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TAXONOMY AND BIOSTRATIGRAPHY OF CONIACIAN THROUGH MAASTRICHTIAN *ANCHURA* (GASTROPODA: APORRHAIIDAE) OF THE NORTH AMERICAN PACIFIC SLOPE

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ABSTRACT—North American Pacific Slope deposits of Coniacian to Maastrichtian age have yielded eight biostratigraphically useful species of *Anchura*: *A. (Helicaulax?) popenoei* new species, Coniacian; *A. halberdopsis* new species, early Campanian; *A. callosa* Whiteaves, 1903, early Campanian; *A. falciformis* (Gabb, 1864), late early to middle Campanian; *A. phaba* new species, middle to late Campanian; *A. ainikta* new species, middle to late Campanian; *A. gibbera* Webster, 1983, late Campanian to early Maastrichtian; *A. baptos* new species, late Maastrichtian to early Danian. In addition, two other possible species are *A. nanaimoensis* (Whiteaves, 1879), middle to late Campanian, and *Anchura?* new species, late Maastrichtian. These species together with two additional Turonian species, *A. (Helicaulax) tricosa* Saul and Popenoe, 1993, and *A. (H.) condoniana* Anderson, 1902, allow the definition at least eight Late Cretaceous *Anchura* zones for the Pacific Slope. These zones have durations of 1.5 m.y. to 4 m.y.

Anchura (H.?) popenoei from northern California appears most closely related to *A. (Helicaulax) tricosa* Saul and Popenoe, 1993, of Turonian age from southern California. *Anchura callosa, A. falciformis, A. nanaimoensis,* and *A. phaba* appear to be closely related based on sculptural elements, as does *A. gibbera* despite having an anterior spur on the wing. However, these species appear to belong to two latitudinally differentiated faunal provinces. Species having a northern range include *A. callosa, A. falciformis,* and *A. nanaimoensis,* whereas *A. phaba* and *A. gibbera* are from more southern deposits, as are also *A. halberdopsis, A. ainikta,* and *A. baptos.*

INTRODUCTION

THE HIGH-SPIRED aporrhaid *Anchura* is one of the more widely distributed gastropods of Late Cretaceous age from Pacific Slope deposits. The genus is known from rocks as old as the late Early Cretaceous and ranges into early Paleocene age rocks on the Pacific Slope. One to several species of *Anchura* were present at any one time throughout much of the Late Cretaceous, giving it biostratigraphic utility comparable to that of *Turritella.* In addition, some species appear to have been geographically constrained, providing some paleobiogeographic information in this tectonically complex region. *Anchura* is generally less common than *Turritella* but may be locally abundant. Specimens are usually more abundant in fine-grained sandstone or siltstone facies representing middle to outer shelf environments, where they may be the only biostratigraphically useful fossil present. In contrast, *Turritella* is typically more abundant in slightly coarser-grained deposits than those yielding *Anchura,* possibly reflecting a more nearshore or shallower water habitat for the former. *Anchura halberdopsis* and *A. (H.) condoniana,* which resemble one another, have been recovered from coarser-grained sediment than the other species.

Anchura is characterized by complex morphological features that allow it to be readily broken down into species and evolutionary lineages. These features include complex ornamentation, typically of both axial and spiral sculpture, a variable outer lip and wing that develop processes, and whorl peripheries that may develop one or more carinae. Regardless of the potential to subdivide the Pacific Slope *Anchura* based on these features, most previously documented Campanian and Maastrichtian age specimens from the West Coast have been assigned to *Anchura falciformis* (Gabb, 1864). However, this study indicates that *A. falciformis,* which was described from specimens collected from the top of the Chico Formation on Chico Creek, Butte County, California, is confined to rocks of late early and middle Campanian age. Other previously described Campanian and Maastrichtian age species are *A. callosa* Whiteaves, 1903, probably from the Cedar District Formation (Ward, 1978) on Vancouver Island, British Columbia, *A. gibbera* Webster, 1983, from the Rosario Formation near Santa Catarina Landing, Baja California, Mexico, and *"Potamides tenuis" nanaimoensis* Whiteaves, 1879, which is undoubtedly an *Anchura,* but is based upon immature specimens.

Several additional Late Cretaceous *Anchura* species have been documented from the Pacific Slope. Anderson (1958) listed four species, of which only *A. falciformis* is discussed herein. None of the other three is a typical *Anchura*; two, *"Anchura" angulata* (Gabb, 1864) and *"Anchura" biangulata* Anderson, 1938, are probably of Albian and Cenomanian age, and *"A." carinifera* Gabb, 1869, may be of early Tertiary age. *"Anchura" carinifera,* based on a very small specimen, is comparable to *Teneposita* Loch, 1989, in size, but the spire has indications of spiral sculpture only and lacks the arcuate axial ribbing of *Teneposita* and juvenile *Anchura.* Saul and Popenoe (1993) discussed two species of Turonian age, *A. (Helicaulax) condoniana* (Anderson, 1902) and *A. (H.) tricosa* Saul and Popenoe, 1993. *"Alaria" fairbanksi* Davis, 1913, from near Slates Hot Springs is possibly of late Campanian age based upon *Baculites* specimens from that vicinity (Matsumoto, 1960, p. 74). Davis thought the species to be congeneric with *Anchura stenoptera* of Whiteaves, 1879 (= *A. callosa* Whiteaves, 1903, from Vancouver Island, British Columbia), but it bears a stronger resemblance to *Tessarolax* Gabb, 1864, than to *Anchura.*

Within the Coniacian to Maastrichtian interval, we recognize nine *Anchura* species, five of them new. Figure 1 illustrates the stratigraphic ranges of these species relative to Pacific Slope ammonite and *Turritella* zonations that have been calibrated to the recently revised geochronology and chronostratigraphy of Obradovich (1993) and Gradstein et al. (1994). Identified *Anchura* species are as follows: *A. (H.?) popenoei* new species, Coniacian; *A. halberdopsis* new species, early Campanian; *A. callosa* Whiteaves, 1903, early and early middle Campanian; *A. falciformis* (Gabb, 1864), middle Campanian; *A. phaba* new species, late middle and late(?) Campanian; *A. ainikta* new species, late middle and late Campanian; *A. gibbera* Webster, 1983, late Campanian and early Maastrichtian, and *A. baptos* new species, late Maastrichtian. Two additional species may occur,

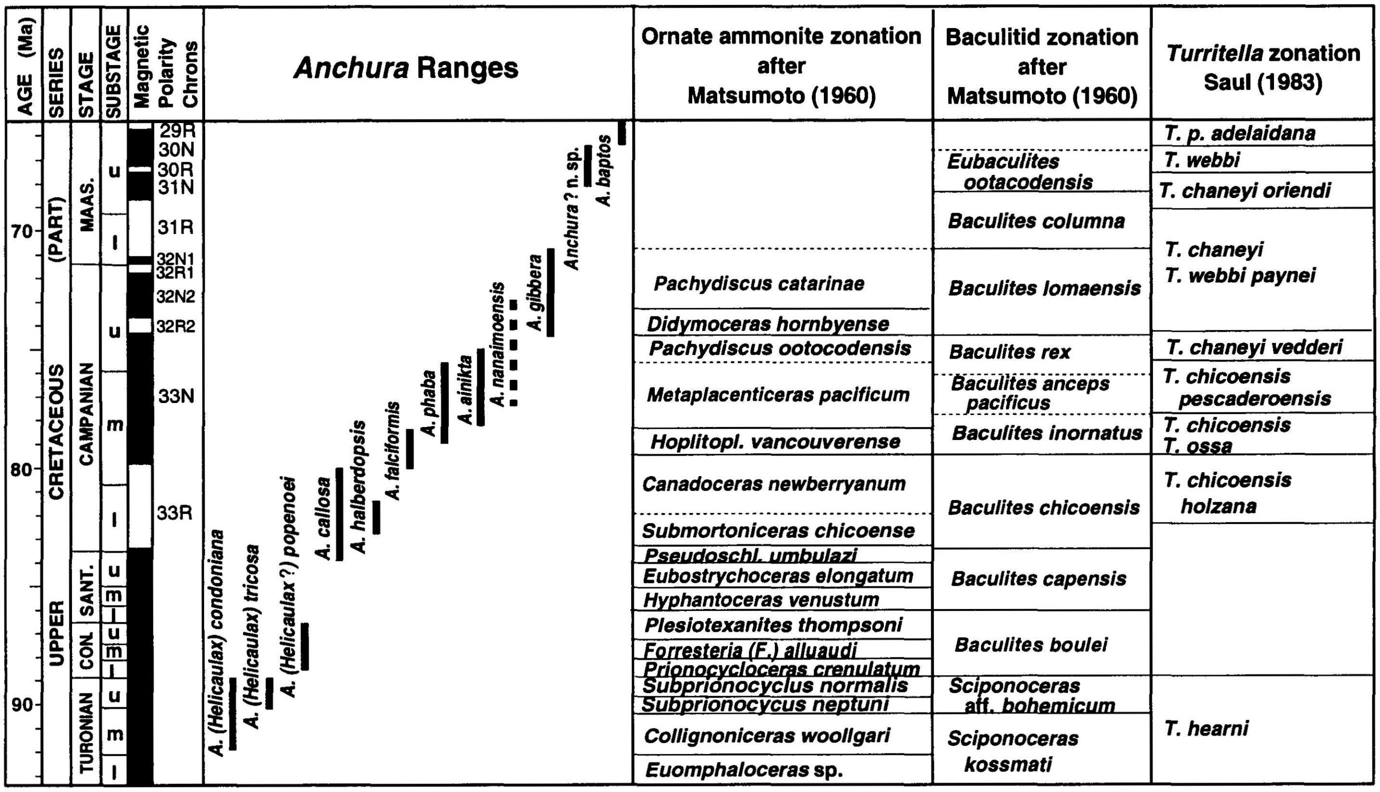

FIGURE 1—*Anchura* ranges plotted against time, rock-stratigraphic units, magnetostratigraphy, and Pacific Slope ammonite and *Turritella* zones. Ages of stage boundaries based on Obradovich (1993). Magnetic polarity chronology based on Verosub et al. (1989) and Bannon et al. (1989) for ties to Pacific Slope biostratigraphy and Gradstein et al. (1994) for ties to geochronology and chronostratigraphy. Ammonite genera abbreviations are *Hoplitopl.* for *Hoplitoplacenticeras* and *Pseudoschl.* for *Pseudoschloenbachia.*

A. nanaimoensis (Whiteaves, 1879), of middle or late Campanian age, based on juveniles, and an incomplete specimen of late Maastrichtian age referred to *Anchura?* new species. The geochronologic data indicate that most of these species had durations of 2 to 3 m.y.; but some apparently ranged as long as 4 m.y. or as short as 1.0 to 1.5 m.y. (Figure 1). These durations are consistent with the 2.0 to 2.5 m.y. ranges estimated by Sohl (1977) for Western Interior and Gulf Coast species of the aporrhaid genus *Drepanochilus.*

Some of the species noted in this study display restricted geographic distributions. For example, *A. callosa* and *A. falciformis,* which are found from the Sacramento Valley northward to Puget Sound, are not recognized from southern California deposits of appropriate age. Instead, *Anchura halberdopsis* is restricted to southern California rocks of early Campanian age, and *A. phaba* occurs widely in southern California strata of middle and early late Campanian age and is only found to the west of the San Andreas fault as far north as the Pigeon Point area, San Mateo County, California. *Anchura gibbera* also has a southern distribution, having been found from San Diego County, California, south to Arroyo Santa Catarina, Baja California, Mexico.

MORPHOLOGIC OBSERVATIONS AND COMPARISONS

Protoconchs have been found for some of the species discussed herein. All have about four apparently smooth whorls. The earliest teleoconch whorls, herein referred to as juvenile whorls (usually two), have fine arcuate axial sculpture, concave toward the aperture. Juvenile whorls have at least one and a half times as many of these axial ribs per whorl as do the adolescent whorls. On the adolescent whorls, the spiral sculpture becomes obvious, and an angulation or carina usually develops on one of the spiral cords.

The juvenile and adolescent whorls of *Anchura (Helicaulax?) popenoei A. halberdopsis,* and *A. ainikta,* have randomly occurring varices. Similar varices also are present on the Turonian *A. (H.) tricosa* Saul and Popenoe, 1993. *Anchura (H.?) popenoei* and *A. (H.) tricosa* have several other characteristics in common, but the other two species are not otherwise notably similar; *A. halberdopsis* bears a greater resemblance to *A. (Helicaulax) condoniana* (Anderson, 1902) than to *A. (H.) tricosa.* Varices are not mentioned in the descriptions or discussions of any Gulf Coast species (Wade, 1926; Sohl, 1960; Dockery, 1993), but *A. substriata* Wade, 1926, from the Ripley Formation along Coon Creek, Tennessee, has varices on its early whorls (see Sohl, 1960, p. 106, plate 12, figures 2–3). Varices are considered to be of little or no systematic importance within the closely related Strombidae family by Davies (1971, p. 328), but Abbott (1960, p. 34) found certain types of varices to be typical of some subgenera in the genus *Strombus* Linnaeus, 1758. Abbott additionally suggested that the varices served to strengthen the fragile juvenile shell. Among the Pacific Slope species these varices have not been found on specimens of *A. callosa, A. falciformis, A. phaba,* and *A. gibbera.*

Anchura callosa, A. falciformis, A. phaba, and *A. gibbera* may form a lineage from oldest to youngest, even though they display disjunct distributions. All four species have two strong cords anterior to the carina. The sculpture of the spires in these species consists of somewhat curved, round-topped axial ribs with interspaces wider than the ribs. The axial rib number appears to increase through time. The axial ribs are crossed by narrower spiral cords, which also have interspaces wider than the cords. The axial ribs tend to be weakest posteriorly and strongest at the periphery. The profile of the anterior portion of the outer lip is slightly scalloped. *Anchura callosa* and *A. falciformis* are very similar, and *A. callosa* grades morphologically into *A. falciformis* within the Chico Creek section. Whiteaves' (1879) figure of an *Anchura* from Vancouver Island, British Columbia, that he first identified with *A. stenoptera* (Goldfuss, 1844) and later renamed *A. callosa* Whiteaves, 1903, is similar to *A. falciformis,* although Whiteaves did not compare the Vancouver Island species to *A. falciformis. Anchura callosa* appears to be the species figured as *A. falciformis* by Taff, Hanna, and Cross (1940), and *A. callosa* occurs in the Tenmile Member (Haggart and Ward, 1984) of the Chico Formation on Chico Creek, Butte County, from about 548 m to about 915 m above the base of the section. Large specimens of *A. falciformis* are common near the top of the Tenmile Member of the Chico Formation on Chico Creek, and from the Chico Formation on Butte Creek and near Pentz, Butte County, California. *"Potamides tenuis" nanaimoensis* Whiteaves (1879) is an *Anchura* very similar to *A. falciformis* and *A. phaba,* but the type specimens are too immature either to separate *A. nanaimoensis* with certainty from these species or to combine it with one of them.

SYSTEMATIC PALEONTOLOGY

Morphologic terminology used and parameters measured in this paper are shown in Figure 2. Terminology for the extended outer lip of *Anchura* is that of Dockery (1993). The *shank* extends laterally from the body whorl and bears a *posterior arm* that extends posteriorly as a long spine or spur. The shank may bear an *anterior arm,* which is generally a short spur extending anteriorly from the terminus of the shank's anterior margin. Measurement abbreviations and symbols used in Tables 2–11 are: H = height of specimen; Hp = height of penultimate whorl, in immature specimens the largest whorl bounded by sutures; Db = diameter of largest whorl available, in mature specimens the body whorl; Dp = diameter of whorls measured for Hp; Dp/Hp = ratio of whorl width to whorl height; R = length of rostrum, uncertain that any are complete; PA = pleural angle, measured along spire whorls, excluding body whorl; S = shank length, from posterior outer lip inboard of sulcus, parallel to keel, to point of greatest flexure of keel; Ct = total number of primary spiral cords on a spire whorl; Cp = cords posterior to angulation or carina of whorl; A = axial ribs, counted on whorl measured for Hp; † = crushed; • = ribs counted on half whorl and doubled.

Institutional abbreviations used in this paper are: ANSP = Academy of Natural Sciences of Philadelphia; CASG = California Academy of Sciences, Geology; CIT = California Institute of Technology; GSC = Geological Survey of Canada; IGM = México Museo del Paleontologia del Instituto de Geología; LACMIP = Natural History Museum of Los Angeles County, Invertebrate Paleontology; UCLA = University of California, Los Angeles; USGS = United States Geological Survey; USNM = United States National Museum; UWBM = University of Washington, Burke Museum.

Superfamily STROMBACEA Rafinesque, 1815
Family APORRHAIDAE Gray, 1850
Genus ANCHURA Conrad, 1860

Type species.—*Anchura abrupta* Conrad, 1860, by monotypy, from the Gulf Coast Maastrichtian.

Diagnosis.—Medium- to large-sized aporrhaids with high, evenly tapering spires; sculpture ornate, with both axial and spiral elements, commonly noded at intersections; aperture sublenticular; anterior rostrum long and narrow; outer lip elongate, extended into a falcate wing, bent posteriorly.

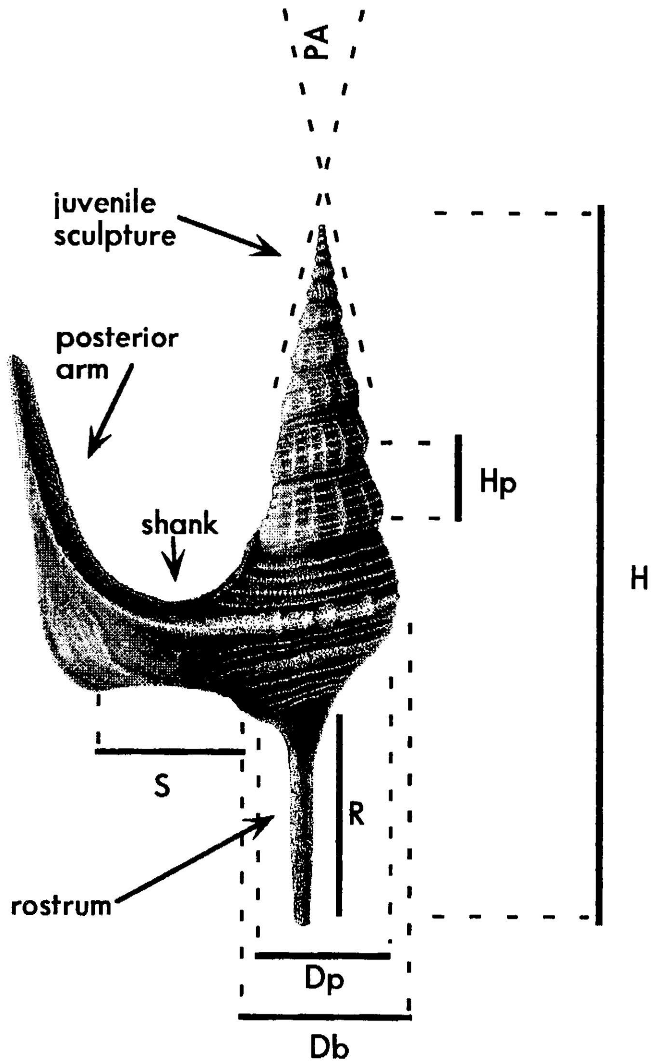

FIGURE 2—Morphology of *Anchura* and diagram of features measured.

Discussion.—The above diagnosis differs from that of Sohl (1960, p. 104) and Dockery (1993, p. 62) in omitting reference to an anterior arm or lobe on the wing. This is the projection that gives Conrad's original illustration its T-shaped wing. Among Pacific Slope species only *Anchura gibbera* is known to have such an anteriorly directed extension. *Anchura falciformis* has a broad, rounded expansion at the posteriorward bend of the wing, which is similar to that of *A. corniculata* Dockery, 1993, from the Campanian of the Gulf Coast.

Dockery (1993) has described the protoconch of *A. chapelvillensis* Dockery, 1993, from the Coffee Sand of Mississippi, as having the last one and a quarter whorls smooth but with a rounded carina or shoulder. Transition to the teleoconch is abrupt, and the first few whorls are carinate and sculptured with eight spiral lirae, the fourth abapical spiral forming the carina and fine opisthocline ribs that are concave toward the aperture. The next four adolescent whorls are evenly convex and are sculptured with eight strong spiral lirae and weaker opisthocline ribs. Although there are similarities to the pattern of develop-

TABLE 1—Comparative tabulation of some characteristics of species of *Anchura* and *A. (Helicaulax)*. Whorl profiles that are straight to slightly curved are listed as straight. The number under "angulate" indicates the placement of the angulation, and for *A. callosa* the position of maximum curvature: 2 = mid whorl, 3 = anterior third line of whorl, 4 = anterior quarter line. Pleural angles are averaged from those in Tables 2–11. Whorl diameter/height ratios are averaged from Dp/Hp ratios of Tables 2–11. *Anchura baptos* and *A.?* new species have axial ribs on less mature whorls only. The axial rib category "straight" includes slightly arcuate ribs. Cord count is from a spire whorl, posterior is the number of cords posterior to the angulation, maximum curvature, or strongest cord (=Cp of Tables 2–11); total is the suture to suture number of cords (=Ct of Tables 2–11). Standard deviation (±) of averages reflects post-depositional damages as well as variation.

Species of *Anchura* and *Anchura (Helicaulax)*	Number of specimens	Whorl profile: Straight	Whorl profile: Rounded	Whorl profile: Angulate	Pleural angle	Whorl diam/ht ratio	Varices	Axial ribs: Arcuate	Axial ribs: Straight	Axial ribs: Number	Spiral cords: Posterior	Spiral cords: Total
A. baptos new species	1			XXX 2	28°	1.9					1	3
A.? new species	1		XXX		18°	1.8						
A. gibbera Webster	3			XXX 2	23° ± 3.6	1.5 ± 0.02					2	4
A. nanaimoensis (Whiteaves)	3			XXX 2	20° ± 1.5	1.7		XXX		14	3 ± 0.0	8 ± 0.6
A. ainikta new species	5			XXX 2	18° ± 1.3	1.6 ± 0.26	XXX	XXX		14 ± 1.0	1 ± 0.0	4 ± 0.0
A. phaba new species	10			XXX 3	25° ± 3.4	1.7 ± 0.15		XXX		18 ± 2.3	3 ± 0.4	6 ± 1.0
A. falciformis (Gabb)	8			XXX 3	24° ± 2.6	1.7 ± 0.11			XXX	13 ± 1.5	4 ± 0.4	8 ± 0.5
A. halberdopsis new species	7	XXX			25° ± 2.8	2.0 ± 0.22	XXX		XXX	13 ± 1.8	3 ± 0.8	6 ± 0.4
A. callosa Whiteaves	14		XXX	2	21° ± 1.2	1.6 ± 0.77		XXX		13 ± 1.6	4 ± 0.7	8 ± 1.1
A. (H.?) popenoei new species	1			XXX 3	22°	2.0	XXX	XXX		18	2	6
A. (H.) tricosa Saul and Popenoe	7			XXX 4	26° ± 2.7	1.8 ± 0.14	XXX	XXX		15 ± 1.0	3 ± 0.0	6 ± 0.6
A. (H.) condoniana (Anderson)	6	XXX			35° ± 3.3	2.0 ± 0.22			XXX	20 ± 0.9	4 ± 0.5	7 ± 0.8

ment in Pacific Slope *Anchura, A. chapelvillensis* differs in having the juvenile whorls carinate rather than rounded, and the earliest adolescent whorls rounded rather than angulate, as seen in *A. callosa, A. falciformis, A. nanaimoensis,* and *A. gibbera.*

In the type species of *Anchura,* the shank is without posterior or anterior secondary spurs. Saul and Popenoe (1993) mistakenly suggested that typical *Anchura* be confined to species with no secondary spurs on the shank of the outer lip and having the anterior rostrum deflected to the left in apertural view. These features are, apparently only of specific importance, for Dockery (1993) has illustrated species of *Anchura* from the Campanian of Mississippi that have undeflected rostra and secondary spurs along the shank. Although the shanks of Pacific Slope Turonian species *Anchura (Helicaulax) condoniana* and *A. (H.) tricosa* Saul and Popenoe, 1993, have secondary spurs, none of the Pacific Slope Coniacian to Maastrichtian species discussed herein is known to have secondary spurs on its shank despite Gabb's (1864, 1868) original illustration of *A. falciformis* showing a secondary spur on the anterior edge of the shank. *Anchura abrupta* has the anterior rostrum deflected to the left in apertural view; the rostra of West Coast species *A. callosa, A. falciformis, A. phaba, A. ainikta, A. gibbera,* and *A. baptos* are not so deflected, but the rostrum of *A. falciformis* is bent slightly backward.

Some important characteristics used in differentiating Pacific Slope species of *Anchura* are tabulated in Table 1. Among the species included in this paper *Anchura halberdopsis* is most similar to *A. abrupta* in its sculpture. *Anchura callosa, A. falciformis, A. phaba,* and *A. gibbera* form a group, the *Anchura falciformis* group, having two strong cords anterior to the carina, spire sculpture of more or less arcuate, round-topped axial ribs crossed by narrower spiral cords, the axial ribs weakest posteriorly and strongest at the periphery, the anterior portion of the outer lip profile slightly scalloped, the aperture with a thick callus pad posterior to the basal sinus. *Anchura nanaimoensis* probably also belongs to this group. *Anchura ainikta, A. baptos,* and *Anchura?* new species are dissimilar. *Anchura (H.?) popenoei* is most similar to *A. (H.) tricosa,* although its sculpture also is rather similar to that of *A. callosa.*

Age.—The total age range of *Anchura* is poorly understood and in need of reevaluation, as many forms previously assigned to the genus do not belong to it (see Sohl, 1960, p. 105). The genus appears to be constrained to the Late Cretaceous in the Gulf Coast region of North America (Sohl, 1960), but, on the Pacific Slope, undocumented species of *Anchura* apparently occur in the Early Cretaceous and *A. baptos* ranges into the Paleocene.

ANCHURA HALBERDOPSIS new species
Figure 3.1–3.4

Diagnosis.—A relatively small *Anchura* with strong, nearly straight costae on the spire and randomly occurring varices on the early whorls. Falcate outer lip strong and shaped like a halberd.

Description.—Shell medium-sized, high-spired, pleural angle about 30 degrees, drawn out anteriorly into anterior rostrum; whorl gently, unevenly rounded becoming slightly angulate on penultimate whorl and strongly angulate on last whorl; whorls about eight in number; suture appressed; protoconch unknown; varices randomly present on juvenile and adolescent whorls; growth line antispirally concave on spire. Mature sculpture strong, of both axial ribs and spiral cords; axial ribs nearly straight on spire, strongest on early whorls, weakening on body whorl, 11–13 on penultimate whorl, forming nodes where crossed by spiral cords, strong nodes developed on angulation of last whorl; spiral cords stronger on penultimate and ultimate whorls, four to five cords showing on spire whorls, fourth cord strongest, forming

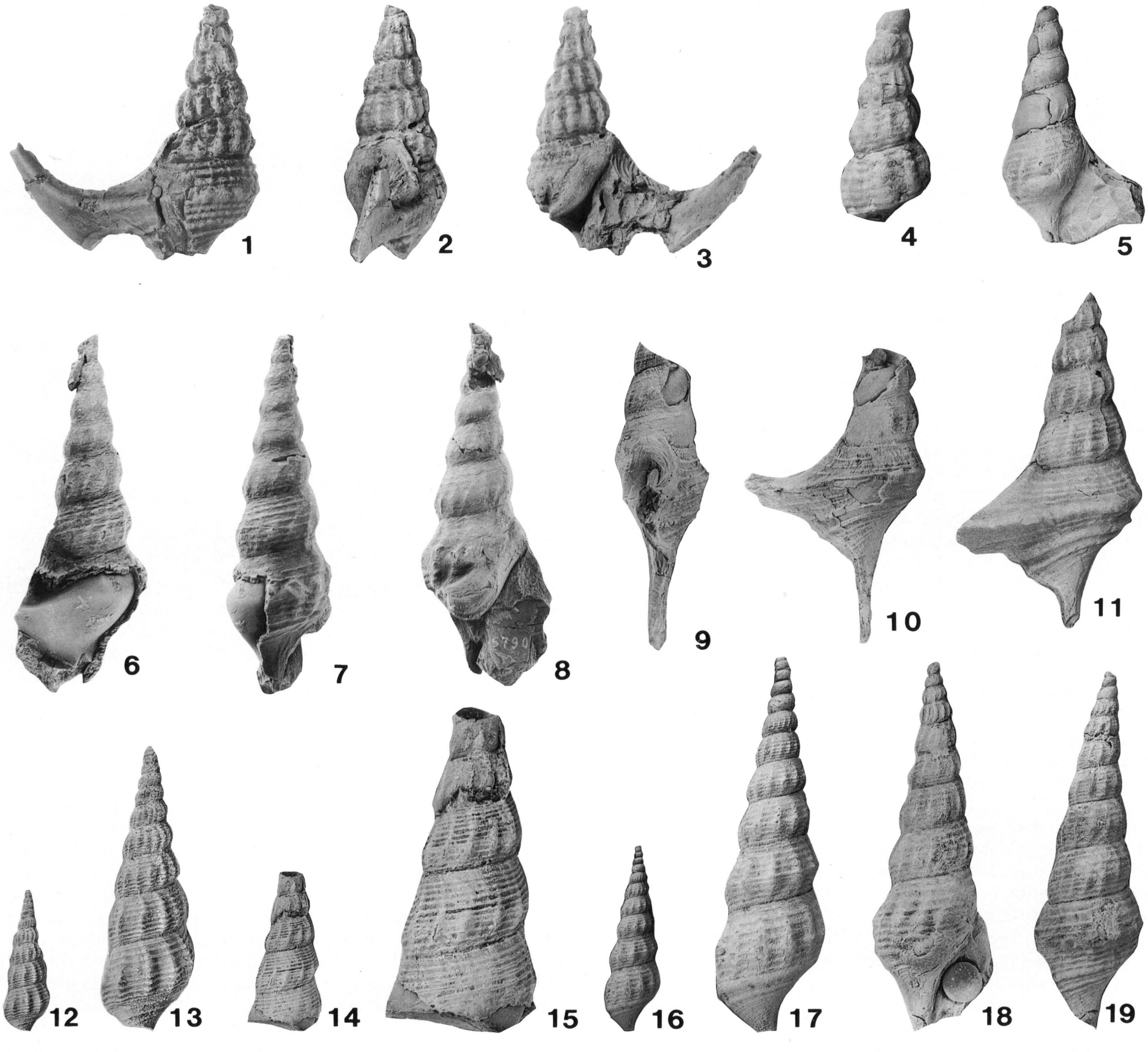

FIGURE 3—*1–4, Anchura halberdopsis* new species. *1–3,* Holotype, abapertural, side, and apertural views, ×1, LACMIP 11305, locality CIT 1053; *4,* paratype, spire showing varices, ×1.5, LACMIP 11311, locality CIT 1053. *5–19, Anchura callosa* Whiteaves. *5,* Hypotype, apertural view, ×1, LACMIP 11315, locality UCLA 3637; *6–8,* holotype, abapertural, side, and apertural views, ×1, GSC 5790; *9, 10,* hypotype, side and abapertural views, ×1, LACMIP 11314, locality UCLA 3637; *11,* hypotype, abapertural view, ×1, LACMIP 11344, locality 3643; *12, 13,* hypotype, abapertural view, ×1 and ×2, LACMIP 11313, locality UCLA 3635; *14, 15,* hypotype, abapertural view, ×1 and ×2, LACMIP 11317, locality UCLA 3637; *16, 17,* hypotype, abapertural view, ×1 and ×2, LAMCIP 11319, locality UCLA 3643; *18, 19,* hypotype, apertural and abapertural views, ×1, LACMIP 11312, locality UCLA 3635.

a noded keel on ultimate whorl and extending onto shank as carina; six to seven cords anterior of keel on ultimate whorl, third cord usually strongest; juvenile sculpture of closely spaced arcuate axial ribs on at least two whorls. Outer lip expanded into ax-shaped wing, anterior margin angulate (near 90 degrees) at posteriorward bend, thickened internally and filled with callus; posterior end of wing tilted near 15 degrees abaperturely to axis of spire. Aperture with moderately thick, broad inner lip extending apically almost to previous suture. Thick, sinuous, elongate callus pad formed on base along inner lip edge.

Remarks.—Although two dozen specimens are available, the rostrum is not preserved on any specimen, nor is the entire outer edge of the lip between the keel and the rostrum. The cords anterior to the keel on the ultimate whorl are of variable strength; commonly the third is strongest, but the third and fourth or the third, fourth, and fifth may be about equally strong and stronger than the other cords.

The thickened wing of this species with its angled anterior outline at the posteriorward bend is very different from those of *A. callosa* and *A. falciformis,* which are broader, less thick-

TABLE 2—Measurements in mm of *Anchura halberdopsis* new species. For abbreviations and symbols used, see introduction.

Specimen	H	Hp	Db	Dp	Dp/Hp	R	PA	S	Ct	Cp	A	Remarks
LACMIP 11305	38.2	7.0	17.0	13.8	1.97	—	26°	15.5	6	4	13	body + 5 whorls
LACMIP 11306	37.5	6.8	13.0†	12.8	1.88	—	27°	17.0	6	3	16	body + 6 whorls
LACMIP 11307	30.3	6.1	15.8	13.0	2.13	—	27°	—	5	2	13	body + 4 whorls
LACMIP 11308	37.0	6.2	—	12.6	2.03	—	22°	—	7	3	14	penult. + 6 whorls
LACMIP 11309	33.4	6.6	17.2	13.6	2.06	—	28°	—	6	2	13	body + 4 whorls
LACMIP 11310	29.8	6.5	17.5	13.5	2.08	—	27°	—	6	3	14	body + 3 whorls
LACMIP 11311	16.8	3.8	8.1	6.2	1.63	—	21°	—	7	—	10	juv. 5 whorls

ened, and have a more roundly expanded anterior margin at the posteriorward bend. The wing of *A. halberdopsis* is essentially similar to that of *A. abrupta* (see Sohl, 1960, plate 12, figures 1 and 4), but the former has a much shorter posterior arm, and the anterior arm is represented by little more than an abrupt angulation. The varices on the early whorls occur irregularly and are inconsistent in number; LACMIP 11311 consists of five whorls and has seven varices. The inner lip callus of *A. halberdopsis* is relatively thicker and extends higher on the apertural face than that of *A. callosa* or *A. falciformis,* reaching almost to the previous suture. The callus pad of *A. halberdopsis* is, however, less thick than that of *A. callosa, A. falciformis, A. phaba, A. gibbera,* or *A. baptos. Anchura halberdopsis* is stouter than *A. callosa.* None of the mature specimens of *A. halberdopsis* is as large as winged specimens of *A. falciformis* or *A. phaba,* and its sculpture is relatively rougher with a stronger axial component. *Anchura halberdopsis* has at least four cords, one of which is strongest, instead of the pair of strong basal cords characteristic of *A. callosa, A. falciformis, A. phaba,* and *A. gibbera.* The pattern of sculpture on *A. halberdopsis* more closely resembles that of *A. abrupta* than does the sculpture of *A. falciformis* or *A. phaba.* The sculpture of *A. halberdopsis* is still more similar to that of *A. (H.) condoniana,* differing mainly in the former having fewer axial ribs per whorl. *Anchura halberdopsis* also resembles *A. (H.) condoniana* in spire height, pleural angle, whorl profile, and in having a strongly noded keel on the ultimate whorl. *Anchura halberdopsis* differs in lacking the posterior digitation on the outer lip (but the posterior digitation is inconsistently developed in *A. (H.) condoniana*), in having varices on the early whorls, straighter axial ribs than those of condoniana, and in having a shorter shank to the wing, a more posteriorly directed posterior arm, and more of an anterior arm. As in *A. (H.) condoniana, A. (H.) tricosa,* and *A. abrupta* the anterior outer lip profile is evenly convex rather than scalloped as in species of the *A. falciformis* group.

Anchura pacifica Olsson, 1944, from the Maastrichtian "*Baculites* Zone" of Peru (Olsson, 1944) has similar distant, nearly straight axial ribs and cords on its spire, but on the body whorl *A. halberdopsis* has a more strongly noded periphery and fewer spiral cords on the base.

Type specimens.—Holotype LACMIP 11305, paratypes LACMIP 11306–11311 from CIT locality 1053

Type locality.—CIT locality 1053, northeast-southwest trending spur north of Santiago Creek, 200'N, 2850'E of SW corner sec. 20, T5N, R7W, El Toro quadrangle, Santa Ana Mountains, Orange County, California. Ladd Formation, upper part of Holz Shale Member.

Measured specimens.—See Table 2.

Age.—Early Campanian, Turritella chicoensis holzana Zone; associated with *Submortoniceras chicoense* (Trask) at UCLA locality 4192.

Geographic distribution.—Santa Ana Mountains, Orange County, California in the upper part of the Holz Shale Member of the Ladd Formation [CIT 1053, (20 specimens); UCLA 4192 (2 specimens)], where it is locally common.

Etymology.—English, halberd, a shafted weapon with an axlike cutting blade + Greek, *opsis,* having the aspect of.

ANCHURA CALLOSA Whiteaves, 1903
Figure 3.5–3.19

Anchura stenoptera Goldfuss. Whiteaves, 1879, p. 123, pl. 15, figs. 11–11a. Not *Rostellaria stenoptera* Goldfuss, 1844.
Anchura callosa Whiteaves, 1903, p. 358 (nom. nov. for *A. stenoptera* Goldfuss of Whiteaves).
Anchura falciformis (Gabb). Taff, Hanna, and Cross, 1940, p. 1327, pl. 2, figs. 7–9. Not *Anchura falciformis* (Gabb, 1864).

Diagnosis.—An Anchura with 12–14 slightly curved axial ribs per whorl; whorl profile rounded on spire with greatest curvature slightly below mid point, angulate on body whorl.

Description.—Shell large, high-spired, drawn out anteriorly into a moderately long anterior rostrum; pleural angle about 22 degrees; whorls about ten in number, nearly evenly convex with greatest curvature slightly below mid whorl; last whorl strongly carinate; suture appressed; growth line antispirally concave on spire; protoconch possibly of about three whorls, not obviously set off from teleoconch. Juvenile sculpture of fine, curved axial ribs; mature sculpture of both axial ribs and spiral cords; axial ribs slightly curved concavely to the aperture, distant, 12–14 on penultimate whorl, slightly nodose where crossed by cords, nodes strongest on angulation of ultimate whorl; eight to ten cords on spire, slight angulation on fifth or sixth cord, forming noded keel on ultimate whorl, base of whorl with two strong cords and four to five weaker cords. Outer lip expanded into falcate wing with shank of moderate length and longer posterior arm; keel of body whorl extends onto wing near posterior margin of wing; wing somewhat expanded with anterior edge rounded at posteriorward bend, thickened along posterior margin, interior channeled opposite keel; distal margin bent adaperturally; posterior arm inclined abaperturally at angle of about 10 degrees to coiling axis. Aperture with broad posterior sulcus and broad anterior sulcus delineated posteriorly by parietal callus pad. Inner lip forming a broad, thin wash to whorl angulation and onto whorl face, developing an elongate, thick callus pad at two strong subperipheral spiral cords. Callus wash continuing around base and onto base of rostrum.

Remarks.—Chico Creek specimens of *Anchura* occurring between about 549 m and 915 m above the base of the Chico Formation constitute a species differing from *A. falciformis* in having a narrower pleural angle, a more rounded profile to the spire whorls, weaker spiral ornament, usually lower axial ribs, sculpture on the abapertural side of the body whorl that is not effaced, producing a more angulate body whorl. Specimens are most distinct from *A. falciformis* low in the Tenmile Member of the Chico Formation but become more similar upsection. Specimens are abundant at UCLA locality 3637 (approx. 625 m above the base) but are difficult to extract from the matrix,

TABLE 3—Measurements in mm of *Anchura callosa* Whiteaves. For abbreviations and symbols used, see introduction.

Specimen	H	Hp	Db	Dp	Dp/Hp	R	PA	S	Ct	Cp	A	Remarks
GSC 5790	56.6	8.4	16.7	13.0	1.55	—	23°	—	8	4	14	body + 7 whorls
CASG 28738.21	47.3	8.6	20.5	14.3	1.66	16.6	—	18.1	7	3	—	body + 1 whorl
CASG 27838.22	36.5	8.1	—	14.1	—	—	21°	—	8	4	14	7 spire whorls
CASG 27838.23	25.6	6.1	—	10.1	—	—	21°	—	8	4	12	6 spire whorls
LACMIP 11312	58.3	9.4	18.4	13.7	1.46	—	20°	—	8	4	15	body + 10 whorls
LACMIP 11313	22.8	4.0	—	6.7	—	—	20°	—	9	4	10	10 spire whorls
LACMIP 11314	48.5	7.7	17.0	12.5	1.62	15.1	—	—	8	4	—	body + 2 + rostrum
LACMIP 11315	38.6	7.5	14.6	—	—	—	23°	—	—	—	—	body + 5 whorls
LACMIP 11316	50.0	10.0	18.5	15.6	1.56	—	22°	12.0	8	4	14•	body + 4 whorls
LACMIP 11317	26.6	7.0	—	11.5	1.64	—	20°	—	11	6	12	5 spire whorls
LACMIP 11318	32.7	5.4	10.8	8.9	1.65	—	21°	—	7	4	12	juv. 8 whorls
LACMIP 11319	30.0	4.7	9.8	7.8	1.66	—	20°	—				juv. 11 whorls
LACMIP 11320	18.3	3.4	7.0	5.8	1.70	—	23°	—	7	4	14	juv. 8 whorls
LACMIP 11344	53.4	8.5	19.5	14.5	1.71	—	21°	—	8	5	15	body + 4 whorls

and no complete specimen has been recovered from that locality. Most specimens from this horizon have a narrower pleural angle and fewer axial ribs than do specimens farther up section, such as those from UCLA locality 3643. The specimen figured by Whiteaves (1879) as *A. stenoptera* from 2.25 miles up the Nanaimo River, Vancouver Island, British Columbia, resembles specimens from about 885 m above the base. That specimen, therefore, appears to fall within the range of the Chico Creek species but is not representative of its most distinctive form. In 1903, Whiteaves decided that he had been mistaken in identifying his Vancouver Island specimen with a species from Westphalia and provided the new name *Anchura callosa* for it. Accordingly, *A. callosa* is taken as the appropriate name for the Chico Creek species.

At the same time that Whiteaves (1903) provided a name, he reported the locality as "Trent River" without indicating that this was a rectification of his earlier locality description. Bolton (1965, p. 7) gave the locality as 2.5 miles up the Nanaimo River, also without indication that this was a correction for Whiteaves' published locality data. According to Muller and Jeletzky (1970, p. 32), Whiteaves' original locality "2 ¼ miles up the Nanaimo River" is within the Cedar District Formation and is the type locality of *Inoceramus vancouverensis* Shumard, 1859, which ranges through the *Submortoniceras chicoense* and *Hoplitoplacenticeras vancouverense* Zones (Ward, 1978, p. 416). A precise locality on the Trent River is not specified, but beds of the Pender Formation that have yielded *Submortoniceras chicoense* are present along the lower Trent River, Vancouver Island. (Haggart and Ward, 1989). The type locality of *Forsia popenoei* Saul, 1988, was inferred to be 2.5 miles up the Nanaimo River. This species occurs with *A. falciformis* and comes from a younger horizon than does *A. callosa* along Chico Creek, Butte County, California. Perhaps future collecting in the Nanaimo basin will elucidate which of the indicated localities would be the most probable provenance for the holotype of *A. callosa.*

Although Whiteaves' illustration strongly resembles *Anchura falciformis,* he did not mention *A. falciformis* and instead (Whiteaves, 1903) compared *A. callosa* to *Anchura transversa* Gabb (1869). *"Anchura" transversa* is based on a specimen 10 mm high and 12.4 mm in diameter including the wing (Stewart, 1927). Its horizon is uncertain, and it does not appear to belong in *Anchura.*

Specimen GSC 5790 appears to be somewhat worn, and the sculpture is subdued. The shell breakage on the body whorl of Whiteaves' (1879, plate 15, figure 11a) drawing corresponds with that of this specimen, but less outer lip is present and more of the spire is missing than in the illustration. The specimen has either been additionally broken since the drawing was made, or the original was in part a reconstruction.

The last whorl of the protoconch is present on LACMIP 11319 but its surface is too poorly preserved to determine whether or not sculpture was present. The fifth? whorl, the first juvenile whorl, has faint remnants of fine, arched axial ribs. Two or three whorls display these arched ribs, which are approximately twice as numerous per whorl as the axial ribs on the adolescent whorls. The change from juvenile to adolescent sculpture is abrupt.

Anchura callosa differs from *A. phaba, A. gibbera,* and *A. baptos* in having stronger and fewer axial ribs, as well as more numerous and relatively weaker spiral cords. *Anchura callosa* further differs from *A. phaba* and *A. gibbera* in having a less protuberant callus pad.

Type specimens.—Holotype GSC 5790 (Bolton, 1965, p. 7). Hypotypes LACMIP 11312–11313 from UCLA locality 3635; LACMIP 11314–11317 from UCLA locality 3637, LACMIP 11318–11320 from UCLA locality 3643; CASG 27838.21 (ex 5794) (figured by Taff et al., 1940, plate 2, figure 9), CASG 27838.22 (ex 5794A) (Taff et al., 1940, plate 2, figure 7), CASG 27838.23 (ex 5794B) (Taff et al., 1940, plate 2, figure 8) from CASG locality 27838, Chico Creek, Butte County, California.

Type locality.—2.25 miles up the Nanaimo River, Vancouver Island, British Columbia (Whiteaves, 1979, p. 123); Trent River (Whiteaves, 1903, p. 359; 2.5 miles up the Nanaimo River. Vancouver Island, British Columbia (Bolton, 1965, p. 7).

Measured specimens.—See Table 3.

Age.—Santonian(?) to early middle Campanian, *Submortoniceras chicoense* Zone, *Turritella chicoensis holzana* Zone. This species is present in the lower part of the Tenmile Member of the Chico Formation on Chico Creek, throughout the zone of reversed magnetic polarity chron 33r and into the beginning of the succeeding normal polarity zone (from UCLA locs. 3632 to 3643).

Geographic distribution.—Cedar District Formation, Nanaimo Basin, Vancouver Island, British Columbia; lower part of the Tenmile Member of the Chico Formation on Chico Creek [from UCLA localities 3632 to 3643], lower beds near Pentz [UCLA locality 4340], Butte County, Tenmile Member of the Chico Formation on Deer Creek [LACMIP localities 15790 and 15792], and Mill Creek [UCLA localities 4662 and 4664], Tehama County, California.

ANCHURA FALCIFORMIS (Gabb, 1864)
Figure 4.1–4.12

Aporrhais falciformis Gabb, 1864, p. 127, pl. 20, fig. 83.
Anchura falciformis Gabb, 1864. Gabb, 1868, p. 145, pl. 14, fig. 14;

Gabb, 1869, p. 165; Grabau and Shimer, 1909, p. 755, fig. 1099; Stewart, 1927, p. 360, pl. 22, fig. 9; Shimer and Shrock, 1944, p. 497, pl. 203, fig. 26; Anderson, 1958, p. 165 (in part); Elder and Saul, 1993, pl. 3, fig. 4.

Diagnosis.—An *Anchura* with about 14 straight to slightly curved axial ribs per whorl; carina and axial ribs suppressed abaperturally on body whorl; whorl profile subangulate on spire with greatest curvature about at anterior third of whorl, angulate on body whorl.

Description.—Shell large, high-spired, drawn out anteriorly into a moderately long anterior rostrum; rostrum deflected abaperturally; pleural angle about 25 degrees; whorls about nine in number, unevenly convex, strongly carinate on last whorl; suture appressed. Protoconch apparently smooth, of four whorls, rapidly expanding. Three juvenile whorls scarcely expanding, with fine, curved axial ribs and very fine spiral cords, approximately twice as many ribs per whorl as on mature whorls. Adolescent whorls expanding as in adult, two whorls with coarser axial ribs and stronger spiral cords; next whorl with 12–14 axial ribs, medially angled giving appearance of a medial row of nodes; growth line antispirally concave on spire. Mature sculpture of both axial ribs and spiral cords; axial ribs straight to curved concavely toward the aperture, distant, about 14 on penultimate whorl, forming nodes where crossed by cords, nodes strongest on angulation; seven to eight cords on spire, fifth being strongest, forming bluntly noded keel on ultimate whorl, base of whorl with two strong cords and four to five weaker cords. Outer lip expanded into falcate wing with broad shank of moderate length and longer posterior arm; fifth spiral cord extended onto wing as keel near thickened posterior margin; anterior margin of wing expanded, slightly sinuous, and rounded anteriorly at posteriorward bend; wing interior channeled opposite keel; distal margin bent adaperturally; posterior arm inclined abaperturally at about 10 degrees to axis of spire. Aperture with broad posterior sulcus and broad anterior sulcus delineated posteriorly by parietal callus pad. Inner lip forming a broad, thin wash to whorl angulation and onto whorl face, developing an elongate, thick callus pad at two strong subperipheral spiral cords. Callus wash continued around base and onto base of rostrum.

Remarks.—Gabb's (1864) original figure of *A. falciformis* differs from topotype specimens in having the pleural angle 20 degrees, rather than about 26 degrees, lacking a carina on the last whorl, having a secondary spur on the shank, and in having a more sharply angled wing. However, Stewart (1927) considered this figure to be a synthetigraph, and the lectotype that he designated corresponds well to worn topotype specimens. Well-preserved topotypes commonly have finely beaded cords adapical to the carina. No specimen of *A. falciformis* has been found to have a secondary spur on the shank.

The protoconch of *A. falciformis* described above is from a specimen (LACMIP 11326) from the Cedar District Formation on Sucia Island (UCLA locality 4878). UCLA 11323 has a rostrum 29.5 mm long and UCLA 11324 has a rostrum 29.3 mm long; both are from Butte Creek and in both the rostrum is about one-third of the height of the shell.

The whorl profile of *A. falciformis* is less angulate than that of *A. phaba* or *A. gibbera,* and *A. falciformis* has fewer axial ribs than *A. phaba.* Spiral cords of *A. falciformis* are more numerous than in *A. baptos* and the latter two species. The carina and axial ribs of *A. falciformis* are commonly suppressed on the abapertural side of the body whorl. Although the parietal callus pad is variable in size and shape, the callus pad of *A. falciformis* is usually less elongate and thicker than that of *A. callosa* but less protuberant than those of *A. baptos* and *A. gibbera. Anchura falciformis* lacks the anteriorly directed prong at the bend in the wing that is present in *A. abrupta* and *A. gibbera. Anchura falciformis* has a narrower pleural angle than does *A. abrupta,* and a rostrum deflected backward rather than to the left. The wing of *Anchura falciformis* is more similar to that of *A. haydeni* White, 1879, from the Pierre Shale of Colorado, than to the wing of *A. abrupta.*

Anderson (1958, p. 41) reported *A. falciformis* from CASG locality 28323 on Del Puerto Creek, Stanislaus County, California, in the Panoche Formation, but that specimen is too poorly preserved to be identified to genus.

Type specimens.—Lectotype ANSP 4269; hypotypes LACMIP 12127, 11322–11324 from UCLA locality 6044, Butte Creek, LACMIP 11321 from UCLA locality 3648, Chico Creek, Butte County, LACMIP 11325 from CIT locality 1018, Pentz, Butte County, California, LACMIP 11326 from UCLA locality 4878, Sucia Island, San Juan County, UWBM 16734 from UWBM locality A9254, Sucia Island, San Juan County, Washington.

Type locality.—Chico Creek, Butte County, California

Measured specimens.—See Table 4.

Age.—Middle Campanian, late *Submortoniceras chicoense* Zone to *Hoplitoplacenticeras vancouverense* Zone; *Turritella chicoensis* Zone.

Geographic distribution.—Cedar District Formation, Sucia Island, San Juan County, Washington; Chico Formation, upper part of Tenmile Member, Chico Creek, Butte Creek, higher beds near Pentz, Butte County, and Tuscan Springs (UCLA locality 4082), Tehama County, California.

ANCHURA PHABA new species
Figure 5.1–5.13

Anchura aff. *A. falciformis* (Gabb, 1864). Elder and Saul, 1993, p. 184, pl. 2, figs. 3, 4. Not *Anchura falciformis* (Gabb, 1864).

Diagnosis.—An *Anchura* with about 20 arching axial ribs per whorl forming noticeable nodes on prominent keel (=4th or 5th spiral cord); axial ribs weaker than spiral cords; whorl profile subangulate, angulation at anterior one-third of whorl.

Description.—Shell large, high-spired, drawn out anteriorly into an anterior rostrum; pleural angle about 27 degrees; whorls about nine in number, slightly angulate at fourth spiral cord on spire, strongly carinate on last whorl; suture appressed; protoconch unknown; growth line antispirally concave on spire. Sculpture of both axial ribs and spiral cords; axial ribs curved concavely to the aperture, distant, about 20 on penultimate whorl, forming nodes where crossed by cords; cords dominant, especially on more mature whorls, six to seven cords on spire; cords noticeably noded, especially on penultimate and ultimate whorls; nodes strongest on angulation at fourth cord; base of whorl with two strong and at least two weaker cords; falcate wing with shank relatively short and broad; fourth spiral cord extended onto wing as keel near posterior margin; wing expanded anteriorly an unknown length at posteriorward bend. Anterior margin slightly sinuous. Rostrum nearly straight.

Remarks.—Although more than 30 specimens are identified as *A. phaba,* all are fragmental, and most are poorly preserved. No juvenile specimens without some exfoliation of the shell are known. In all available specimens of *A. phaba,* the anterior rostrum is broken; the longest preserved is that of LACMIP 11333, which is 14.6 mm long and nearly straight. The falcate wing is also incomplete; specimen USNM 468578 shows the shank and the posteriorward bend, but lacks the tip of the anterior extension and part of the posterior arm. That specimen suggests that the shank was relatively wide and short, and that

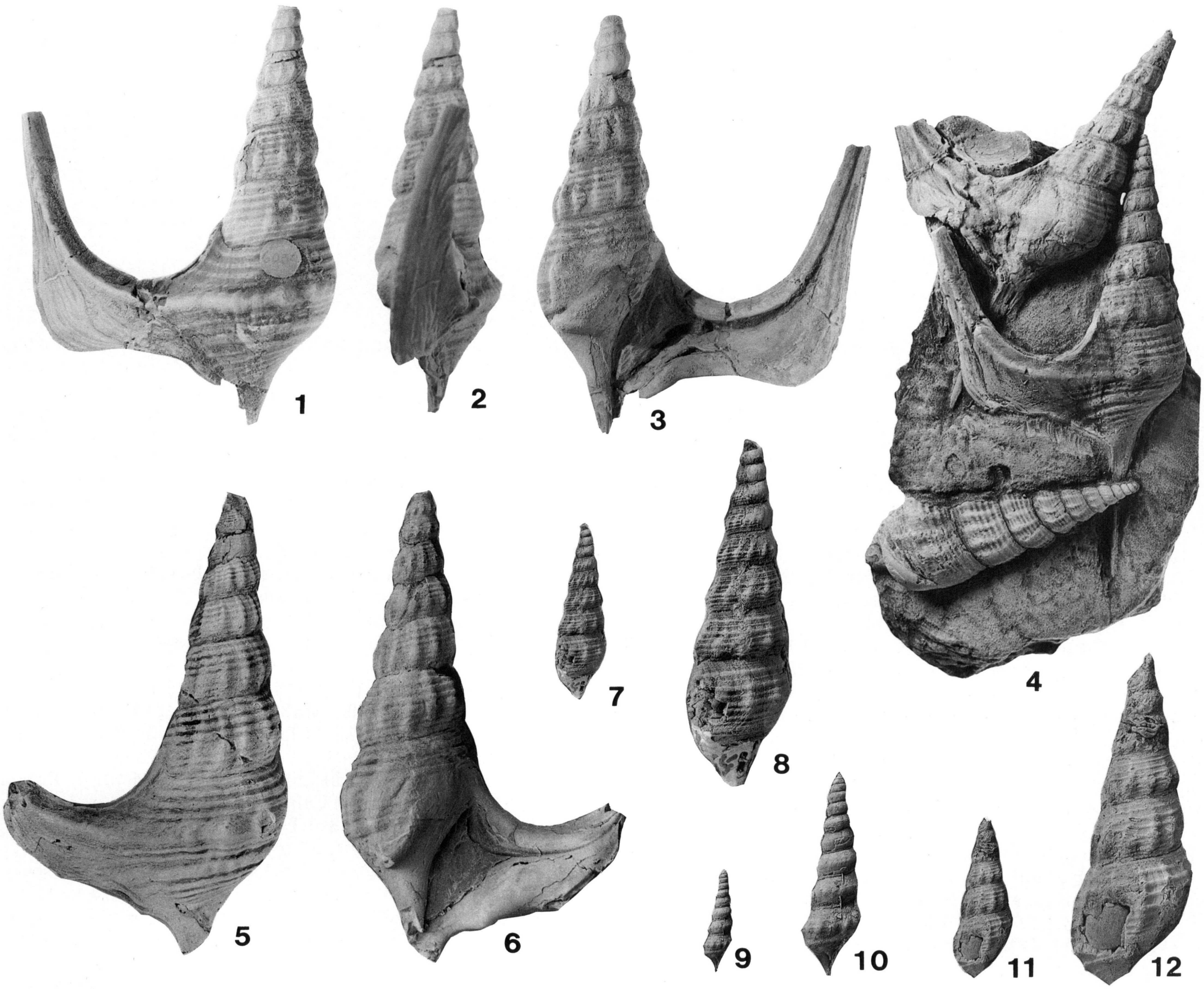

FIGURE 4—*Anchura falciformis* Gabb. *1–3,* hypotype, abapertural, side, and apertural views, ×1, LACMIP 12127, locality UCLA 6044; *4,* hypotypes, slab with one unmeasured and two measured specimens, ×0.75, LACMIP 11323 and LACMIP 11324, locality UCLA 6044; *5, 6,* hypotype, abapertural and apertural views, ×1, LACMIP 11321, locality UCLA 3648; *7, 8,* hypotype, abapertural view, ×1 and ×2, UWBM 16734, locality A9254; *9, 10,* hypotype, abapertural view with protoconch, ×1 and ×2, LACMIP 11326, locality UCLA 4878; *11, 12,* hypotype, abapertural view, ×1 and ×2, LACMIP 11325, locality CIT 1018.

the anterior expansion at the posteriorward bend was relatively broad and may have developed into a short spur. In general, *A. phaba* appears to have had the same type of wing as *A. falciformis.*

The geologically oldest of the specimens identified as *A. phaba* are from the Holz Shale Member of the Ladd Formation in the Santa Ana Mountains, Orange County. These and specimens from the stratigraphically lowest outcrops of the Chatsworth Formation in Bell Canyon, Ventura County, have slightly fewer axial ribs with larger nodes and a stronger whorl angulation on the spire than specimens from younger horizons such as the Pleasants Sandstone Member of the Williams Formation in the Santa Ana Mountains, Orange County, and higher beds of the Chatsworth Formation in Dayton Canyon, Los Angeles County. Specimens from Manzanita Mountain, Santa Barbara County, also correspond to this younger morphology which has a stronger angulation on the body whorl. The holotype from Pigeon Point appears to have intermediate characteristics.

Anchura phaba differs from *A. falciformis* in having a more angulate whorl profile, more numerous axial ribs that are more concave, a keel lower on the whorl, stronger cords with stronger and more nodes on them, and the basal two cords more distant from each other. The inner lip of *A. phaba* is thicker, and the parietal callus pad is thicker and more elongate than in *A. falciformis.*

Anchura phaba has stronger nodes, more axial ribs per whorl, a more angulate whorl profile, and thicker inner lip and parietal callus pad than *A. callosa.* It is stouter than *A. gibbera* and has stronger nodes on the keel, a shorter and broader lateral arm, stronger axial ribs, and a less protuberant parietal callus pad.

TABLE 4—Measurements in mm of *Anchura falciformis* Gabb. For abbreviations and symbols used, see introduction.

Specimen	H	Hp	Db	Dp	Dp/Hp	R	PA	S	Ct	Cp	A	Remarks
LACMIP 11321	71.0	11.7	24.2	18.8	1.61	—	26°	18.7	8	4	14	body + 7 whorls
LACMIP 11322	52.6	10.8	23.0	18.9	1.75	—	25°	23.4	7	4	14	body + 3 whorls
LACMIP 12127	64.6	10.1	21.5	15.8	1.56	—	23°	21.8	8	4	13	body + 6 whorls
LACMIP 11323	92.3	10.0	—	17.9	1.79	29.5	26°	18.1	8	4	14●	body + 9 whorls
LACMIP 11324	90.0	10.2	19.1	16.9	1.66	29.3	27°	19.6	8	4	14●	body + 7 whorls
LACMIP 11325	25.9	5.0	—	8.3	1.66	—	24°	—	8	4	12	juv. 6 whorls
LACMIP 11326	15.3	2.5	—	4.8	1.92	—	19°	—	7	3	—	protochonch + 7
UW 16734	26.8	4.7	—	7.9	1.68	—	22°	—	8	4	10	8 spire whorls

Anchura phaba is larger than *A. halberdopsis,* has a more angulate whorl profile, and weaker, arched, rather than straight, axial ribs.

Type specimens.—Holotype USNM 468578 from USGS locality M8611, paratypes USNM 485423 from USGS locality M8591, LACMIP 11327 from CIT locality 974, LACMIP 11335–11336 from LACMIP locality 6965, LACMIP 11333–11334, 11345 from CIT locality 1159, LACMIP 11330 from CIT locality 1054, LACMIP 11328–11329 from CIT locality 1057; LACMIP 11332 from CIT locality 1158.

Type locality.—USGS locality M8611, Southeast of Pigeon Point, San Mateo County, California.

Measured specimens.—See Table 5.

Age.—Middle to early late Campanian. Late *Turritella chicoensis* and *T. chicoensis pescaderoensis* Zones.

Geographic distribution.—Pigeon Point Formation, southern sequence, near Pigeon Point, San Mateo County (USGS M8611 (1 specimen); Manzanita Mountain (USGS M8591, 2 specimens), Santa Barbara County; Bell [UCLA 6996 (1 specimen); CIT 1158 (1 specimen)] and Dayton Canyons [CIT 1159 (10+ specimens), LACMIP 6965 (4 specimens)], Simi Hills, Los Angeles and Ventura Counties, in the lower part of the Chatsworth Formation of Colburn et al. (1981); Santa Ana Mountains, Orange County, California, near the top of the Holz Shale Member of the Ladd Formation. [UCLA 1527 (1 specimen), UCLA 6950 (1 specimen), CIT 1060 (1 specimen); CIT 1057 (3 specimens), LACMIP 10934 (1 specimen), CIT 1054 (2 specimens)]; Pleasants Sandstone Member of the Williams Formation [CIT 974 (1 specimen)].

Etymology.—Greek, *phabos,* a wild pigeon.

ANCHURA AINIKTA new species
Figure 5.14–5.21

Diagnosis.—An *Anchura* with about 14 axial ribs per whorl forming noticeable nodes on prominent carina at second spiral cord near mid-whorl; early whorls with randomly occurring varices.

Description.—Shell apparently small, high-spired, drawn out anteriorly into anterior rostrum; pleural angle about 20 degrees; whorls more than 14 in number, angulate submedially at second spiral cord on spire, whorl profile concave posterior to carina; suture appressed; protoconch of about four whorls; juvenile sculpture of about 28 fine, slightly curved axial ribs crossed by two spiral cords, strongest cord medially placed; mature? sculpture on spire of about 14 slightly curved axial ribs, weaker than four spiral cords; three posterior cords noded at axial ribs, first cord weak, second cord strong, forming carina, third cord nearly as strong as and close to second, fourth cord just posterior to suture, strong and unnoded; weaker fifth cord on base of whorl; randomly occurring varices present on early whorls.

Remarks.—All specimens assigned to this taxon are relatively small and may be immature, because none has the adult wing. The largest specimens are natural rock molds from Horse Canyon, Santa Barbara County, California (Figure 5.20). *Anchura phaba* and *A. ainikta* occur in close proximity in the Pigeon Point Formation, and *A. ainikta* may possibly be the juvenile and adolescent stages of *A. phaba,* which are poorly understood. However, *A. ainikta* differs from *A. phaba* in having fewer spiral cords and having a double-keeled appearance to the whorls produced by the close spacing of the strong, second cord and the subequal third cord. The fourth cord is stronger on *A. ainikta* and shows on the spire just posterior to the suture thus making the whorl profile more basally angulate. In its angulate whorl profile *A. ainikta* resembles the early whorls of *A. gibbera,* but *A. gibbera* does not have varices and the keel does not appear double.

Type specimens.—Holotype USNM 485425; paratypes USNM 485426 from USGS locality M8756, USNM 485424 from USGS locality M8759, LACMIP 11337–11338 from UCLA locality 7135.

Type locality.—USGS locality M8756, 1 km SE of Pigeon Point, San Mateo County, California.

Measured specimens.—See Table 6.

Age.—Middle to early late Campanian

Geographic distribution.—USGS locality M8756 (2 specimens) Pigeon Point Formation, near Pigeon Point, San Mateo County; UCLA locality 7135 (2 specimens), Horse Canyon, Bates Canyon quadrangle, Sierra Madre Mountains, Santa Barbara County, California.

Etymology.—Greek, *ainiktos,* baffling, obscure, enigmatic.

ANCHURA NANAIMOENSIS (Whiteaves, 1879)
Figure 5.22–5.27

Potamides tenuis nanaimoensis Whiteaves, 1879, p. 121, pl. 15, fig. 9, 9a.

Discussion.—Three of Whiteaves' type specimens of *"Potamides tenuis" nanaimoensis* are immature *Anchura.* The rock mold, GSC 5763, displays three protoconch whorls, sculpture of next four whorls is indistinct because much of the shell has adhered to the mold and the sculpture is seen from the inside. The sculpture is made up of many fine arched axial ribs and about six spiral cords; the axial ribs may be more prominent on the earliest of these whorls, but the axial ornamentation becomes subordinate to the spiral. Sculpture on the remaining four whorls of the impression is clearly defined and strongly spiral, consisting of three narrow cords above the noded keel and four below. Interspaces are considerably wider than the cords. Axial sculpture is evinced as arcuate swellings that are strongest across the keel. On the earlier two of these four whorls the axial ribs are more numerous than on the later two by about a third. GSC 5763a lacks the protoconch and first teleoconch whorls. It consists of three and a half whorls, and, if it was the basis for the

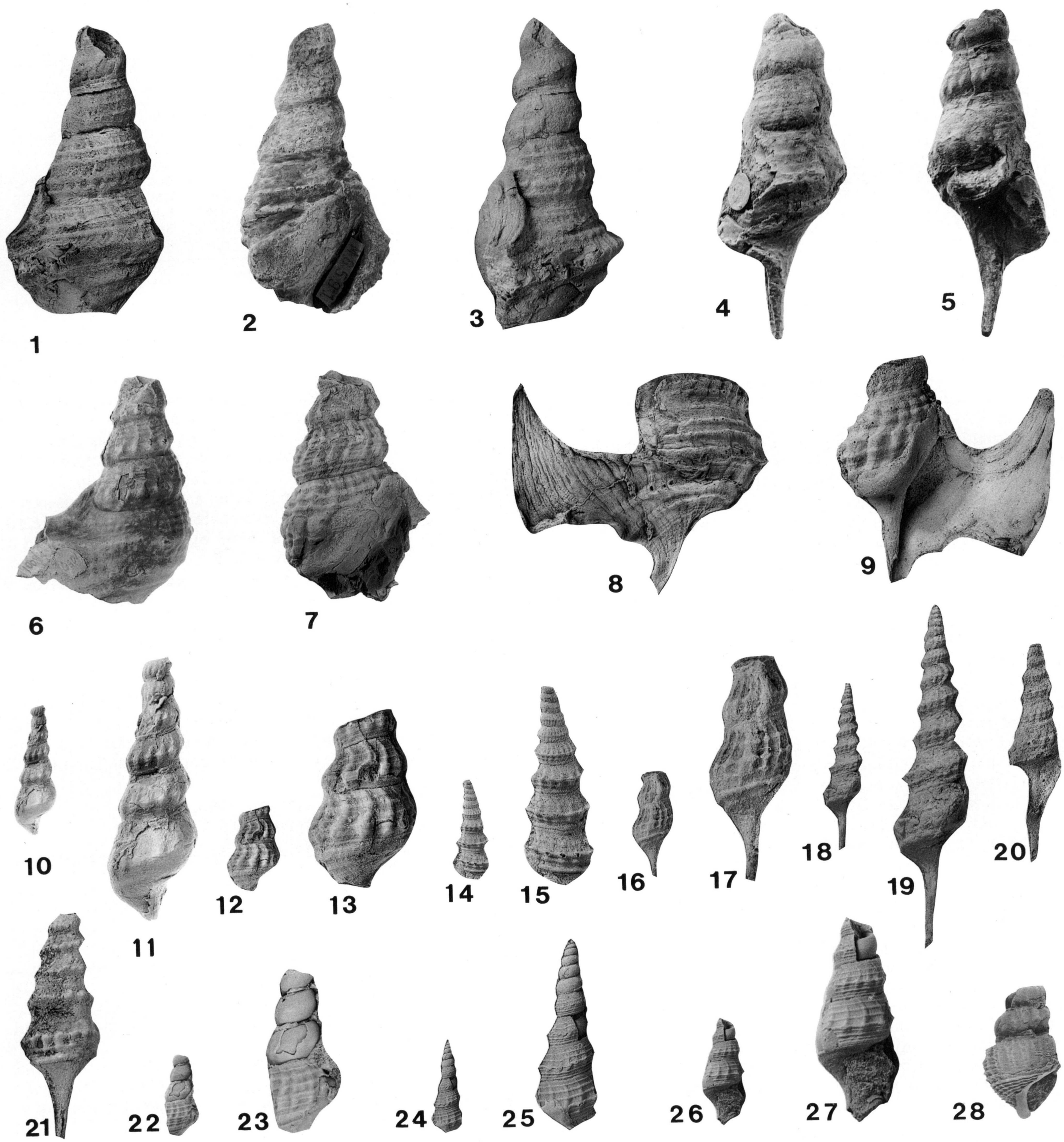

FIGURE 5—*1–13, Anchura phaba* new species. *1–3,* Paratype, abapertural, side, and apertural views, ×1, USNM 485423, locality M8591; *4, 5,* paratype, abapertural and apertural views, ×1, LACMIP 11333, locality CIT 1159; *6,* paratype, abapertural view, ×1, LACMIP 11328, locality CIT 1057; *7,* paratype, apertural view, ×1, LACMIP 11329, locality CIT 1057; *8, 9,* holotype, abapertural and apertural views of latex pull, ×1, USNM 468578, locality M8611; *10, 11,* paratype, abapertural view, ×1 and ×2, LACMIP 11345, locality CIT 1159; *12, 13,* paratype, abapertural view, ×1 and ×2, LACMIP 11332, locality CIT 1158. *14–21, Anchura ainikta* new species. *14, 15,* Paratype, latex pull, ×1 and ×2, LACMIP 11337, locality UCLA 7135; *16, 17,* paratype, abapertural view, ×1 and ×2, USNM 485424, locality M8759; *18, 19,* holotype, abapertural view, ×1 and ×2, USNM 485425, locality M8756; *20,* paratype, latex pull, ×1, LACMIP 11338, locality UCLA 7135; *21,* paratype, abapertural view, ×2, USNM 485426, locality M8756. *22–27, Anchura nanaimoensis* (Whiteaves). *22, 23,* Syntype, side view, ×1 and ×2, GSC 5763c; *24, 25,* syntype, abapertural view of latex pull, ×1 and ×2, GSC 5763; *26, 27,* syntype, apertural view, ×1 and ×2, GSC 5763a. *28, "Potamides tenuis" nanaimoensis* (Whiteaves), syntype, not *Anchura nanaimoensis* (Whiteaves), side view, ×2, GSC 5763b.

TABLE 5—Measurements in mm of *Anchura phaba* new species. For abbreviations and symbols used, see introduction.

Specimen	H	Hp	Db	Dp	Dp/Hp	R	PA	S	Ct	Cp	A	Remarks
USNM 468578	—	—	—	—	—	—	—	15.0	5	3	20●	latex pull
USNM 485423	52.0	10.7	26.5	17.4	1.63	—	26°	—	5	3	20●	body + 3 whorls
LACMIP 11333	57.9	9.8	21.7	16.4	1.67	14.6	23°	—	7	3	19	body + 2 whorls
LACMIP 11334	41.9	9.7	18.2	13.8	1.42	—	25°	—	6	3	—	body + 3 whorls
LACMIP 11345	23.6	4.4	8.8	7.4	1.68	—	18°	—	—	—	15	juv. 6 whorls
LACMIP 11328	40.7	9.0	20.5	16.8	1.87	—	28°	—	7	4	17	body + 3 whorls
LACMIP 11329	39.0	9.0	—	—	—	—	—	—	7	3/4	18	body + 2 whorls
LACMIP 11330	35.0	8.0	19.6	14.7	1.83	—	27°	—	8	4	20●	body + 3 whorls
LACMIP 11332	14.3	4.4	—	8.3	1.89	—	28°	—	7	3	14	3 spire whorls
LACMIP 11335	53.7	9.6	20.0	16.0	1.67	—	27°	—	6	3	16	8 whorls, no rostrum

last whorls in Whiteaves' figure 9, it has had shell breakage of the last volution. Enough shell remains to show a strong basal cord and a subordinate abapical cord.

No adult *Anchura nanaimoensis* are known. The type locality is only generally stated and covers an area where rocks of differing ages are present. These immature specimens are similar to immature *A. falciformis*, but *A. falciformis* has a broader keel involving more cords and has more and broader cords. *Anchura nanaimoensis* has more spiral cords than does *A. ainikta*. *Anchura nanaimoensis* cannot be distinguished from *A. phaba* with certainty because similar sized specimens of *A. phaba* are too poorly preserved, but *A. nanaimoensis* has a narrower pleural angle, more spiral cords, and the angulation nearer mid-whorl than does *A. phaba*. *Anchura nanaimoensis* is more strongly keeled than *A. callosa* but has fewer and weaker cords. In all of these species, very few such immature specimens have been available for study, and ranges of variability are conjectural. The number of cords per whorl, although varying by one or two in some species, is rather consistent, almost surprisingly so, through ontogeny from adolescent to adult whorls. Specimens of greater maturity are, however, needed for defining this species. In the absence of undoubtedly conspecific specimens of more maturity, well-located geographically and stratigraphically, *A. nanaimoensis* must be considered nominum dubium.

"Potamides" tenuis Gabb, 1864, and immature specimens of *Anchura falciformis* are common at several localities on Butte Creek and near Pentz. Although the submedial row of nodes on *"P." tenuis* appears similar to the axial ribs on *A. falciformis* specimens that are near 15 mm in height, these taxa can be distinguished. Specimens of *Anchura* have a juvenile sculpture dominated by fine, arched axial ribs followed by adolescent and mature whorls with fewer axial ribs and several spiral cords that form nodes where they override the ribs. *"Potamides" tenuis* lacks fine, arched axial juvenile sculpture but has widely spaced, submedial nodes with other axial or spiral sculpture so fine that it is commonly indiscernible without magnification. An undescribed species similar to *"P." tenuis,* but having a few widely spaced spiral cords is present in the Chatsworth Formation at Dayton Canyon (CIT locality 1159), Simi Hills, Los Angeles County, California. The spiral ribbing on this species corresponds better to Whiteaves' description than does the sculpture of typical *"P." tenuis*. Specimens similar to *"P." tenuis* and conspecific with those from Dayton Canyon, were not included among Whiteaves' syntypes, but his description suggests that he possessed such specimens. If so, they might aid in identifying the horizon from which *A. nanaimoensis* was collected.

Type specimens.—Four syntypes of *"Potamides tenuis" nanaimoensis* Whiteaves, 1879, GSC 5763, a–c (Bolton, 1968, p. 68). One specimen, GSC 5763b, is not an *Anchura* but resembles *"Mesostoma" suciensis* (Whiteaves, 1879) (plate 15, figure 10; 1903, plate 44, figure 7). GSC 5763 may be the impression of 5763a, and Whiteaves' figure 9 may have been based on GSC 5763a and 5763. GSC 5763a is here chosen as the lectotype of *"Potamides tenuis" nanaimoensis* Whiteaves, 1879.

Type locality.—NW side of Hornby Island, British Columbia, Canada.

Measured specimens.—See Table 7.

Age.—Middle to late Campanian, "*pacificum* subfauna" or "*hornbyense* subfauna" (Jeletzky *in* Muller and Jeletzky, 1970).

Geographic distribution.—Probably Spray Formation (upper = late Campanian or lower = late middle to early late Campanian), northwest side of Hornby Island, British Columbia.

ANCHURA GIBBERA Webster, 1983
Figure 6.1–6.4

Anchura gibbera Webster, 1983, p. 1095, fig. 3B–E; Sundberg and Riney, 1984, p. 105, fig. 3.7.

Description of early whorl sculpture.—Protoconch of four rounded whorls. First four whorls of teleoconch rounded, sculptured by three narrow spiral cords and about 14 slightly stronger axial ribs; fifth whorl made slightly angulate by increasing strength of middle cord; eighth whorl noticeably angulate with about 18 weaker axial ribs and five narrow cords slightly beaded at intersections with ribs, the middle cord at the angulation and strongest.

Remarks.—*Anchura gibbera* is the tallest and most slender Pacific Slope *Anchura*. It is the only Late Cretaceous Pacific Slope species whose wing is known to have an anterior arm at the bend of the wing, similar to that of *A. abrupta* of the Gulf

TABLE 6—Measurements in mm of *Anchura ainikta* new species. For abbreviations and symbols used, see introduction.

Specimen	H	Hp	Db	Dp	Dp/Hp	R	PA	S	Ct	Cp	A	Remarks
USNM 485425	29.6	3.6	8.7	6.9	1.92	5.1	20°	—	4	1	14●	12 whorls, crushed
USNM 485426	21.5	3.0	6.6	5.2	1.73	4.7	19°	—	4	1	—	5 whorls, crushed
USNM 485424	19.9	4.7	8.6	6.2	1.32	—	18°	—	4	1	16●	2 whorls + rostrum
LACMIP 11337	18.8	3.5	6.5	6.2	1.77	—	17°	—	4	1	14●	10 whorls, latex pull
LACMIP 11338	38.0	4.6	9.2	6.4	1.39	7.5	17°	—	4	1	14●	7 whorls, latex pull

TABLE 7—Measurements in mm of *Anchura nanaimoensis* (Whiteaves). For abbreviations and symbols used, see introduction.

Specimen	H	Hp	Db	Dp	Dp/Hp	R	PA	S	Ct	Cp	A	Remarks
GSC 5763	17.0	—	—	—	—	—	19°	—	8	3	—	latex pull
GSC 5763a	17.8	4.3	—	6.9	1.72	—	22°	—	8	3	14	4 spire whorls
GSC 5763c	14.3	3.4	—	—	—	—	20°	—	7	3	—	3.5 spire whorls

Coast. Although it has both axial and spiral sculpture on the early whorls, the axial ribs are much weaker and finer on the more mature whorls than in *A. callosa, A. falciformis,* or *A. phaba.* In addition, its peripheral angulation is stronger, its parietal callus is more protuberant than in the above species, and it has one dominant basal spiral with a subdominant spiral below and a weaker cord above. Its whorl profile differs from that of *A. falciformis* and *A. callosa* in being concave adapical to the median angulation.

The specimen, hypotype LACMIP 11340, upon which the description of the early whorls is based, is a nearly complete specimen. Although the mature whorls of this specimen are too crushed to photograph well, they allow identification of the species.

Type specimens.—Holotype LACMIP 6465; paratypes LACMIP 6466–6471, IGM 3284; hypotypes LACMIP 11340 from UCLA locality 7235, 11339 from LACMIP locality 8068.

Type locality.—LACMIP 2858, top of south slope, north fork of Ammonite Ravine, Arroyo Santa Catarina, Baja California, Mexico.

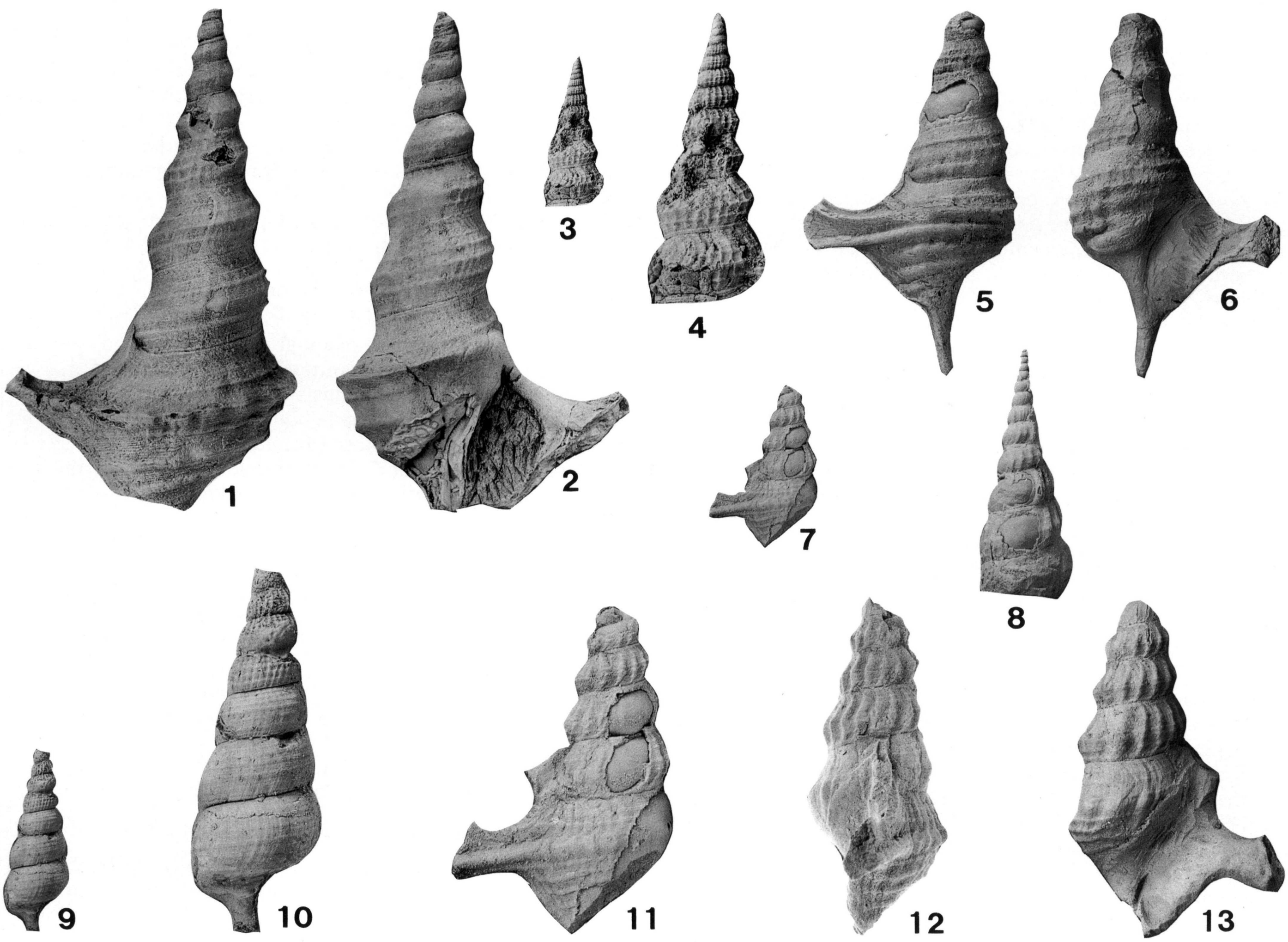

FIGURE 6—*1–4, Anchura gibbera* Webster. *1, 2,* Hypotype, abapertural and apertural views, ×1, LACMIP 11339, locality LACMIP 8068; *3, 4,* hypotype, abapertural view of juvenile, ×1 and ×2, LACMIP 11340, locality UCLA 7235. *5, 6, Anchura baptos* new species, holotype, abapertural and apertural views, ×1, USNM 485427, locality M5906. *7, 11–13, Anchura (Helicaulax?) popenoei* new species, holotype, abapertural, side, and apertural views, ×1 (*7*), and ×2 (*11–13*), LACMIP 11342, locality UCLA 5990. *8, Anchura (Helicaulax) tricosa* Saul and Popenoe, hypotype, side view showing varices, ×1.5, LACMIP 11343, locality CIT 92. *9, 10, Anchura?* new species, abapertural view, ×1 and ×2, LACMIP 11341, locality CIT 1545.

TABLE 8—Measurements in mm of *Anchura gibbera* Webster. For abbreviations and symbols used, see introduction.

Specimen	H	Hp	Db	Dp	Dp/Hp	R	PA	S	Ct	Cp	A	Remarks
LACMIP 6465	70	10.8	—	16.6	1.54	—	19°	16.0	4	2	—	body + 4.5 whorl
LACMIP 11339	70.8	11.7	31.8	18.2	1.56	—	24°	—	4	2	—	body + 7 whorls
LACMIP 11340	62.5	10.9	22.2	16.7	1.53	—	26°†	—	4	2	—	body + 7 whorls

Measured specimens.—See Table 8.

Age.—Late Campanian to early Maastrichtian, *Pachydiscus ootocodensis* (?), *Didymoceras hornbyense,* and *Pachydiscus (Neodesmoceras) catarinae* Zones.

Geographic distribution.—Point Loma Formation, Carlsbad, (UCLA 7235) San Diego County, Calif.; Rosario Formation, Punta San Jose (LACMIP 8068), Arroyo Santa Catarina, Baja California, Mexico.

ANCHURA BAPTOS new species
Figure 6.5, 6.6

Diagnosis.—*Anchura* with axial sculpture reduced to nodes and three to four spiral cords on spire whorls; lower two extend onto shank at wing.

Description.—Shell moderately large, high-spired, drawn out anteriorly into a very narrow, moderately long, backwardly bent rostrum; pleural angle about 28 degrees; whorls angled medially, slightly concave posterior to middle and convex anteriorly; suture appressed. Sculpture on earliest preserved whorl of arcuate axial ribs and three strong spiral cords; medial cord strongest, forming the angulation, posterior cord weakest; axial ribs becoming weaker on more mature whorls, reduced to barely more than nodes on cords by penultimate whorl; ultimate whorl with six cords (three equally spaced, additional cords anterior to three of spire), anterior cord weakest; three cords of spire extended onto shank of wing; posterior cord meeting posterior edge near center of posterior sulcus; median cord forming keel of wing, and anterior cord forming secondary anterior angulation. Outer lip expanded to form wing with short shank. Aperture with broad posterior sulcus and broad anterior sulcus delineated posteriorly by parietal callus pad. Inner lip expanded onto whorl face, developing a spirally elongate, thick callus pad, thickest along fifth cord but overlapping onto fourth and sixth cords.

Remarks.—*Anchura baptos* is based on one incomplete specimen consisting of five whorls, including the body whorl, most of the rostrum, and the shank of the wing. The shank is relatively narrow and lacks secondary spurs. The shell is recrystallized and some surface details such as growth lines have been lost.

In its sculpture, *A. baptos* is most similar to *A. gibbera* and *A. phaba.* It differs from *A. gibbera* in having a wider pleural angle, one less cord on the whorls of the spire, and a lower, more elongate parietal callus pad. It differs from *A. phaba* and geologically older Pacific Slope *Anchura* species in having the axial ribs of the mature whorls reduced to no more than nodes on the cords and in having fewer spiral cords. *Anchura baptos* is the only Pacific Slope species to have two strong cords extending onto the shank and presumably the wing. Four specimens from the San Francisquito Formation on Warm Springs Mountain, Los Angeles County, California, are probably also this species. The specimen from LACMIP 14313 was associated with *Roudairia squiresi* Kirby and Saul, 1995, and is considered to be of latest Maastrichtian age. LACMIP 14314 is eight meters upsection from LACMIP 14313, and the three specimens from this higher horizon are associated with *Turritella peninsularis quaylei* Saul, 1983, and considered to be of early Danian age (Kirby, 1991). The San Francisquito Formation specimens differ from the Dip Creek specimen in having a fourth adapical cord on the spire. This cord is weaker than the other cords and may be variably present.

Type specimen.—Holotype USNM 485427.

Type locality.—USGS locality M5906, east side of Dip Creek, 2300'S, 1000'W of NE corner sec. 30, T25S, R10E, Lime Mountain quadrangle, San Luis Obispo County, California.

Measurements.—See Table 9.

Age.—Latest Maastrichtian, *Turritella peninsularis adelaidana* Zone to early Danian *Turritella peninsularis quaylei* Zone.

Geographic distribution.—The type locality on Dip Creek, San Luis Obispo County, and two localities [LACMIP 14313 (1 specimen) and 14314 (3 specimens)] near the base of the San Francisquito Formation on Warm Springs Mountain, Los Angeles County, California.

Etymology.—The name *baptos,* Greek, dipped, dyed, refers to the type locality on Dip Creek.

ANCHURA? new species
Figure 6.9, 6.10

Discussion.—A fragment of a high-spired gastropod from the Tierra Loma Shale Member of the Moreno Formation may be an *Anchura.* The specimen consists of about seven whorls, the earliest preserved of which have both fine arcuate axial ribs and spiral cords giving an almost cancellate appearance. The ribs and cords form nodes at their intersections. The axial ribs fade on the fourth whorl leaving about six primary spiral cords plus intermediaries. The cords appear to be fading on the last whorl. The whorl profile is rounded and there is no indication of a keel on any whorl.

Sculpture of the earliest whorls of this specimen is similar to that of young *A. gibbera,* but reduced sculpture from the fourth whorl on is distinctly different from any other Pacific Slope *Anchura* species.

Figured specimen.—LACMIP 11341 from CIT locality 1545 = LACMIP 8147, Laguna Seca section, Merced County, California

Measured specimen.—See Table 10.

Age.—Early late Maastrichtian

Subgenus HELICAULAX Gabb, 1868

Type species.—*Rostellaria ornata* d'Orbigny, 1843, by subsequent designation (Cossmann, 1904), from the Turonian of France.

TABLE 9—Measurements in mm of *Anchura baptos* new species. For abbreviations and symbols used, see introduction.

Specimen	H	Hp	Db	Dp	Dp/Hp	R	PA	S	Ct	Cp	A	Remarks
USNM 485427	52.5	8.0	21.0	15.0	1.88	10.1	28°	11.1	3	1	—	body + 4 whorls

TABLE 10—Measurements in mm of *Anchura*? new species. For abbreviations and symbols used, see introduction.

Specimen	H	Hp	Db	Dp	Dp/Hp	R	PA	S	Ct	Cp	A	Remarks
LACMIP 11341	27.8	4.9	9.6	8.7	1.78	—	18°	—	6	—	—	juv.

Discussion.—In overall shape and type of sculpture, *Helicaulax* resembles *Anchura* but differs in having an additional elongate, reflexed posterior digitation that is adnate to the spire for most of its length (Sohl, 1960, p. 103). Sohl (1960) considered *Anchura* and *Helicaulax* to be closely related. However, Roy (1994) divided 33 aporrhaid genera including *Anchura* and *Helicaulax* into two morphologic groups, placing *Helicaulax* into one group, M1 with multidigitate apertures, and *Anchura* into the other group, M2 with simpler apertures. Saul and Popenoe (1993) included *Anchura (Helicaulax) condoniana* (Anderson, 1902) and *A. (H.) tricosa* Saul and Popenoe, 1993, in *Helicaulax* on the basis of their having an elongate, reflexed posterior digitation adjacent to but not adnate to the spire, straight rostra, and spurs along the shank of the wing. The latter two characteristics do not, however, separate *Helicaulax* from some *Anchura* species, which also display straight rostra and spurs along the shank. Campanian and Maastrichtian faunas of the Gulf Coast contain several species placed in *Anchura* that have short posterior digitations (i. e., *A. chapelvillensis* Dockery, 1993 and *A. corniculata* Dockery, 1993), but none of these digitations approach the length of those of *A. (H.) tricosa.* This prominent digitation gives *A. (H.) tricosa* a multidigitate apertural margin like that of *Helicaulax* and removes it from Roy's M2 group. Roy (1994) listed 25 characteristics that he used in differentiating genera of aporrhaids; six of these separate *Helicaulax* from *Anchura.* All six, however, relate to the posterior digitation. As species having a very short posterior digitation are included in *Anchura,* the distinction depends upon the length of the digitation and the length of its attachment to the spire. Based on these criteria, species such as *A. (H.) tricosa* do not fit neatly into either *Anchura* s. s. or *Helicaulax.* Pending thorough evaluation of the distribution in time and space of these features and their evolutionary significance, *A. (H.) tricosa* is left in *Helicaulax,* which seems, as Sohl (1960) suggested, close to *Anchura* s. s. Although the new species, *Anchura (Helicaulax?) popenoei,* is very similar to *A. (H.) tricosa,* it has a much shorter posterior digitation and, thus, is questionably assigned to *Helicaulax.*

Age.—Critical study of *Anchura (Helicaulax)* is needed in order to exclude forms improperly assigned to the subgenus. Sohl (1960) considered *Helicaulax* to be restricted to the Late Cretaceous, but Roy (1994, figures 5, 6) listed it from the Aptian through Maastrichtian stages. On the Pacific Slope, *A. (Helicaulax)* has been identified from strata of Turonian and, if our tentative assignment of *A. (Helicaulax?) popenoei* is correct, Coniacian age.

ANCHURA (HELICAULAX?) POPENOEI new species
Figure 6.7, 6.11–6.13

Diagnosis.—A relatively small *Anchura* with short posterior digitation at its base adjacent to the spire, but not otherwise adnate; sculpture dominantly axial with about 18 slightly curved ribs; about six cords on spire, third and fourth spiral cords coalesced on body whorl, forming angulation and continuing onto extended outer lip.

Description.—Shell medium-sized, high-spired; pleural angle about 22 degrees; whorl profile slightly angulate just anterior to middle on spire and strongly angulate on last whorl; five whorls preserved in holotype; suture appressed; protoconch unknown; varices randomly present but not obvious; growth line antispirally concave on spire. Mature sculpture of slightly arched axial ribs, forming nodes at the periphery, 18 on penultimate whorl, axial ribs weakening on body whorl but persisting as nodes on carina; spiral cords strongest anterior to angulation on ultimate whorl, about six cords showing on spire whorls, third and fourth cords strongest, coalescing and forming noded keel on ultimate whorl and extending onto shank as carina, about six cords anterior of keel on ultimate whorl with second and third strongest. Outer lip expanded, forming narrow shanked wing with additional short posterior digit adjacent to spire.

Remarks.—*Anchura (Helicaulax?) popenoei* is described from one specimen lacking protoconch, rostrum, and outermost portion of wing. Because the wing is broken, the length of the shank is undetermined. The posteriorward extension at the break is probably, considering the position of the carina, part of a secondary spur rather than the inception of the posterior arm. The earliest preserved whorl has many fine equal spiral cordlets, but on the next whorl five cords have begun to dominate the spiral sculpture. It is considerably smaller than *A. (H.) condoniana* Anderson, 1902, and has more convex whorls that are more strongly angulate; its sculpture is less strongly beaded, and its axial ribs are noticeably more arcuate than those of *A. (H.) condoniana.* In whorl profile, shape and beading of ribs, and possession of varices *A. (H.?) popenoei* is most similar to *A. (Helicaulax) tricosa* Saul and Popenoe, 1993. On the spire, *A. (H.?) popenoei* has two cords posterior to the carina rather than three and only about two anterior to the carina. Strength of cords, noding, and axial ribs also resemble those of *A. callosa* and *A. falciformis,* but *A. (H.?) popenoei* is smaller, less high spired, has fewer spiral cords, and the shank to the outer lip is narrower.

Anchura (Helicaulax?) popenoei is questionably included in *Helicaulax* because of its short posterior digitation that is adjacent to the spire at its base. Dockery (1993) includes species with similarly small posterior digitations in *Anchura,* but *A. (H.?) popenoei* bears so great a resemblance to *A. (H.) tricosa* that it is included in the same supraspecific taxon.

Type specimens.—Holotype LACMIP 11342.

Type locality.—UCLA 5990, sandstone cropping out in bed of small NW-flowing gully tributary to French Creek, near south end of Swede Basin, 300'S, 1800'E of NW corner sec. 9, T33N, R2W, Millville quadrangle, Shasta County, California. Collector: W. P. Popenoe, 1/1/1959.

Measured specimens.—See Table 11.

Age.—Coniacian

TABLE 11—Measurements in mm of *Anchura* (*Helicaulax*?) *popenoei* new species. For abbreviations and symbols used, see introduction.

Specimen	H	Hp	Db	Dp	Dp/Hp	R	PA	S	Ct	Cp	A	Remarks
LACMIP 11342	24.3	4.2	10.8	8.2	2.0	—	22°	6.0	6	2	18	body + 4 whorls

Geographic distribution.—Redding Formation, Hooten Gulch Mudstone Member (Haggart, 1986), Swede basin, Redding area, Shasta County, California.

Etymology.—For W. P. Popenoe, who collected the holotype, in recognition of his study of aporrhaids of the Redding area.

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ACCEPTED 23 OCTOBER 1995

CITED LOCALITIES

92 CIT (=LACMIP 10100): Concretions in shale 100′ above stream and near fence on N side of Harding Canyon, about 0.25 mi N of road fork in Santiago Canyon at Harding/Modjeska Canyon junction, near section line NW 1/4, NW 1/4 sec. 28, T5S, R7W, Santiago Peak quadrangle, Santa Ana Mountains, Orange County, California. Collected by: B. N. Moore, 1928. Ladd Formation, basal Holz Shale Member; late Turonian.

974 CIT (=LACMIP 10105): SW slope of Aliso-Santiago Creek divide, 475′N, 1200′W of SE corner of sec. 29 and edge of topo sheet, El Toro quadrangle, Santa Ana Mountains, Orange County, California. Collected by: W. P. Popenoe, 1/14/33. Williams Formation, Pleasants Sandstone Member; late middle to early late Campanian, *Metaplacenticeras pacificum* Zone (Matsumoto, 1960, p. 99; Popenoe and Saul, 1987, p. 34; Saul and Popenoe, 1992, p. 60).

1018 CIT (=LACMIP 10833): Fossiliferous layers cropping out in beds of small gullies in field along Durham-Pentz Rd., approximately 0.75 mi W of Pentz, approximately 950′S, 350′E of NW corner sec. 25, T1N, R3E, W side Messila Valley, Cherokee quadrangle, Butte County, California. Collected by: W. P. Popenoe and D. Scharf, 8/19/1931. Chico Formation; late early Campanian

1053 CIT (=LACMIP 10093): First prominent NE-SW spur north of Santiago Creek near junction with Modjeska Creek, 200′N, 2850′E of SW corner sec. 20, T5S, R7W, El Toro quadrangle, Santa Ana Mountains, Orange County, California. Collected by: W. P. Popenoe, 4/9/34. Ladd Formation, upper part of Holz Shale Member; late early Campanian (Matsumoto, 1960, p. 102).

1054 CIT (=LACMIP 10793): Shale beds above conglomerate, near head of Aliso Creek, 1725′N, 1575′W of SE corner sec. 33, T5S, R7W, Santiago Peak quadrangle, Santa Ana Mountains, Orange County, California. Collected by: W. P. Popenoe, 10/14/34. Ladd Formation, upper part of Holz Shale Member; late early Campanian.

1057 CIT (=LACMIP 10794): Shale beds overlying conglomerate lens, about 250′ NW of CIT 1054, 1925′N, 1725′W of SE corner sec. 33, T5S, R7W, Santiago Peak quadrangle, Santa Ana Mountains, Orange County, California. Collected by: W. P. Popenoe, 10/26/34. Ladd Formation, upper part of Holz Shale Member; late early Campanian.

1060 CIT (=LACMIP 8196): Crest of high NE-SW trending ridge between Santiago and Williams Canyons, 1900′N, 1650′E of SW corner sec. 20, T5S, R7W, El Toro quadrangle, Santa Ana Mountains, Orange County, California. Collected by: W. P. Popenoe, 10/14/35. Ladd Formation, uppermost part of Holz Shale Member; early middle Campanian

1158 CIT (=LACMIP 10710): SE slope of Simi Hills, north bank Bell Canyon, 1.15 mi due west of Los Angeles-Ventura County line on boundary (extended) between T1 and 2N, 500′S, 9000′W of NE corner sec. 4, T1N, R17W. Calabasas quadrangle, Ventura County, California. Collected by: W. P. Popenoe, 6/18/35. Chatsworth Formation; middle Campanian.

1159 CIT (=LACMIP 10715): Prominent fossil bed on crest of spur between forks of Dayton Canyon, about 400′E of Los Angeles-Ventura County line, 400′N, 2350′W of SE corner sec. 28, T2N, R17W, Calabasas quadrangle, Los Angeles County, California. Collected by: W. P. Popenoe, H. L. Popenoe, and R. Durbin, 6/21/35. Chatsworth Formation; late middle Campanian (Matsumoto, 1960, p. 103; Popenoe, Saul, and Susuki, 1987, p. 99; Saul and Popenoe, 1992, p. 60).

1527 UCLA: South of Santiago Creek, along Santiago Truck Trail, SW 1/4, SW 1/4 sec. 28, T5S, R7W, Santiago Peak quadrangle, Santa Ana Mountains, Orange County, California. Collected by: T. Bear, 1940. Ladd Formation, Holz Shale Member; probably late early Campanian.

1545 CIT (=LACMIP 8147): Laguna Seca Section, 2500′S, 1300′E of sec. 13, T12S, R10E, on cliff in pebbly bed approximately 50′ above contact with silty clay-stone, Los Baños quadrangle, Merced County, California. Collected by: B. Adams. Moreno Formation, Tierra Loma Shale Member; early late Maastrichtian.

2858 LACMIP: (Webster locality 25) Top of S slope, elevation 272′, N fork of Ammonite Ravine, about 1125 m E of mouth of Ammonite Ravine, E side Arroyo Santa Catarina, about 6.4 km inland from Pacific Ocean, Baja California, Mexico. Collected by: M. Webster, 1966. Rosario Formation; late Campanian-early Maastrichtian.

3632 UCLA: West side Chico Creek about 1/3 mi up deep ravine, 2/3 mi S of Mickey's Place, 1750′S, 25′W of NE corner sec. 11, T23N, R2E, Paradise quadrangle, Butte County, California. Collected by: L. R. and R. B. Saul, 1952. Chico Formation, basal part of Tenmile Member, late Santonian or early Campanian.

3635 UCLA: On E bank of Chico Creek W from HB House and approximately 400′ S of twin meadows, 1800′S, 400′E of NW corner sec. 13, T23N, R2E, Paradise quadrangle, Butte County, California. Collected by: L. R. and R. B. Saul, 8/17/1952. Chico Formation, Tenmile Member, early Campanian.

3637 UCLA: East bank Chico Creek, 1250′N of SE corner sec. 14, T23N, R2E, Paradise quadrangle, Butte County, California.

Collected by: L. R. and R. B. Saul, 8/18/1952. Chico Formation, Tenmile Member, early Campanian.

3643 UCLA: W bank Chico Creek, 1500'S, 2500'W of NE corner sec. 26, T23N, R2E, Paradise quadrangle, Butte County, California. Collected by: L. R. and R. B. Saul, 8/22/1952. Chico Formation, Tenmile Member; early Campanian.

3648 UCLA = LACMIP 10861, 23648: Fossil Bluff, W side Chico Creek, 1750'S, 1800'E of NW corner sec. 35, T23N, R2E, Paradise quadrangle, Butte County, California. Collected by: L. R. and R. B. Saul, 8/21/1952. Chico Formation, Tenmile Member; early middle Campanian.

4082 UCLA: Tuscan Springs, on Little Salt Creek, about 10 mi NE of Red Bluff, near center NE 1/4 sec. 32, T28N, R2W, Tuscan Springs quadrangle, Tehama County, California. Collected by: W. P. Popenoe et al. Chico Formation; early middle Campanian.

4192 UCLA: Hills N of Santiago Canyon on crest of long NE trending ridge, 200'N, 2600'E of SW corner sec. 20, T5S, R7W, El Toro quadrangle, Santa Ana Mountains, Orange County, California. Collected by: M. A. Murphy, W. P. Popenoe and T. Susuki, 2/4/59. Ladd Formation, Holz Shale Member, about 105' below top; late early Campanian, *Submortoniceras chicoense* Zone.

4224 UCLA: From nodules in mine tunnel on E bank of Butte Creek, about 10' above water's edge, 2.8 mi by road NW of Honey Run Road covered bridge, approximately 2000'S, 250'E of NW corner sec. 17, T22N, R3E, Paradise quadrangle, Butte County, California. Collected by: W. P. Popenoe, Aug. 29, 1952. Chico Formation, Ten Mile Member; middle Campanian.

4662 UCLA: N side Mill Creek, approximately 1700'S, 2250'W of NE corner sec. 19, T27N, R2E, Panther Spring quadrangle, Tehama County, California. Collected by: P. U. Rodda, 1954. Chico Formation; late(?) Santonian.

4664 UCLA: Just below contact of volcanics and Cretaceous, mouth of Rancheria Creek, 1700'S, 1550'E of NW corner sec. 19, T27N, R2E, Mill Creek Canyon, Panther Spring quadrangle, Tehama County, California. Collected by: P. U. Rodda, 1954. Chico Formation, Kingsley Cave Member (Haggart and Ward, 1984); late Santonian.

4878 UCLA: Sucia Island from bluffs on S side of Fossil Bay about 1/4 mile E of W (closed) end of the bay, sec. 26, T38N, R2W, San Juan County, Washington. Collected by: W. P. Popenoe, 8/23/1952. Cedar District Formation; middle Campanian.

M5906 USGS: On E side of Dip Creek, 2300'S, 1000'W of NE corner sec. 30, T25S, R10E, Lime Mountain quadrangle, San Luis Obispo County, Santa Lucia Mountains, California. Collected by: D. L. Durham and R. J. McLaughlin, 1969; W. O. Addicott, Koichiro Masuda, D. L. Durham, and T. W. Dibblee, Jr., 1970. Asuncion Formation (Taliaferro, 1944); late late Maastrichtian.

5990 UCLA: Sandstone cropping out in bed of small northwestward-flowing gully tributary to French Creek, near S end of Swede Basin, 300'S, 1800'E of NW corner sec. 9, T33N, R2W, Millville quadrangle, Shasta County, California. Collected by: W. P. Popenoe, 1/1/1959. Redding Formation, Hooten Gulch Mudstone Member; Coniacian.

6044 UCLA: (P 1–72) Soft massive sandstone cropping out on left (east) bank of Butte Creek, just downstream from high bluff at water's edge, and across stream from A-frame house. About 1000'N and 2800'W of SE corner sec. 8, T22N, R3E, Paradise 15 minute (1953) quadrangle, Butte County, California. Collected by: W. P. Popenoe, 6/21/72. Chico Formation, Tenmile Member; late early Campanian.

6950 UCLA: Roadcut N side Silverado Truck Trail, very fossiliferous bed (1'+ thick) immediately below Schultz Conglomerate Member of the Williams Formation, 950'S, 125'W of NE corner sec. 18, T5S, R7W, El Toro quadrangle, Santa Ana Mountains, Orange County, California. Collected by: L. R. Saul, 12/4/81. Ladd Formation, uppermost part of Holz Shale Member; early middle Campanian.

6965 LACMIP: Prominent fossil bed on crest of spur between forks of Dayton Canyon, about 400'E of Los Angeles-Ventura County line, 400'N, 2350'W of SE corner Sec. 33, T2N, R17W, Calabasas quadrangle, Simi Hills, Los Angeles County, California. Collected by: J. Alderson, 1974. Chatsworth Formation; middle Campanian, *Hoplitoplacenticeras bowersi* Zone.

6996 UCLA: N bank of Bell Canyon about 1 mi W of Los Angeles-Ventura County line on the boundary (extended) between T1N and T2N, R17W, Calabasas quadrangle, Simi Hills, Ventura County, California. Collected by: W. P. Popenoe, 3/27/46. Chatsworth Formation; middle Campanian.

7135 UCLA: Fossils collected within 3 m of section in highly fossiliferous zone, W side Horse Canyon near 1800' contour, 1.125 km N, 1.2 km E of SW corner of topo, T9N, R30W, Bates Canyon quadrangle, Sierra Madre Mountains, Santa Barbara County, California. Collected by: Greg Smith, January, 1984. Unnamed formation; late middle or late Campanian.

7235 UCLA: Carlsbad Research Park, N side of Faraday Street from cut slope destined to be used for filling Letterbox Canyon, approximately 0.7 mi N, 1.55 mi W of SE corner of San Luis Rey quadrangle, San Diego County, California. Collected by: L. R. Saul, A. R. Loeblich, and J. Loch, 6/21/1984. Point Loma Formation; late Campanian or earliest Maastrichtian.

8068 LACMIP: Punta San Jose, Baja California, Mexico. Collected by: unknown. Rosario Formation; late Campanian or early Maastrichtian.

M8591 USGS Mesozoic: (J 979–199–11) Manzanita Mountain, Santa Barbara County, California. Approximately 11,400'N and 17,025'W of SE corner Manzanita Mountain quadrangle (1964), altitude approximately 1560' in South Fork La Brea Creek near mouth of Lion Canyon, approximately 1.5 miles NE of Manzanita Mountain. Collected by: J. Joyce and J. Vedder, 1979. Unnamed unit; middle or early late Campanian.

M8611 USGS Mesozoic: Pebbly sandstone just S of head 0.7 mi E of Pigeon Point, latitude 37° 10.86'N, longitude 122° 22.79'W, Pigeon Point 1:24000 quadrangle, San Mateo County, California. Collected by: W. P. Elder, 1990. Pigeon Point Formation; middle to early late Campanian.

M8756 USGS Mesozoic: (91E-16) Sandstone turbidite 100 m NW of small creek, 1 km SE of Pigeon Point, Pigeon Point 1:24000 quadrangle, San Mateo County, California. Collected by: W. P. Elder, 1991. Pigeon Point Formation; middle or early late Campanian.

M8759 USGS Mesozoic: (PPLH-A) W end of beach 200 m NE of Pigeon Point Lighthouse, Pigeon Point 1:24000 quadrangle, San Mateo County, California. Collected by: W. P. Elder, 1991. Pigeon Point Formation; middle or early late Campanian.

A9254 UWBM: Sucia Island, San Juan County, Washington. Latitude 48°46', Longitude 122°52'. Collected by: Peter Ward?, 1972. Cedar District Formation; middle(?) Campanian.

10934 LACMIP: Fossils collected along 1450' outcrop of sandstone bed on N-facing slope of canyon N of Modjeska Canyon, 150'S, 1250'E of SW corner sec. 20, to 600'N, 2600'E of SW corner sec. 20, T5S, R7W, El Toro quadrangle, Santa Ana Mountains, Orange County, California. Collected by: L. J. Czel, 1957. Ladd Formation, Holz Shale Member, uppermost sandstone bed; early middle Campanian.

11950 LACMIP: Approximately 6.4 km inland from Pacific Ocean, on NW wall of Arroyo Santa Catarina near base (approximately 100 m), Baja California, Mexico. Collected by: R. Demetrion, January 1987. Rosario Formation; late Campanian and early Maastrichtian.

14313 LACMIP (=CSUN 1447P): About 450 meters north by northwest of lookout on Warm Springs Mountain, elevation 3460', 47 meters above basement complex—San Francisquito Formation contact in Kirby's measured section number 2 (Kirby, 1991, p. 119), Los Angeles County, California. Collected by: M. X. Kirby, 1990. San Francisquito Formation; late Maastrichtian.

14314 LACMIP (=CSUN 1447G): 460 meters north by northwest of lookout on Warm Springs Mountain, elevation 3480′, 55 meters above basement complex—San Francisquito Formation contact in Kirby's measured section number 2 (Kirby, 1991, p. 119), Los Angeles County, California. Collected by: M. X. Kirby, 1990. San Francisquito Formation; early Danian.

15790 LACMIP: West bank Deer Creek, 160 m N, 240 m E of SW corner sec. 32, T26N, R2E, Panther Spring quadrangle, Tehama County, California. Collected by: John Russell, 1985. Chico Formation, Tenmile Member; early Campanian.

15792 LACMIP: East bank Deer Creek 200 m S, 375 m E of NW corner sec. 5, T25N, R2E, Panther Spring quadrangle, Tehama County, California. Collected by: John Russell, 1986. Chico Formation, Tenmile Member; early to early middle Campanian, *Submortoniceras chicoense* Zone.

27135 LACMIP [=7135 UCLA]: Fossils collected within 3 m section in highly fossiliferous zone, W side Horse Canyon, near 1800′ contour, 1.125 km N, 1.2 km E of SW corner of topo, T9N, R30W, Bates Canyon quadrangle, Sierra Madre Mountains., Santa Barbara County, California. Collected by: G. Smith, January 1984. Unnamed Formation; late Campanian.

27838 CASG: Chico Creek, 3.6 miles from "10 Mile House" on Humboldt Road, U.S.G.S. Chico quadrangle (1895, reprint 1932), Butte County, California. Collected by: H. A. Taff, G D., Hanna, and C. M. Cross, May, 1934. Chico Formation, Tenmile Member; early Campanian.

28323 CASG: Gully on N side of Del Puerto Creek, 1000′ below conglomerate, SW 1/4, 1/4 of sec. 35, T5S, R6E., Copper Mountain 1:24000 quadrangle, Stanislaus County, California. Collected by: J. A. Taff, 1935. Panoche Formation; early Santonian(?).