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Cover: Exterior view of the left valve of *Lyropecten terrysmithae* Powell, Millard and Garcia, n. sp. Holotype specimen no. CAS 5900. Scale bar=1 cm.

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A new *Lyropecten* (Pectinidae, Bivalvia, Mollusca) from the central California Miocene, USA

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A new pectinid, *Lyropecten terrysmithae* n. sp., has been recognized in middle to late Miocene rock units referred to as the Monterey Formation and Santa Margarita Sandstone in the southern Salinas Valley, central California. Previously, *L. terrysmithae* had been identified as a flat form belonging to either *L. estrellanus* or *L. catalinae*, then more recently to *Argopecten* sp. The earlier assignments were based on its moderate size and a radial rib count nearly identical to these taxa. However, its hinge, flat unledged valves, looped lamellar growth lines, and hinge crura set *L. terrysmithae* apart from *Argopecten* and all species of *Lyropecten*. Localities where it occurs in the Salinas Valley that can be accurately dated are from the late middle to middle late Miocene "Margaritan" California provincial molluscan stage. While *L. terrysmithae* has been collected at other sites, those localities lack diagnostic age-specific species necessary to determine an accurate geological age and maybe older.

Keywords: fossil pectinids, "Margaritan" CPMS, Monterey Formation, Santa Margarita Sandstone, Salinas Valley

INTRODUCTION

The new *Lyropecten* species proposed here was recognized by the senior author (CLP) during a review of invertebrate faunas in late middle to middle late Miocene "Margaritan" California provincial molluscan stage (CPMS) age deposits of the Salinas Valley, central California (Powell 2007). Smith (1991) had previously referred specimens of this type to *Argopecten* sp. but further study has shown they are most similar to *Lyropecten.* Therefore, we are pleased to name these specimens, *Lyropecten terrysmithae* n. sp., in honor of Dr. Judy Smith for her years of work on California and Baja California, Mexico invertebrate paleontology.

The genus *Lyropecten* has a well-documented history in California dating back to the late Oligocene (Smith 1991), with seven of the nine species known from the Miocene of California (Smith 1991). The California *Lyropecten* species reported by Smith (1991) include: *L. catalinae* (Arnold, 1906), *L. cerrosensis* (Gabb, 1866), *L. crassicardo* (Conrad, 1856), *L estrellanus* (Conrad, 1857a), *L. miguelensis* (Arnold, 1906), *L. miguelensis* supervariant form of Smith (1991), *L. pretiosus* (Hertlein, 1925), *L. terminus* (Arnold, 1906), and *L. tiburonensis* Smith (1991). These species have stratigraphic significance and several are considered index fossils because they are usually common where they occur and extend through a limited stratigraphic interval. *Lyropecten terrysmithae* is restricted to the southern Salinas Valley in rocks of the late middle to middle late Miocene "Margaritan"CPMS, and possibly into older middle Miocene rocks. Because of its limited geographic distribution in central California, *L. terrysmithae* would not make a good index fossil.

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MATERIALS AND METHODS

Over 50 specimens of *Lyropecten terrysmithae* were found during review of fossil collections at the California Academy of Sciences (including the Leland Stanford Junior University collection), the Natural History Museum of Los Angeles County, and the University of California Museum of Paleontology (including the United States Geological Survey Menlo Park collection) in conjunction with a survey of "Margaritan" CPMS age mollusks from the Salinas Valley. The specimens show varying degrees

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of preservation from complete adult articulated valves with intact auricles, to isolated left and right valves with or without their auricles, and the right valve of at least one juvenile.

Powell (2007) first recognized these specimens as similar to ones Smith (1991) had earlier attributed to the genus *Argopecten*. However, consultation with Thomas Waller (personal communication, 12/2019) indicated the specimens were best placed in the genus *Lyropecten* based on hinge morphology. Smith (1991) also reported specimens from three United States Geological Survey Cenozoic localities: USGS M1936, USGS M1940, and USGS M1968; however, none of these specimens could be located at UCMP. Additionally, we did not examine specimens reported by Smith (1991) from Cenozoic localities USGS 12922 and USGS 16833 that are housed at the Smithsonian. The geographic divisions of California (southern, middle , northern) follow Moore (1983, fig. 1).

Measurements

Eight specimens, including the seven types, were measured using calipers. This suite of specimens was selected from among the best preserved, and the largest and smallest in order to document the species' diagnostic characters and size range. Measurements are defined as follows: **height**=the greatest distance between the dorsal and ventral termini (edge); **length**=the greatest distance between the anterior and posterior termini; **convexity**=the greatest distance between the valve or valves, depending on the specimen. Descriptive morphology follows Waller (1986, 1991, 2007) and Smith (1991).

Institutional Abbreviations

Abbreviations used for institutional catalogs and (or) locality numbers are as follows: **CAS**, Invertebrate Zoology and Geology, California Academy of Sciences, San Francisco, California; **LACMIP**, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section, Los Angeles, California; **LSJU**, Leland Stanford Junior University (=Stanford University [**SU**], now housed at CAS), Stanford, California; **UCMP**, Museum of Paleontology, University of California, Berkeley, California; USGS, U.S. Geological Survey, Washington, D.C.; **USGS M**, United States Geological Survey, Menlo Park, California (now housed at UCMP).

SYSTEMATIC PALEONTOLOGY

BIVALVIA Linnaeus, 1758
OSTREOIDA Ferussac, 1822
PECTINIDAE Rafinesque, 1815

LYROPECTEN TERRYSMITHAE N. SP.

FIGS. 1–5

Pecten (Lyropecten) estrellanus Conrad. Arnold (1906), pl. XXI, f. 2, 2a, 2b. Not of Conrad (1857a, b). Hanna and Hertlein (1941):172, fig. 63-7. Not of Conrad (1857a, b).

Argopecten sp. Smith 1991:56, pl. 22, fig. 5, 6. Powell (2007), appendix 2.

Diagnosis—*Lyropecten terrysmithae* n. sp. differs from similar central California Neogene *Lyropecten* [*L. estrellanus* (Conrad, 1857a) and *L. catalinae* (Arnold, 1906)] in being equivalve and lacking ledges, having beaks that do not project dorsal above the hinge line, a proportionately shorter hinge line, and non-rectangular auricles. The interior of the shell shows well-defined ribs, which extend much further inward from the shell margin than those of similar-sized fossil California *Lyropecten*.

Holotype—CAS 5900 (articulate valves).

Paratypes—Specimen numbers: CAS 78554 (right valve), CAS 78555 (right valve), CAS 78556 (right valve), CAS 78557 (right valve), CAS 78558 (right valve), CAS 78563 (left valve).

Type localities—Holotype locality: CAS 28473. Paratype localities: CAS 78553 (spec. no. CAS 78554–78556), CAS 28473 (spec. nos. CAS 78557, 78558). See Appendix 1 for locality details.

Referred specimens and occurrences—The specimens in parentheses are bulk cataloged under the following locality numbers: CAS 28473 (19 articulate specimens; CAS 448 (four double valve specimens mostly missing their auricles); CAS 67089 (=LSJU 2607) (ten single valves); CAS 78553 (=R. Arnold field no. C1011) (seven valves); CAS 68632 (=LSJU locality 1081) (one articulate specimen, three small right valves as cf.); CAS 78561 (=LSJU specimen no. 30145) (one articulate specimen), CAS 74822 (=Schenck acquisition 146) (one articulate specimen, five small right valve, four small left valves, and three small indeterminate valves); CAS 74827 (=Schenck acquisition 1904) (one articulate specimen, one valve as cf.), CAS 74824 (=Schenck acquisition 1885) (one valve as cf. encased in sediment), CAS 68631 (=LSJU 1054, =SU1054a) (one juvenile right valve, one valve as cf.); USGS M1969 (this collection contains poorly preserved pectinids two of which are identified to this species and three more are identified provisionally [cf.]), USGS M3995 (three articulate specimens, and three single valves, one with a cast of the other valve, one partial single valve). See Appendix 1 for locality details.

Etymology—Named in honor of Dr. Judy Terry Smith for her contributions to our understanding of pectin biodiversity.

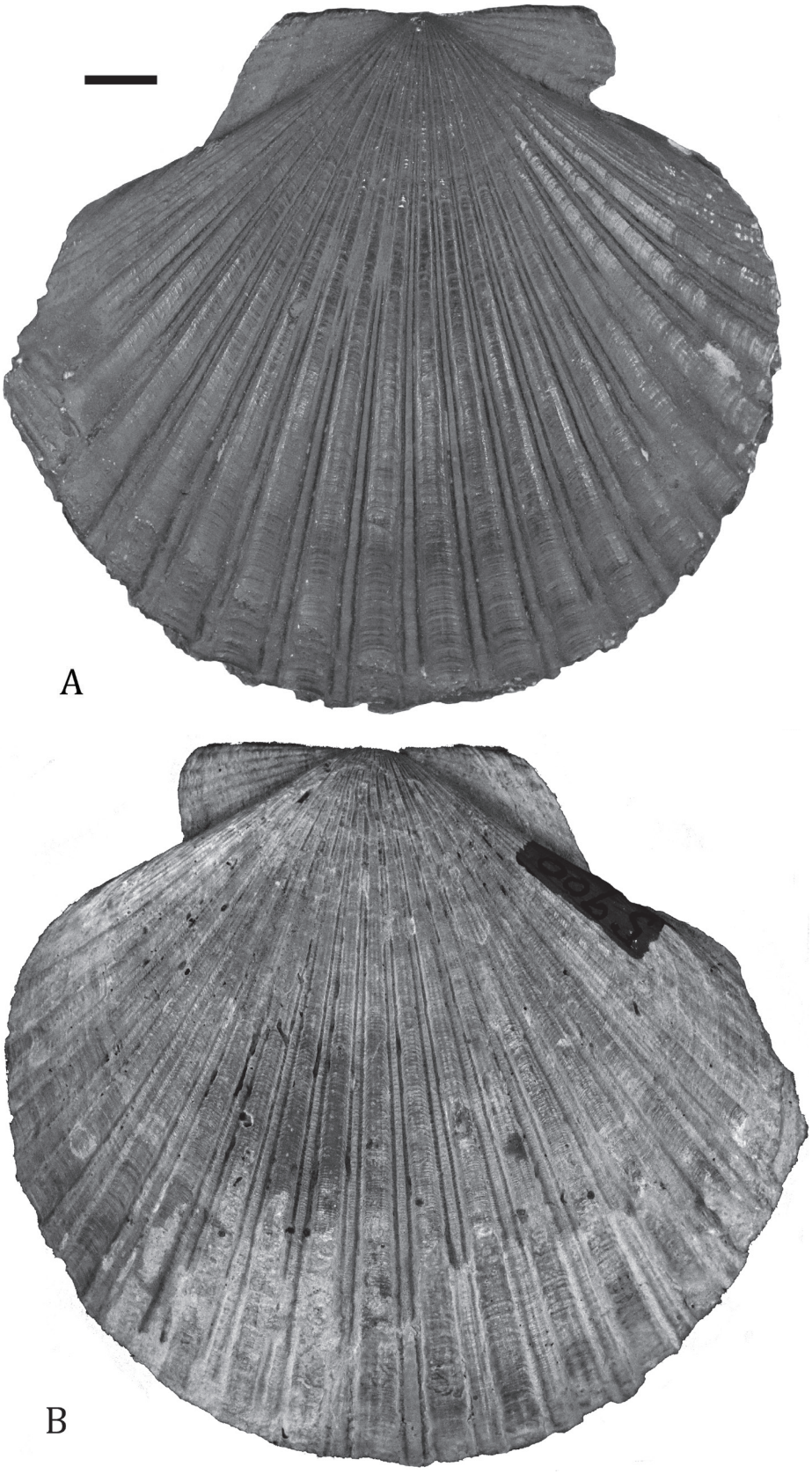

Figure 1. *Lyropecten terrysmithae* Powell, Millard and Garcia, n. sp., holotype CAS 5900. **A**. Interior right valve coated with black to better illustrate the shell features (see Sakamoto 1973). **B**. Left valve with no coating. Scale bar=1 cm.

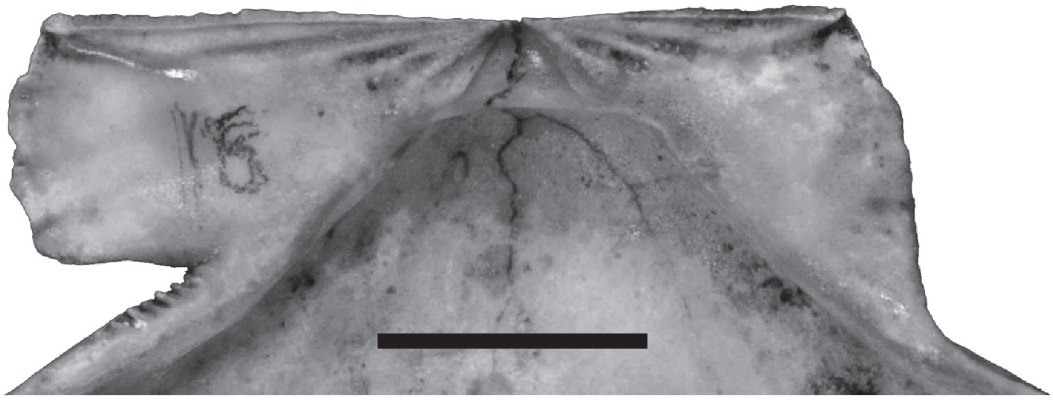

Figure 2. *Lyropecten terrysmithae* n. sp. Interior of right valve showing hinge, paratype CAS 78557. Scale bar=1 cm.

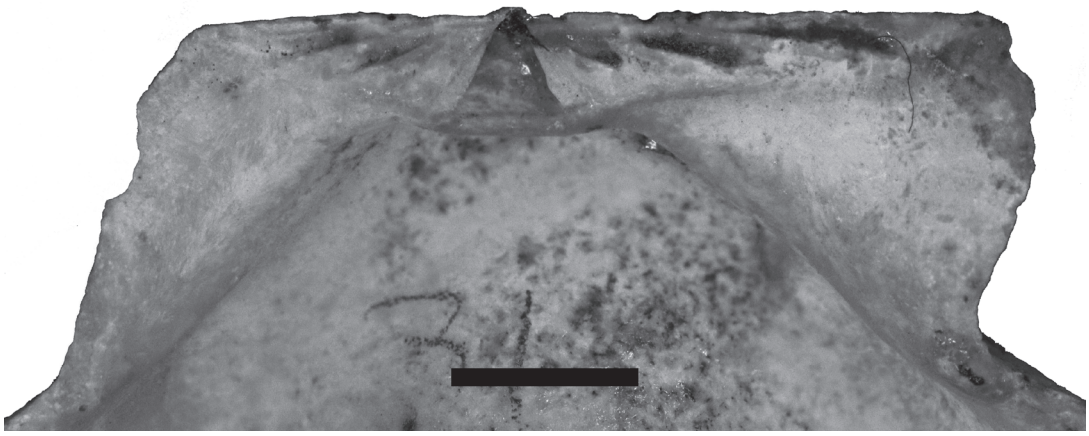

Figure 3. *Lyropecten terrysmithae* n. sp. Interior of left valve showing hinge (juvenile), paratype CAS 78563. Scale bar=1 cm.

Description—Specimens of *Lyropecten terrysmithae* in the CAS collections range in height from 42.0 to 92.5 mm, and 42.6 to 95.4 mm in length (Table 1). These specimens are medium-sized with relatively flat, unledged valves, of roughly uniform convexity (see Smith 1991, pl. 22, fig. 5), and are much flatter in profile than *L. estrellanus* (see Smith 1991, pl. 22, fig. 7). *Lyropecten terrysmithae* displays a length slightly greater than its height. Both valves exhibit between 16 to 20 radial ribs that are flat topped and visible on the interior of the valve from one-third to two-thirds the height of the shell. The umbos meet at the dorsal margin of the auricles with an umbonal angle between 113° to 115°.

The right valve (Fig. 1) has flat-topped, flat-sided, strong radial ribs showing only intermittent looped growth lamellae as sculpture (Fig. 1). The posterior disk flank has four to six radial riblets, while the anterior disk flank shows about half that number (Fig. 1). Rib interspaces are variable and generally about half as wide as the ribs, with a wide riblet down the middle of each interspace that is channeled on both sides (Fig. 1). The anterior auricle is vertically truncate with rounded upper and lower corners, with three to five radial costae that are narrow and rounded, a relatively shallow byssal notch, and small distinct ctenolium on well-preserved valves. The posterior auricle slants towards the posterior margin making the auricle wider at the base than at the top. The valve has a number of indistinct radial costae that

Table 1. Measurements of type specimens.

Specimen No.	Type Status	Height (mm)	Convexity (mm)
CAS 5900	Holotype	85	93
CAS 78554	Paratype	56	60
CAS 78555	Paratype	55	60
CAS 78556	Paratype	66	67
CAS 78557	Paratype	70	71
CAS 78558	Paratype	71	72
CAS 78563	Paratype	82	86

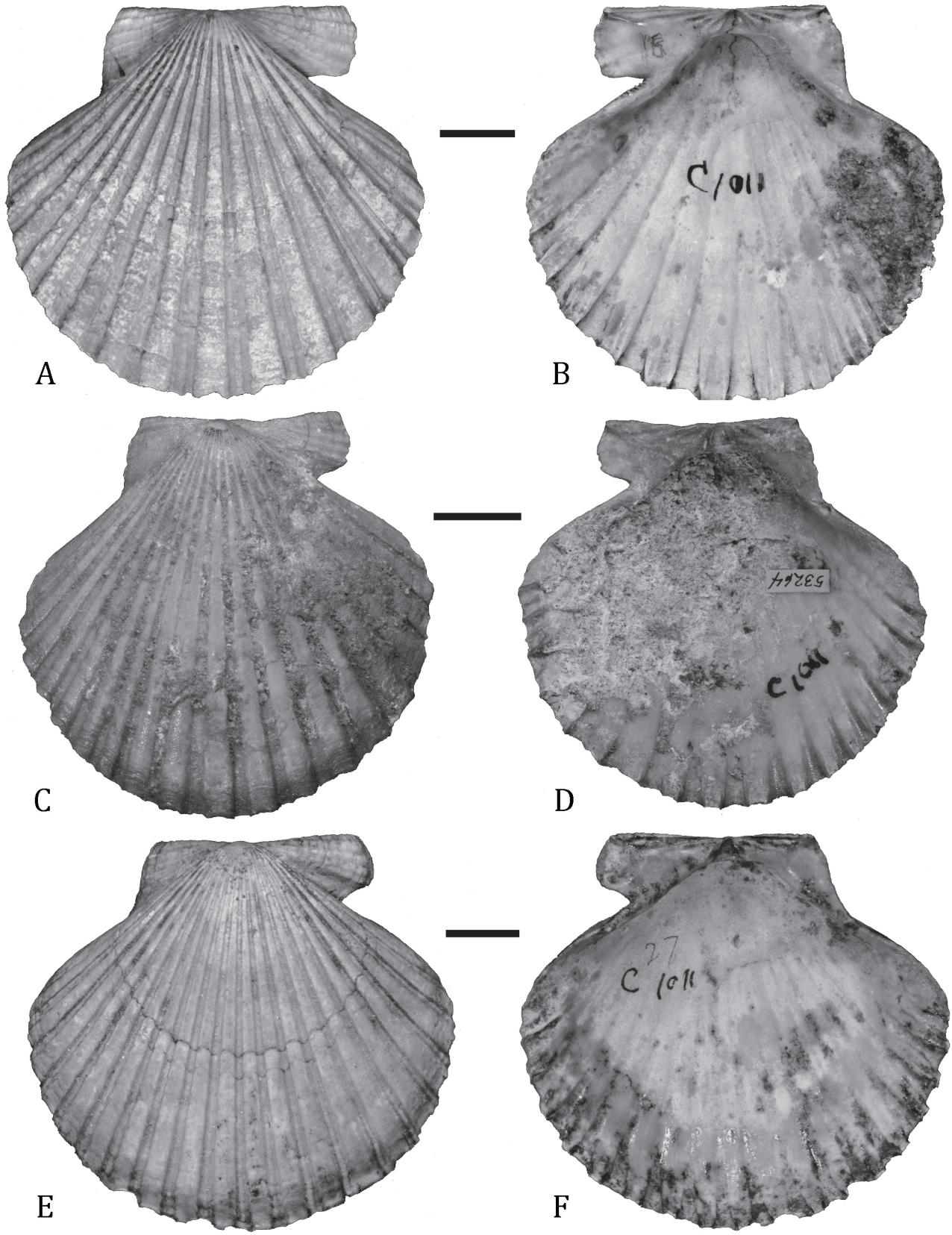

Figure 4A–F. *Lyropecten terrysmithae* n. sp., locality CAS 78553. Right valve of paratype CAS 78554 in exterior (**A**) and interior (**B**) views. Right valve of paratype CAS 78556 in exterior (**C**) and interior (**D**) views. Right valve of paratype CAS 78555 in exterior (**E**) and interior (**F**) view. Scale bar=1 cm.

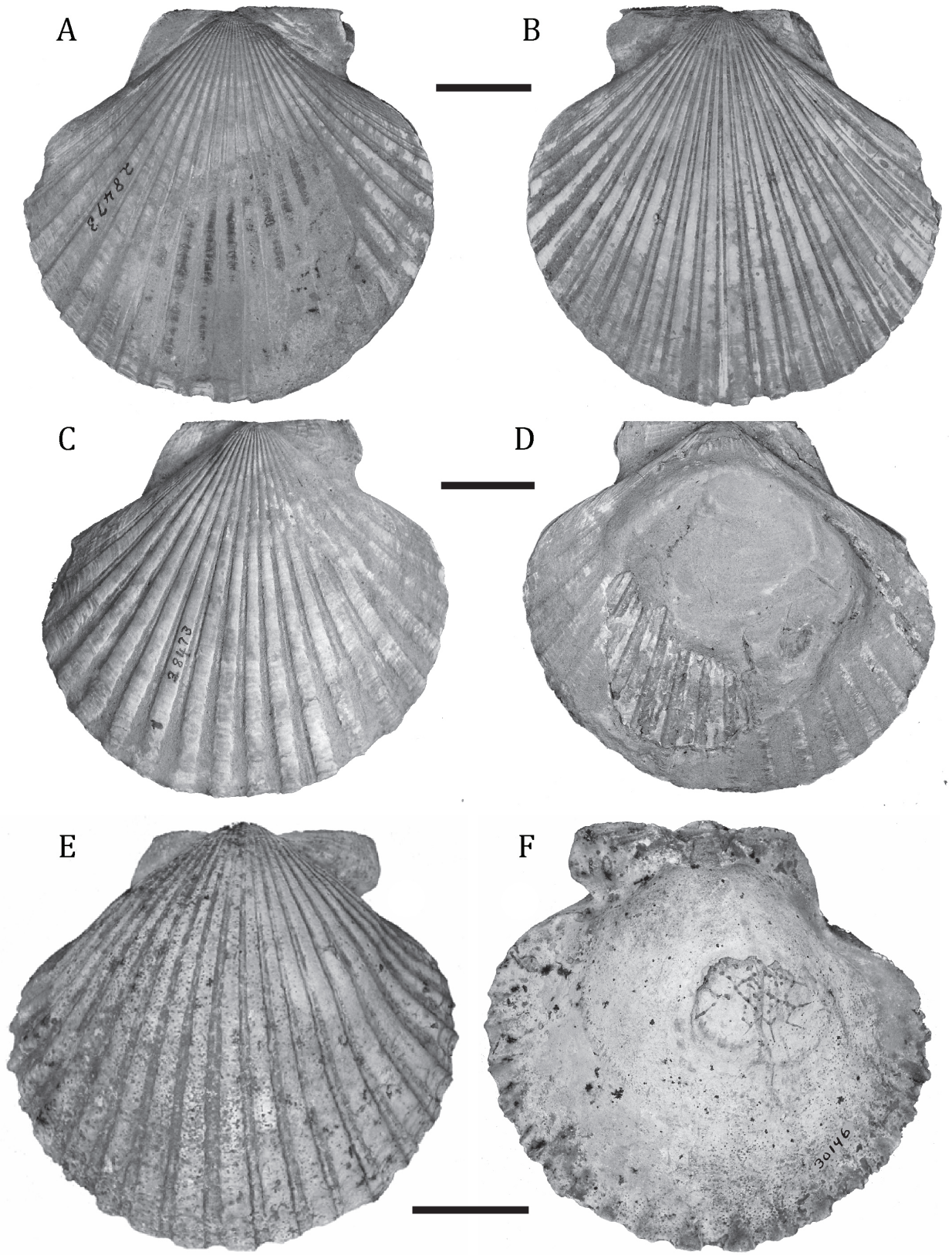

Figure 5A–F. *Lyropecten terrysmithae* n. sp. and *L. estrellanus* (Conrad, 1857a). Right (**A**) and left (**B**) exterior valves of *L. terrysmithae* paratype CAS 78557, locality CAS 28473. Right (**C**) and left (**D**) exterior valves of *L. terrysmithae* paratype CAS 78558, locality CAS 28473. Right valve of *L. estrellanus*, hypotype CAS 78560, locality CAS 78559, in exterior (**E**) and interior (**F**) views. Scale bar = 1 cm.

radiate away from a point near the umbo. The minimum hinge width when compared to the overall width of the shell is approximately 47%, with a maximum of about 55%. The top of both auricles slant slightly downward towards the umbonal region. The hinge of the right valve (Fig. 2) consists of a large resilifer, with two low, resilifer teeth adjacent, three dorsal teeth to the anterior of the broad resilifer, or and two to the posterior, expressed at different angles across the resilifer, and a large dorsal tooth on each side of the umbo, which is flat on top, with a very wide triangular base. Only a single immature left valve (Fig. 3) from locality CAS 78553 is well enough preserved for description. This hinge consists of a triangular resilifer, with faint resilifer teeth on each side, followed by two dorsal teeth on either side, and then by a very faint linear depression just below the top of the auricles. The interior of each valve exhibits impressions of the external ribs, which extend from the shell margin one-third to two-thirds the height of the shell.

Radial ribs on the left valves are also flat-topped, and they may have an equal number or one less rib than on the right valve. On well-preserved specimens the ribs have moderately strong, looped lamellar growth lines. Well-preserved specimens also exhibit an interstitial channeled riblet that also show the looped lamellar growth lines. The anterior auricle is ornamented with up to five narrow, rounded ribs radiating outward, while the posterior auricle has numerous fine, radial costa with three to five subdued ribs which radiate at different angles than the anterior auricle. The bending downward of the ribs on the anterior auricle on the holotype is probably the result of a repaired injury, as indicated by disturbed growth lines.

SPECIES COMPARISONS, STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION

Currently, there are nine *Lyropecten* species in the Paleogene–Neogene of California: *L. catalinae*, *L. cerrosensis*, *L. crassicardo*, *L estrellanus*, *L. miguelensis*, *L. miguelensis* supervariant form of Smith (1991), *L. pretiosus*, *L. terminus*, and *L. tiburonensis* (Smith 1991). Although first illustrated by Arnold (1906, pl. XXI, figs. 2, 2a, 2b), *L. terrysmithae* was not recognized as a species separate from *L. estrellanus* (Fig. 5E, F) until Smith (1991). Arnold (1906) regarded *L. terrysmithae* as a flat form of *L. estrellanus* grading into *L. catalinae.* In a discussion of *L. estrellanus,* Smith (1991, p. 56) noted the difference in the following statements: "Arnold's 'flat form grading into *catalinae'* is a flat, short-hinged scallop from the Vineyard Canyon-Indian Valley area … is a convergent *Argopecten* sp. related to but different from undescribed forms from eastern Baja California Sur.…" She distinguished it from *L. estrellanus* and *L. catalinae* "… in [having] hinge crura and a proportionally shorter length of the dorsal margin of the auricles that is not perfectly straight. Beaks meeting at the dorsal margin of the auricles, auricles are not rectangular, and valves are flat and unledged. Looped lamellar growth lines are distantly spaced." This description is interesting as neither *L. estrellanus* nor *L. catalinae* have auricles with straight dorsal margins, although they are straighter than in *L. terrysmithae*.

Lyropecten catalinae occurs in rocks of late middle Miocene age ("Margaritan" CPMS; Fig. 6) on Santa Catalina Island in the southern California Bight and in the eastern Ventura Basin, southern California (Smith 1991). *Lyropecten catalinae* appears most similar to *L. terrysmithae* but can be distinguished from *L. terrysmithae* in having comarginal rounded ledges on its valves and wider interspaces. Addicott in Durham (1968), reported *L. catalinae* from the Santa Margarita Sandstone in the Bradley (locality USGS M1936) and Tierra Redondo Mountain 7.5' (locality USGS M1940) quadrangles, Monterey County. In a review of "Margaritan" CPMS mollusks in the Salinas Valley, Powell (2007) examined Cenozoic specimens from USGS M1936 and assigned them to Smith's (1991) indeterminate *Argopecten* sp. here assigned to *L. terrysmithae.* Cenozoic specimens reported from USGS M1940 could not be located (Powell, 2007). Elimination of the *L. terrysmithae* specimens from *L. catalinae,* restricts the geographic occurrence of *L. catalinae* to southern California and Baja California, Mexico. Therefore, the geographic range of *L. terrysmithae* is now limited to the southern Salinas Valley, Monterey County in central California. Smith (1991), citing an oral communication and field maps of T.W. Dibblee, Jr., reported the stratigraphic occurrence of *L. terrysmithae* as restricted to a hard sandy facies of the Monterey Formation in the Cholame Hills, Monterey and San Luis Obispo Counties. Other occurrences reported here are in the Santa Margarita Sandstone. In several collections *L. terrysmithae* is found in association with *L. estrellanus*, which is restricted in age to the "Margaritan" CPMS. Unfortunately, several collections including *L. terrysmithae* cannot be attributed with confidence to a specific California provincial molluscan stage because index taxa are lacking, so the stratigraphic range of this species includes, but may not be restricted to the "Margaritan" CPMS.

Occurring from the Salinas Valley south to Baja California Sur, Mexico in late Miocene to late Pliocene rocks ("Etchegoin" to "San Joaquin" CPMS; Fig. 6) (Smith 1991),

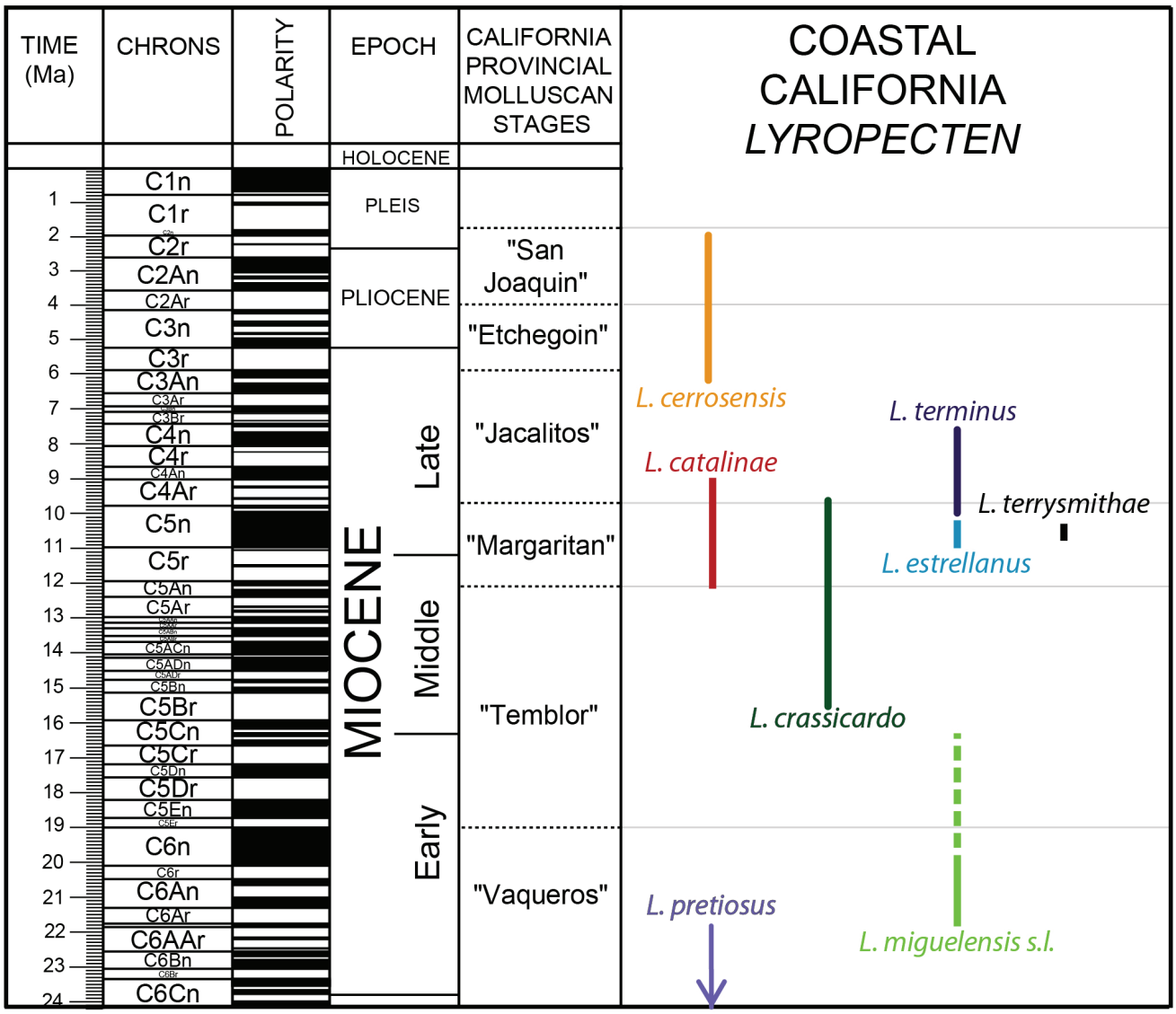

Figure 6. Time scale showing the stratigraphic ranges of coastal California *Lyropecten*. Age ranges are approximate as are California provincial molluscan stage boundaries (after Smith 1991). Solid green line above *Lyropecten miguelensis* marks the range of Smith (1991), while the dashed line is the inferred range for this species following evaluation of fossils attributed to the "Vaqueros" Formation on nearby Santa Rosa Island (Powell and Greiger 2019). Not shown is *L. tiburonensis* from the Salton Trough, south–central California.

L. crassicardo is easily distinguished from *L. terrysmithae* by its larger size, beaks that projects slightly beyond the dorsal margin of the auricles, and rounded radial ribs that commonly have radial striae. *Lyropecten estrellanus* in part co-occurs with *L. terrysmithae* in central California in middle late Miocene (upper "Margaritan" CPMS) age rocks. This "Margaritan" index fossil is distinguished by commonly having rounded comarginal ledges on more inflated valves, beaks that project beyond the dorsal margin of the auricles, and a wider shell at a similar size. Both *L. miguelensis* and *L. miguelensis* supervariant form of Smith (1991) are distinguished from our new species by having valves that are strongly inflated and with the right-valve beak extending beyond the left-valve beak and both extending beyond the dorsal margin of the auricles. Also the right valve has slightly fewer ribs and both valves have radial striae when well preserved. *Lyropecten miguelensis* is only reported from the early Miocene (upper "Vaqueros" CPMS) of San Miguel Island, Santa Barbara County in the southern California Bight (Smith 1991), however, we believe these rocks are likely middle Miocene in age ("Temblor" CPMS) as rocks referred to the "Vaqueros Formation" are on nearby Santa Cruz Island, Santa Barbara County were recently determined to be middle Miocene in age (Powell and Geiger 2019, Powell unpublished data). The supervariant form

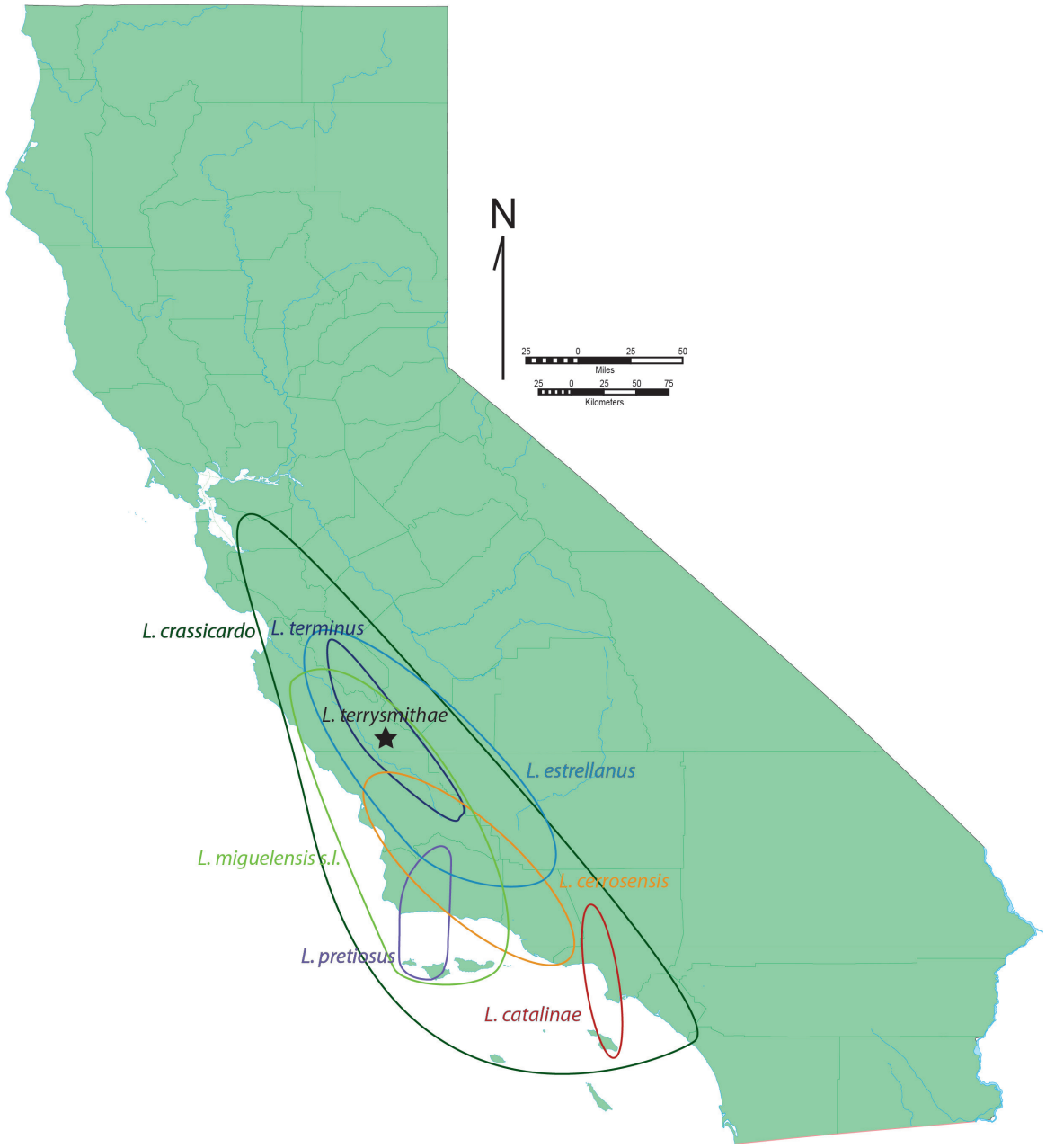

Figure 7. Generalized geographic range of coastal California *Lyropecten*. Ranges adapted from localities cited in Smith (1991). This does not include *L. tiburonensis* from the Salton Trough, south–central California.

of *L. miguelensis* is reported in rocks of early to middle Miocene age (upper "Vaqueros" to lower "Temblor" CPMS age) from the northern Channel Islands (San Miguel, Santa Cruz, and Santa Rosa islands), Cuyama Valley, and Santa Madre Range in Santa Barbara County, the La Panza Range, San Luis Obispo County, the Santa Lucia Mountains, Monterey County, and the Temblor Range, San Luis Obispo and Kern counties. Occurring in older rocks *L. pretiosus* is reported by Smith (1991) from late Oligocene(?) to early Miocene age rocks (upper lower to middle "Vaqueros" CPMS) from the northern Channel Islands, Santa Barbara County, south to Baja California Sur, Mexico, and possibly (poorly identifiable specimens) as far north as the La Panza Range, San Luis Obispo County, central California (Smith 1991). *L. pretiosus* tends to form slightly angular ledges in the left valve and has subdued rounded radial ribs, beaks that extend slightly above the dorsal margin of the auricles and has few radial ribs (14–15; Smith 1991) and fine striae on well preserved specimens all of which serve to distinguish it from our new species. The "Jacalitos" CPMS (late Miocene) index fossil *L. terminus* occurs from the southern Salinas

Valley to the Jacalitos Hills and canyons south of Coalinga in the western San Joaquin Valley. It is distinguished in having fewer ribs (right valve, 14–15; left valve, 13–14), beaks that project slightly, but equally above the dorsal margin of the auricles, juveniles with one riblet in interspaces and four or more costae in adults, while the left valve interspaces may contain four to five or more costae. It is similar to *L. terrysmithae* in having valves with rectangular ribs. Lastly, *L. tiburonensis,* occurs in rocks associated with the proto-Gulfo de California from the Salton Trough in south-central California south to Isla Tiburon, Sonora, Mexico, and on islands in the Gulfo de California; all these occurrences are late Miocene in age (Matti et al. 1985, McDougall et al. 1994, 1999, Rymer et al. 1994, 1995, Bennett et al. 2015), not late middle to late(?) Miocene as reported by Smith (1991). The late Miocene age is equivalent, at least in part to the "Jacalitos" CPMS in coastal California. It is easily distinguished from *L. terrysmithae* by its beaks, which project equally slightly above the dorsal margin of the auricles, radial ribs with costae and valves having significantly fewer ribs (right valve 11–12, left valve 9–10), which are rounded rectangular in shape with wider interspaces.

CONCLUDING REMARKS

Smith (1991) formerly referred specimens of *Lyropecten terrysmithae* to *Argopecten* sp. based on it having 1) hinge crura, 2) a short hinge line that is not perfectly straight, 3) beaks that meet at the hinge line, 4) auricles that are not rectangular, 5) valves that are flat and unledged, and 6) looped lamellar growth lines. However, all these features can be observed in various California *Lyropecten* species to some extent with the exception of beaks meeting at the hinge line.

Waller (1986, 1991) identified the hinge of the *Lyropecten/Nodipecten* clade as having a three-element hinge dentition with a resilial, intermediate and dorsal teeth, a condition not found in *Argopecten*. Smith (1991) apparently was not able to observe the hinge of this new species given Waller's (1986, 1991) early work on the subject since she lists the hinge of *Lyropecten* as having three pairs of hinge teeth in the right valve and two in the left valve, and the hinge of *Argopecten* as "...teeth weak to moderately strong," without giving the number of teeth (Smith 1991, table 2). If she had seen the hinge she would not have misassigned the genus.

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APPENDIX

Appendix 1. Locality numbers and descriptions are arranged by collection. They follow a standard format and the descriptions have been modified. Precise locality information can be obtained from the institution housing the collection

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California Academy of Sciences (Golden Gate Park, San Francisco, CA) (Includes Leland Stanford Junior University collections [Smith 1978])

CAS 448. Ranchito Canyon 7.5' Quadrangle, Monterey County, California. Branch of Vineyard Canyon. Collected by W. Kew. Santa Margarita Sandstone.

CAS 28473. Stockdale Mountain 7.5' Quadrangle, Monterey County, California. Cholame Hills, between Indian Valley and Portuguese Canyon. Collected by N.L. Taliaferro, 1935, field no.: 1-P.P. Santa Margarita Sandstone.

CAS 28474. Ranchito Canyon 7.5' Quadrangle, Monterey County, California. Middle fork of Vineyard Canyon. Collected by N.L. Taliaferro, May 17, 1935, field no.: 1-F. Santa Margarita Sandstone.CAS 67089 (=LSJU locality 2607). San Ardo 7.5' Quadrangle. Monterey County, California. Pancho Rico Creek, east of San Ardo, Salinas Valley. Collected by H. Ashauer and T. Baldwin, April, 1948. Pancho Rico Formation.

CAS 68631 (=LSJU 1054 and 1054a). Priest Valley 7.5' Quadrangle, Monterey County, California. Zone A, *Astrodapsis* zone. Collected by G.L. Richards and R.M. Kleinpell, March 4, 1932.

CAS 68632 (=LSJU 1081). San Lucas 7.5' Quadrangle, Monterey County, California. Coarse sandstone collected by G.L. Richards, Jr., 1931. Santa Margarita Sandstone. Note added to label by W.O. Addicott, date unknown, states "probably north side of Long Valley. Pancho Rico Formation," although it was not included in Durham and Addicott (1965). This collection contains *L. estrellanus* (Conrad), which is restricted to the "Margaritan" CPMS (Smith 1991), but it has been reported as reworked from the late Miocene to early Pliocene Pancho Rico Formation (Powell 2008). Formational assignment uncertain.

CAS 74822 (=H. G. Schenck acquisition 146). San Lucas 7.5' Quadrangle, Monterey County, California. Label reads: King City 15' Quadrangle, Monterey County, California. Up Long Valley. Collected by F.A. Menken Santa Margarita Sandstone or Jacalitos Formation.

CAS 74824 (=Schneck acquisition 1885). San Miguel Quadrangle, Monterey County, California. Collected by N.L. Taliaferro, June 11, 1935, field no. I-RR.

CAS 74827 (=Schenck acquisition no 1904). Stockdale Mountain 7.5' Quadrangle, Monterey County, California. Collected by N.L. Taliaferro, May 15, 1935, field no. I-C. Santa Margarita Sandstone.

CAS 78553. Salinas Valley, east of King City, Monterey County, California. Collected by R.B. Moran. Delos and Ralph Arnold locality catalogue locality C1011at CAS.

CAS 78559. Pancho Rico Canyon, Monterey County, California. Santa Margarita Sandstone.

CAS 78561. Vineyard Canyon, Salinas Valley, Monterey County, California. Santa Margarita Sandstone.

U.S. Geological Survey (USGS) Menlo Park, CA, Cenozoic register (collections housed at the Museum of Paleontology, University of California, Berkeley, CA)

USGS M1936. Tierra Redonda Mountain 7.5' Quadrangle, Monterey County, California from leached, limonitized fine sand. Santa Margarita Sandstone.

USGS M1940. Tierra Redonda Mountain 7.5' Quadrangle, Monterey County, California. Collected by W.O. Addicott and D.L. Durham, 1963. Santa Margarita Sandstone.

USGS M1968. Stockdale Mountain 7.5' Quadrangle, Monterey County, California. Southeast of Vineyard Canyon Road, about 3.7 m (12 ft) stratigraphically below USGS Cenozoic locality M1969. Collectors: W.O. Addicott and D.L. Durham, 1964. Santa Margarita Sandstone

USGS M1969. Stockdale Mountain 7.5' Quadrangle, Monterey County, California. Southeast of Vineyard Canyon Road, about 3.7 m (12 ft) stratigraphically above USGS Cenozoic locality M1968. Collectors: W.O. Addicott and D.L. Durham, 1964. Santa Margarita Sandstone.

USGS M3995. Stockdale Mountain 7.5' Quadrangle, Monterey County, California. Collected by D.L. Durham, 1968, field no. 684018.

U.S. Geological Survey and United States National Museum localities, Washington, D.C. register

USGS 12922. San Miguel 15' Quadrangle [Stockdale Mountain 7.5' Quadrangle], Monterey County, California. In creek bed near Vineyard Canyon. = USGS locality 16833.

USGS 16833. Stockdale Mountain 7.5' Quadrangle, Monterey County, California. Middle fork of Vineyard Canyon.

USNM 16833. San Miguel 15' Quadrangle, Monterey County, California. Middle fork of Vineyard Canyon. (= USGS locality 12922).