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Abstracts and papers from the 56th annual meeting of the Western Society of Malacologists

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Western Society of Malacologists

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	Hans Bertsch
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4:15 PM	INVERTEBRATE EPONYMS HONORING WOMEN MEMBERS OF THE WESTERN SOCIETY OF MALACOLOGISTS
	Hans Bertsch, Lindsey T. Groves, Robert Dees

Oral Presentations

Alphabetical by First Author

Presenting author in **bold**
Student presentations marked by an asterisk *

CAVITURRITELLA (FRIEND & ANDERSON, 2023) - A NEW GENUS OF TURRITELLIDAE DEFINED IN PART BY THE ABSENCE OF A COLUMELLA (HOLLOW NEWEL STATE)

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In examining Plio-Pleistocene turritellids from the Atlantic coastal plain we recently discovered a previously undescribed character state where the inner shell wall appears to have not been formed. This state along with a C1B2A3 apical ontogeny pattern for spiral sculpture appears to characterize a clade of turritellids now extirpated from Florida and the Atlantic coastal plain, but including several common eastern Pacific species. We designate *Turritella gonostoma* Valenciennes, 1832 as the type species for this genus and refer the eastern Pacific species *Turritella banksii* Gray in Reeve, 1849, *Turritella broderipiana* d'Orbigny, 1840, *Turritella abrupta*† Spieker, 1922 along with several western Atlantic fossil species to this genus. It is likely that numerous additional fossil and extant eastern Pacific turritellids should be referred to this genus.

We designate this newly described character state as hollow newel morphology, based on an analogy to spiral staircases where the absence of a central supporting post is termed hollow (or open) newel construction. The hollow newel state also occurs in other gastropod taxa, though it appears to be rare among those with high spires. We also distinguish this state from other axis forms including a columella, an umbilicus, a hollow columella, and a partially resorbed columella.

INVERTEBRATE EPONYMS HONORING WOMEN MEMBERS OF THE WESTERN SOCIETY OF MALACOLOGISTS

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Although honoring folks with eponyms has long been a scientific tradition, this history has reflected a societal patriarchal bias in gender representation (Dees, 2023; Vendetti, 2022). In this presentation we look specifically at a group of women who, despite traditional disparities, have been so honored.

A total of 247 species and subspecies (14 synonyms) have been named in honor of 37 women members of the WSM, representing 138 Recent and 109 fossil taxa. There are 171 (69.2%) gastropod eponyms, 49 bivalves (19.8%), and 27 (10.9%) "other" taxa, (e.g., hexactinellid sponge, fossil scleractinian, polyclad flatworm, amphipods, copepods, brachyuran crab, carabid beetle, polyplacophorans, and scaphopods). Fifteen genera have been named for 7 women, and 151 (61.1%) of the species-level taxa were named in honor of five women: Carole Skoglund (14), LouElla Saul (15), Katherine Van Winkle Palmer (38), A. Myra Keen (40), and Emily Vokes (45).

We present a brief biography and portrait of each woman, and descriptions and illustrations of all the eponyms.

"The WSM has been an empowering force for inclusion, not only of women but also other under-represented groups, by practicing malacology without borders" (Hickman, 2022).

References

Dees, Robert. 2023. Who Are They? Notes on Commemorative Molluscan Genera and Species Names, Alaska to Baja California. https://www.thesandiegoshellclub.com/reference-resources.html

Hickman, Carole. 2022. Anomalies in the field: women chasing their molluscan dreams. Annual Report, Western Society of Malacologists 51: 41.

Vendetti, Jann. 2022. Gender Representation in Molluscan Eponyms: Disparities and Legacy. American Malacological Bulletin 39(1): 1-13.

Malacologists in the field

Carole Hickman

WSM's FIRST FIELD TRIP TO MEXICO.

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After the 2001 WSM meeting in San Diego, Drs. Miguel Téllez-Duarte (Ciencias Marinas, Universidad Autónoma de Baja California) and Hans Bertsch led a field trip to coastal sites in northwestern Baja California. Participants viewed Pleistocene, Pliocene, Miocene, and Cretaceous sties, including the former sea terraces in the Tijuana area, the ammonite mold at CETMAR in El Sauzal, and the *Coralliochama* rudist bivalve beds at Punta Banda. We also observed numerous shell midden mounds that had been left behind by the indigenous peoples over more than 7,000 years of occupation.

We concluded the excursion with a marvelous sea food dinner at the Haliotis Restaurant in Ensenada.

References

Téllez-Duarte, Miguel & Hans Bertsch. 2003. Field trip: paleontology in northwestern Baja California. Western Society of Malacologists, Annual Report 34: 53-66 (bilingual).

Bertsch, Hans. 2021. The "Cactus Man" and his clams: Charles Russell Orcutt, *Coralliochama orcutti* and *Chlamydoconcha orcutti*.

WSM members at La Joya, Baja California, Mexico

USING COMMUNITY SCIENCE OBSERVATIONS TO GENERATE ROBUST SPECIES ACCOUNTS OF TERRESTRIAL GASTROPODS

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Terrestrial gastropods are important for many ecological processes, including nutrient cycling. However, very little is known about the natural history and life history of many members of this group. One such species is the Pacific Sideband (*Monadenia fidelis*), the largest land snail in, and endemic to, the Pacific Northwest; a literature review for this species returned little information on their life history and natural history. We curated observations of *Monadenia fidelis* identified by expert malacologists on the community science platform iNaturalist, a network which allows individuals to share and identify biological occurrences. Then we annotated these observations to quantify their natural history and life history characteristics. Here we report on life history and natural history categories including the snail's life stage (adult or juvenile), number of whorls in juveniles, and food items. For the first time, we identify *Monadenia fidelis* as an important consumer of lichens. This study demonstrates that the community science platform iNaturalist can assist in developing a better ecological understanding of various species.

AN UNEXPECTED *CREPIDULA* FOUND ON CALIFORNIA'S CENTRAL COAST SNAILS

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The slipper snail, *Crepidula adunca* Sowerby, 1825 is especially common on ubiquitous intertidal black turban snails, *Tegula funebralis* (A. Adams, 1855), along the Central Coast of California. It has also been assumed that slipper snails occasionally found on other trochoidean snails, none of which are typically as high in the intertidal as *T. funebralis*, were also *C. adunca*. Our recent study has introduced a different possibility. Castelin and co-authors (2022; *Biol. Bull*. 242: 222-234), including my former undergraduate student, Erica Spence, discovered that a closely related slipper snail, *Crepidula norrisiarum* (Williamson, 1905), extends farther north, unlike its typical (southern only) host in southern California, *Norrisia norrisii* (Sowerby, 1838). Surprisingly, *C. norrisiarum* is also common in Washington and British Columbia, where its most common host is *Calliostoma ligatum* (Gould, 1849). In fact, a number of studies have been performed at Friday Harbor Labs in the San Juan Islands on *C.* "*adunca*" but we documented that instead only *C. norrisiarum* is found there, whereas *C. adunca* is restricted to the outer coast like its most common host snail there (as in California), *T. funebralis*. In central California, I have been finding that *C. norrisiarum* outnumbers *C. adunca* in the low intertidal and deeper on brown teguline snails, *T. brunnea* (Philippi, 1849), *C. ligatum*, etc. Using shell and DNA features to distinguish the two slipper limpet species, I am studying how often *C. adunca* is found on subtidal snails and investigating the interesting latitudinal transition in host species for *C. norrisiarum* within California.

REFLECTIONS ON WSM AND THE REUNITING OF THE CALIFORNIAS

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There have been four in-person (2004, 2007, 2011, 2016) and one virtual (2021) meetings of the Western Society of Malacologists (WSM) in La Paz or Ensenada on the Baja California Peninsula of Mexico and these have been tremendous opportunities for international exchange and collaboration, not to mention highly enjoyable gatherings. They have also led to greater participation of Mexican malacologists and students at WSM meetings held in California, and the first few were an important impetus leading to the WSM joining three other societies in Mexico City for Mollusca 2014: The Meeting of the Americas. I have participated in all of these meetings, usually attending with my students, and these have greatly enriched our collaborative molluscan research. They have helped extend the comparisons we have made to both coasts of the Baja California Peninsula and we have benefited in many ways from all of our interactions with Mexican molluscan researchers and students. Here, I would like to personally thank Dr. Hans Bertsch for his role in promoting this international expansion of the WSM and, by giving examples of the highlights of these six WSM meetings held in Mexico, I hope to promote further similar cross-border gatherings in the future. This has always involved logistical hurdles but the rewards have been many. It is important for both long-time and newer WSM members to be proactive in finding ways to encourage collaboration and travel opportunities in both directions. My images are selected from a past-conference archive at the former WSM website: http://biology.fullerton.edu/wsm/conferences.html

TWO NEW SPECIES OF LATE CRETACEOUS CYPRAEOIDEANS (MOLLUSCA: GASTROPODA) FROM OREGON AND BRITISH COLUMBIA

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Two new species of Late Cretaceous cypraeoideans are described. *Protocypraea* n.sp. is from the uppermost Santonian strata of the upper Haslam Formation, near Brannen Lake, Nanaimo District, Vancouver Island, British Columbia and *Eocypraea*? n.sp. is from the Cenomanian, Osburger Gulch Sandstone Member of the Hornbrook Formation, Bellinger Hill, Jackson County, southwestern Oregon.

Twenty species of Cretaceous Cypraeidae and Eocypraeidae have been described from North American strata: eighteen are cypraeids and two are eocypraeids. Thirteen species are from the northeast Pacific, two are from the East Coast, four are from the Gulf Coast, and one is from the Western Interior Seaway.

****EXTENDED CONTENT****

FIRST PACIFIC COAST FOSSIL RECORDS OF OCTOPOD CEPHALOPOD BORINGS (*Oichnus* ispp.) IN GASTROPOD SHELLS

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Abstract: Drill holes made by predatory octopodoid cephalopods (Mollusca: Octopodoidea) are rare in the fossil record and have only been documented a few times in Europe (Italy, Greece, and UK), Asia (Japan), and the United States. In the US, they are known from the Pliocene and Pleistocene of Florida and the Upper Cretaceous of South Dakota, but had not previously been reported in the fossil record of the Pacific Coast region of western North America. Tiny (mm to sub-mm) drill holes attributable to octopod cephalopods are, however, common to abundant in some molluscan prey species found in upper Pleistocene marine terrace deposits along the southern California coast. Mainly molluscan fossil assemblages from 12 localities on the ~ 80,000-year-old Bird Rock Terrace in coastal San Diego County have yielded 5,160 specimens of the purple olivella shell, *Callianax biplicata* (Sowerby 1825), of which 749 (14.5%) had been drilled by octopods. However, in any one collection, the percentage of drilled *Callianax* specimens ranged between 2.4 percent and 26.4 percent. This suggests that a careful reexamination of existing museum fossil collections should reveal a previously overlooked, but rich fossil record of octopod predation in the marginal eastern Pacific in the recent geologic past.

The presence of a variety of borings as trace fossils in fossil shell assemblages, particularly from southern California Pleistocene marine terrace deposits, is well documented by existing museum collections. Borings include those created by various algas, clionaid sponges, spionid polychaete worms, acrothoracican barnacles, as well as bivalve and gastropod mollusks. Borings (drill holes) made by octopod cephalopods (Mollusca: Octopodoidea) in bivalve and gastropod mollusks, decapod crustaceans, and barnacles are known in fossil assemblages in Europe (Italy, Greece, UK), Asia (Japan), and North America (Robba & Ostinelli, 1975; Bromley, 1993; Todd & Harper, 2011; Klompmaker et al., 2013). In North America they are known from the western Atlantic coastal region (Pliocene and Pleistocene of Florida; Harper, 2002; Klompmaker & Kittle, 2021; Klompmaker et al., 2015) and from the U.S. midcontinent (Upper Cretaceous of South Dakota; Klompmaker & Landman, 2021), but have been overlooked in the Pacific Coast fossil record probably due to their rarity and their tiny size in comparison to the more common borings made by other organisms. In the Pacific Coast Cenozoic record, the most common molluscan borings can be attributed to muricid and particularly naticid gastropods, the much larger boreholes of which have been given their own trace fossil names (the ichnotaxa *Oichnus simplex* Bromley 1981 and *O. paraboloides* Bromley 1981, respectively). The distinctive subcircular to oval trace fossil drill holes attributed to octopods have been assigned the ichnofossil name *O. ovalis* by Bromley (1993), although *O. simplex* has also been used for some examples. Unlike in biological nomenclature, these names only refer to the borehole morphotype and not to the organisms responsible for creating them (Bromley, 1981, 1993).

The predatory drilling behavior of octopods is widely known among marine biologists, but not all paleontologists seem to be aware of this phenomenon. At least some of the eastern Pacific octopod cephalopods, such as *Octopus bimaculatus* Verrill 1883, *O. bimaculoides* Pickford & McConnaughey

1949, *O. rubescens* Berry 1953, and the Giant Pacific Octopus, *Enteroctopus dofleini* (Wülker 1910), are known to drill small holes in prey mollusks (Pilson & Taylor, 1961; Hochberg & Fields, 1980; Ambrose et al., 1988; Anderson et al., 2008; Tuskes, 2021), as well as in other shelled invertebrates (mainly decapod crustaceans; Dodge & Scheel, 1999; Klompmaker et al., 2013). According to Runham et al. (1997) octopod drill holes are created by rasping action of the radula and by decalcifying secretions from the salivary glands aided by the actions of the salivary papilla (Nixon, 1979, 1980), but "the relative importance of these two mechanisms remains uncertain" (Runham et al., 1997). The circumstances need further investigation.

Octopod drill holes, although tiny, are considerably variable in both size and shape, as has been demonstrated by Arnold & Arnold (1969, fig. 2), who made casts of the drill holes made by a single individual octopus over a several-day period. As such, the holes can best be described as being somewhat circular, to conical or funnel-shaped, with a wider surface opening tapering down to a smaller, often tiny, ventral hole that allows access into the body cavity of the prey organism and through which a muscle-paralyzing toxin is introduced. Functionally, an octopod drill hole should be considered complete when the inner shell wall of the prey species is perforated, there not being any need to further expand the opening, as it is with gastropods that need access for the odontophore and radular ribbon before it can begin feeding. Smaller-diameter holes tend towards being rounded or subrounded with steeper tapering sidewalls, often with the ventral perforation being much smaller than the remainder of the drill hole (e.g., Figure 3). Larger diameter holes (>1 mm in long dimension) are typically more oval or elongated with sloping sidewalls (e.g., Figure 2), giving the hole a scooped-out appearance. Small holes are typically less perfect in circular outline than either muricid or much larger naticid holes and may have remnant indentations, or notches, around their perimeter. The mechanical rasping aspect of octopod drilling begins with creating overlapping straight-line grooves with different radial orientations due to manipulation (rotation) of the shell during the early rasping process (Wodinsky, 1969). These early rasping marks are more apparent when the prey shell has a smooth or polished surface, such as in cowries (e.g., Oleinik, 2023, fig. 10) and in some other smooth-shelled gastropod prey (e.g., the purple olivella shell, *Callianax biplicata* (Sowerby 1825)), rather than on a rough surface such as found in pectinid bivalves that are known to have been drilled by octopods. However, the early irregular holes (e.g., Arnold & Arnold, 1969, fig. 2G; Oleinik, 2023, fig. 10), which often have very ragged edges, cannot in any way be considered 'round' holes and thus may not fit nicely within the current definitions of existing *Oichnus* ichnotaxa, even though the source of the drill hole has been established (biologically) as octopodal.

Octopod borings (drill holes) had not previously been recognized in the Pacific Coast fossil record, the first report of which being from upper Pleistocene (late last interglacial; $\delta^{18}O$ substage 5a [MIS 5.1]) basal marine terrace sediments overlying the abrasion platform of the ~ 80,000-year- old Bird Rock Terrace in Pacific Beach, San Diego, San Diego County, California (Kennedy, 2023, and expanded upon herein). The single original example (SDSNH 144223, Figure 1) is an incomplete shell of the extralimital northern trochid gastropod *Tegula brunnea* (Philippi 1849) with a well preserved, oval drill hole (*Oichnus ovalis*) approximately 1.2 mm in long dimension and 0.85 mm in width located on the side of the body whorl (Figure 2). The specimen was recovered from a basal marine shell bed exposed in a sewer line trench in the 4900 block of Ocean Boulevard south of San Diego City sewer pump station 18 in coastal Pacific Beach (City of San Diego Sewer & Water Replacement Group project 814; SDSNH loc. 7134).

Although Pacific Coast fossil examples were previously unknown, several biological accounts (e.g., Pilson & Taylor, 1961; Ambrose, 1983, 1984; Tuskes, 2021) have shown that, in fact, shells with octopod drill holes are more common in marine shell beds (i.e., octopod middens or their debris fields) than might otherwise have been suggested by their paucity in the local fossil record. On this basis, a follow-up investigation was conducted with further examinations of Bird Rock Terrace fossil assemblages from coastal San Diego County, from San Onofre bluff in Camp Pendleton, to Solana Beach, La Jolla, Pacific Beach, and Ocean Beach, as well as from the older, ~ 120,000-year-old, $\delta^{18}O$

substage 5e, Nestor Terrace at San Clemente State Beach, in La Jolla, and at Border Field State Beach. Several of these assemblages were quite diverse, and seven yielded between 100 and 200 species. However, with one notable exception, the numbers of specimens per taxon were typically relatively small and only the purple olivella shell, *Callianax biplicata* (Sowerby), was regularly common to superabundant in all of the collections (Table 1). Interestingly, Tuskes (2021) had previously documented two *Octopus bimaculoides* den sites in Mission Bay in San Diego that yielded large numbers of *C. biplicata*, of which 91 percent of the 150 recovered specimens had been drilled by octopods.

Table 1 lists the numbers of *Callianax biplicata* shells from six Bird Rock Terrace locations (12 locality collections) archived in the San Diego Natural History Museum (SDSNH), and the numbers and percentages of drilled *C. biplicata* shells at each locality. In addition to borings in *C. biplicata*, octopod drill holes were also noted in the gastropods *Norrisia norrisi* (Sowerby 1838) and *Tegula montereyi* (Kiener 1850), and possibly in *T. funebralis* (Adams 1855) and *Megastraea undosa* (Wood 1828), but are not further discussed herein. Drilled examples of three of these species were also reported by Tuskes (2021) from octopod midden debris fields in Mission Bay.

The numbers of drilled *Callianax biplicata* specimens (Table 1) are striking, especially considering the lack of any previously recognized fossils from the entire North American Pacific Coast region, or even from southern California Pleistocene marine terrace deposits. Clearly a further examination of these collections is warranted. The 12 locality collections from Bird Rock Terrace exposures yielded 5,160 specimens of *C. biplicata*, of which 749 (14.5 percent) exhibited tiny drill holes that are attributed to octopods, including beginning failed attempts and incomplete (unfinished) holes. This is by far the largest collection of octopod drilled shells known in the fossil record. In any one collection, the percentage of drilled *Callianax* specimens ranged between 2.4 percent and 26.4 percent. At one prolific locality in Ocean Beach (SDSNH loc. 6352), 1,407 *C. biplicata* were recovered, with 296 being drilled by octopods (21 percent), and an additional 509 specimens (36 percent) being bored primarily by naticid gastropods. Seventeen specimens had been drilled by both octopods and gastropods, which probably can be attributed to the use of empty olivella shells by hermit crabs, which are also known to be consumed by octopods (Wodinsky, 1969). Ambrose (1983) noted that empty shells in front of some octopod dens are removed by scavenging hermit crabs. Apparently octopods do not drill into empty shells, there not being any obstruction within the body cavity to trigger a drilling response (Wodinsky, 1969).

The positions of the tiny drill holes in *Callianax biplicata* shells that are here attributed to octopod drilling activities show strong site selectivity, and are primarily (consistently) located on the apertural side of the shell near the whorl suture and in the penultimate whorls of the adjacent apical spire (Figures 3-5). Shells with this drill site typically only possess a single drill hole, whereas those few shells without any drill holes on or near the spire, but present elsewhere on the body whorl, sometimes have multiple holes on the apertural side of the body whorl. Octopods are often known to drill more than one hole in a prey organism (Wodinsky, 1969), and of the 296 drilled *Callianax* shells from SDSNH loc. 6352, 21 had two drill holes, sometimes close together, six shells had three holes, and three shells had four or more holes. Typically, one hole (presumably the first?) is distinctly larger than the remaining ones, which may be incomplete.

Size of the holes: Compared to the size of the drill hole in *Tegula brunnea* shown in Figure 2, which measures about 1.2 mm in long dimension, most of the *Callianax* drill holes are tiny, mostly ranging between about 0.15 mm and 0.85 mm in outer diameter. However, in Mission Bay, the drill holes made by the small *Octopus bimaculoides* range between 1.05 mm and 1.5 mm in outer diameter in the gastropod *T. eiseni* Jordan 1936 (with a shell thickness of 0.7 mm to 1.4 mm), and up to 3.5 mm in outer diameter in the large *Megastraea undosa* (with a shell thickness of 3.5 mm) (Tuskes, 2021, p. 91). However, regardless of the shell thickness, the final diameter of the inner opening exposing the prey organism was approximately 0.3 mm in diameter, about the same as had been noted by Pilson & Taylor

(1961) for holes drilled by *O. bimaculoides* or *O. bimaculatus* in a laboratory setting. Octopod holes drilled in the larger (thicker shelled) venerid bivalve *Saxidomus giganteus* (Deshayes 1839) by the large *Enteroctopus dofleini* ranged between 1.04 mm and 1.58 mm in exterior diameter with a mean of 1.27 mm and a standard deviation of 0.33 mm; interior diameters ranged between 0.38 mm and 0.82 mm (Ambrose et al., 1988, table 1). The typical size of the tiny drill holes measured in this study, based on a random sample of multiple *C. biplicata* shells, ranged between 0.15 mm and 1.3 mm; the size of the inner openings ranged between 0.15 mm and 0.7 mm in a smaller subsample. However, the drill hole profiles varied considerably, and the exterior and interior hole dimensions were not necessarily proportional, nor were the openings always in alignment vertically, further supporting the range of drill hole variability demonstrated by Arnold & Arnold (1969, fig. 2).

Summary: Despite the overall paucity of evidence (tiny drill holes) of octopod cephalopod predation in the fossil record, as well as the complete absence of any previous reports of such paleoactivity along the eastern Pacific margin of North America, tiny drill holes (the ichnotaxa *Oichnus ovalis* and *O.* ispp.) attributable to octopod (Octopodoidea) predation can be relatively common to abundant in certain molluscan prey species in Pleistocene marine terrace deposits along the southern California coast. In coastal San Diego County, for example, 5,160 specimens of the olivellid gastropod *Callianax biplicata* (Sowerby) recovered from 12 fossil localities on the ~ 80,000-year-old Bird Rock Terrace yielded 749 specimens (14.5 percent) with octopod drill holes. This is by far the largest accumulation of octopod drill holes known in the fossil record. In any one collection, the percentage of drilled *Callianax* specimens ranged between 2.4 percent and 26.4 percent. This suggests that a careful reexamination of existing museum fossil collections should reveal a rich, but previously overlooked, fossil record of octopod predation in the marginal eastern Pacific in the recent geologic past.

Acknowledgements: I thank fellow geologist Todd A. Wirths for unknowingly collecting the original specimen (Figure 1), Charlotte Seid (Scripps Institution of Oceanography) for checking the SIO invertebrate collections for drilled specimens possibly deposited there by Pilson & Taylor (1961) (none found), Paul M. Tuskes for providing modern examples of drilled *Callianax* specimens and for discussions on living octopods and their habits, Bo P. Schultz in Denmark for providing the Olympus TG-6 digital camera (with built-in stacked imaging), Kesler Randall and Thomas Deméré at the SDNHM for collection assistance and the loan of specimens, Gene Kennedy for PhotoShop assistance, and Richard F. Ambrose (UCLA) and Adiël A. Klompmaker (University of Alabama) for assistance and providing copies of their own studies on modern and fossil octopod predation. Review comments contributed by Adiël Klompmaker helped tighten the final manuscript and are greatly appreciated.

TABLE 1. List of late Pleistocene *Callianax biplicata* (Sowerby) specimens from 12 collection sites on the ~ 80,000-year-old Bird Rock Terrace along coastal San Diego County, California, including numbers and percentages of shells drilled by octopod cephalopods (Octopodoidea).

Location	SDSNH locality	# of taxa [1] [sp. lots]	# of *Callianax biplicata*	# of drilled *Callianax* [2]	percentage drilled
San Onofre bluff, Camp Pendleton [3]					
	4298	78	381	27	7.1
	6654	60+	90	12	13.3
Solana Beach south [4]					
	2966	83	206	5	2.4
Pacific Beach, Loring St. [5]					
	5479	111	332	75	22.6
	5480	118	450	28	6.2
	5481	106	174	14	8.0
Pacific Beach, S&W Group 814 [6]					
	7134	82	162	5	3.1
	7136	79	96	4	4.2
Pacific Beach, Tower 23 Hotel [7]					
	4912	104	405	15	3.7
Ocean Beach, S.C. trunk sewer [8]					
	6352	200	1,407	296	21.0
	6353	127	613	162	26.4
	6354	188	844	106	12.6
Totals	12 Localities	>1,336 sp. Lots	5,160 *C. biplicata*	749 drilled	14.5% drilled

Notes:

1, Approximate, includes trace fossils and unidentified lots.

2, Only *C. biplicata* were examined.

3, Sea cliff exposure south of San Onofre State Beach in northwestern Camp Pendleton Marine Corps Base, northwestern San Diego County; see Kennedy et al., 2020.

4, Sea cliff exposure south of Solana Beach, below the Del Mar Beach & Tennis Club.

5, Spoils from sewer force main trenches in 600 block of Loring St., Pacific Beach; see Kennedy & Rockwell, 2009.

6, Spoils from sewer trenches in 4900 block of Ocean Blvd., and around corner of Ocean Blvd. & Law St., Sewer & Water Group 814 project, Pacific Beach; see Kennedy & Rockwell, 2009.

7, Building excavation for Tower 23 Hotel & Restaurant, 723 Felspar St., Pacific Beach; see Kennedy & Rockwell, 2009.

8, Spoils from Sunset Cliffs Trunk Sewer trenches, 4900 block of West Point Loma Blvd., and 2100 & 2200 blocks of Cable St., Ocean Beach; see Kennedy & Rockwell, 2009.

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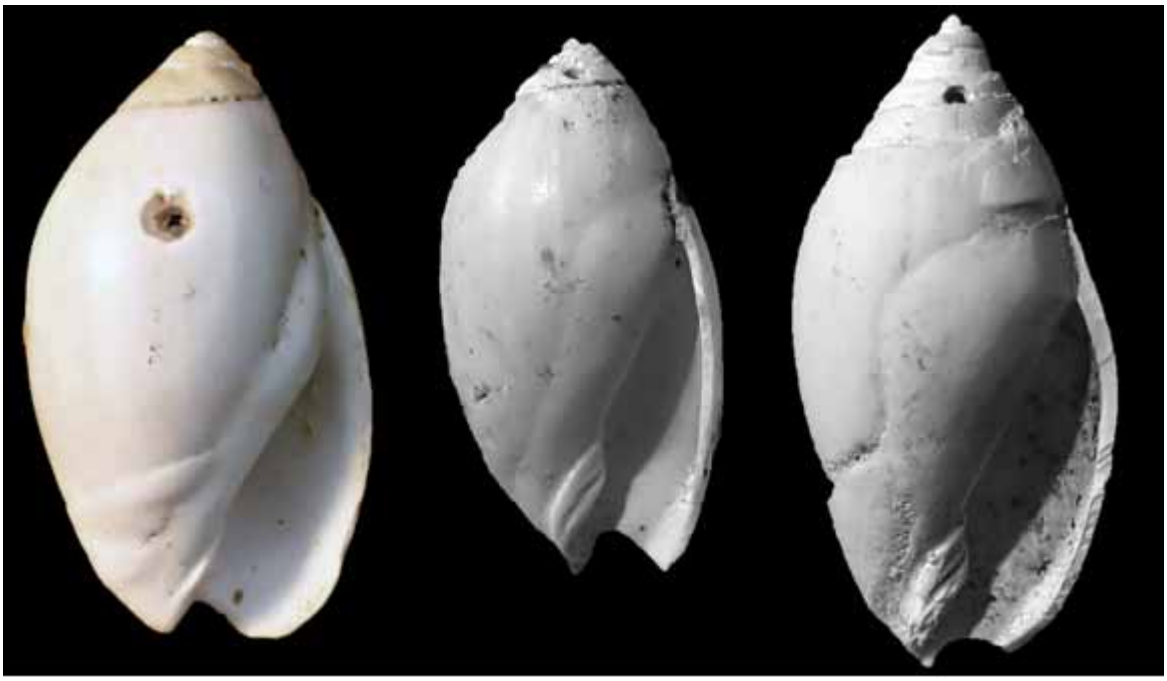
Figure 1 (left): Tegula brunnea (Philippi) with octopod drill hole (*Oichnus ovalis* Bromley), SDSNH 144223 from SDSNH loc. 7134 (Pacific Beach); width of shell, ~ 14 mm. *Figure 2 (right):* Octopod drill hole (*Oichnus ovalis* Bromley), ~ 1.2 mm in long dimension, ~ 0.85 mm in width; SDSNH 144223 from SDSNH loc. 7134.



Figures 3-5: Callianax biplicata (Sowerby), three specimens with octopod drill holes, SDSNH lot no. 130714 from SDSNH loc. 6352 (Ocean Beach). *Figure 3 (left)*: SDSNH 130714[-*a*], shell length, ~ 16 mm; exterior hole diameter, ~ 1.2 mm; dimensions of interior perforation in bottom of drill hole, ~ 0.2 mm x ~ 0.4 mm. *Figure 4 (center):* SDSNH 130714[-*b*], shell length, ~ 14 mm; exterior hole diameter, ~ 0.6 mm. *Figure 5 (right):* SDSNH 130714[-*c*], shell length, ~ 17 mm; exterior hole diameter, ~ 0.7 mm; interior hole diameter, ~ 0.4 mm.

ABALONE WITHERING SYNDROME: THE CASCADING IMPACTS OF ONE BACTERIAL INVADER

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Abalone Withering Syndrome is a disease characterized by presence of an intracellular parasite, *Candidatus Xenohaliotis californiensus* (CaXc), causing abnormal digestive gland morphology, muscle atrophy, and shrinking of the abalone foot tissue. Only a handful of studies have investigated the microbial and host response to this disease. To form a more holistic understanding of abalone withering syndrome, this project investigates how CaXc exposure impacts the microbiome and gene expression of endangered white abalone in captivity. Over a period of 11 months, abalone were exposed to CaXc via the feces of other infected abalone. Fecal samples were taken longitudinally to track changes in microbe composition over time. Tissue samples were taken prior to exposure to CaXc and again at the end of the experiment. qPCR is used to quantify pathogen loads in exposed and control animals. Results show that the abalone fecal microbiome is volatile over time and impacted by exposure to CaXc. CaXc differentially infects early digestive tract (Post Esophagus) more than late digestive tract and contributes to a drop in microbial evenness of the early digestive tract. Changes to the exposed abalone microbiome are primarily related to replacement of key taxa by CaXc in the Post Esophagus and Distal Intestine, and to a minor extent, presence or absence of rarer ASVs. RNA sequencing analysis is still underway.

IMPACT OF INCREASING TEMPERATURE ON OSTREID HERPESVIRUS IN NATURAL *CRASSOSTREA GIGAS* SPATFALL FROM SAN DIEGO

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The ostreid herpesvirus (OsHV-1) was detected in oysters in San Diego Bay in 2018 and has since been a concern for the development of oyster aquaculture and for the welfare of wild oysters. Multiple cases demonstrate that OsHV-1 proliferates when water temperatures increase. Therefore, future detection of OsHV-1 in San Diego Bay is likely to coincide with ocean heatwaves, such as those experienced in San Diego in 2018. This study focuses on determining the role of temperature in triggering OsHV-1 infection of wild oysters in San Diego Bay. Wild oyster spat from San Diego Bay were settled onto recruitment tiles from May to September of 2022 and brought into a climate-controlled room at Scripps Institution of Oceanography for a simulated marine heatwave trial. Settlement varied greatly across the five sites used for tile dispersal. Each tile was given its own tank, which sat within a water bath at either a control temperature of 20°C or a “heatwave” temperature of 28°C. However, no OsHV-1 DNA was detected in any of the oysters sampled throughout the experiment. Oysters experienced more mortality in the “heatwave” temperature but died in both conditions. Future directions of this research will be aimed at naïve, farmed oysters. When given direct exposure to the virus at a range of temperatures, at what point will the OsHV-1 San Diego Bay microvariant be able to kill an oyster?

OCTOPUS VELIGERO: THE SCB IS A FAVORITE VACATION DESTINATION

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During the summer of 1994 the City of San Diego's Ocean Monitoring Lab participated in the Southern California Bight Pilot Project (SCBPP), a regional monitoring program sponsored by the Environmental Protection Agency (EPA) and managed by the Southern California Coastal Water Research Project (SCCWRP). Part of this program involved sampling demersal fish and megabenthic invertebrate populations. During this project, a previously unseen species of octopus, *Octopus veligero*, was discovered. Its presence in the SCB represented a northern range extension from central Baja California.

Since 1994, *Octopus veligero* has been intermittently collected in the monitoring programs of the City of San Diego (CSD), Orange County Sanitation Districts (OCSD), Los Angeles County Sanitation Districts (LACSD), and City of Los Angeles Environmental Monitoring Division (CLAEMD), during both regular monitoring and special projects. The area covered by the combined programs ranges from Baja California, Mexico, to southern Ventura County, CA. Since the original publication examining this species (Lilly 2004), we have added another 22 years of occurrence data. The data show that *O. veligero* is consistently making forays into the SCB and may even have set up permanent residence in some regions. As of this presentation, its northern range is extended to southern Ventura County. There are many questions that remain about this interesting and somewhat cryptic octopus species in the SCB and further research is required.

MOLLUSKS IN ENGLISH-LANGUAGE CHILDREN'S LITERATURE: INACCURACIES, TAXONOMIC REPRESENTATION, AND ANDROCENTRIC BIAS

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Fictional narratives with animal protagonists are common in children's literature across cultures and societies. They convey life lessons and cultural norms as well as the proclivities, assumptions, and biases of their authors. In a survey of 785 English-language children's picture books and Aesop's fables, 30% of animal characters were female, while 70% were male, and most animals of both sexes were mammals or birds. To test author bias toward male or female molluscan characters and assess the taxonomic and accurate representation of mollusks as protagonists, 100 English-language children's fiction books featuring mollusks were surveyed from public library collections in Glendale, California. The majority of children's stories with molluscan protagonists featured the stylommatophora (e.g., land snails and slugs, 57%) and cephalopoda (36%). The representation of characters by sex was: 62% male; 17% unspecified; 14% female; 5% male and female as co-protagonists; and 2% hermaphrodites. Stories by female and male authors both presented male protagonists more often than female ones. In 80% of stories that featured land snails and slugs their sex was inaccurate, and 42% included illustrations that inaccurately placed their eyes not on their eye stalks. Mollusks are not common protagonists in fictional narratives for children: this analysis provides a glimpse into how they are introduced to English-speakers at a young age.

IDENTIFYING AN INTRODUCED LEATHERLEAF SLUG SPECIES FROM THE HUNTINGTON BOTANICAL GARDENS: AN INTEGRATIVE TAXONOMIC APPROACH

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In December 2022 an iNaturalist observation indicated a tropical slug within the Conservatory for Botanical Science at the Huntington Botanical Gardens in San Marino, California. It was clearly a leatherleaf slug, a terrestrial gastropod not known to be established in California and considered pest species where introduced. In January–April, these slugs were collected from the Conservatory and analyzed by researchers from the Natural History Museum of Los Angeles County (NHMLAC), Bernice Pauahi Bishop Museum in Hawai'i, and the United States Department of Agriculture. Based on morphology, the slug was considered either *Veronicella cubensis,* from the Caribbean islands and established as introduced in Hawai'i, *or Leidyula floridana*, from Florida. Its presence at the Conservatory caused its closure by the County of Los Angeles in February 2023 until the species can be eradicated. To determine its species identity, specimens were collected, sequenced for their CO1 barcode gene, dissected, and examined for their radula and jaw. These traits and data were compared with that of unambiguously identified specimens of *Veronicella cubensis* from Hawai'i (from the collections of Oregon State University and the Bernice Pauahi Bishop Museum in Hawai'i), *Leidyula floridana* from the Florida Museum of Natural History, and *Laevicaulis alte* from the collections of the Bernice Pauahi Bishop Museum. It is likely *Veronicella cubensis* and shares its CO1 haplotype with species collected from Hawai'i. All molecular data presented and collected will be added to GenBank.

Poster Presentations

Alphabetical by First Author

Presenting author in **bold**
Student presentations marked by an asterisk *

SOFT BOTTOM BIVALVE COMMUNITIES OVER TIME NEAR SAN DIEGO, CALIFORNIA

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The city of San Diego has been monitoring the soft bottom benthos near each of its two ocean outfalls for more than 25 years. In that time, several significant climatological events have occurred including the warm 1998 and 2015 El Niño Southern Oscillation events, the cool events of 2003-2004 and 2012-2013, and the marine heatwaves that began in 2014. The two outfalls are located on the coastal shelf with one offshore of Point Loma, San Diego at 98 m and one near the US/Mexico border at 28 m. These two regions also differ significantly in average grain size and average bottom temperature. Changes in bivalve abundance and diversity over time along the two outfall depth contours reflect varying dominant species, responses to environmental changes, and potential interactions with other disturbance events.

BIOGEOGRAPHIC AND PHYLOGENETIC AFFINITIES OF NORTHEASTERN PACIFIC CALLIOSTOMATIDAE

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Calliostoma and other Calliostomatidae genera are well known for their beautiful shells, but they are challenging to study globally with so many deep-water and geographically restricted species, so that phylogenetic studies across Calliostomatidae are still lacking. Only in recent years has Calliostomatidae been recognized as well separated from other lineages within the extremely species-rich vetigastropod grouping of Trochoidea. The northeastern Pacific (NEP) members of Calliostomatidae vary considerably in shell shape and sculpturing, and this could reflect either diverse biogeographic affinities or else impressive rates of shell diversification, perhaps related to ecological differences. We have assembled and analyzed a combined mitochondrial COI+16S phylogenetic estimate of Calliostomatidae from publicly available and newly sequenced specimens to investigate biogeographic patterns and species relationships for NEP Calliostomatidae. As in previous studies that were based on fewer species, our results support three monophyletic groupings within Calliostomatidae: a North Pacific (NP), a New World tropical, and a northwestern Atlantic. Within the large NP grouping, there is some evidence of shared affinities between the NEP and northwestern Pacific (NWP). Our results suggest a geological history of limited biotic exchange across the Pacific but also support endemic radiations within the NEP. We are unable to infer either a NEP or NWP origin of the NP fauna, and our study is limited by the lack of data for many tropical and southern hemisphere species. Our results also suggest that some genera proposed within the last century, *Akoya*, *Otukaia*, and *Tristichotrochus*, are phylogenetically nested within *Calliostoma*; their recognition makes *Calliostoma* paraphyletic.

EXTENT OF SEDIMENT BURIAL IN NATIVE, *OSTREA LURIDA*, AND NON- NATIVE, *MAGALLANA GIGAS*, OYSTER POPULATIONS IN SOUTHERN CALIFORNIA, USA

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The Olympia oyster (*Ostrea lurida*) is the only oyster native to North America's west coast but it lives alongside the Pacific oyster (*Magallana gigas*) which is native to Japan but was introduced and has increased in population density in Southern California over the past decade. Oyster reef persistence

relies on oyster growth, which must outpace reef degradation and oyster burial due to sediment deposition. Exact tolerances to burial and the extent of oyster burial in soft sediment habitats are unknown for both oyster species. To build an understanding of the extent of sediment burial, we completed surveys at Pacific Coast Highway (PCH), Newport Bay, and Kellogg Beach, San Diego Bay, CA. At each site, random quadrats (0.5m x 0.5m) were surveyed for both oyster species; we recorded the extent of burial of each individual oyster and analyzed the effects of species and site on the percentage of each population that were buried and the average extent of burial per individual shell using 2-way ANOVA. More oysters were buried at Kellogg Beach (23-27% of the population) compared to PCH (3-13%). Among buried individuals, *O. lurida* was buried more deeply than *M. gigas* at Kellogg Beach (65% of shell length buried compared to 41%) and compared to *O. lurida* (38%) at PCH. This investigation provides a conceptual framework about the extent of sedimentation in native and non-native oyster populations and improves the likelihood of success in restoring native oyster populations.

Meeting Minutes

Minutes, Business Meeting, Western Society of Malacologists
Fifty-sixth Annual Meeting, 24 June 2023, Orange, CA

Present: Bill Wright (president), Christine Parent (online, vice-president), Kelvin Barwick (treasurer), Wendy Enright (secretary), 22 members (5 online)

Meeting called to order at 11:35

The ceremonial gavel was passed virtually to incoming president Christine Parent

Secretary's Report (Wendy Enright)

- Three annual reports have been published over the past year so we are caught up through 2021 with 2022 ready to send out this summer
- Most of our reports are available through the Biodiversity Heritage Library. Pat La Follette is our contact with this organization
- Hans Bertsch and co-authors have a manuscript honoring the women of WSM that they propose be published as an "occasional paper" within the next year. It is a massive effort with about 150 pages
- Doug Eernisse moved to accept the secretary's report, with Hans Bertsch second

Treasurer's Report (Kelvin Barwick)

- At this time, the inflow vs outflow for annual meetings is not covered by the conference fees
- There was a discussion of membership benefits
  - What might be the best way to keep our international colleagues involved?
- We currently have 39 individual and 7 institutional members
- A member encouraged us to keep soliciting the San Diego Shell Club for student grant/presentation moneys
  - The secretary will send a thank you note in the mail for this year's generosity
- Pat LaFollette asked whether the WSM had a historian. George Kennedy had previously filled that position but it has been inactive for several years.
- Hans Bertsch moved to accept the treasurer's report, Megan Lilly second

Student Grants (Jann Vendetti)

This year's McLean grantee is Priyanka Soni
She was granted $945 for her project titled "Shifting Molluscs in Coastal California – An Ecomorphological Analysis of Extralimital Species"
We will invite her to present at next year's meeting

WSM 2024 (Christine Parent)

This will be a joint meeting with the American Malacological Society with their incoming president, Pat Krug
Tentative dates are August 4-7, 2024 and it will likely be held at the Pasadena Hilton

Officers for 2024

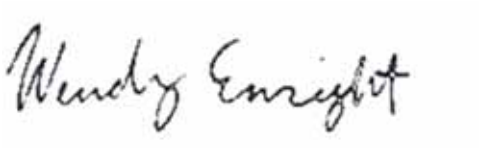
President: Christine Parent
1st Vice President: vacant
2nd Vice President: vacant
Secretary: Wendy Enright
Treasurer: Kelvin Barwick
Members-at-large: Jann Vendetti, vacant

Some additional suggestions to solicit for future leadership included Vanessa Delnavaz, Maria Moreno, and Alyssa in Bodega. The struggle of finding new participants remains.

Doug Eernisse formally entered a statement of gratitude to outgoing president Bill Wright for hosting the meeting, which was enthusiastically echoed by all present and on line.

Hans Bertsch moved to adjourn the meeting with Doug Eernisse second. Meeting adjourned on behalf of President Christine Parent at 12:20 pm

Respectfully submitted,



Wendy Enright

WSM Secretary

Treasurer's Report

Treasurer's Report June 24, 2023

WSM Cash Flow for June 19, 2021 to June 1, 2022

Outflows*	
Student Poster/Talk awards	$(200.00)
Student Grant	$(1,985.35)
Annual report production and mailing (2018,2019,2021)	$(1,492.86)
Office Supplies	$(62.85)
Web page backup (Dreamhost)	$(3.12)
Reimbursement for 2022 Conference expenses (of $2,568.05 incurred)	$(1,827.09)
2022 keynote travel (Dr. Kenneth Hayes)	$(1,323.02)
Total out	$(7,065.69)
Inflows	
Membership	$959.25
Interest	$11.14
Student Grant ($4,876.75 available)	$1,278.00
2022 Conference	$1,827.09
Total in	$4075.48
Net	**$(2,990.21)**

*PayPal cost on $335 not realized above (2.9% plus $0.30 per transaction): $(16.60)

Cash on hand as of June 23, 2023:	
Operating	$11,861.33
Savings	$13,206.12
Credit card	$0.00
Total	**$25,067.45**

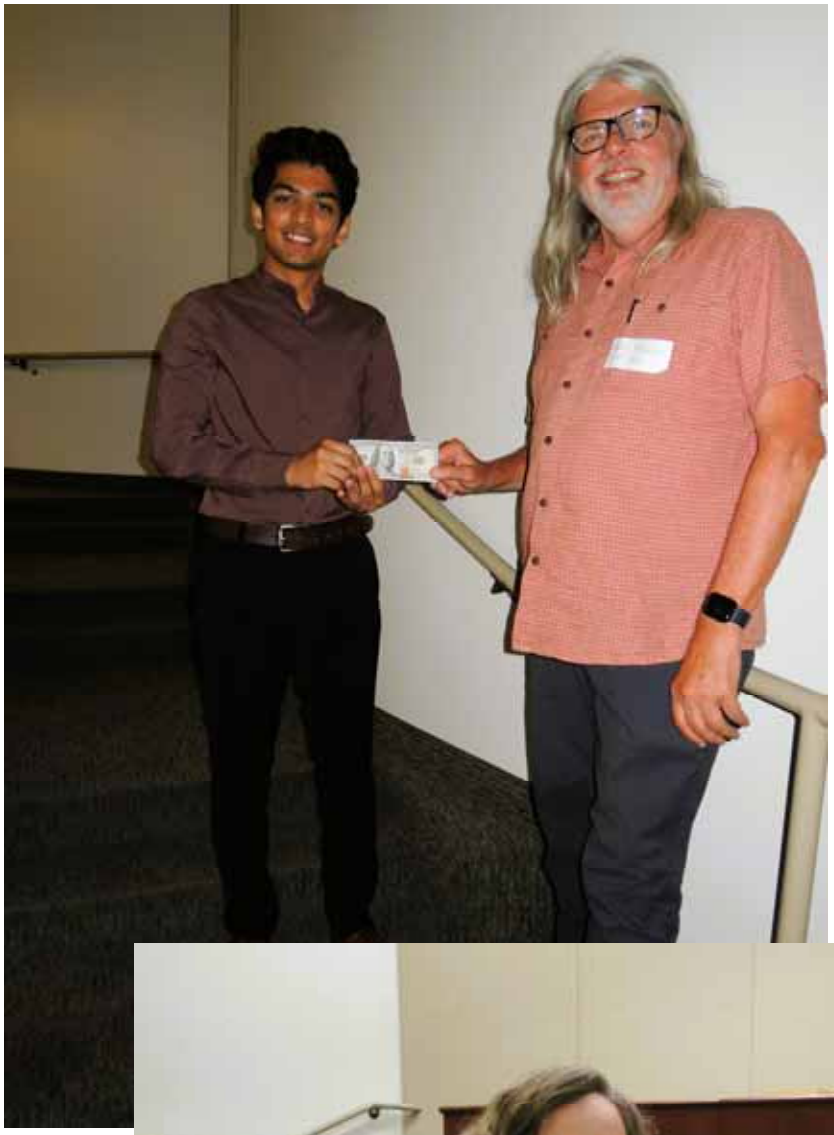
Kelvin Barwick

WSM Treasurer

Top: Attendees of the 2023 meeting

Middle: Presenter Megan Lilly

Bottom: Past president Michael Vendrasco, Treasurer Kelvin Barwick, 2023 President Bill Wright



Top: Student presentation award winner Shriyas Timbadia with Treasurer Kelvin Barwick

Bottom: Secretary Wendy Enright and Past president Doug Eernisse

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