Moto X Track on Dumont Road, north of Nanaimo, Vancouver Island, British Columbia (Area 4). LOWER LOWER CAMPANIAN: lowermost? Cedar District Formation, Blunden Point, Lantzville, north of Nanaimo, Vancouver Island, British Columbia (Area 4); Chico Formation, Tuscan Springs, Tehama County, California (Area 10); Chico Formation, Chico Formation, Ten Mile Member, Chico Creek, Butte County, California; Chico Formation, Pentz Road member, Pentz area, Butte County, California (Area 12); Ladd Formation, upper Holz Shale Member, Santa Ana Mountains, Orange County, California (Area 28). UPPER LOWER CAMPANIAN: Cedar District Formation, Sucia Island, San Juan County, Washington (Area 5); Chatsworth Formation, Bell Canyon, Simi Hills, Los Angeles County, California (Area 26). LOWER MIDDLE CAMPANIAN: Chatsworth Formation, Dayton Canyon and ridge west of Dayton Canyon, Simi Hills, Los Angeles County, California (Area 26); Valle Formation, north of Punta Abreojos, Baja California, Mexico (Area 35). LOWER? MIDDLE CAMPANIAN: Cedar District Formation, "White House" site, west shore Denman Island, British Columbia (Area 3); Williams Formation, Schulz Member, Santa Ana Mountains, Orange County, California (Area 28). UPPER MIDDLE TO LOWER UPPER CAMPANIAN (*Metaplacenticeras pacificum* ammonite zone): Punta Baja Formation, Punta Baja, California, Mexico (Area 32). Tuna Canyon Formation, upper part, Temescal and Rivas canyons, Santa Monica Mountains, Los Angeles County, California (Area 27); Williams Formation, Pleasants Sandstone Member, Santa Ana Mountains, Orange County, California (Area 28). UPPER MIDDLE TO LOWER UPPER CAMPANIAN (UNDIFFERENTIATED): Pigeon Point Formation, southern sequence, Bolsa Point, San Mateo County, Califoria (Area 18). UPPER CAMPANIAN: Jalama Formation, Jalama Creek, western Santa Ynez Mountains, Santa Barbara County, California (Area 23).

Discussion.—A total of 673 specimens was studied. Preservation is good to excellent, although radial striae are only rarely preserved and mainly on the geologically early forms ranging from middle to late Turonian to Coniacian in age. The earliest unequivocal specimens of *Glycymerita veatchii* are small (height less than 17 mm), have a subquadrate shape (a few approach a quadrate shape), and have fine superposed radial striae alternating with very narrow, raised radial ribs (e.g., Fig. 6.1). They occur at a locality (LACMIP loc. 24651) placed by Jones et al. (1978) in the lower part of the Frazier Siltstone Member of the Redding Formation (Area 8). Based on ammonites, Haggart (1986) assigned this member a middle to late Turonian age. Most of these earliest *G. veatchii* specimens resemble *Glycymeris yoloensis* but differ by having a smaller size, shorter and narrower posterodorsal slope, and more numerous and more closely spaced radial riblets that are more uniformly raised.

At most localities, including the type locality, most of the specimens are subquadrate and only a few are quadrate or approach a quadrate shape. Specimens showing shapes intermediate between the subquadrate and quadrate forms are not common. Variations in shape, as well as in rib width and interspace width, can be found on specimens from the same locality (e.g., Fig. 6.27, Fig. 7.1), as well as on individual valves of the same specimen. On some of these specimens, rib width remains uncommonly relatively narrow with growth (e.g., Fig. 6.26, Fig. 7.4). On other specimens, the ribs are wider than normal (e.g., Fig. 8.5). Although *G. veatchii* shows variation in shape and sculpture, as well as a gradual increase in size through time, in each formation in which there is a representative number of specimens (more than 10 specimens), there are specimens that are either very similar to or morphologically indistinguishable from the lectotype of *G. veatchii*.

Several specimens of *G. veatchii* from Chico Creek (Area 12) are also well enough preserved to retain the fine superposed radial striae. Saul (1959) also noted these. She also commented that the crossing of these riblets by growth lines might give the cancellate appearance described by Whiteaves (1903, p. 391, pl. 47, fig. 4) for specimens from Vancouver Island, British Columbia. Saul's (1959) attempt to recognize Smith's varieties of *G. veatchii*, based on average rib count with the smallest number of ribs occurring earliest, was unsuccessful. Saul reported that the number of ribs seems to be more related to preservation than to stratigraphic position.

Specimens of *Glycymerita veatchii* from the lower Campanian Cedar District Formation on Sucia Island (Area 5) are mostly small sized (e.g., Fig. 6.25), but a few are up to height 33 mm and length 35 mm. McLellan (1927) named these smaller sized specimens *Glycymeris suciensis* and named the larger ones *Cucullaea suciensis*. Saul (1959) found similarly small-sized *G. veatchii* in the Chico Creek area. In both areas, these small specimens are found in fine-grained sandstone, and Saul believed that ecology was the controlling factor of their small size. The holotype of *Glycymeris suciensis* is shown in Figure 6.24. Specimens of so-called *Glycymeris suciensis* McLellan listed by Dailey and Popenoe (1966, fig. 3) as being present in the Jalama Formation were examined. These specimens are all juveniles or very early adults of *G. veatchii*.

Starting in the late early Campanian, as represented in the upper Holz Shale Member (Area 28), some subquadrate specimens (e.g., Fig. 6.26) of *G. veatchii* had narrow ribs that remained narrow with continued growth. These specimens have 6 ribs/10 mm, measured at 40 mm ventrally from the beak, whereas other upper Holz specimens (some from the same localities) have 4 ribs/10 mm. A rare specimen (Fig. 7.3) in the middle Campanian Chatsworth Formation is similar to the narrow-ribbed specimen (Fig. 6.26) from the upper Holz Shale, but on the antero-ventral part of this Chatsworth specimen, the ribs are wider. A specimen (Fig. 7.4) from the upper middle Campanian Punta Baja Formation also shows consistently narrow ribs (6 ribs/10 mm), and this particular specimen (84 mm in length) is the largest studied *Glycymerita* in the study area.

In the upper Campanian Jalama Formation, some, but not all, specimens of *Glycymerita veatchii* have very wide ribs with 3 ribs/10 mm measured 40 mm ventrally from the beak. One of these exceptional specimens (Fig. 8.5) is the holotype of *Glycymeris apletos* Dailey and Popenoe, 1966. Other specimens (e.g., Fig. 8.3) from the Jalama Formation, however, have narrower ribs (5 ribs/10 mm).

Glycymerita veatchii gradually increased to approximately fivefold in size through time: average length of 13 mm for Turonian, 25 mm for Coniacian, 35 mm for early Campanian, 60 mm for middle Campanian, and 70 mm for late middle to late Campanian specimens. The largest specimens are the so-called "giant"-sized specimens (greater than 66 mm in length), and they range in age from the late middle Campanian to late Campanian. The lower half of this range coincides with the ammonite biozone *Metaplacenticeras pacificum* (Fig. 2). These "giants" are found in the Punta Baja Formation (Area 32), Tuna Canyon Formation (Area 27), Pleasants Sandstone Member of the Williams Formation (Area 28), and in the Jalama Formation (Area 23).

Glycymerita veatchii differs from *G. banosensis* by having a much deeper angulation and sulcus posteriorly on the umbones, fewer ribs per 10 mm length measured 40 mm ventrally from beak, more incurved beaks, posteroventral margin more elongate, and commonly smoother posterodorsal margin. *Glycymerita veatchii* shells can also be larger in size.

Tschudin (2001) believed that the lectotype of *Glycymerita veatchii*, which was figured by Stewart (1930, p. 71, fig. 1), appears to belong to genus *Tucetona*. According to Tschudin, this genus is characterized by subcircular shape, short hinge with straight teeth, small cardinal area, opisthogyrate beaks, raised ribs (that can be divided), and an absence of radial striae (i.e., little or no periostracum). The lectotype of *G. veatchii* (Fig. 6.21), however, has a subquadrate shape (i.e., a truncate posterior projection), long hinge with curved teeth, large cardinal area, orthogyrate beaks, flattish ribs (never divided), and the presence of radial striae. This specimen is like all the other specimens of *G. veatchii* from its type locality. Stewart's illustration shows the posterodorsal subtruncation, but it does not show it very well. In conclusion, the lectotype definitely does not belong in genus *Tucetona*.

Crandall (1907) was the first worker to use the name "*Glycymeris*" for a fossil glycymeridid in the study area. He included *Glycymeris veatchii* in a faunal list for the Pigeon Point Formation in the Bolsa Point/Pigeon Point region (Area 18), but he did not provide any voucher specimens.

Glycymerita veatchii is very widespread, with distribution from British Columbia to southern California (Fig. 1). Its occurrence in the middle to upper Turonian strata is restricted to a few localities in northern California. It is found, however, in most shallow-marine formations of Coniacian through early middle Campanian age in the study area. Toward the end of its geologic range, it once again became more geographically restricted (i.e., Area 23).

Smith (1945) erroneously erected several synonyms of *Glycymeris veatchii*, and, as a result, his so-called "biostratigraphic study" of this species is seriously flawed.

GLYCYMERITA BANOSENSIS (Anderson, 1958) new combination

Figure 3.3, Figure 9, Table 1

Glycymeris veatchii major (Stanton). Smith, 1945, p. 42-42, fig. 8.
Glycymeris banosensis Anderson, 1958, p. 98–99, pl. 73, figs. 1–3.
Glycymeris n. sp. Sundberg, 1979, p. 173, pl. 1, fig. 7.
Glycymeris n. sp. Sundberg and Riney, 1984, p. fig. 12-7.
Glycymeris (*Glycymeris*) n. sp. Saul, 1986, p. 29, figs. 37–38.

Diagnosis.—Shell size medium large. Subquadrate (most specimens) to quadrate. Posterodorsal margin commonly truncate. Posteroventral margin commonly obliquely elongate. Ribs prominently raised, moderately narrow, and widely spaced.

Description.—Shell size medium large, up to height 70 mm and length 65 mm (same specimen); commonly slightly higher than long, height/length ratio = 0.89–1.09. Subquadrate (most specimens) to quadrate. Posterodorsal margin commonly truncate. Posteroventral margin commonly obliquely elongate. Subquadrate forms higher than long, moderately to strongly inflated (single-valve convexity/height ratio = 0.36–0.48). Quadrate forms slightly longer than high, moderately inflated (single-valve convexity/height ratio = 0.36–0.37). Equivalved, subequilateral to inequilateral. Sculpture consisting of approximately 48 ribs, moderately narrow and widely spaced; three to six ribs per 10 mm of distance, measured parallel to length at medial part of valve approximately 40 mm ventral of beak. Anterodorsal and posterodorsal slopes with ribs. Beaks central, prominent, incurved, and orthogyrate. Umbones moderately wide and moderately highly inflated (average single-valve width/height ratio = 0.43); posterior side bearing moderately strong angulation and moderately strong sulcus. Anterodorsal slope can be somewhat extended. Cardinal area long and moderately high and bearing up to six to seven, chevron-shaped, symmetrical, well-defined ligamental ridges/grooves. Hinge plate long, strongly arched, bent ventrally at its margins. Hinge bearing prominent taxodont teeth in two series with anterior series longer: up to nine teeth in anterior series and nine teeth in posterior series. Transverse teeth near beak short, narrow, and vertical. Oblique teeth strong, thick, curved to chevron-shaped. Inner shell margin with strong, moderately narrow crenulations.

Types.—Holotype CASG 28310.01, CASG loc. 28310; paratypes CASG 29116.01 and CASG 29117.01, both from CASG loc. 29116. All types are from the Moreno Formation, Los Banos Creek, Merced County, California.

Occurrence.—Upper Campanian to uppermost Maastricthian. UPPER UPPER CAMPANIAN TO POSSIBLY LOWER MAASTRICHTIAN: Gualala Formation, Mendocino County (Area 14); upper Chatsworth Formation near the former Lang Ranch, western Simi Hills, Ventura County, California (Area 26); Point Loma and Cabrillo formations, Point Loma, San Diego County, California (Area 29); Rosario Formation at 1) Punta Banda, 2) Punta China, 3) Canada Muerto, 4) Rancho San Antonio =? San Antonio del Mar, 5) between Colonet and Colonia Guerrero, 6) south of El Rosario, 6) Punta San Jose, and 7) Santa Catarina ("ammonite ravine"), Baja California, Mexico (Areas 30 to 33). LOWER TO "MIDDLE" MAASTRICHTIAN: Moreno Formation, Garzas Sand, Tierra Loma Sandstone, and Quinto Shale members, Los Banos area, Merced County, California (Area 19). UPPER MAASTRICHTIAN: El Piojo Formation, Cantinas Creek west of Lake Nacimiento, San Luis Obispo County, California (Area 22); Dip Creek Formation, south side of Lake Nacimiento, San Luis Obispo County, California (Area 22); San Francisquito Formation, Warm Springs Mountain, north of Santa Clarita Valley, Los Angeles County, California (Area 24).

Discussion.—Approximately 265 specimens were studied. Many of these are from the Moreno Formation (Area 19). Most specimens have good to excellent preservation, except for specimens from the San Francisquito Formation (Area 24).

The holotype is unusual in that its anterodorsal slope is extremely short. No other specimens of this species have such a short anterodorsal slope. Anderson (1958, pl. 73, fig. 2) illustrated the holotype in a slightly oblique view so that it does not even show the anterodorsal slope. This specimen is illustrated here (Fig. 9.8, 9.9).

Specimens are very abundant at LACMIP loc. 22661 in the Moreno Formation. At this locality, the subquadrate form is predominant. An approximately equal number of specimens show oblique posteroventral elongation versus those that do not. Anderson (1958) noted that the posterior margin of the shell of this species is oblique, but he stated that this condition is confined to the older stages of growth. This is not accurate because the posterior obliqueness can occur in the early stages of growth, as well. The quadrate forms at locality 22661 do not exhibit this posterior obliqueness.

Specimens of *Glycymerita banosensis* in the Rosario Formation (general vicinity of Areas 30 and 31) are mostly medium-sized, late-stage juvenile quadrate forms. Some are doubled-valved specimens.

Dailey and Popenoe (1966) listed several characters (shape, height/length, posterior angulation [sulcus], convexity, number of ribs, and size) to show that specimens of *G. banosensis* from the Garzas Sand of the Moreno Formation (Area 23) differ from *G. apletos*. Although *G. banosensis* is not conspecific with *G. apletos*, the characters used by Dailey and Popenoe (1966) have to reconsidered in the context that both species have two forms with intergrading characters. *Glycymerita banosensis* differs from *G. apletos* in that the former has a smaller size, weaker posterodorsal angulation, and narrower ribs. In addition, *G. banosensis* commonly has an obliquely elongate posteroventral margin.

Elder and Miller (1992) mentioned how the Garzas Sandstone specimens of *G. banosensis* show much variation in populations and how some of the specimens are distorted, but they did not try to explain the reason for the distortion. We also detected that these unusual shapes are all from localities (e.g., LACMIP 22661) where there are very abundant specimens of *G. banosensis*. It seems likely that crowding causing some of these specimens to be slightly distorted.

Two specimens, both poorly preserved, were detected from the Dip Creek Formation. Saul (1986, figs. 37–38), who identified them as *Glycymeris* (*Glycymeris*) n. sp., cleaned and illustrated the hinge of one them. Weak narrow radial ribs can be discerned on this specimen, which is identified here as *Glycymerita banosensis*. The surface sculpture is worn off the other specimen.

GLYCYMERITA ALEUTA new species
Figure 10, Table 1

Diagnosis.—Shell size medium. Trigonal to subquadrate. Valves moderately high inflated. Ribs moderately narrow with narrow interspaces. Sculpture tends to be obsolete ventrally.

Description.—Shell size medium, up to height 43 mm and length 44 mm (same specimen); commonly slightly higher than long, height/length ratio = 0.94–1.04. Trigonal to subquadrate. Equivalved and equilateral. Umbones wide and moderately high inflated (single-valve convexity/height ratio = 0.41–0.46); posterodorsal slope weakly sulcate. Sculpture consisting of approximately 38 raised ribs with additional 10 ribs preserved on posterodorsal slope of at least one specimen (other specimens have smooth posterodorsal slope); five ribs per 10 mm of distance, measured parallel to length at medial part of valve approximately 40 mm ventral of beak. Ribs moderately wide (approximately 1.5 mm wide) and interspaces narrow (approximately 0.25 mm); ribs (if present) on posterodorsal slope very narrow with very narrow interspaces. Sculpture tends to become obsolete ventrally. Beaks central, prominent, protruding, orthogyrate, and incurved. Anterodorsal and posterodorsal slopes steep and approximately same. Cardinal area relatively short and bearing up to seven to eight, chevron-shaped, symmetrical, well-defined ligamental ridges/grooves. Hinge plate long, strongly arched, higher anteriorly, bent ventrally at least on anterior end. Hinge bearing prominent taxodont teeth in two series, anterior series longer or both series approximately same length: up to 13 teeth in anterior series and 12 teeth in posterior series. Transverse teeth near beak short, narrow, and vertical. Oblique teeth strong, thick, angled to horizontal; straight, curved, or chevron-shaped. Inner shell margin with moderately strong, moderately wide crenulations. Growth checks very common and prominent.

Etymology.—The new species is named for the Aleutian Islands, Alaska.

Types.—Holotype UCMP 555899, USGS loc. M6839; paratype UCMP 555900, USGS loc. M6839; paratypes LACMIP 13633, 13634, LACMIP loc. 25107; all primary types from Kaguyak Formation, Alaska Peninsula, Alaska (Area 2).

Occurrence.—Lower Maastrichtian. Kaguyak Formation, Kamishak Hills, Mt. Douglas area, northern Alaska Peninsula, Alaska (Area 2); and Matanuska Formation, upper part of member 3, Flume Creek area on north side of Matanuska Valley, Talkeetna Mountains, northeast of Anchorage, Alaska (Area 1).

Discussion.—A total of 18 specimens were studied. Twelve are from several localities in the Kaguyak Formation (Area 2), and six from LACMIP loc. 25107 in the Matanuska Formation (Area 1) approximately 900 km northeast of the Kaguyak Formation. Preservation is good, but the majority of the specimens from the Kaguyak Formation have been weathered.

According to Jones (1963), the Kaguyak Formation contains a fauna nearly identical with that of the upper part of member 3 of the Matanuska Formation and both can be assigned to the ammonite *Pachydiscus kamishakensis* Zone. Jones and Detterman (1966) assigned this zone to the early Maastrichtian.

The new species is most similar to *Glycymerita veatchii* but the new species differs by having steeper anterodorsal and posterodorsal margins of the valves, less sulcate posterodorsal slope, and coarser radial ribs. *Glycymerita aleuta* can have a very slight subquadrate shape that stands out from the more quadrate shape of *G. banosensis*, the only other known *Glycymerita* from the study area that spans the late Campanian to early Maastrichtian.

GLYCYMERITA MAJOR (Stanton, 1896) new combination
Figure 11, Table 1

Pectunculus veatchii var. *major* Stanton, 1896, p. 1040, pl. 64, figs. 2, 3.
Glycymeris veatchii Gabb var. *major* Stanton. Arnold, 1907a, pl. 39, fig. 4; Arnold, 1907b, pl. 26, fig. 4 [reprint of Arnold, 1907a, fig. 4].
Glycimeris veatchii var. *major* (Stanton). Dickerson, 1914a, p. 151, pl. 10, fig. 5.
Glycimeris veatchi, var. *major* (Stanton). Dickerson, 1914b, p. 295.
Glycimeris veatchii Gabb. Waring, 1917, p. 61, pl. 8, figs. 2, 7, 8.
Glycimeris veatchi major (Stanton). Waring, 1917, p. 75, pl. 10, figs. 3, 4.
Glycymeris major (Stanton). Clark, 1929, pl. 1, fig. 4 [reprint of Dickerson, 1914a, fig. 5]; Zinsmeister, 1983, p. 63, pl. 1, fig. 4.
Glycymeris veatchii major (Stanton). Smith, 1945, p. 42–43, fig. 5; Weaver, 1953, p. 28; Smith, 1975, p. 470.
Glycymeris (*Glycymerita*) *major* (Stanton). Moore, 1983, p. A54, pl. 11, figs. 9, 10.
?*Glycimeris maccrayi* Waring, 1917, p. 93, pl. 15, fig. 1.
Glycymeris (*Tucetona?*) *maccrayi* Waring. Moore, 1983, p. A57, pl. 12, fig. 12.
not *Glycymeris veatchii major* (Stanton). Smith, 1945, fig. 8 [=*Glycymeris* (*Glycymerita*) *banosensis*].

Diagnosis.—Shell size medium. Quadrate (most specimens) but can be subquadrate. Anterodorsal and posterodorsal slopes truncate. Valves moderately inflated. Angulation posterior of umbones weak. Ribs narrow with narrow interspaces.

Description.—Shell size medium, up to height 61.6 mm and length 65.3 mm (same specimen); commonly slightly higher than long, height/length ratio = 0.87–1.03. Quadrate (most