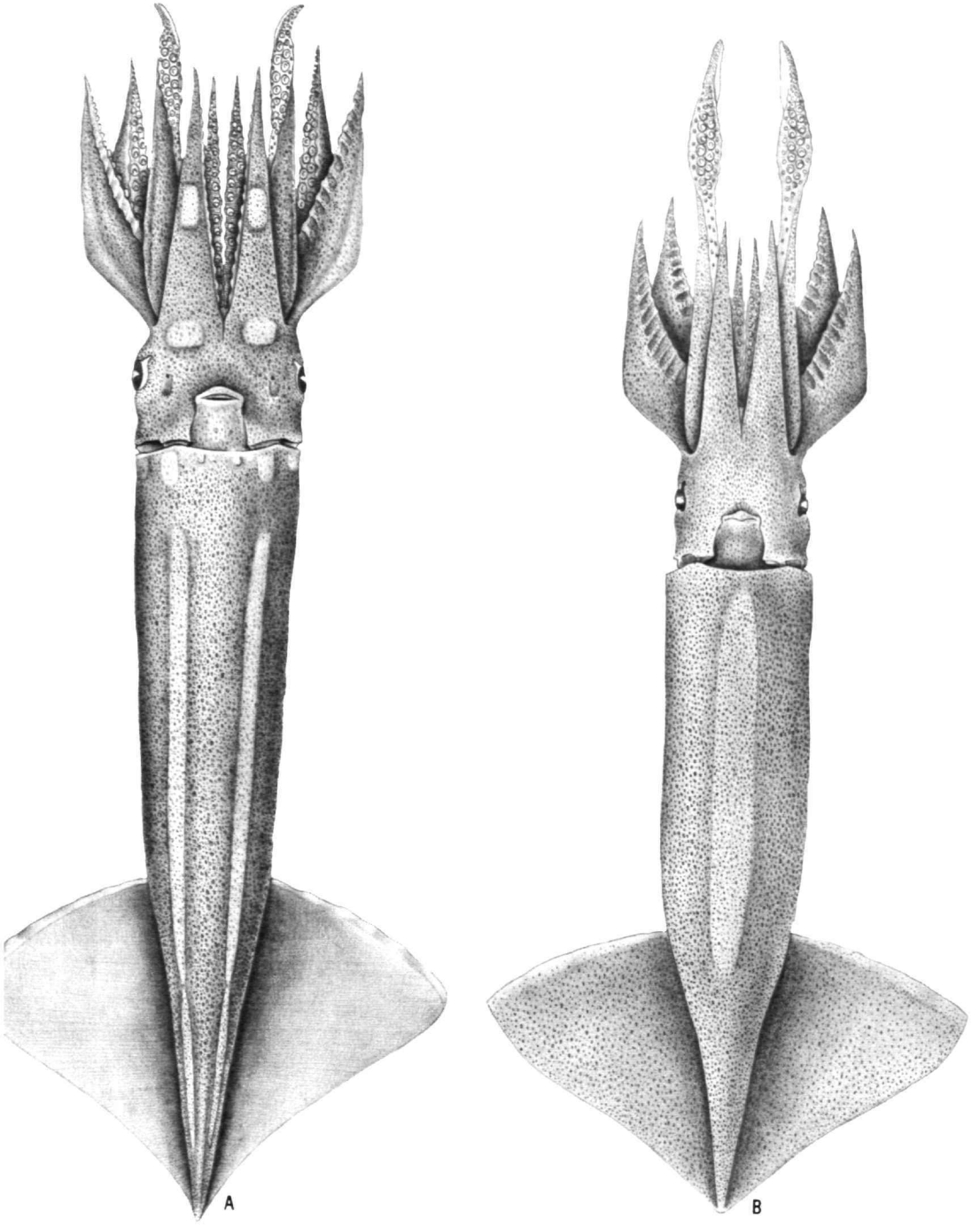


PLATE 5.—A, *Symplectoteuthis luminosa*, ventral view, M.L. 136 mm; B, *Ommastrephes bartramii*, ventral view, M.L. 211 mm.

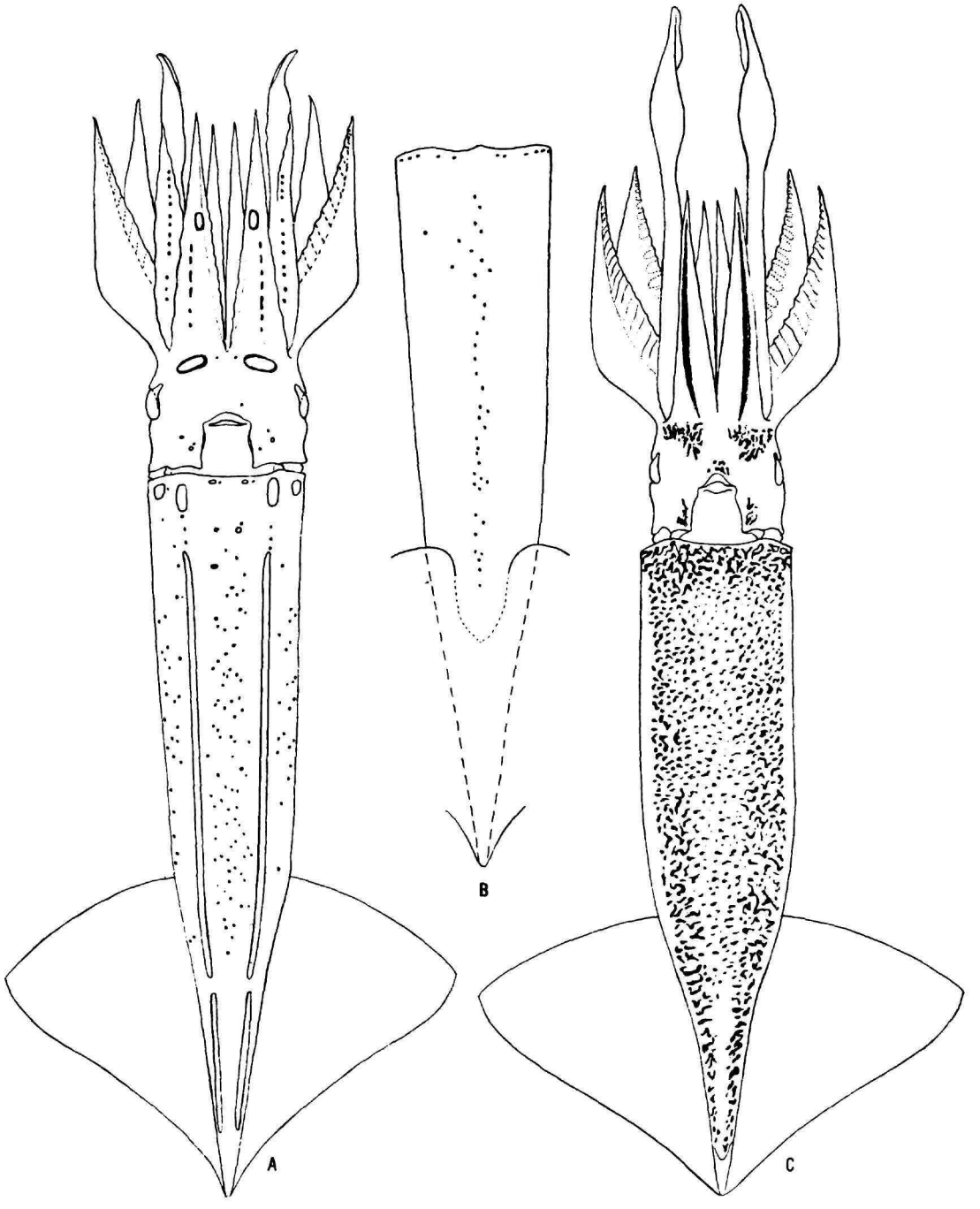
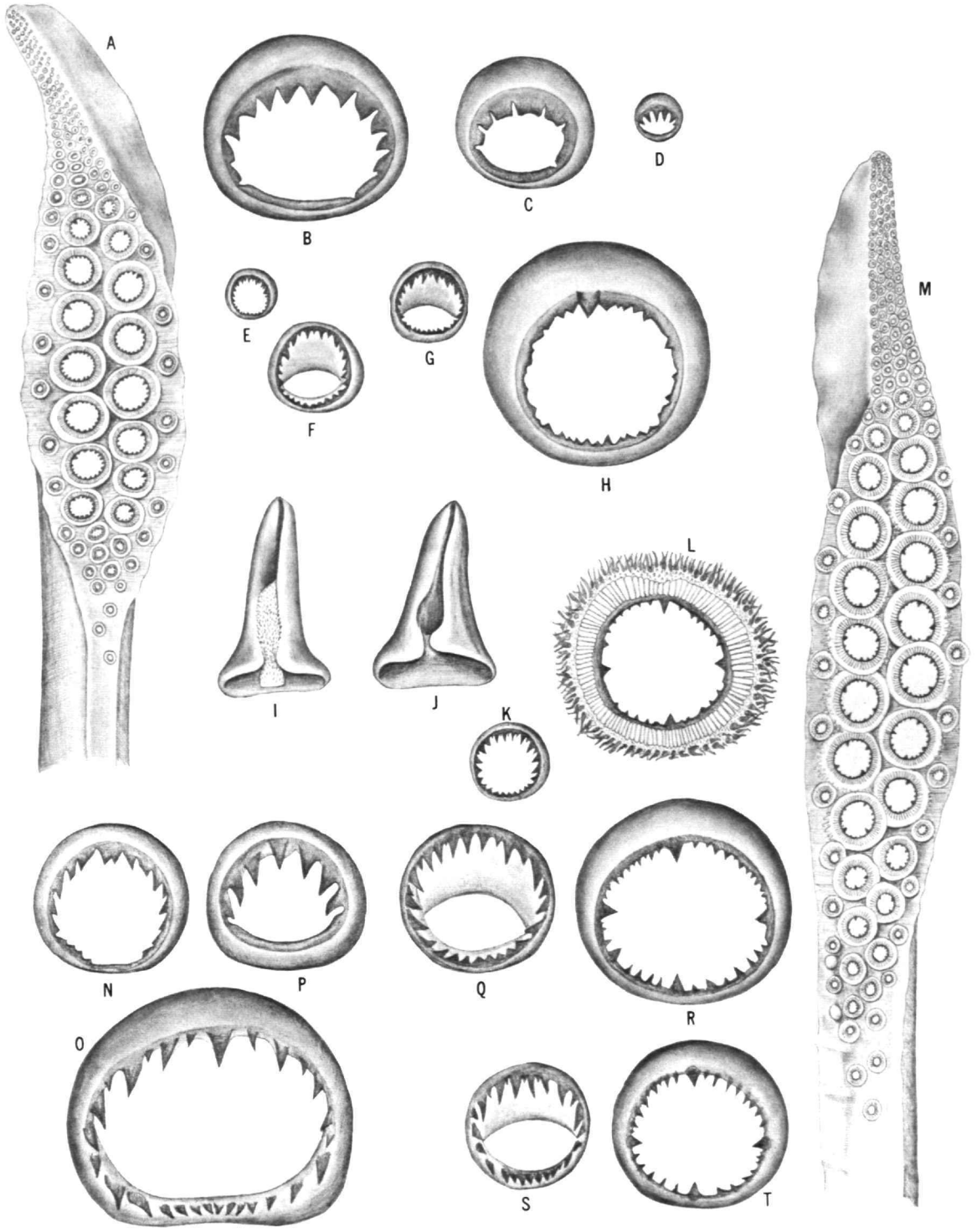


PLATE 6.—A, *Symplectoteuthis luminosa*, photophore pattern, ventral view, M.L. 163 mm; B, Same, dorsal view; C, *Ommastrephes bartramii* photophore pattern, ventral view, M.L. 215 mm.

PLATE 7.—A–I, *Symplectoteuthis luminosa,* M.L. 136 mm; A, tentacular club; B, inner ring of large sucker from 6th row of arm III; C, inner ring of basal sucker of arm III; D, inner ring of sucker from 18th row of arm III; E, inner ring of sucker from middle of dactylus, dorsal row; F, enlargement of E; G, inner ring of largest sucker, manus, marginal row; H, inner ring of largest sucker, manus, medial row; B–E, G–H maintain relative sizes); I, right funnel locking-cartilage showing area of fusion. J–R, *Ommastrephes bartramii* from off Guadalupe Island, Pacific Ocean, M.L. 303 mm: J, right funnel locking-cartilage; K, inner ring of sucker from middle of dactylus, ventral row; L, large medial sucker of manus showing fleshy, marginal papillae; M, tentacular club; N, inner ring of basal sucker, arm III; O, inner ring of 5th row sucker, arm III; P. inner ring of 14th row sucker, arm III; Q, inner ring of largest sucker, marginal row of club (K, N–Q maintain relative sizes); R, inner ring of largest sucker, medial row of club, enlargement half that of other suckers; S, *Ommastrephes bartramii* from off Florida, M.L. 302 mm, inner ring of largest sucker, marginal row of club; T, same specimen, inner ring of largest sucker, medial row of club (enlargement of S and T is the same as Q and R, respectively).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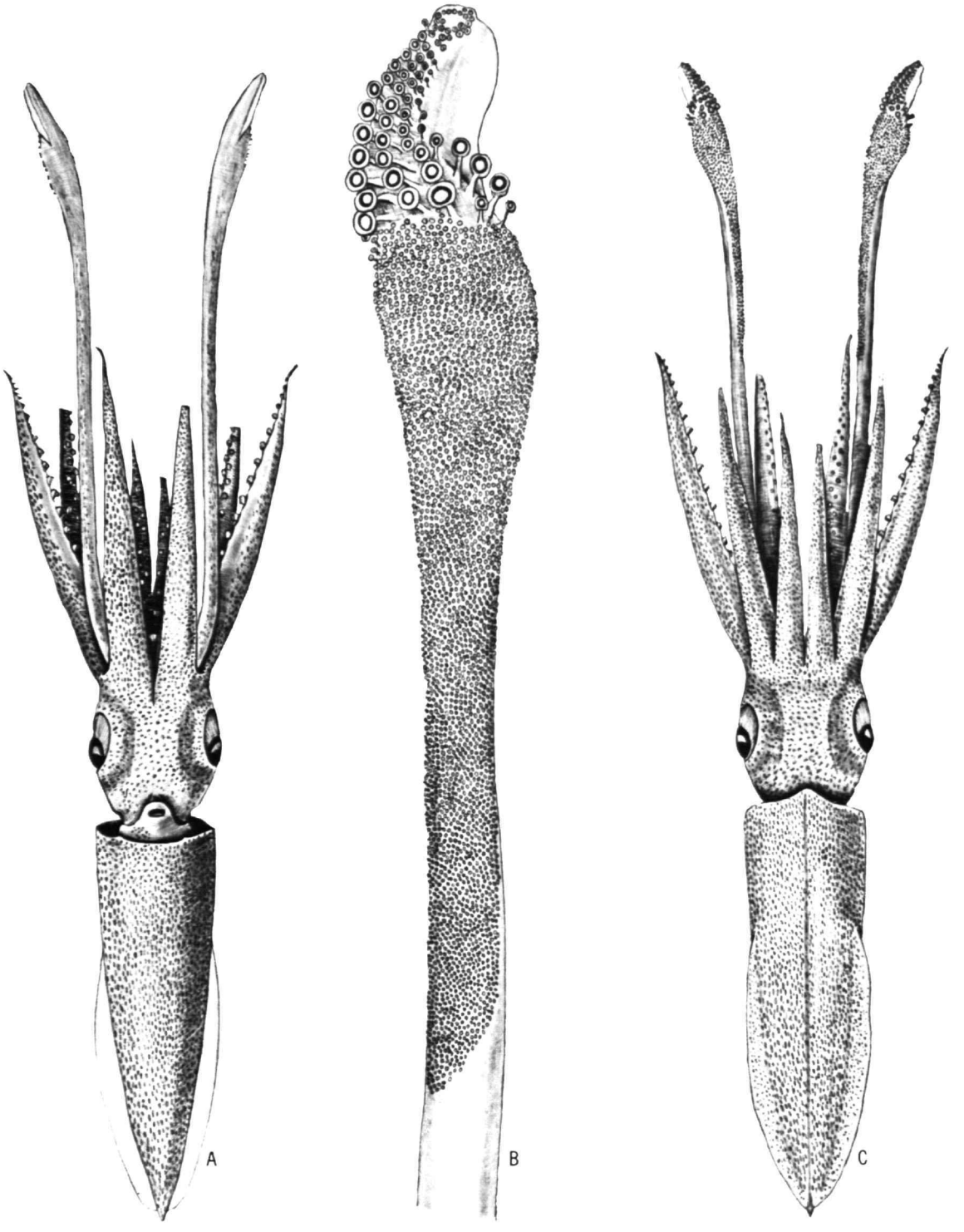


PLATE 8.—*Neoteuthis* sp., M.L. 83 mm: A, ventral view; B, tentacular club; C, dorsal view.

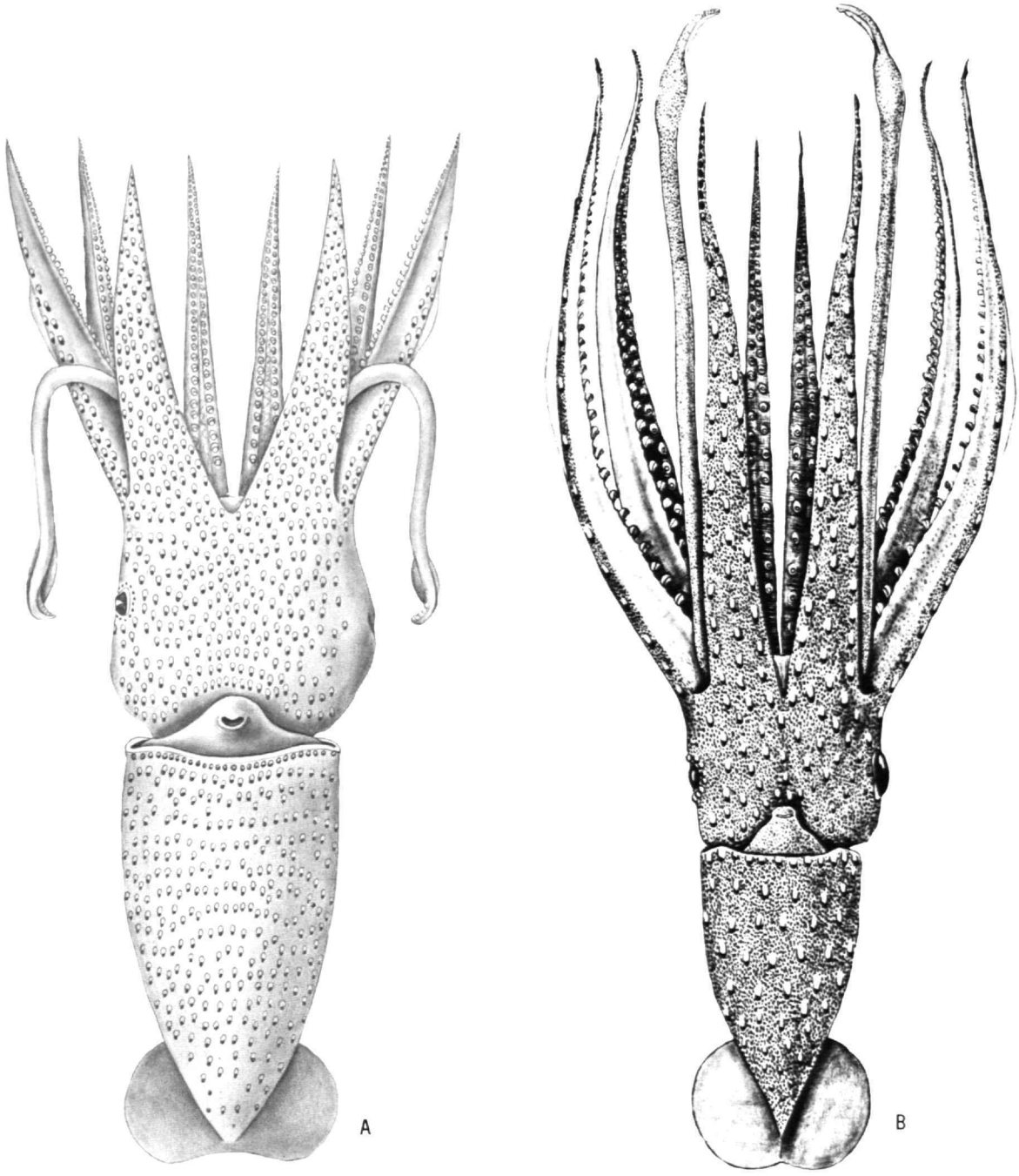


PLATE 9.—A, *Histioteuthis heteropsis*, ventral view, photophore pattern only approximate, M.L. 35 mm; B, *Histioteuthis dofleini*, ventral view, M.L. 150 mm.

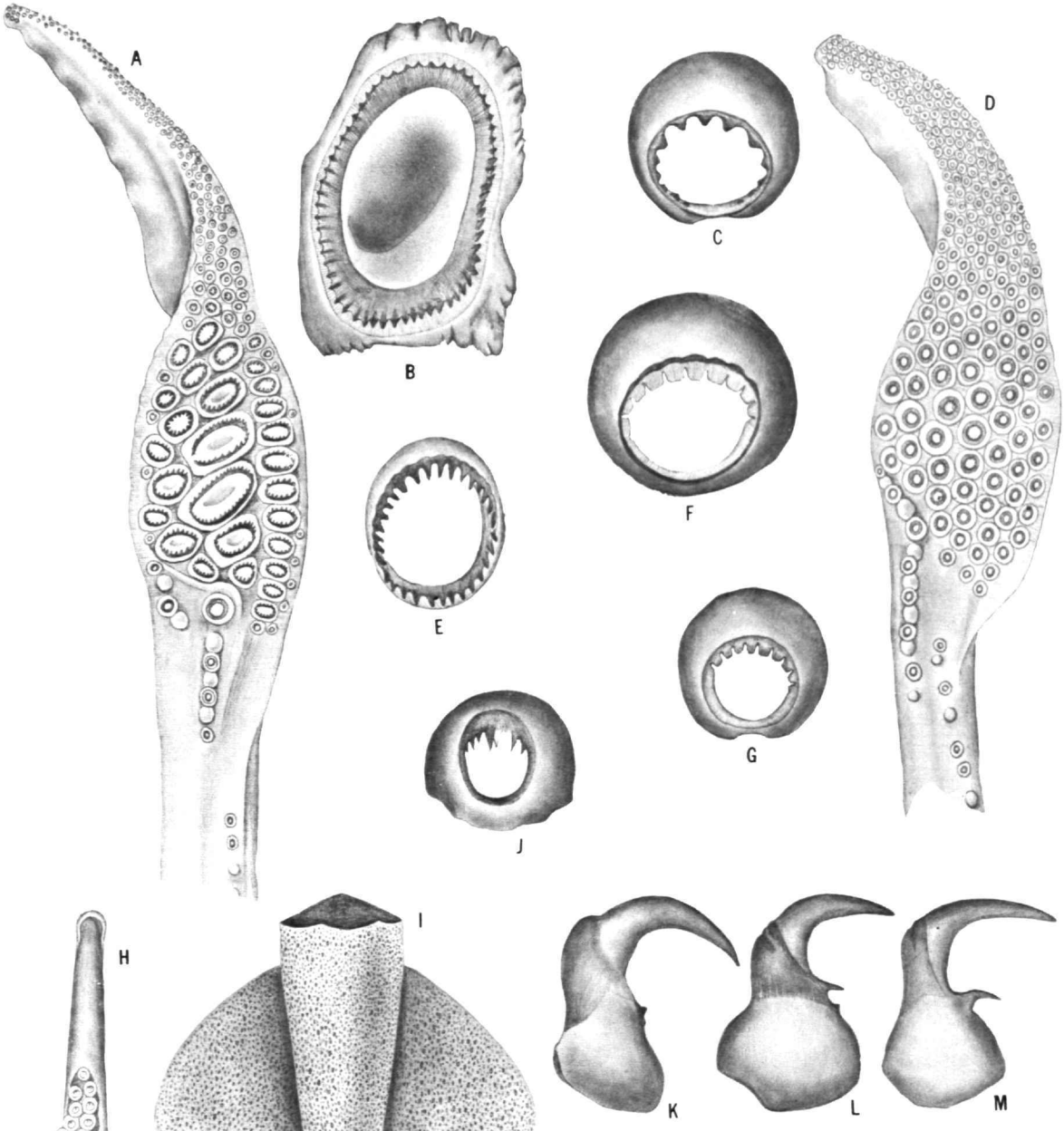


PLATE 10.—A, *Histioteuthis dofleini,* tentacular club, M.L. 150 mm; B, same, large club sucker, M.L. 150 mm; C, same, inner ring of sucker from arm III, 6th row, M.L. 14 mm; D, *Histioteuthis heteropsis,* tentacular club, M.L. 35 mm; E, same, inner ring of large club sucker, M.L. 65 mm; F, same, inner sucker ring, arm III, 11th row; G, same, inner sucker ring, arm IV, eleventh row (E–G maintain relative sizes). H–M, *Octopoteuthis deletron;* H, tip of arm III, M.L. 167 mm; I, ventral view of mantle and fins, M.L. 167 mm; J, inner ring from tip of arm III, fifth row from hooks, M.L. 167 mm; K, large hooks, arm III, M.L. 20 mm?; L, large hook, arm III, M.L. 109 mm; M, large hook, arm III, M.L. 167 mm.

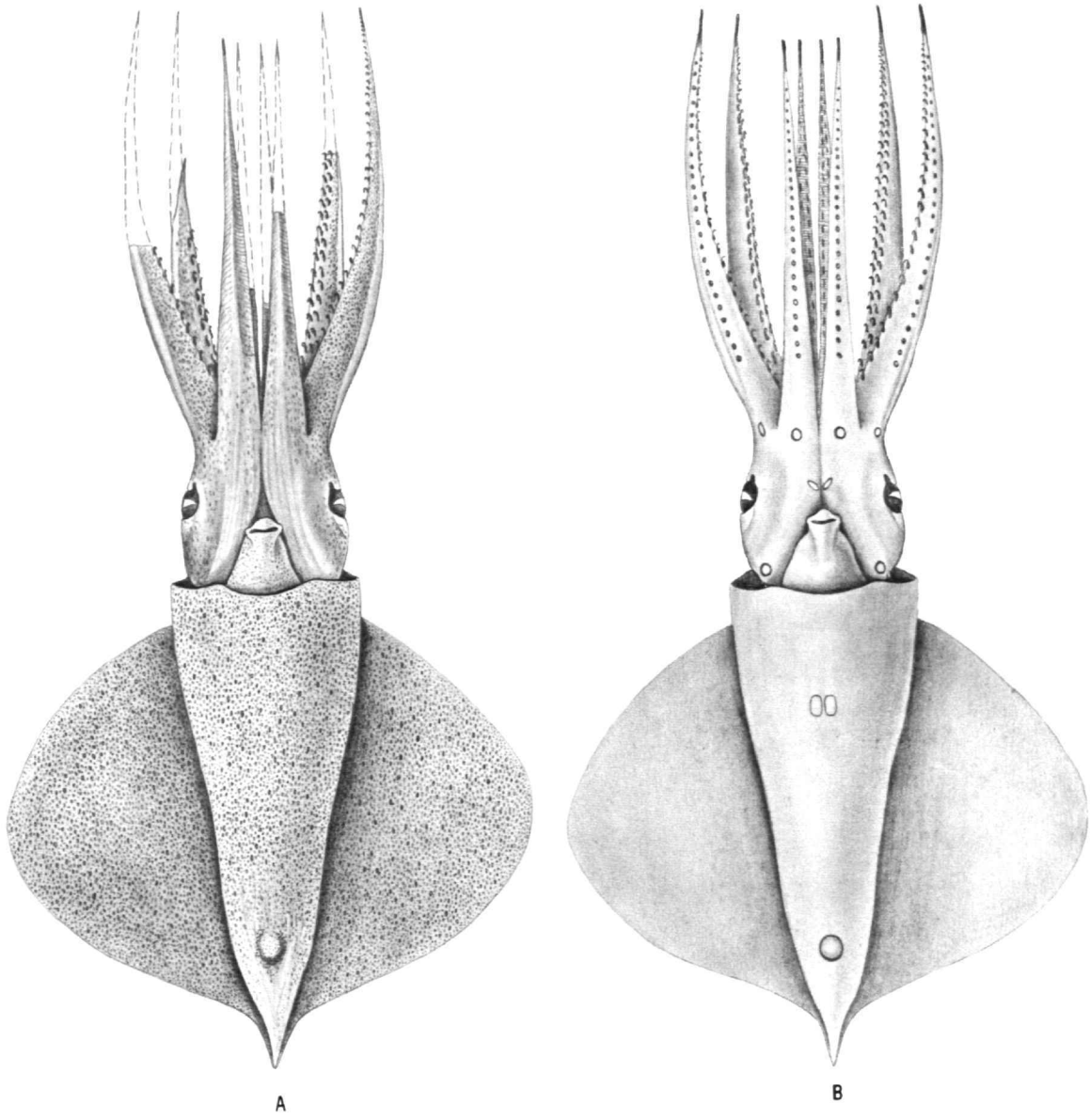


PLATE 11.—A, *Octopoteuthis deletron*, holotype, M.L. 109 mm; B, same showing photophore pattern.

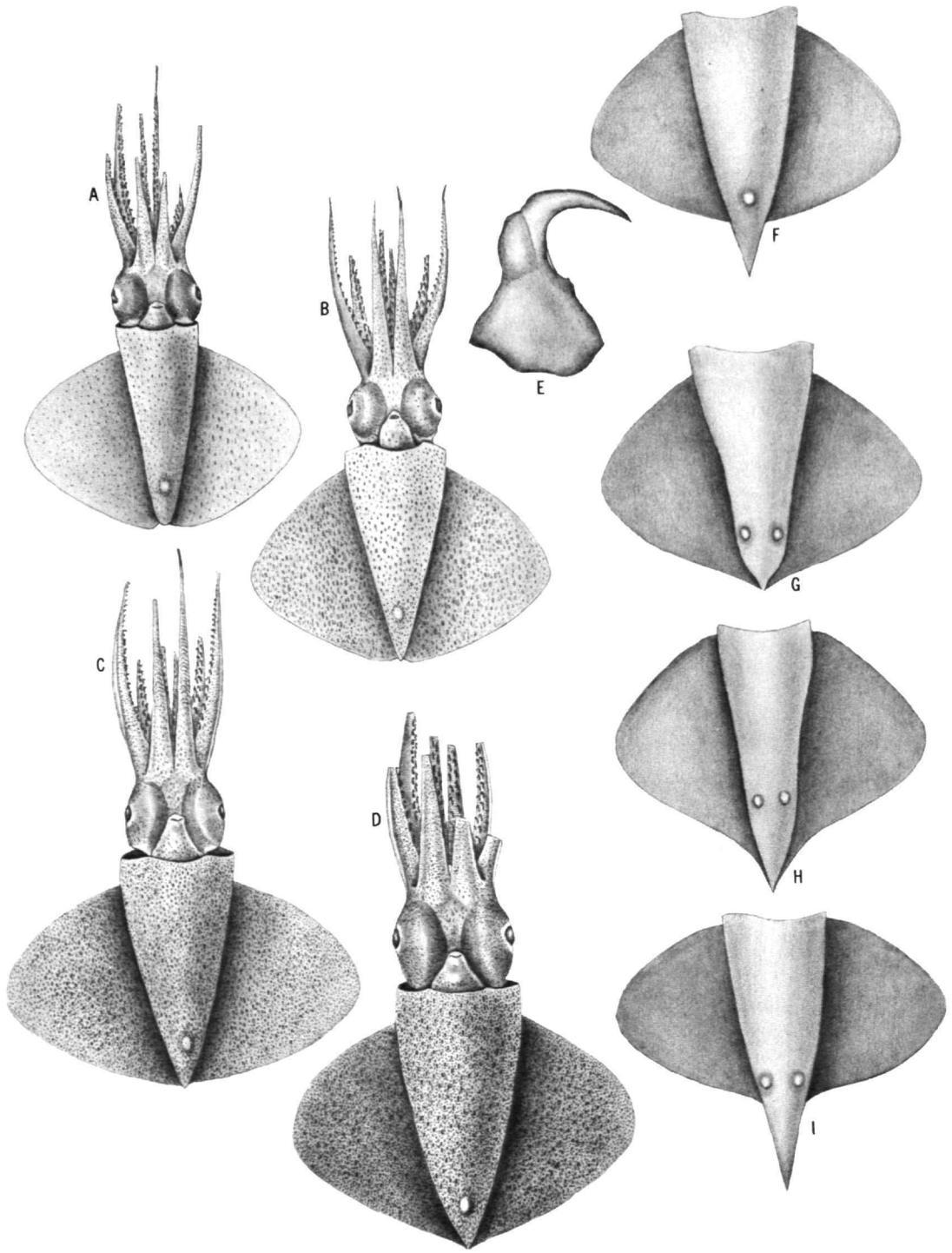


PLATE 12.—A–D, *Octopoteuthis deletron* showing metamorphosis, relative sizes maintained, M.L. 31, 32, 34, 39 mm, respectively; E, *Octopoteuthis* A, large arm hook. M.L. 49 mm; F, *Octopoteuthis* A, ventral view of mantle and fins. M.L. 49 mm; G, *Octopoteuthis neilseni,* ventral view of mantle and fins, M.L. 36 mm; H, *Octopoteuthis danae,* ventral view of mantle and fine, M.L. 53 mm; I, *Octopoteuthis megaptera,* ventral view of mantle and fins, M.L. 38 mm.

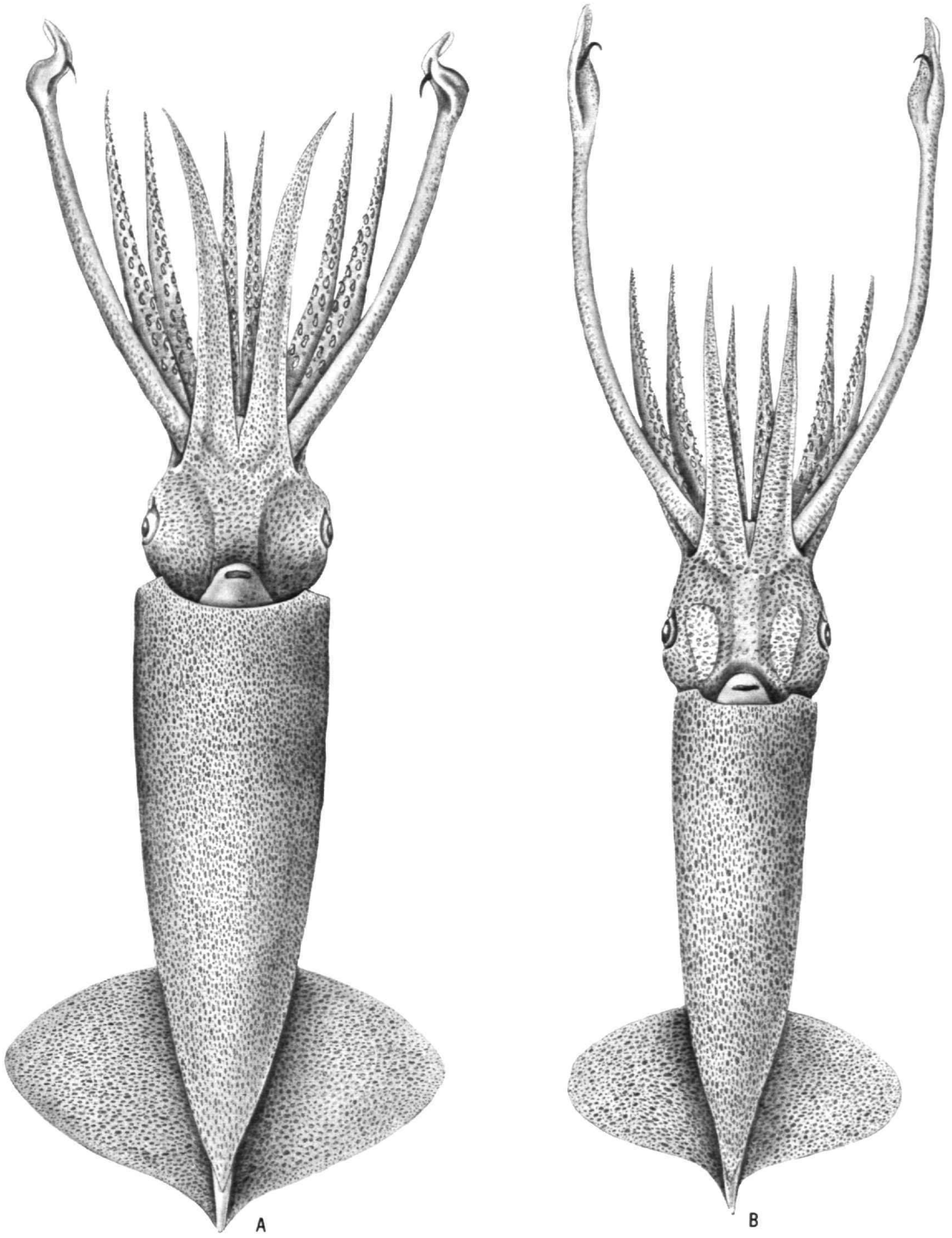
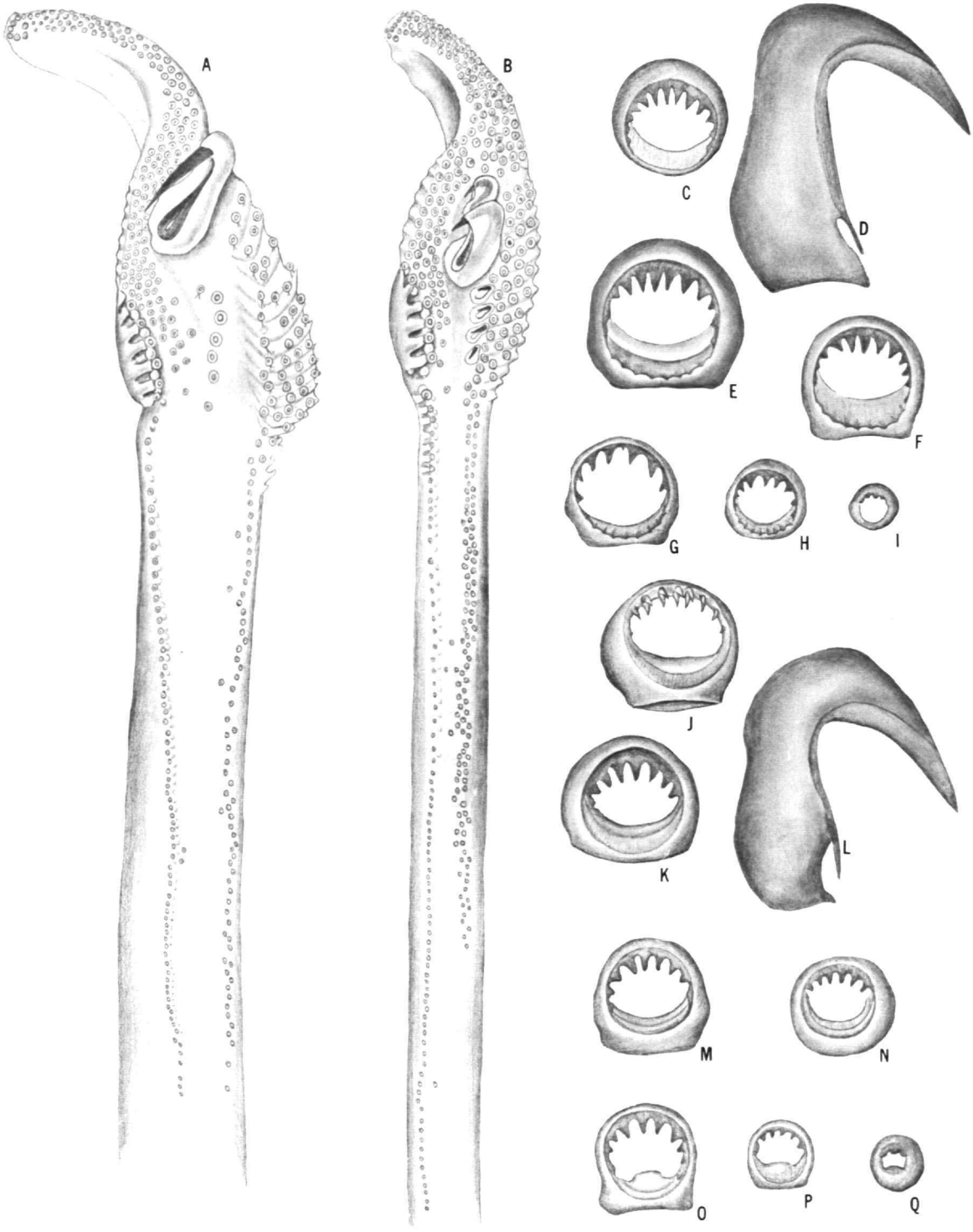


PLATE 13.—A, *Gonatus onyx*, ventral view, P.L. 69 mm; B, *Gonatus pyros*, ventral view, P.L. 39 mm.

PLATE 14.—A, *Gonatus onyx,* tentacle, P.L. 69 mm; B, *Gonatus pyros,* tentacle, P.L. 35 mm?; *Gonatus onyx,* P.L. 69 mm relative sizes maintained except D: C, inner ring of large marginal sucker, arm III; D, large hook, arm III, enlargement half that of suckers; E, inner ring of large medial row sucker, arm IV; F, inner ring of large marginal sucker, arm IV; G, inner ring of largest sucker of ventral marginal zone of club; H, inner ring of sucker from middle of dactylus, ventral row; I, inner ring of sucker taken one-fifth of tentacle length from base of club. J–Q, *Gonatus pyros,* P.L. 39 mm, relative sizes maintained except for L: J, inner ring of arm III sucker tilted to show frequent bicuspid nature of teeth; K, inner ring of large marginal sucker, arm III; L, large hook, arm III, enlargement half that of suckers; M, inner ring of large medial row sucker, arm IV; N, inner ring of large marginal sucker arm IV; O, inner ring of largest sucker from ventral marginal zone on club; P, inner ring of sucker from middle of dactylus, ventral row; Q, inner ring of sucker taken one-fifth of tentacle length from base of club.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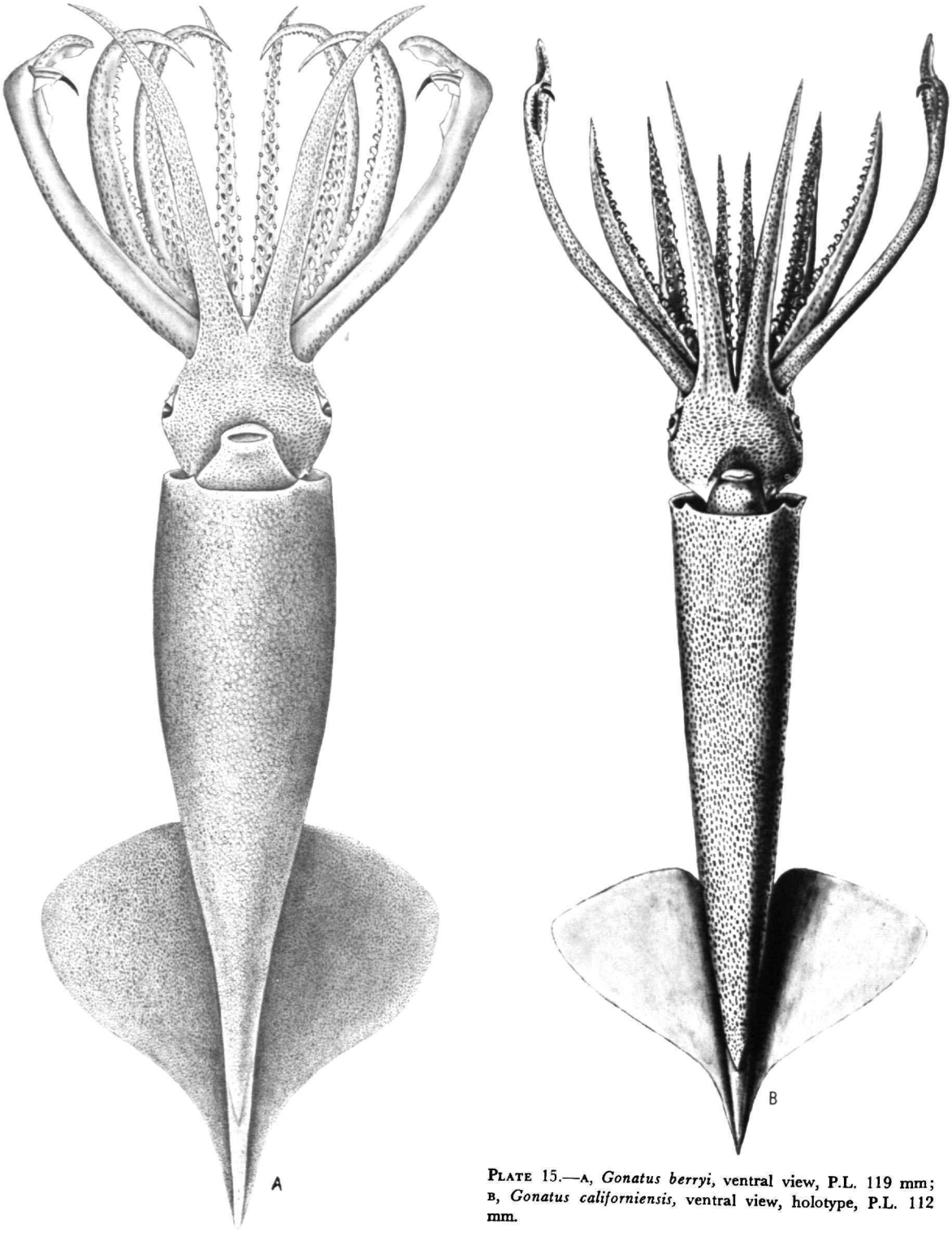

PLATE 15.—A, *Gonatus berryi*, ventral view, P.L. 119 mm; B, *Gonatus californiensis*, ventral view, holotype, P.L. 112 mm.

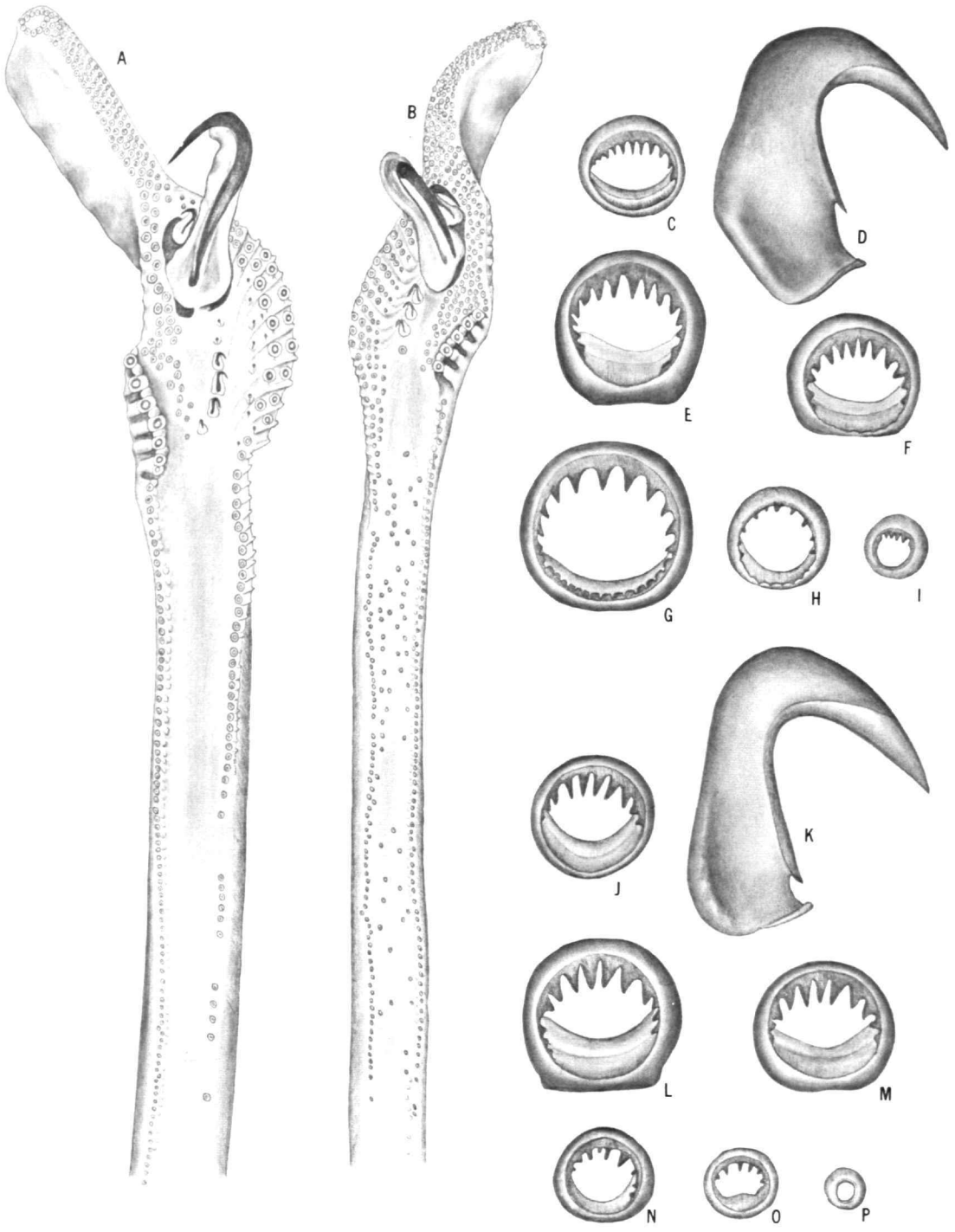

PLATE 16.—A, *Gonatus berryi,* tentacle, P.L. 119 mm; B, Gonatus californiensis, tentacle, holotype, P.L. 112 mm. C–I. *Gonatus berryi,* relative sizes maintained except for D: C, inner ring of large marginal sucker, arm III; D, large hook, arm III, enlargement half that of suckers; E, inner ring of large medial row sucker, ventral arm; F, inner ring of large marginal sucker, arm IV; G, inner ring of largest sucker of ventral marginal zone club; H, inner ring of sucker from middle of dactylus, dorsal row; I, inner ring of sucker taken one-fifth of tentacle length from base of club. J–P, *Gonatus californiensis,* holotype, relative sizes maintained except for K: J, inner ring of large marginal sucker, arm I: K, large hook, arm I, enlargement half that of suckers; L, inner ring of large medial row sucker, arm IV; M, inner ring of large marginal sucker, arm IV; N, inner ring of largest sucker of ventral marginal zone of club; O, inner ring of sucker from middle of dactylus, ventral row; P, inner ring of sucker taken one-fifth of tentacle length from base of club.

PLATE 17.—A–C, club hooks *Gonatus berryi*, P.L. 119 mm (relative sizes maintained): A, central hook, enlargement half that of other hooks; B, distal hook; C, first proximal hook. D–F, *Gonatus californiensis*, P.L. 112 mm, club hook (relative sizes maintained): D, central hook; E, distal hook; F, first proximal hook. G–I, *Gonatus pyros*, P.L. 39 mm, club hooks (relative sizes maintained): G, central hook; H, distal hook; I, proximal hook. J, *Gonatus onyx*, P.L. 69 mm?, central hook of club; K, *Gonatus pyros*, P.L. 37 mm, ventral view of eye showing photophore; L, *Gonatus berryi*, larva, P.L. 10 mm.


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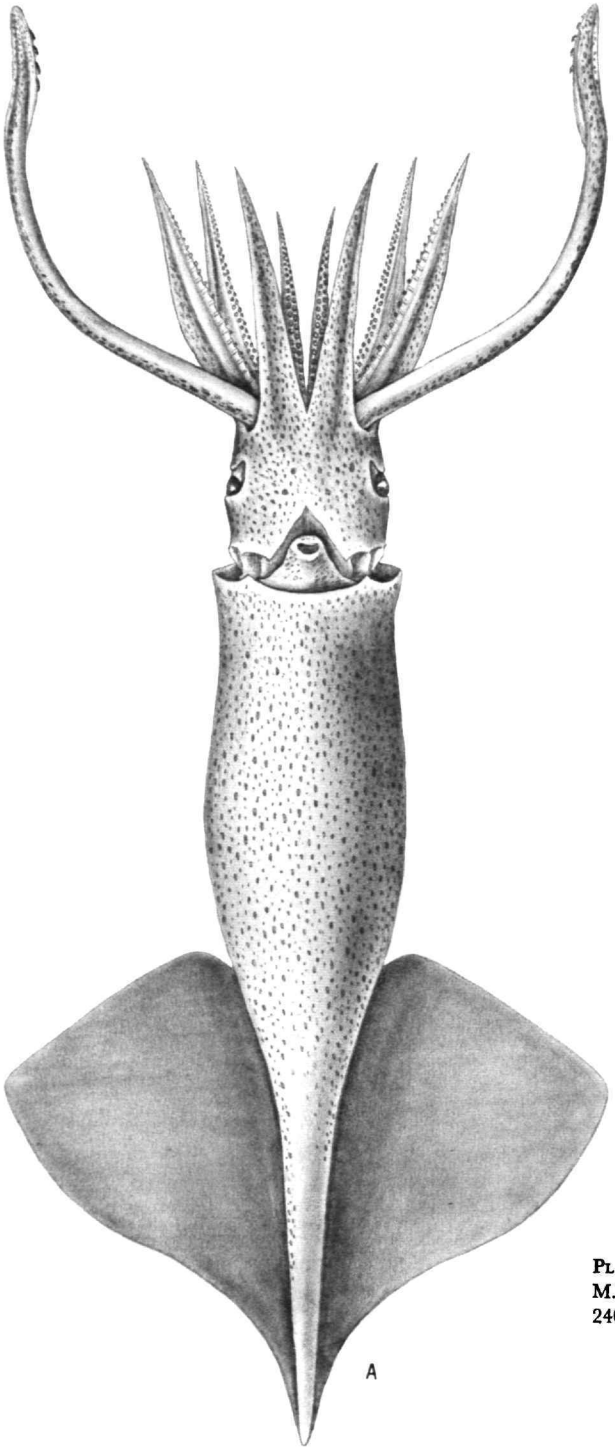

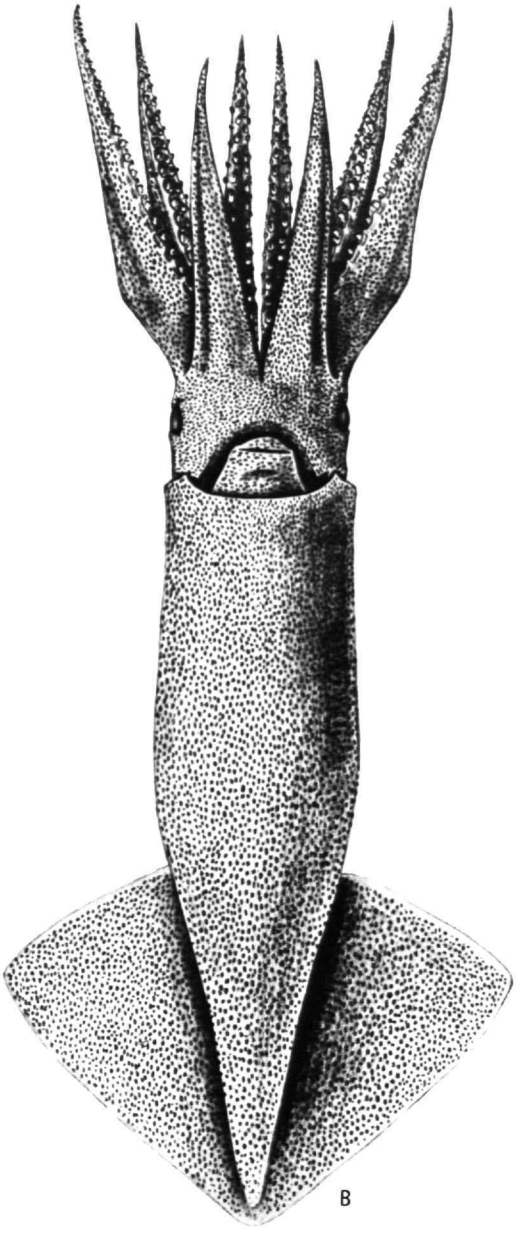

PLATE 18.—A, *Onychoteuthis borealijaponicus*, ventral view, M.L. 50 mm; B, *Gonatopsis borealis*, ventral view, M.L. 240 mm.

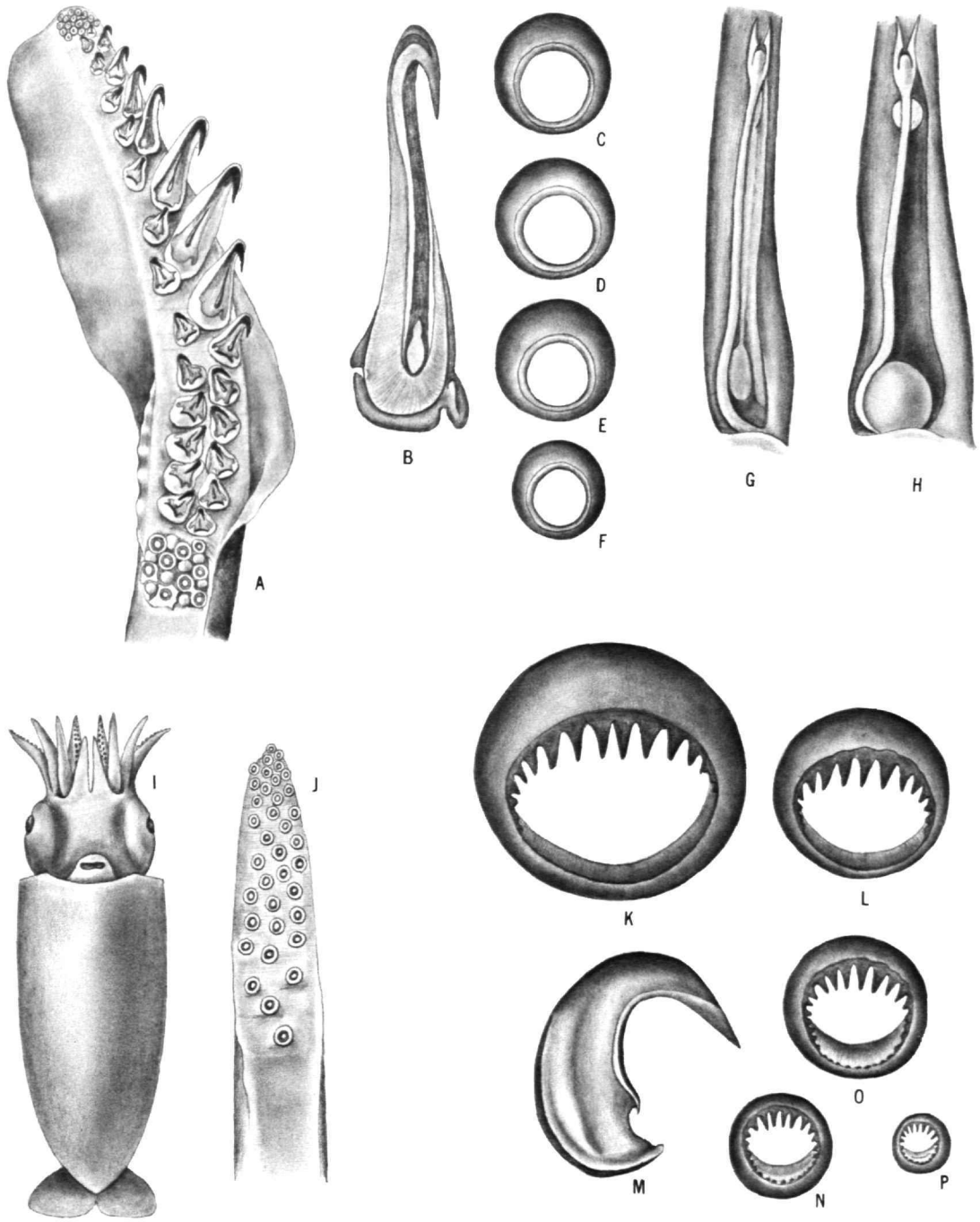

PLATE 19.—A–G, *Onychoteuthis borealijaponicus,* M.L. 81 mm; A, tentacular club; B, ninth hook from proximal end of club in ventral row from club in A; C–F, largest suckers from arms I-IV respectively (B–F retain relative sizes); G, visceral photophores. H, *Onychoteuthis "banksii"* from off Florida, visceral photophores, M.L. 80 mm. I–P, *Gonatopsis borealis:* I, larva, M.L. 9 mm; J, Tentacle from larva, M.L. 7 mm; K–P, *Gonatopsis borealis,* M.L. 200 mm, relative sizes retained except in M: K, inner ring of largest sucker, arm IV, median row; L, inner ring of largest sucker, arm IV, marginal row; M, largest hook, arm III, enlargement half that of suckers. N, inner ring of sucker, arm III tip, medial row; O, inner ring of largest sucker, arm III, marginal row; P, inner ring of sucker, arm III tip, marginal row.

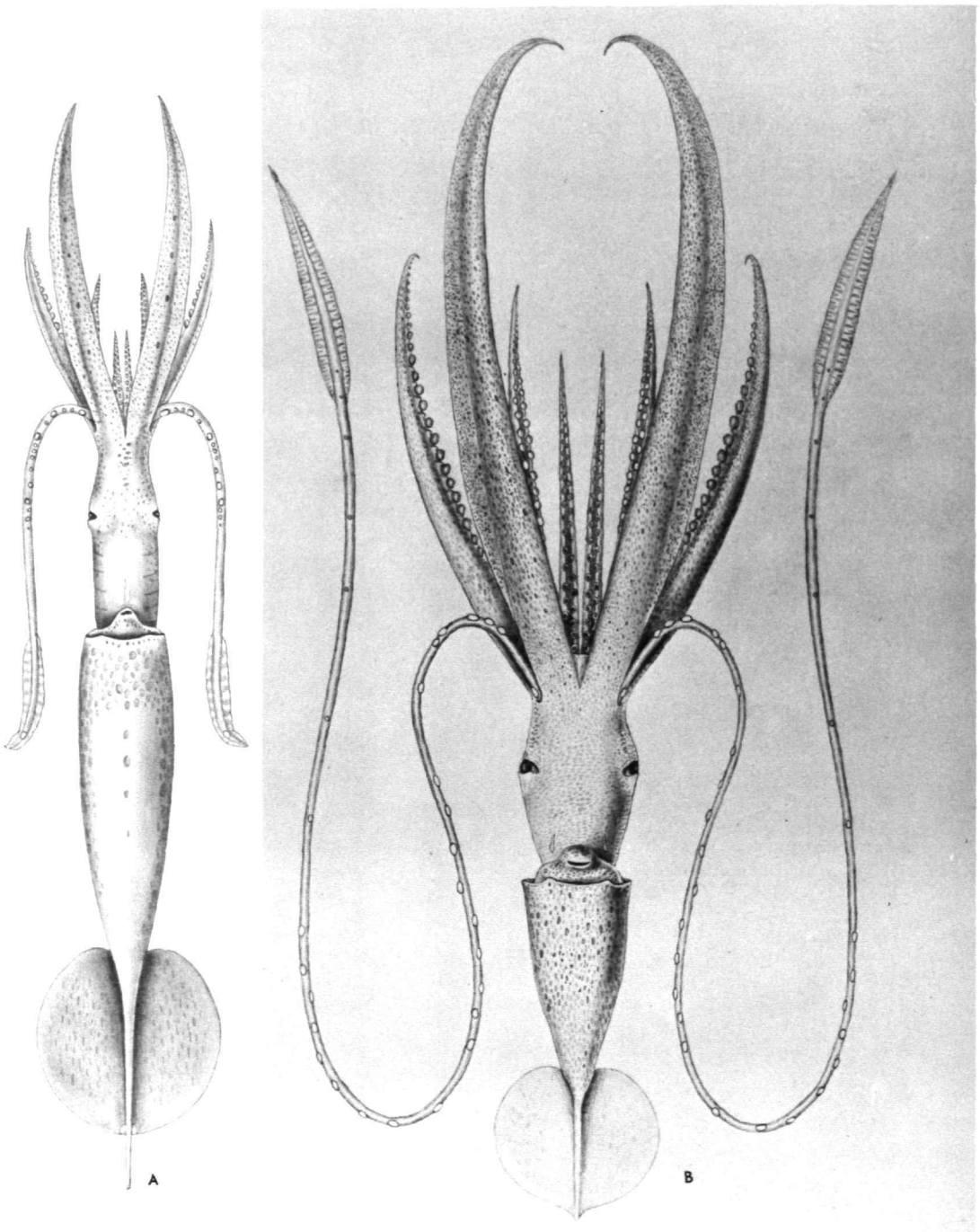

PLATE 20.—*Chiroteuthis calyx:* A, advanced doratopsis stage, ventral view, M.L. 49 mm?; B, ventral view, subadult, M.L. 54 mm.

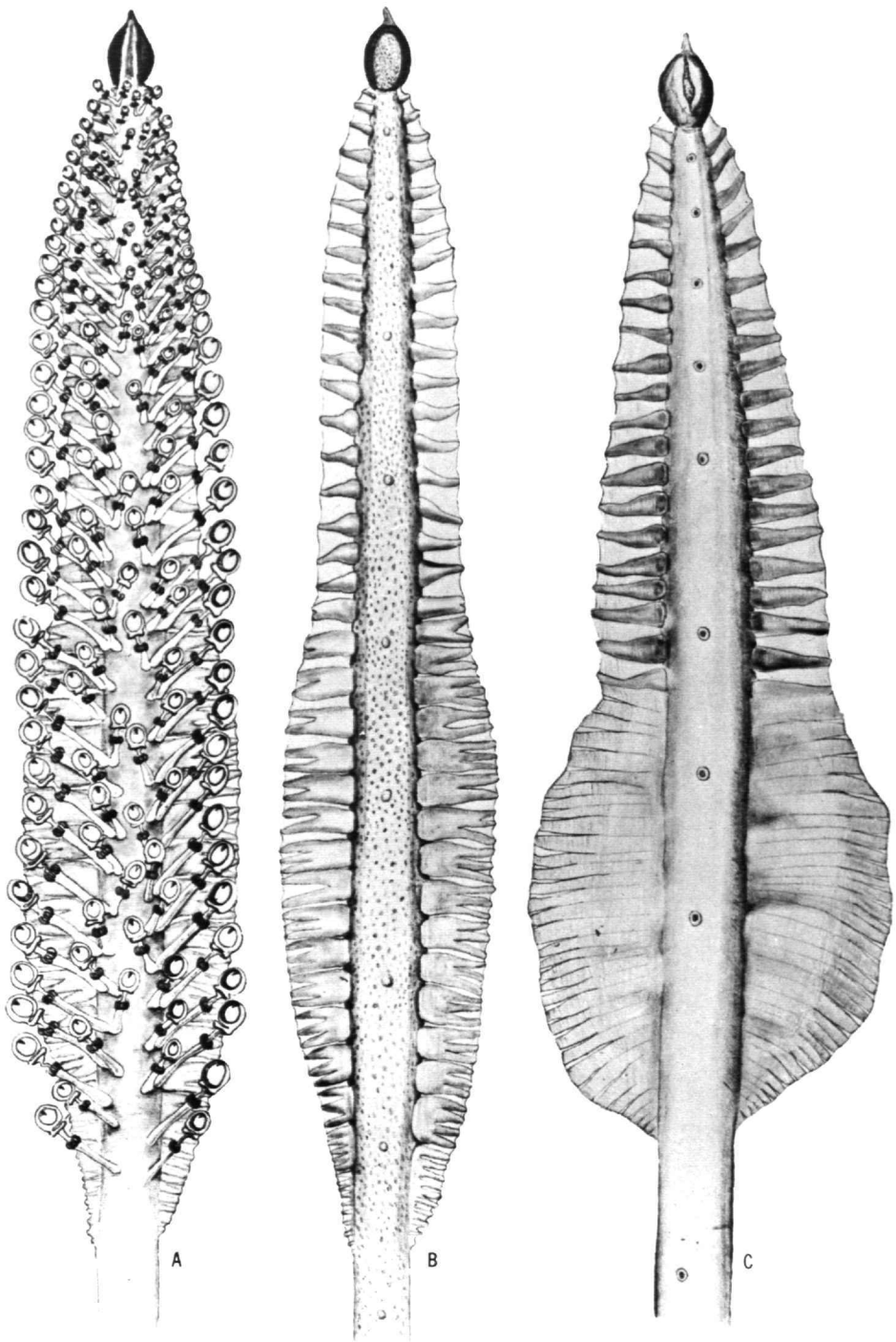

PLATE 21.—A, *Chiroteuthis calyx*, oral view of tentacular club, M.L. 60 mm; B, same specimen, aboral view of tentacular club; C, *Chiroteuthis veranyi* from Mediterranean Sea (DANA 4030 XVIII), M.L. 61 mm, aboral view of tentacular club.

PLATE 22.—*Chiroteuthis calyx* except L and M which are *C. veranyi*. Inner sucker rings in A–I maintain relative sizes except in E, M.L. 60 mm?. A, arm III, second row; B, arm III, thirteenth row; C, arm III, eighteenth row; D, arm III, fourteenth row; E, D enlarged four times; F, arm I, sixth row; G, arm II, tenth row; H, arm IV, first row; I, arm IV, twelfth sucker. J, inner ring of large club sucker; K, largest arm III sucker from advanced doratopsis larva, M.L. 56 mm; L, *C. veranyi* from Mediterranean Sea (DANA 4139 IV), M.L. 68 mm, inner sucker ring, twelfth sucker of arm IV; M, same, inner sucker rings, thirteenth row of arm III; N, ventral view of eye showing photophores, holotype; O, left funnel locking-cartilage, M.L. 60 mm; Q, medial and marginal tentacular suckers and stalks, holotype.

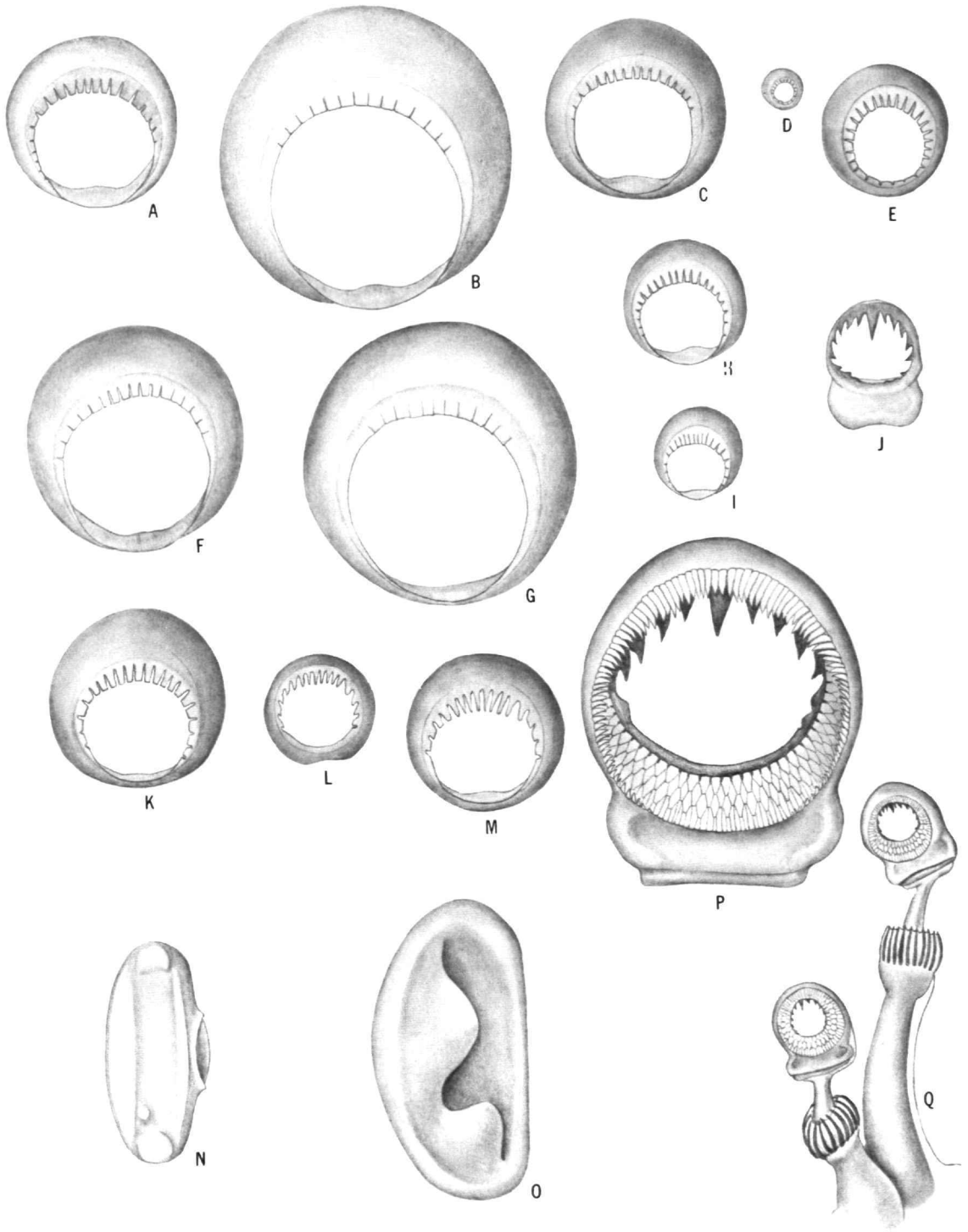
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PLATE 23.—A, *Valbyteuthis oligobessa*, mature female, holotype; B, *Valbyteuthis danae*, ventral view, redrawn from Roper and Young (1967), M.L. 34 mm; C, *Valbyteuthis oligobessa*, juvenile, M.L. 23 mm.

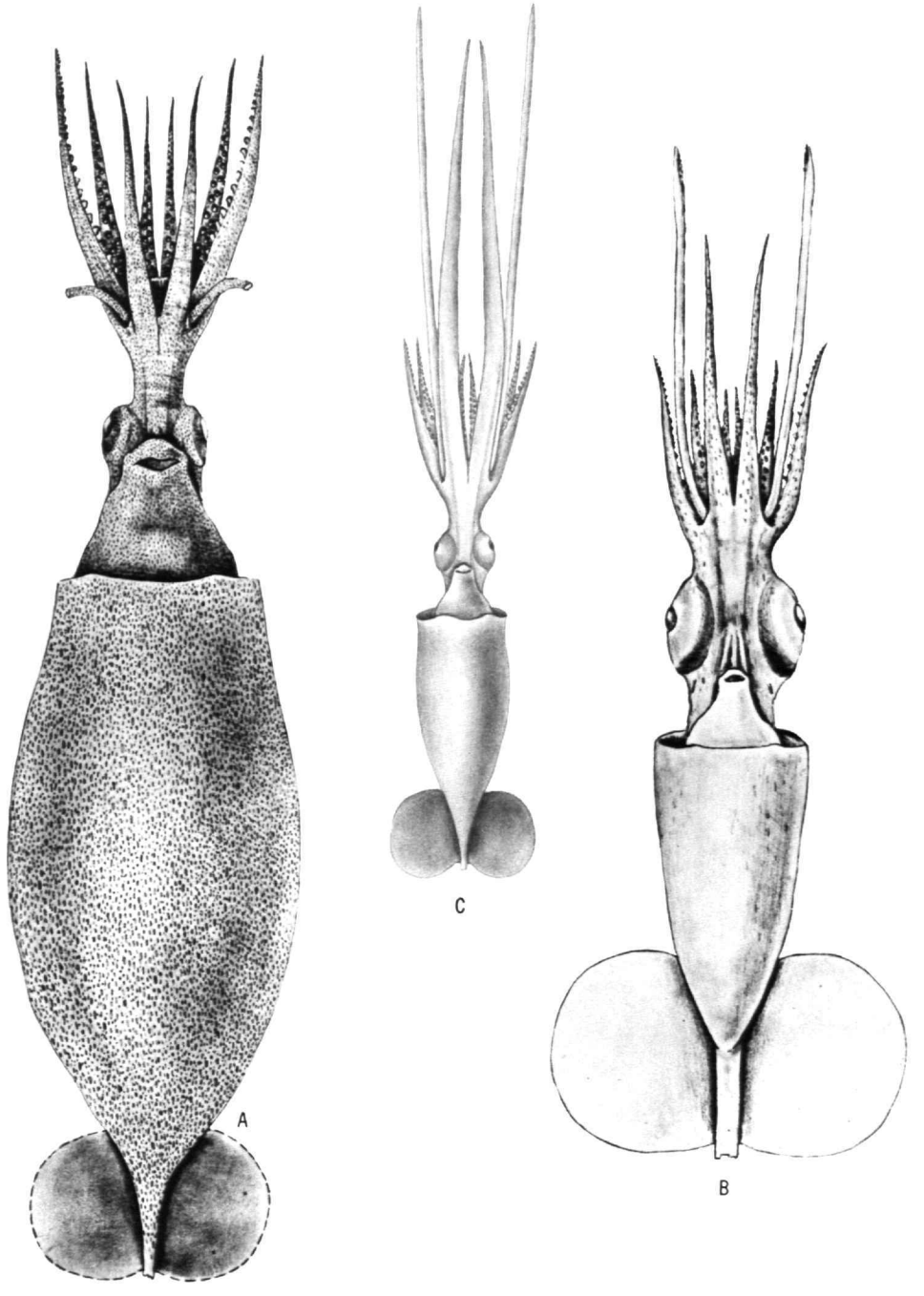
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PLATE 24.—A–G. *Valbyteuthis danae* redrawn from Roper and Young (1967); A, tentacular club, M.L. 47 mm; B–E, largest suckers from arms I–IV, respectively, M.L. 47 mm; F, largest club sucker M.L., 47 mm, (B–F maintain relative sizes); G, mantle and funnel locking–cartilages, M.L. 47 mm. H–N, *Valbyteuthis oligobessa,* V–10976, M.L. 27 mm; H–K, largest suckers from arms I–IV, respectively; L, largest club sucker (H–L maintain relative sizes); M, mantle and funnel locking–cartilages; N, tentacular club; O, *Grimalditeuthis bomplandii,* large sucker and base from arm III, M.L. 89 mm; P, same specimen, inner ring of large sucker from arm III; Q, *Valbyteuthis oligobessa,* section of distal portion of outer ring of arm sucker, M.L. 34 mm; R, same specimen, scale from proximal portion of outer ring of arm sucker (slightly diagrammatic).

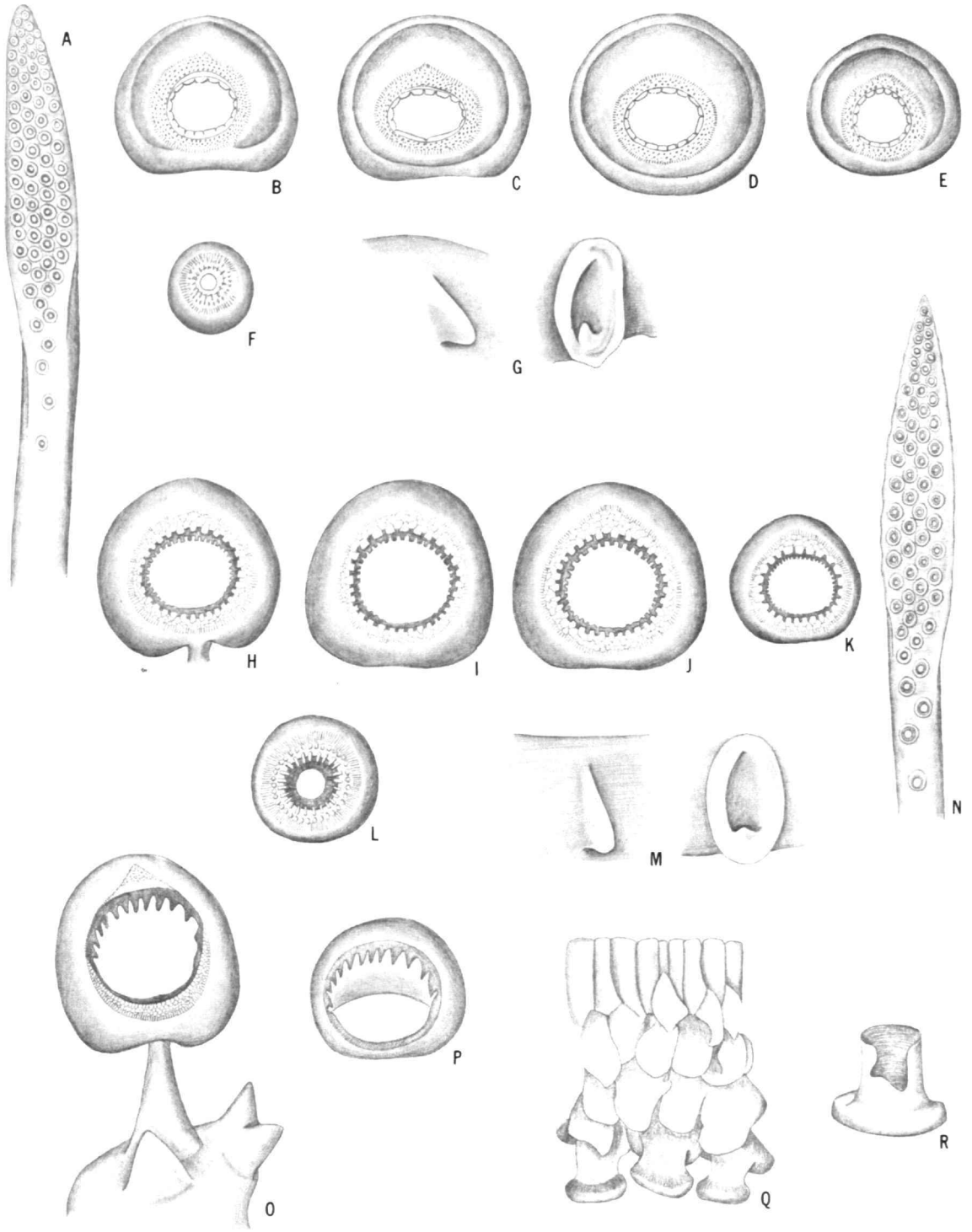
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PLATE 25.—*Mastigoteuthis pyrodes*, holotype, M.L. 110 mm.

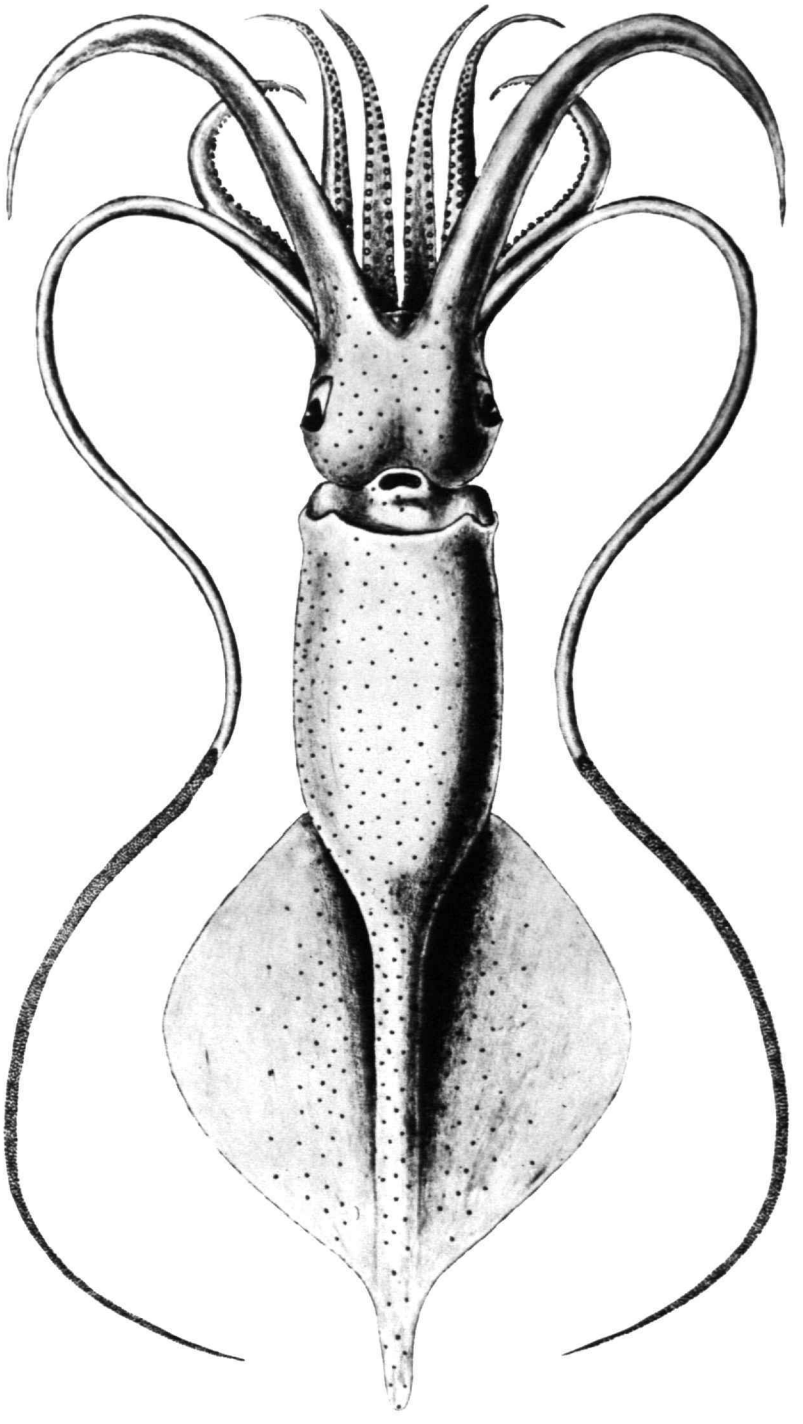
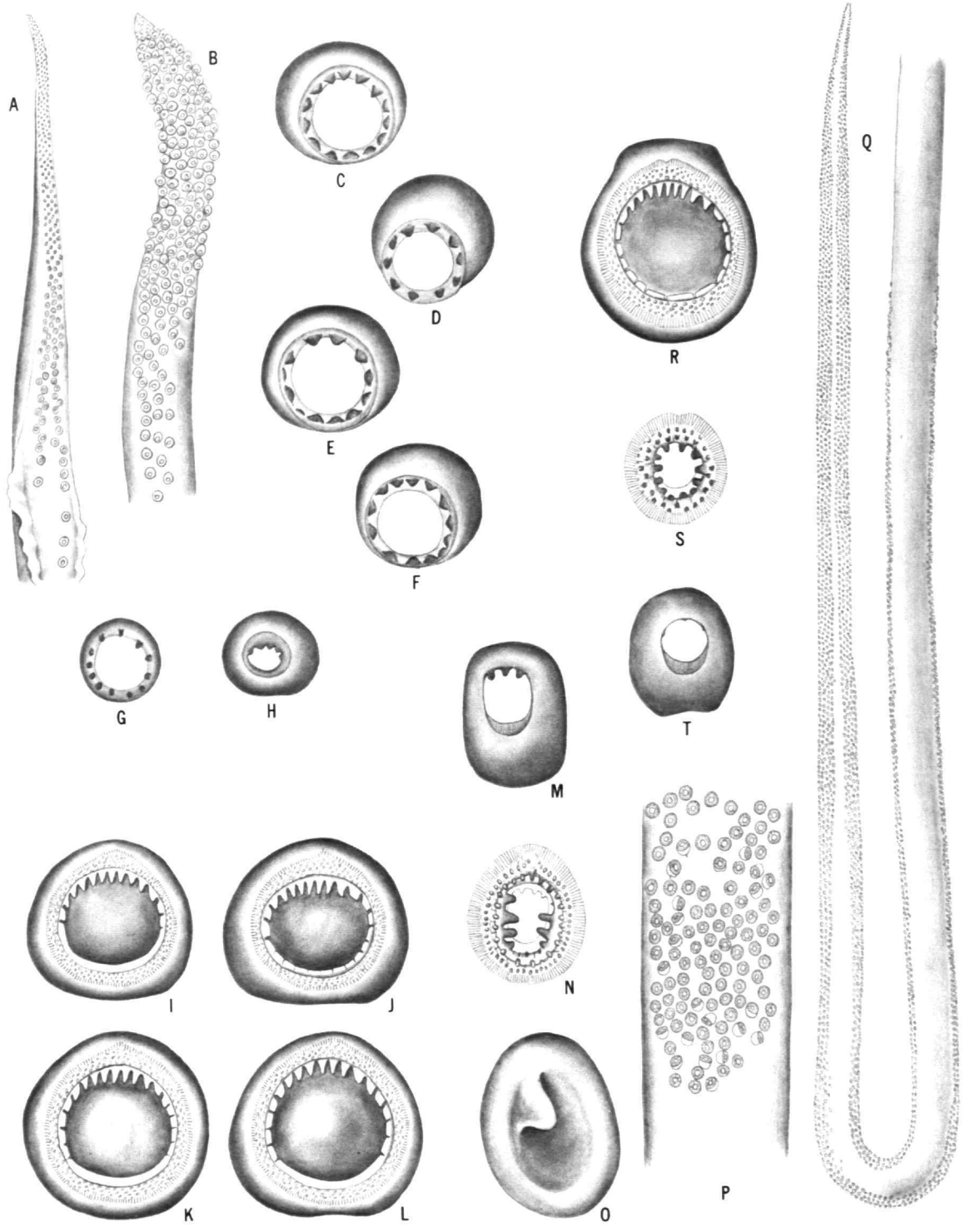


PLATE 26.—A–H, *Bathyteuthis berryi:* A, right arm I, holotype; B, tentacular club, M.L. 19 mm; C–F, suckers from base of arms I–IV, respectively, relative sizes maintained, holotype; G, inner ring of buccal sucker from dorsal lappet, holotype; H, club sucker, M.L. 19 mm. I–Q, *Mastigoteuthis pyrodes:* I–L, largest suckers from arms I–IV respectively, relative sizes maintained, holotype; M, inner ring of club sucker, holotype; N, club sucker enlarged three times relative to arm suckers, holotype; O, left funnel locking–cartilage, holotype; P, base of tentacular club of holotype; Q, aboral view of tentacular club of holotype; R, *Mastigoteuthis dentata* from off Cape Mala, Panama (PILLSBURY 510), large sucker from arm III; S, same specimen, club sucker; T, same specimen, inner ring of club sucker.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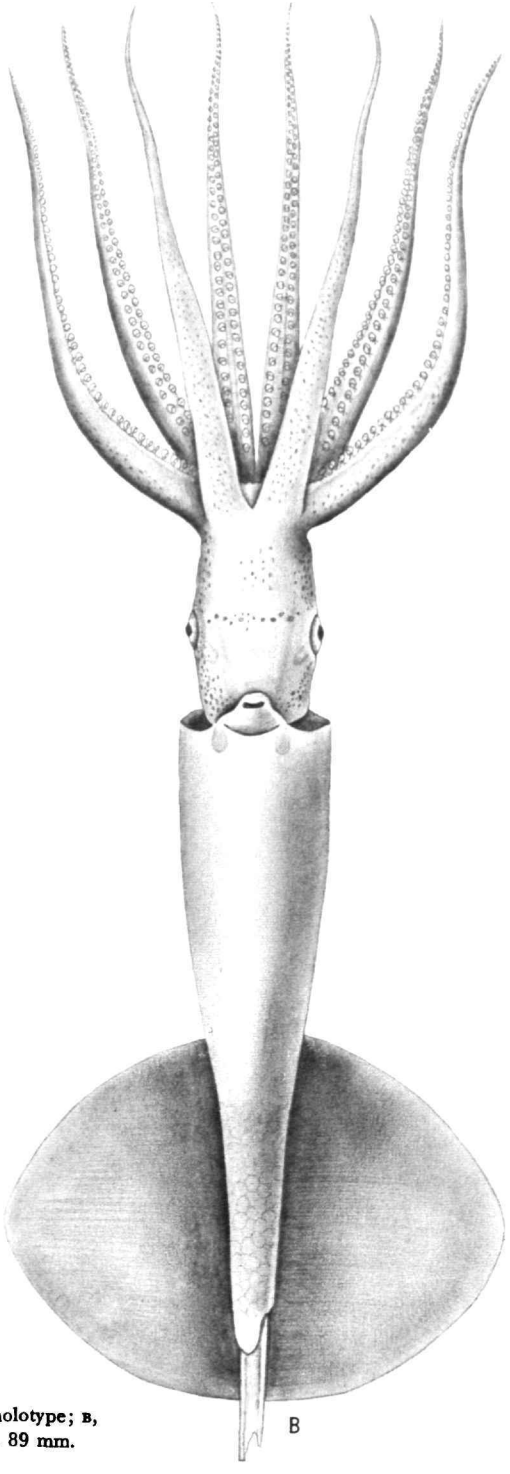

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PLATE 27.—A, *Bathyteuthis berryi*, ventral view, holotype; B, *Grimalditeuthis bomplandii*, ventral view, M.L. 89 mm.

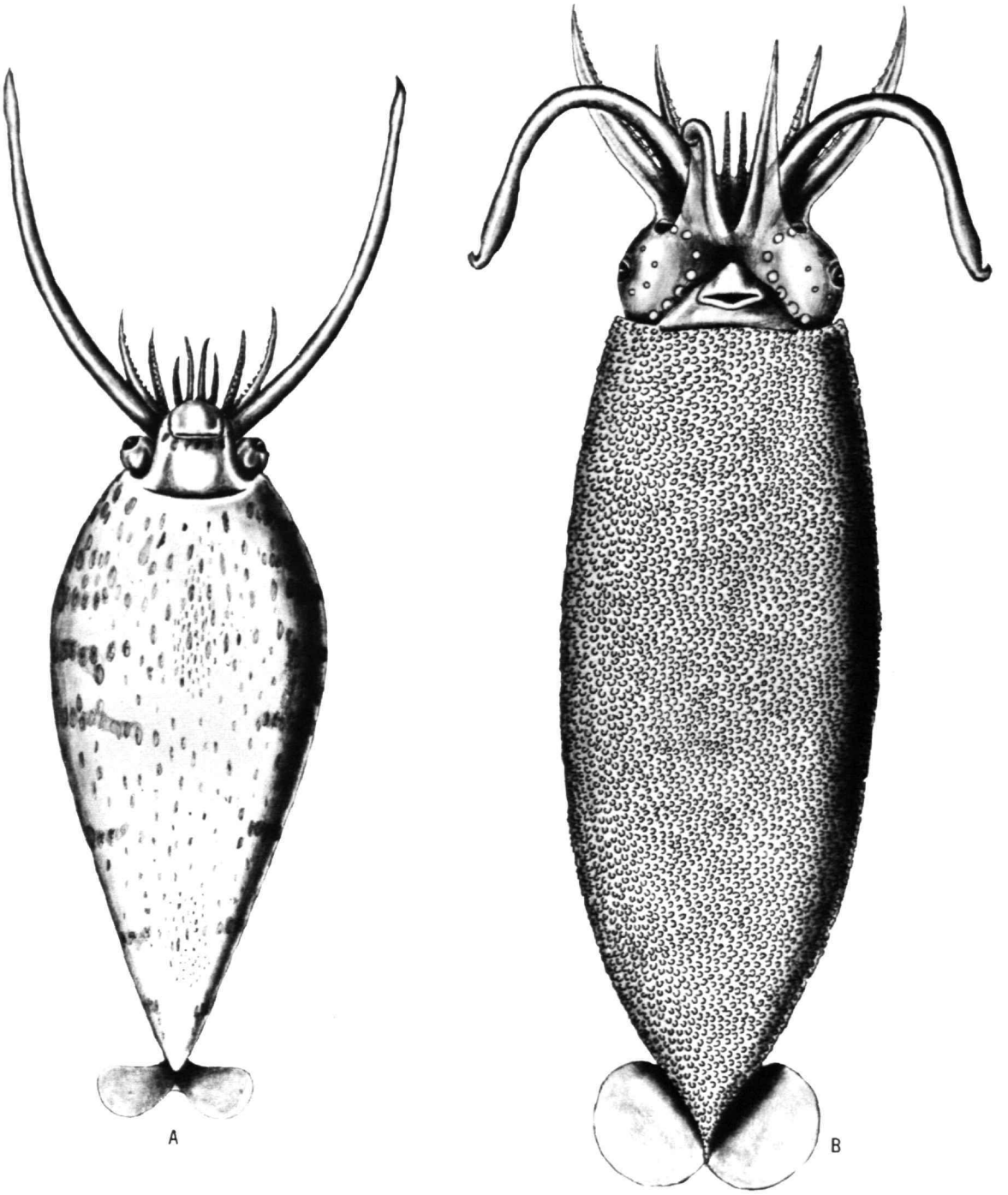
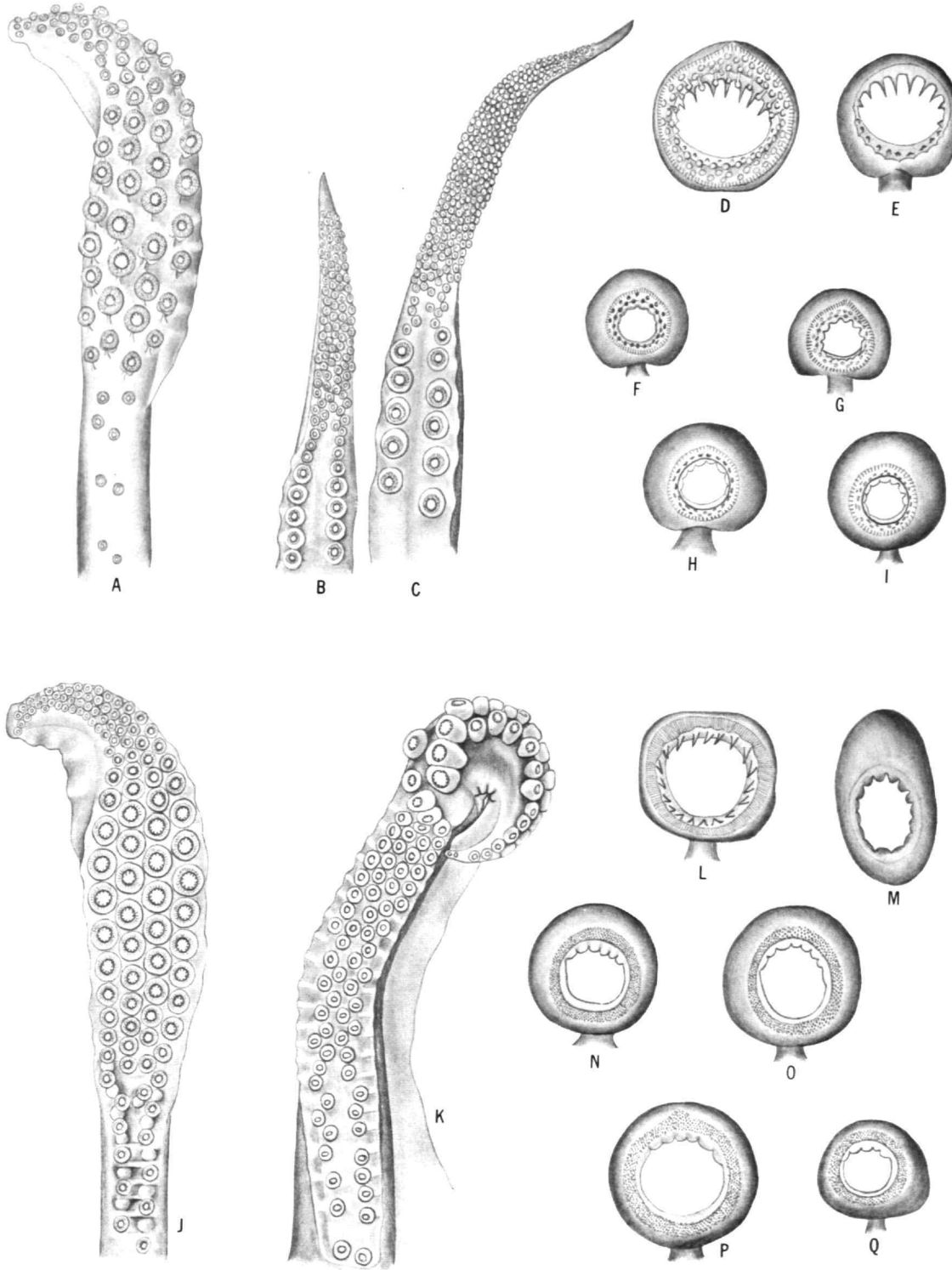


PLATE 28.—A, *Heliocranchia pfefferi,* ventral view, M.L. 41 mm; B, *Cranchia scabra,* ventral view, pattern and shape of tubercules diagrammatic, M.L. 107 mm.

PLATE 29.—A–I, *Heliochanchia pfefferi,* male, P.L. 39 mm: A, tentacular club; B, left arm I; C, left arm II; D, largest club sucker; E, inner ring of same sucker; F–I, largest suckers from arms I-IV, respectively, relative sizes maintained. J–Q, *Cranchia scabra,* male, M.L. 107 mm: J, tentacular club; K, hectocotylized right arm IV; L, largest sucker from tentacular club; M, enlarged sucker from tip of hectoctylus; N–Q, largest suckers from arms I-IV, respectively. L–Q maintain relative sizes.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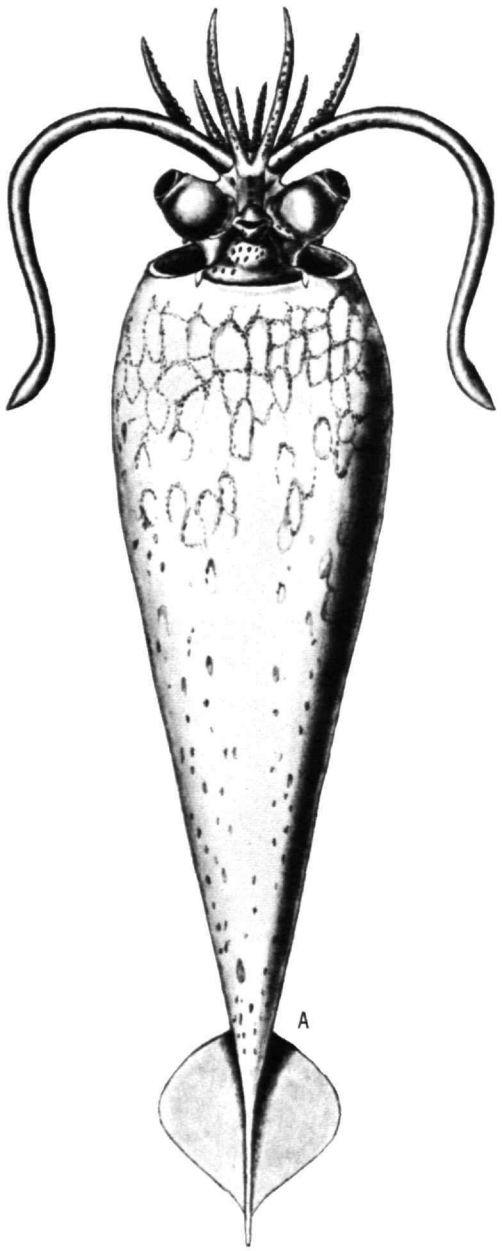


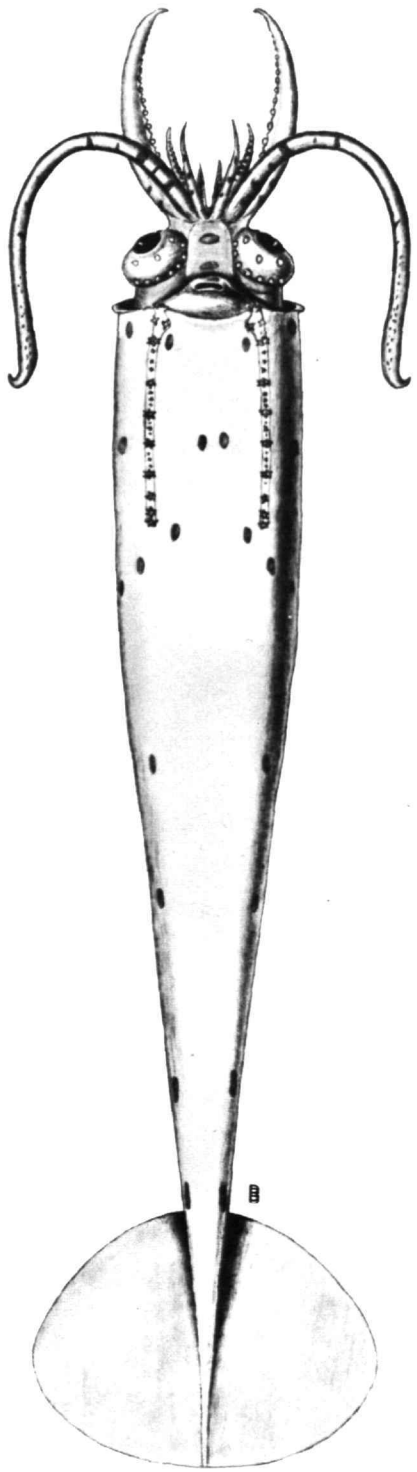
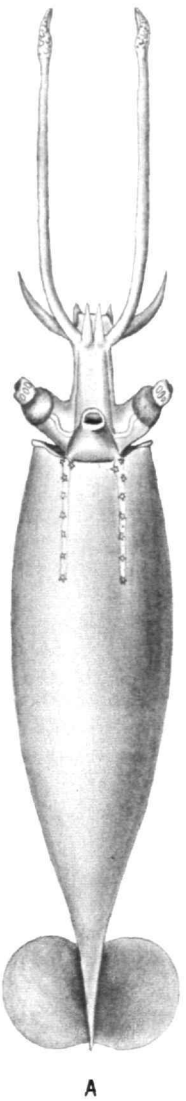


PLATE 30.—A, *Galiteuthis pacifica*, ventral view, P.L. 42 mm; B, *Lechia dislocata*, VELERO 8028, ventral view, P.L. 110 mm.



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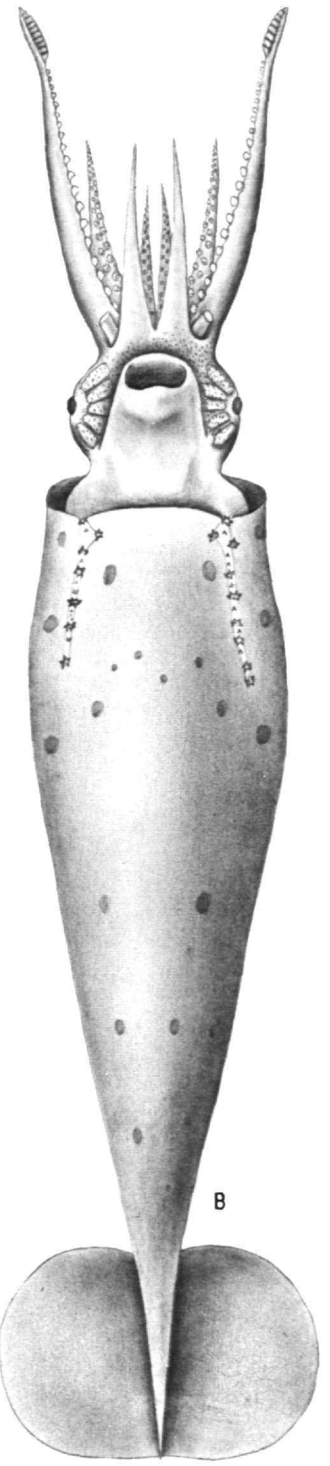

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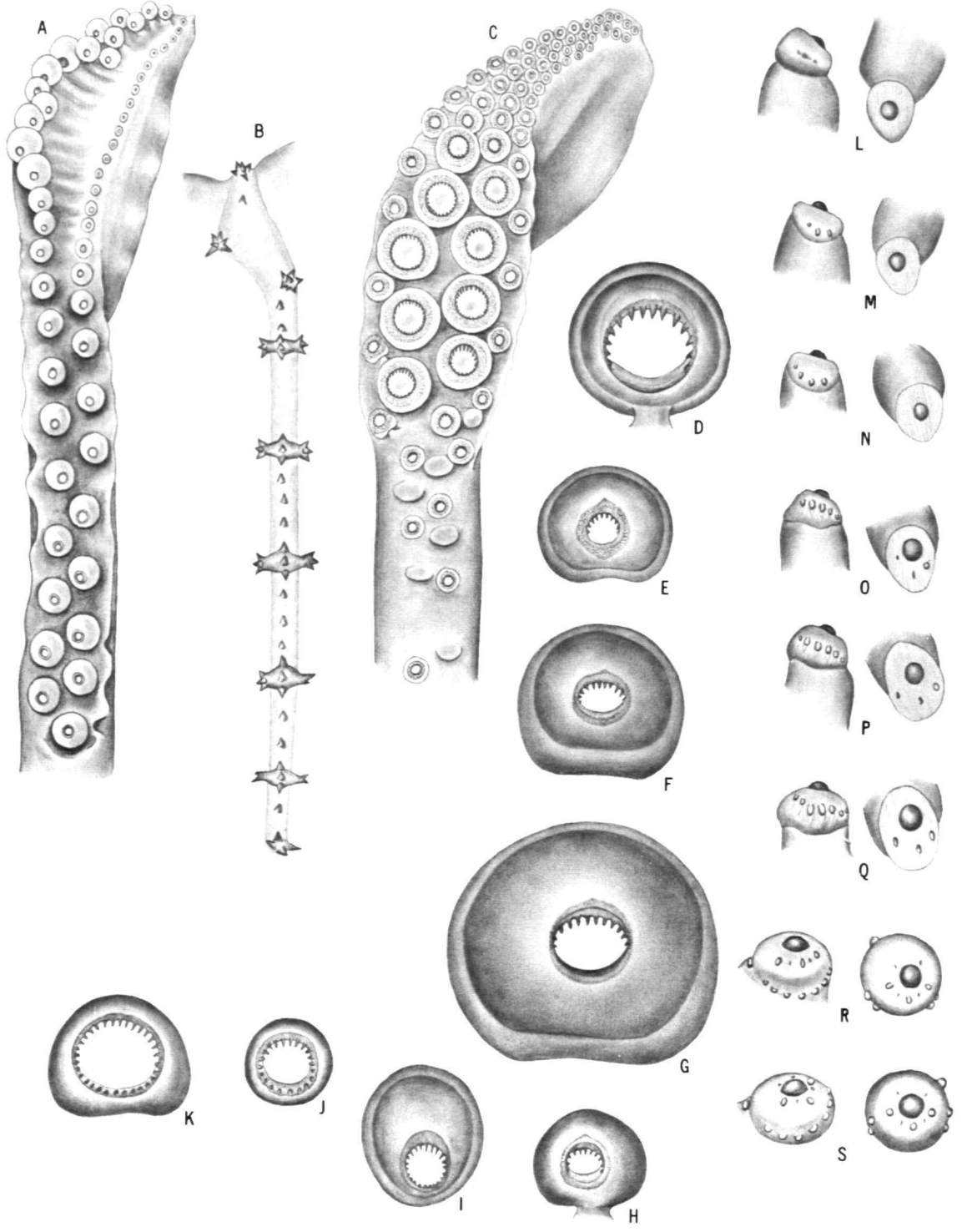
PLATE 31.—*Lechia dislocata:* A, Larva, "pyrgosis stage," P.L. 27 mm; B, mature female, P.L. 145 mm, tips of arms III added from another specimen.

PLATE 32.—*Lechia dislocata:* A, Immature hectocotylus of holotype; B, cartilagenous band and tubercules, left side, P.L. 136 mm: C, right tentacular club of holotype; D, largest sucker from arm III, female, P.L. 136 mm; E–H, largest suckers from arms I-IV, respectively, relative sizes maintained, holotype; I, enlarged sucker from tip of hectoctylus, P.L. 137 mm; J, marginal sucker from manus, holotype, enlargement double that of arm suckers; K, medial sucker from manus, holotype, same enlargement as arm suckers. L–S, development of eye photophores showing lateral and ventral views of eye at each stage: L, P.L. 16 mm; M, P.L. 22 mm; N, P.L. 25 mm; O, P.L. 35 mm; P, P.L. 44 mm; Q, P.L. 64 mm; R, P.L. 125 mm, holotype; S, P.L. 143 mm.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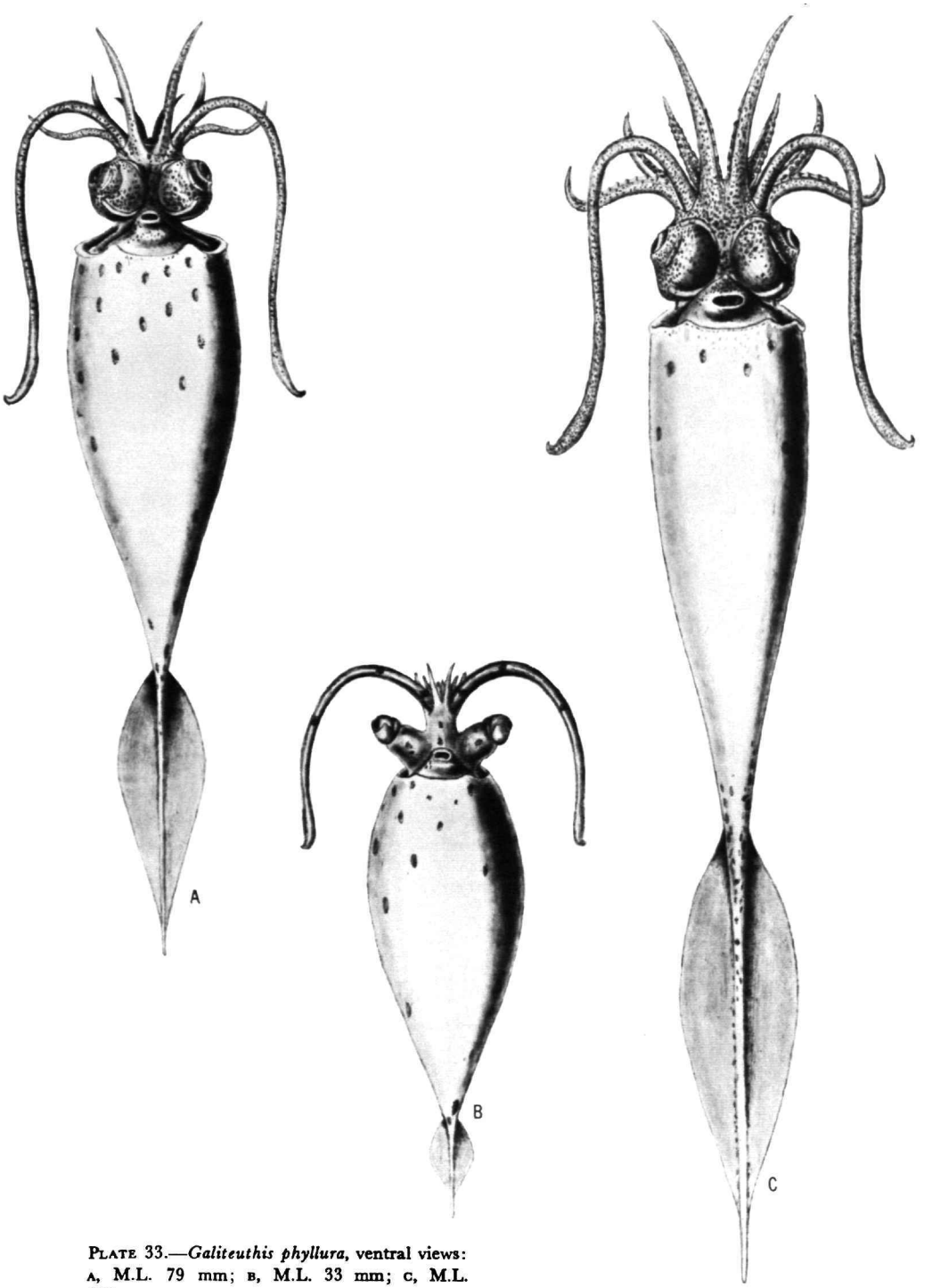


PLATE 33.—*Galiteuthis phyllura*, ventral views: A, M.L. 79 mm; B, M.L. 33 mm; C, M.L. 170 mm.

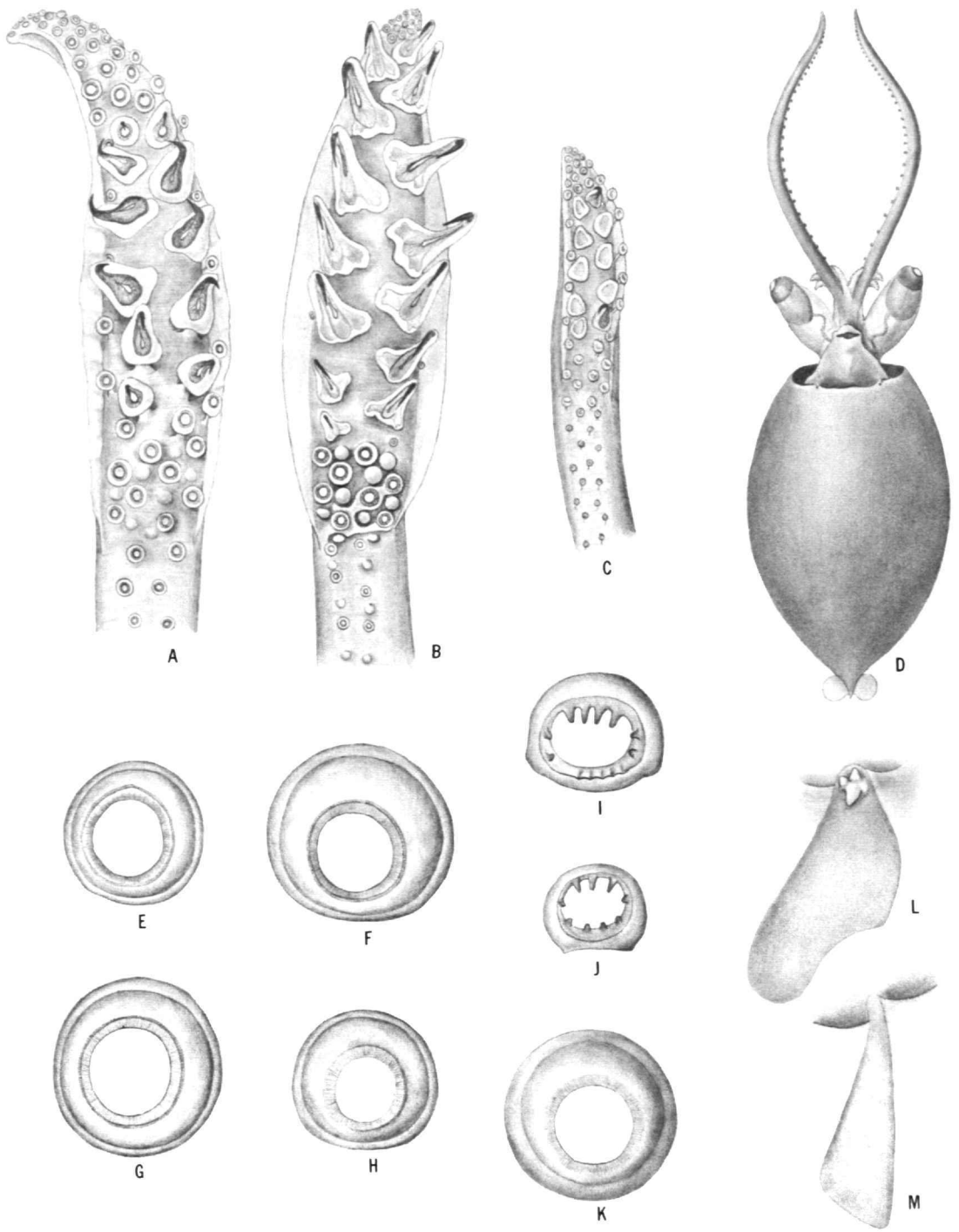
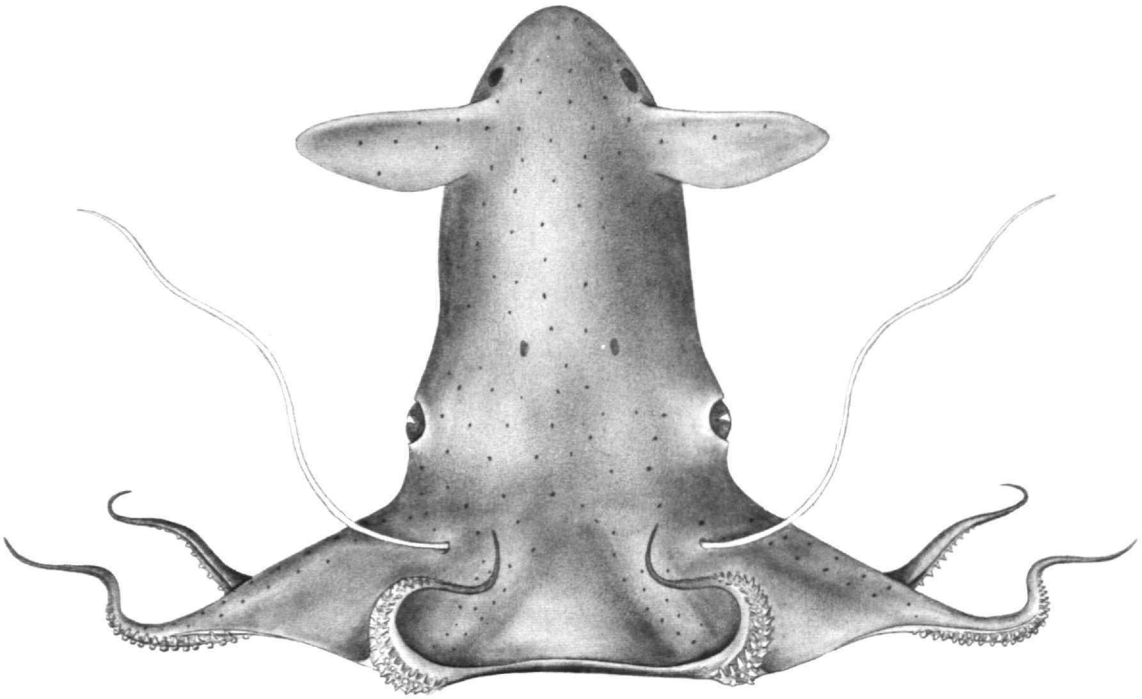


PLATE 34.—A, *Galiteuthis phyllura,* tentacular club, P.L. 79 mm; B, same, tentacular club, P.L. 359 mm; C, *Galiteuthis pacifica,* tentacular club, P.L. 36 mm; D, *G. phyllura,* larva, P.L. 13 mm; E–H, *G. phyllura,* P.L. 211 mm, largest suckers from arms I–IV, respectively, relative sizes maintained; I, same specimen; inner ring of largest dactyl sucker, enlarged four times relative to arm suckers; J, *G. pacifica,* largest dactyl sucker, P.L. 36 mm; K, *G. pacifica,* largest sucker of arms III, P.L. 65 mm; L, *G. phyllura,* cartilage at funnel-mantle fusion, P.L. 173 mm; M, *G. pacifica,* cartilage at funnel-mantle fusion, P.L. 65 mm.



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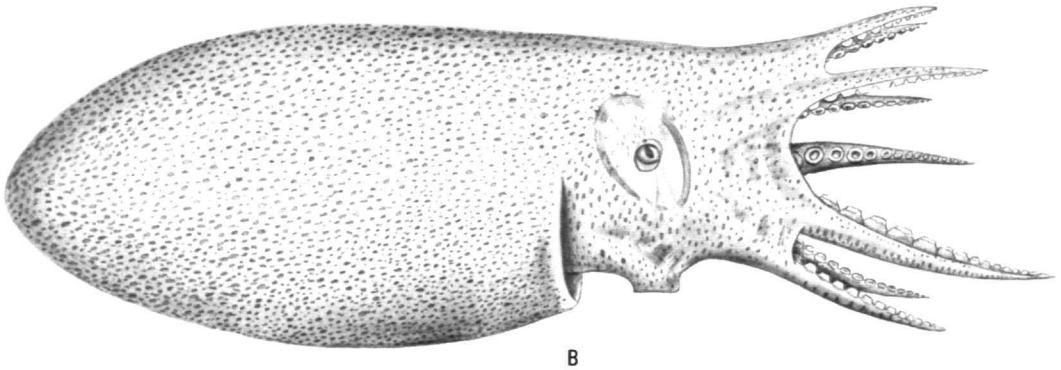

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PLATE 35.—A, *Vampyroteuthis infernalis*, dorsal view, P.L. 50 mm; B, *Japetella heathi*, lateral view.

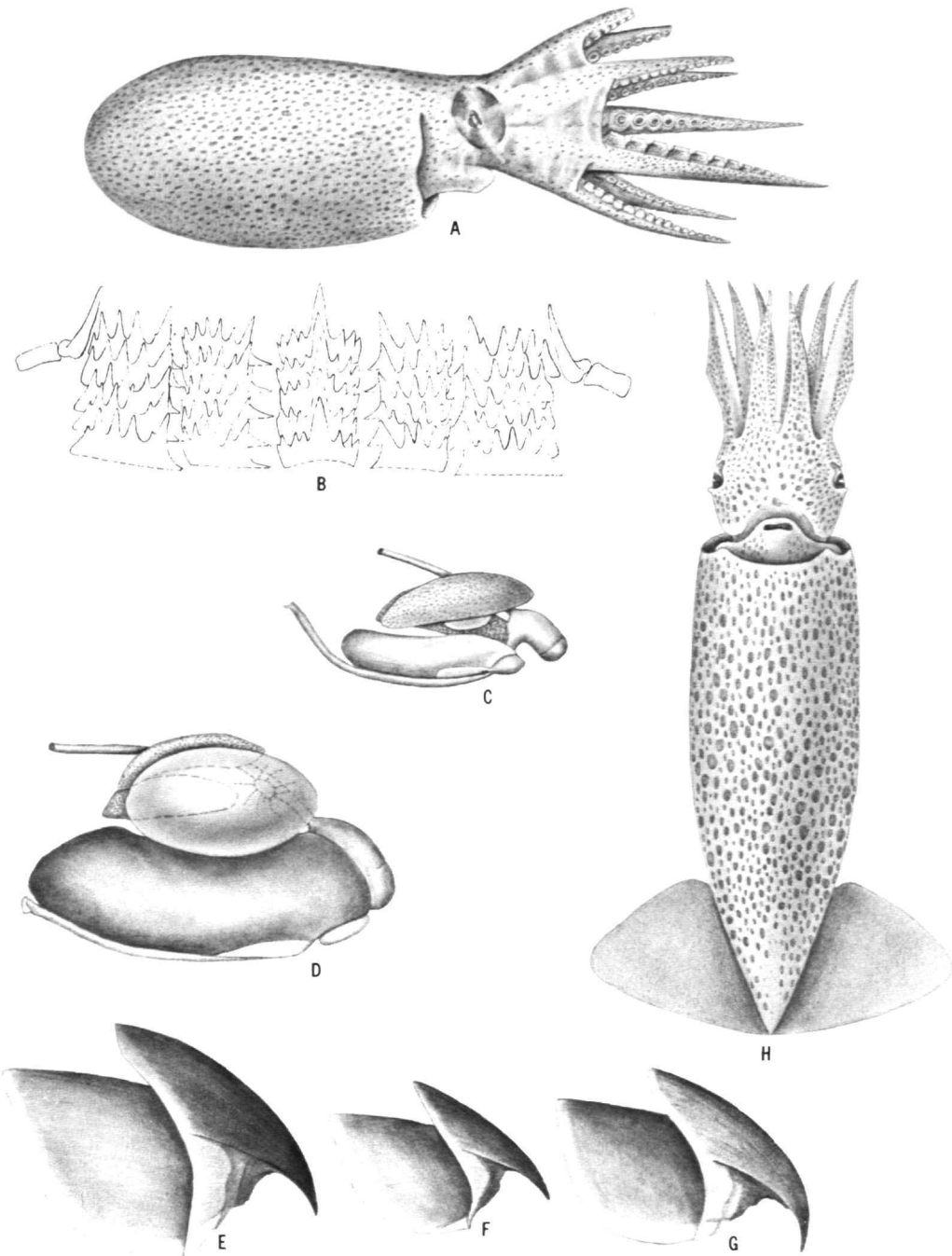

PLATE 36.—A, *Japetella* sp., V–9661, lateral view, M.L. 72 mm; B, same specimen, radula; C, same specimen, viscera; D, *Japetella heathi*, viscera, M.L. 75 mm; E, *Vampyroteuthis infernalis*, upper beak from Atlantic Ocean specimen, P.L. 78 mm; F, same, Californian specimen, P.L. 74 mm; G, same, Atlantic Ocean specimen, P.L. 64 mm; H, *Gonatopsis borealis*, juvenile, M.L. 35 mm.

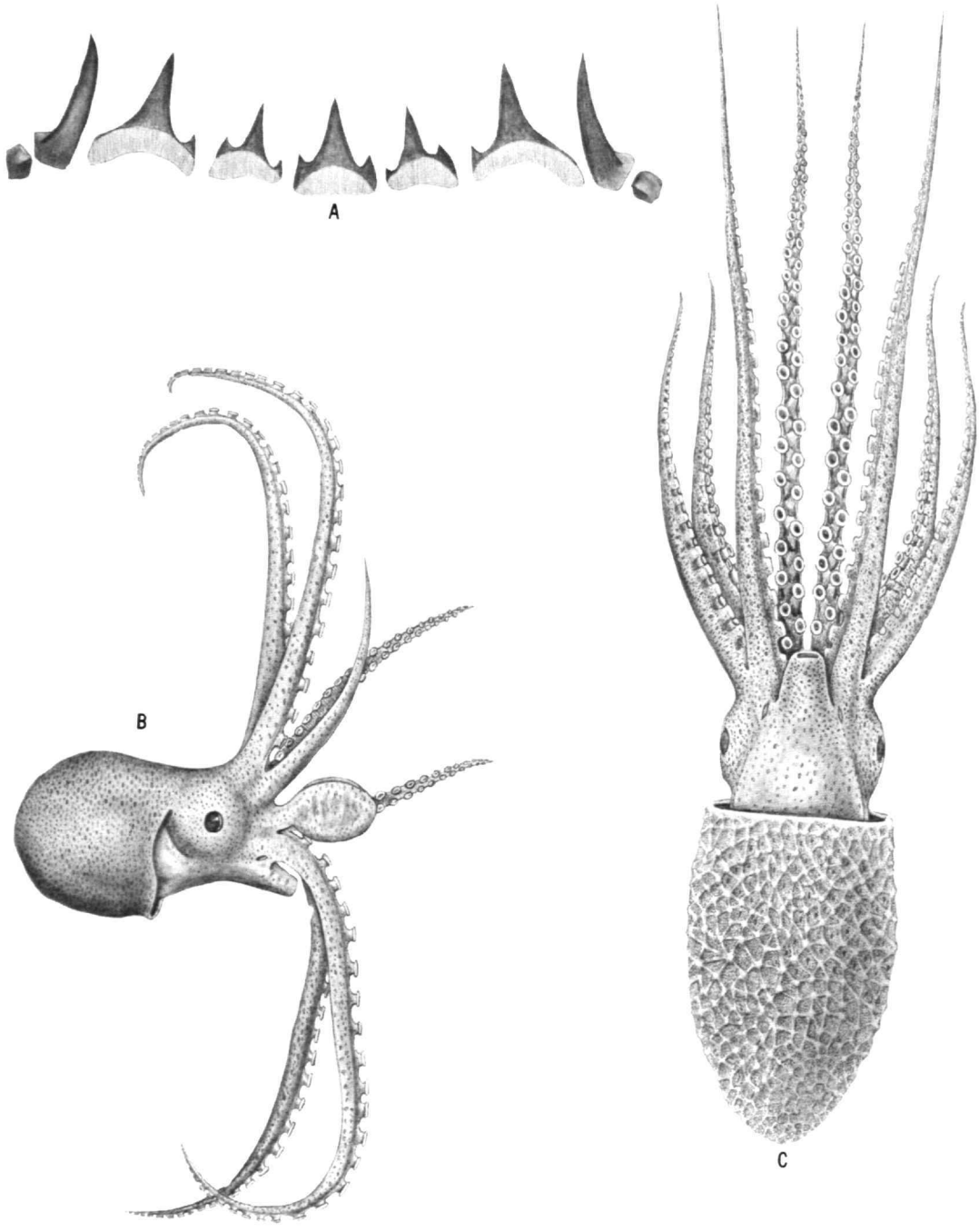

PLATE 37.—*Ocythoe tuberculata:* A, radula, M.L. 80 mm; B, immature male, M.L. 14 mm; C, immature female, M.L. 80 mm.

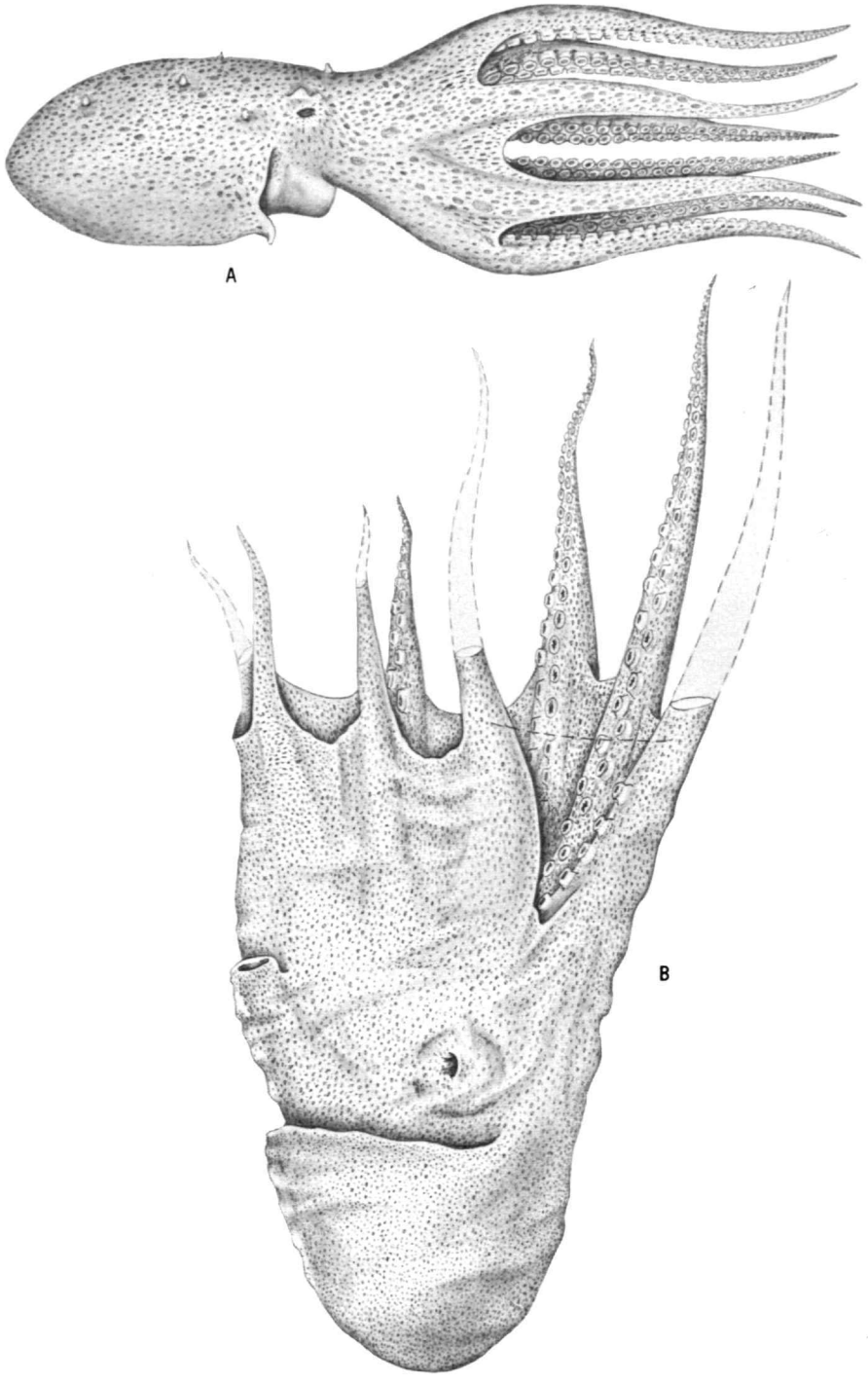

PLATE 38.—A, *Octopus* sp. pelagic juvenile. M.L. 19 mm; B, *Alloposus mollis*, female, M.L. 115 mm.

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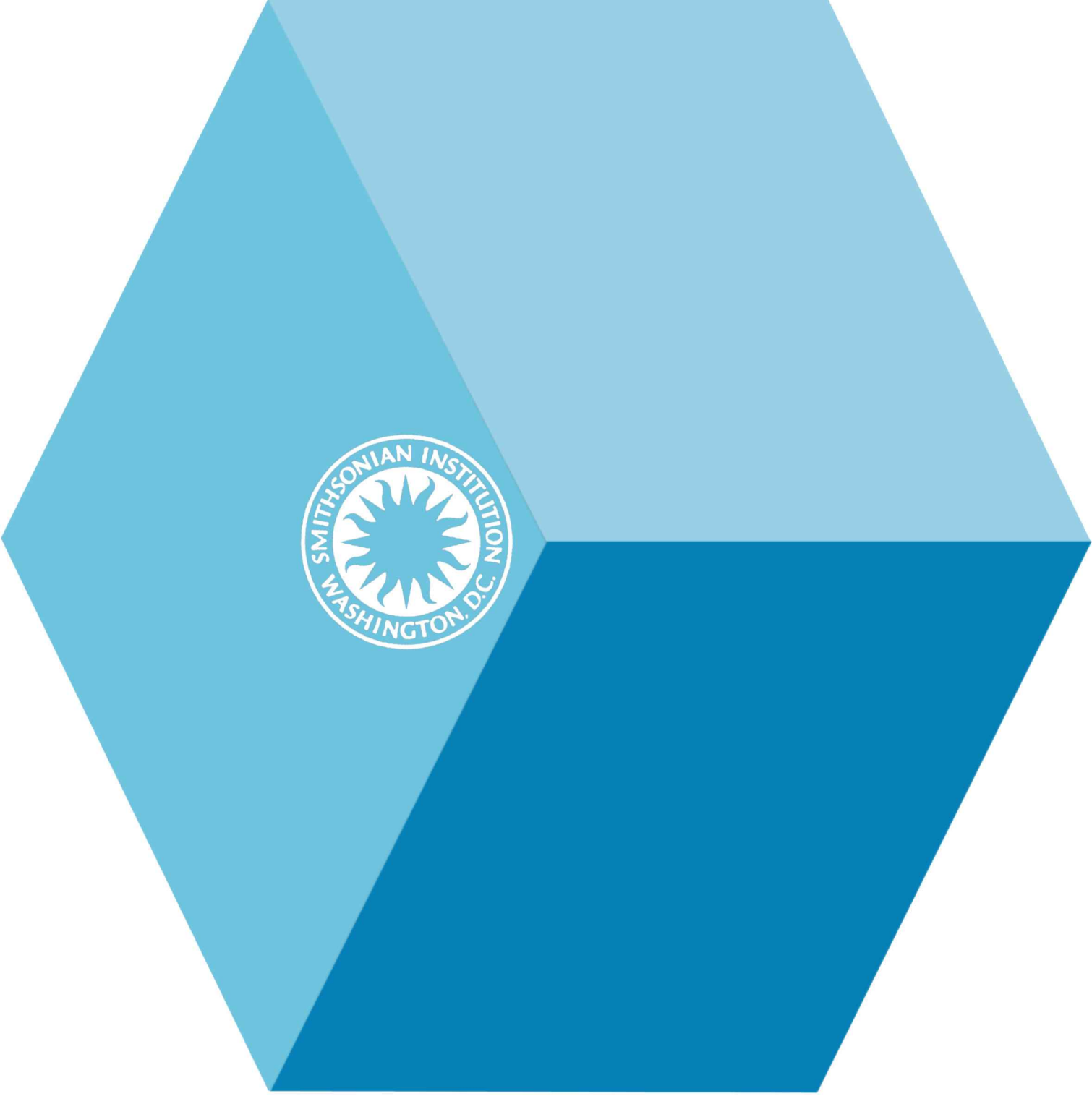
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