THE WESTERN SOCIETY OF MALACOLOGISTS

Annual Report for 2022

Volume 55
September 2023

Abstracts and papers from the 55th annual meeting of the Western Society of Malacologists

Pasadena City College
Pasadena, CA, USA

June 23-26, 2022

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The Annual Report of the Western Society of Malacologists is based on its yearly meeting. Distribution of the Annual Report is free to regular and student members who are, at the time of issue, in good standing. Membership dues are $20.00 for regular and institutional members and $8.00 for student members. Forms and payment information can be found at www.westernsocietymalacology.org.

Correspondence regarding membership and orders for additional or back issues of the **Annual Report** should be addressed to the current WSM Treasurer, Kelvin Barwick, 16391 Del Oro Circle, Huntington Beach, CA 92649 USA; rictaxis@gmail.com.

2022 WSM EXECUTIVE BOARD

President	Michael Vendrasco
First Vice President (2023 President)	Bill Wright
Second Vice President (2024 President)	Christine Parent
Secretary	Wendy Enright
Treasurer	Kelvin Barwick
Members-at-large	Jann Vendetti
	Xochitl Clare

ABOUT THE ANNUAL MEETING:

The 55th annual meeting of the Western Society of Malacologists was held at Pasadena City College from June 23-26, 2022. **Doug Eernisse** kicked off the proceedings on Thursday morning, June 23, with a fun and informative presentation and extended discussion of methods in specimen photography for research. An afternoon session of oral presentations was capped by **Hans Bertsch**, whose special presentation provided an important and educational overview of the cultural and natural history of mollusks and indigenous peoples of southwest North America. The poster session highlighted the late afternoon, with the WSM executive board meeting in the early evening.

Conservation was the theme on Friday, in the morning featuring a Special Session on Invasive Mollusks convened by **Jann Vendetti**, and in the afternoon with a Special Session on Mollusk Conservation convened by **Kenneth Hayes**. Kenneth also provided the late afternoon Keynote Presentation on "Molluscan Conservation in the Anthropocene" and led the panel discussion that followed. After enjoying a variety of hors d' oeuvres like Thai satay and Filipino lumpia in the courtyard, attendees enjoyed the WSM Fundraising Auction with Hans Bertsch as the Auctioneer. WSM members donated very nice items, such as ammonite fossil mollusks, cute mollusk pins, nudibranch paintings by Wes Farmer, several volumes of the Treatise on Invertebrate Paleontology, and a variety of handmade items. The prices were amazingly affordable, and in total the auction raised $406 for student grants.

Saturday was the **LouElla Saul** Memorial Session on fossil mollusks convened by **Lindsey Groves**, highlighting a diversity of talks and bringing back nice memories of LouElla, who was always warm and helpful to me whenever I visited the LACM Invertebrate Paleontology collections. After the Memorial Session for LouElla, the WSM Business Meeting was convened in the late afternoon, wherein Society matters were discussed and the winners of this Annual Meeting's **best student presentations** were announced. The winning presentations were:

> "Broadscale distribution, abundance and habitat associations of the Asian clam (*Corbicula fluminea*) in the lower Columbia River, USA", **Salvador Robb-Chavez**, Washington State University, Vancouver, WA.
>
> "The cost of adaptations: Rate of parental growth of the poecilogonous species *Alderia willowi* (Gastropoda: Sacoglossa: Limapontiidae), as a function of producing lecithotrophic versus planktotrophic eggs", **Mariah S. Scott**, University of Chicago.

Salvador and Mariah each received $100 and a free one-year WSM membership.

The main meeting culminated with an informal dinner across the street from campus where participants enjoyed tacos, refreshments, and the chance to socialize.

On Sunday, participants met at the Southern California Marine Institute in San Pedro and took a boat trip to Catalina Island. Along the way WSM members examined mollusks and other organisms brought up by a dredge. In addition to the East Pacific Red Octopuses, chitons (e.g. *Callistochiton palmulatus*), polychaetes, and many other

types of living organisms observed in the tank, shark teeth and fossil mollusks were also found amongst the seafloor sediment. We arrived at Two Harbors in the late morning, greeted by live music and good food. Water visibility was excellent, rewarding those who went snorkeling. On the way back to the mainland the diehards had another look through the dredge tank and sediment and made many more little discoveries.

This conference provided a wonderful opportunity to reunite in person with old friends plus develop new friendships and partnerships. It was fun to be able to meet one another in person once again, in many cases for the first time in a long while. Thanks to all those who contributed to the success of the conference, including the volunteers **Hannah Aguilar**, **Sabrina Blankinship**, **Sophia White**, and **Rebecca Wilcox**. Thanks also to **Christine Fernandez** who assisted with planning, meeting website management, and editing this Annual Report. Special thanks to **Doug Eernisse** and **Kelvin Barwick** who provided support, advice, and assistance throughout the planning process and during the conference itself.

OTHER WSM BUSINESS:

This year's **James McLean Grant** was awarded to **Alejandro Mendivil** from Peru, providing $2,000 for his project, 'Taxonomic review of *Aplysia* (Mollusca: Heterobranchia) from the eastern Pacific'. Alejandro plans to visit the collections of the Natural History Museum of Los Angeles County as well as those at Cal Poly Pomona.

This year, two WSM Student Research Grants were awarded to the following students:

- $1,000 was provided to **Emily Kunselman**, UC San Diego, for her project, "Impact of increasing temperature on Ostreid Herpesvirus in natural *Crassostrea gigas* spatfall from San Diego Bay". Emily was kind enough to present the results of her impressive research at the 56th Annual Meeting of the WSM held June 2023 at Chapman College.
- $985 was provided to **Bailey McCann**, Humboldt State University, for his project, "Does climate warming amplify the effect of a range-expanding marine gastropod, *Acanthinucella spirata*?".

HISTORY OF THE WESTERN SOCIETY OF MALACOLOGISTS

The Western Society of Malacologists (WSM) was established in 1968 as a society for the furtherance of research in Malacology. The WSM formed in 1968 from the Pacific Division of the American Malacological Union (AMU), now the American Malacological Society (AMS). The WSM was established as an independent society to improve our understanding of mollusks, and members of this society include professional researchers as well as other mollusk enthusiasts.

Group photograph from the first annual meeting of the Western Society of Malacologists in Asilomar, Pacific Grove, CA. From the original description in the first issue of *The Echo*, the annual report of the Western Society of Malacologists*:*

"FRONT ROW: (left to right)

Mr. E. P. Chace, Miss Mary E. Long, Mrs. Charles McLean, Dr. Edwin Allison, Mrs. Bernadine Hughes, Mrs. Fay Wolfson, Mr. David K. Mulliner, Mrs. Helen DuShane, Mrs. Laura Powell, Mrs. Ruth Richmond, Miss Winnifred Wagg, Mrs. Elsie Chace.

SECOND ROW:

Mrs. Ruth French, Mrs. Ondine Brohaska, Mrs. Elmo Adams, Mrs. Virginia McClure, Mrs. Jean Cate, Dr. Rudolf Stohler, Mrs. Douglas Larson, Miss Margaret Dewar, Mrs. Roland Taylor, Mr. Roland Taylor, Dr. Albert Mead, Mrs. Jean Wilkins, Miss Marilyn Vassallo, Dr. Judith Terry, Mrs. Twila Bratcher.

THIRD ROW:

Miss Donna Mulliner, Mr. Frank Russ, Mae Dean Richart, Mrs. Beatrice Burch, Mrs. Diana Wait, Mr. Don Cadien, Miss Carolyn Stover, Mr. Norman Polonsky, Miss Jody Woolsey, Mr. Ford Bratcher, Mrs. Betty Phillips, Mr. Ted Phillips, Mr. Douglas Larson, Mr. Crawford Cate, Mr. Wm. Pitt, Mrs. Wm. Pitt, Mrs. Carol Skoglund, Mr. Ralph Ferguson.

BACK ROW:

Mr. Eugene Coan, Dr. James McLean, Mr. Elmo Adams, Mr. Paul Hughes, Mr. Charles Powell, Mrs. Elizabeth Payne, Mrs. Mary Anna D'Aiuto, Dr. Wm. Emerson, Mr. Ralph Fox, Mr. Gale Sphon, Jr., Dr. A. Myra Keen, Mr. Joseph DuShane, Dr. Warren Addicott.

(Attending the convention, but not in the picture:)

Mrs. Barbara Good, Dr. G. Bruce Campbell, Mr. Ray Summers, Mr. Robert Talmadge, Mr. Lawrence Thomas, Mr. Nelson Baker, Mr. Phillip Crane, Dr. James Nybakken, Mrs. Arthur Robinson, Mrs. F. T. Smith, Mrs. Katherine Stewart."

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WSM 2022 Group Photograph

From left to right: Hans Bertsch, Kelvin Barwick, Judith Smith, Douglas Eernisse, Jann Vendetti, Casey Richart, Mary Stecheson, Chris Shi, Fares Alzahrani, Patrick LaFollette, Bruce Runnegar, George Kennedy, Lindsey Groves, Mariah Scott, Michael Vendrasco, Scott Rugh, Esteban Fernando Félix Pico, and Todd Wirths.

Attending the Annual Meeting but not in the photograph: Hannah Aguilar, Tim Arehart, Sabrina Blankinship, Wesley Chew, Rachel Collin, Emile Fiesler, Karin Fletcher, Daniel Goody, Kenneth Hayes, Patrick Krug, Samantha Nambu, Eric Ostrowski, Salvador Robb-Chavez, John Slapcinsky, Sophia White, Rebecca Wilcox, and Norine Yeung.

Photograph directed by Hans Bertsch, June 25, 2022.

Presenters at the Louella Saul Memorial Session, 2022

Left to right: Chris Shi, Bruce Runnegar, Judith Smith, George Kennedy, Jann Vendetti, Lindsey Groves, Scott Rugh, and Todd Wirths.

Photograph by Casey Richart, June 25, 2022.

MEETING SCHEDULE

THURSDAY, JUNE 23

Note: *The day's events will be held in* ***Room C333*** *of the C Building at Pasadena City College*.

9:00 AM – 10:15 AM	Registration and opening reception
10:15 AM – 10:30 AM	Introduction and announcements
10:30 AM – 11:15 AM	Douglas J. Eernisse: Presentation and discussion on specimen photography
11:15 AM – 11:30 AM	**Break**
11:30 AM – Noon	Discussion on specimen photography continued.
Noon – 1:30 PM	**Lunch**
1:30 PM – 1:40 PM	Opening remarks for main talk sessions.
1:40 PM – 2:00 PM	Hans Bertsch, L. T. Groves, & J. Vendetti: *Ladies of the Seas: Feminine Eponyms Honoring Western Society of Malacologists Members*.
2:00 PM – 2:20 PM	Rachel Collin, A. de Leon, M. Madrid, & D. Vrdoljak: *Diversity and Population connectivity of Atlantid Gastropods in the Tropical Eastern Pacific.*
2:20 PM – 2:40 PM	D. W. Behrens, Karin Fletcher, A. Hermosillo, & G. C. Jensen: *Nudibranchs & Sea Slugs of the Eastern Pacific: Eastern Pacific Nudibranchs Updated*.
2:40 PM – 3:00 PM	**Break**
3:00 PM – 3:20 PM	Esteban Fernando Félix Pico & E. M. Ramírez-Rodríguez: *Fishery management of the Pacific Calico scallop (*Argopecten ventricosus*) and spasmodic stocks pulse of abundance in Magdalena Bay, Mexico*.
3:20 PM – 3:40 PM	Patrick Krug, S. A. Caplins, A. A. Valdés, D. J. Eernisse, & K. M. Kocot: *Phylogenomic resolution of the panpulmonate radiation: new insight into the evolution of air breathing*.
4:00 PM – 5:00 PM	**Special Presentation by Hans Bertsch: *A Natural and Cultural History of Mollusks and Indigenous Peoples of the Californias, Arizona y Sonora.***
5:00 PM – 6:00 PM	Poster Session in Room C333, including: Wendy Enright: *Impact of the pelagic red crab* Pleuroncodes planipes *(Decapoda, Munididae) on benthic molluscan communities off San Diego, southern California.*-[Not presented.]

	Patrick I. LaFollette, C. Patron, & D. J. Eernisse: *We were not first: news that a eulimid snail parasitic on brittlestars in Southern California was discovered 50 years ago*.
	Samantha Nambu & D. J. Eernisse: *Hoof limpet under-rock bliss in LA: A brooder, her harem of males, and their crawl-away snail hatchlings.*
	Rebecca Wilcox: *Shaw's Cove: An ecosystem at a glance.*
6:00 PM – 7:30 PM	WSM Executive Board Meeting and dinner near PCC (all past presidents welcome).

FRIDAY, JUNE 24

Note: *the day's events until 4PM (Keynote presentation) will be held in* ***Room C333*** *of the C Building. The Keynote presentation, panel discussion, and auction will be held at the Circadian Conference Hall next to the cafeteria, north of the CC Building (Creveling).*

9:00 AM – 9:30 AM Registration and reception

Invasive Mollusk Special Session

9:30 AM – 9:40 AM Jann Vendetti: Introduction to the Invasive Mollusk Special Session.

9:40 AM – 10:00 AM Salvador Robb-Chavez, S. M. Bollens, G. Rollwagen-Bollens, & T. Counihan: *Broadscale distribution, abundance and habitat associations of the Asian clam (Corbicula fluminea) in the lower Columbia River, USA.*

10:00 AM – 10:20 AM Norine W. Yeung, J. R. Kim, & K. A. Hayes: *Hawaii's Non-Marine Gastropod Invasion Stories: Frustrating Cryptic Species Complexes, Unknown Species Identifications, and New Introductions.*

10:20 AM – 10:40 AM Emile Fiesler: *Introduced terrestrial molluscs of Southern California*.

10:40 AM – 11:00 AM Break

11:00 AM – 11:20 AM Casey H. Richart, D. K. Howe, D. R. Denver, & R. J. Mc Donnell: *Mortality of* Deroceras reticulatum *and Annual Ryegrass crop protection conferred by three species of* Phasmarhabditis nematodes.

11:20 AM – 11:40 AM Lindsey T. Groves: *Here to stay? A review of introduced freshwater mollusks in southern California*.

11:40 AM – Noon Fares Alzahrani, C. H. Richart, & R. J. Mc Donnell: *Toxicity of essential oils to the pest slug, Arion circumscriptus, in laboratory bioassays*.

Noon – 1:30 PM Lunch

Mollusk Conservation Special Session

1:30 PM – 1:40 PM Kenneth Hayes: Introduction to the Mollusk Conservation Special Session.

1:40 PM – 2:00 PM Kenneth Hayes, K. M. Bustamente, D. R. Sischo, & N. W. Yeung: *Reassessing the conservation and taxonomic status of Hawaii's Lymnaeidae: Understudied, underestimated, and endangered.*

2:00 PM – 2:20 PM Eric Ostrowski, A. C. Bird, & D. J. Eernisse: *Do new higher resolution maps of southern California kelp forests improve our Habitat suitability Models of Pinto Abalone (*Haliotis kamtschatkana*)?*

2:20 PM – 2:40 PM Mariah S. Scott: *The cost of adaptations: Rate of parental growth of the poecilogonous species* Alderia willowi *(Gastropoda: Sacoglossa: Limapontiidae), as a function of producing lecithotrophic versus planktotrophic eggs*.

2:40 PM – 3:00 PM Break

3:00 PM – 3:20 PM Norine Yeung, D. R. Sischo, G. Blanchet, K. M. Bustamente, C. E. Hee, Jan Kealoha, T. Maruno, S. Stiefel, K. L. Troumbley, & K. A. Hayes: *Reducing the rate of extinctions: Hawaiian land snail conservation efforts from rediscovering species to manning the lifeboats.*

3:20 PM – 3:40 PM John Slapcinsky, C. Earl, K. A. Hayes, & N. W. Yeung: *Pacific Island Land Snail Biodiversity Repository (PILSBRy); documenting an imperiled fauna*.

3:40 PM – 4:00 PM Break

***Note**: at this time we will move to the **Circadian Conference Hall** north of the CC Building (Creveling) for the remainder of the afternoon.*

4:00 PM – 5:00 PM

KEYNOTE PRESENTATION

Kenneth Hayes: Molluscan Conservation in the Anthropocene.

5:00 PM – 5:30 PM Panel discussion on Molluscan conservation

4:00 PM – 5:00 PM WSM Fundraising Auction and hors d' oeuvres.

A wide variety of items of malacological interest will be available at the auction. Shells will not be allowed for reasons of conservation. Proceeds from the auction will go to the Student Grant Fund of the Western Society of Malacologists, a nonprofit 501(c)(3) charity. Auctioneer: Hans Bertsch

SATURDAY, JUNE 25

Note: *all the day's events will be held in* ***Room C333*** *of the C Building at Pasadena City College.*

9:00 AM – 9:30 AM Registration and reception

LouElla Saul Memorial Session

10:00 AM – 10:15 AM Lindsey T. Groves: *Overview of the career of LouElla R. Saul and her numerous contributions to the study of west coast fossil mollusks*.

10:15 AM – 10:30 AM Richard L. Squires: *Overview of the career of LouElla R. Saul and her numerous contributions to the study of west coast fossil mollusks [continued]. [Presented by Lindsey Groves.]*

10:30 AM – 10:45 AM Judith T. Smith: *How old is Baja California Sur's Salada Formation and why is this important?*

10:45 AM – 11:00 AM N. Scott Rugh: *New fossil records of the bivalve genera Acesta (Family Limidae) and Malletia (Family Malletiidae) for the Eocene of San Diego County, California.*

11:00 AM – 11:30 AM Break

11:30 AM – 11:45 AM Richard L. Squires: *Shallow-marine thermophilic gastropod and bivalve genera endemic to the northeast Pacific during the latest Cretaceous and Paleogene time. [Presented by Lindsey Groves.]*

11:45 AM – 12:00 AM Jann E. Vendetti & C. C. Visaggi: *Eponyms of women among Cretaceous mollusks of California: The special case of LouElla Saul.*

12:00 AM – 1:30 PM Group photo, lunch

1:30 PM – 1:45 PM George L. Kennedy: *Taxonomic notes on faunal and floral assemblages of the San Diego middle Eocene.*

1:45 PM – 2:00 PM Todd A. Wirths & N. S. Rugh: *First report of megafossils from the Tourmaline Surfing Park outcrop of the Eocene Mount Soledad Formation, La Jolla, California.*

2:00 PM – 2:15 PM Bruce Runnegar: *Hypercalcification in Permian circumpolar seas: Not what you expect.*

SATURDAY, JUNE 25 CONTINUED

2:15 PM – 2:30 PM	Chris S. Shi & A. J.W. Hendy: *Pleistocene fossil assemblages from Ponte Vista, San Pedro, California: Contributions from mitigation paleontology.*
2:30 PM – 2:45 PM	Lindsey T. Groves & R. L. Squires: *Revision of northeast Pacific Paleogene cypraeoidean gastropods, including recognition of three new species: Implications for paleobiogeographic distribution and faunal turnover.*
2:45 PM – 3:00 PM	**Break**
3:00 PM – 4:00 PM	Western Society of Malacologists Business Meeting *All WSM members are invited.*
4:00 PM – 5:00 PM	Informal group dinner in Pasadena at Teddy's Tacos, 1655 E Colorado Blvd., Pasadena.

Field Trip to Santa Catalina Island

The field trip to Two Harbors, Santa Catalina Island will be led by Professor Douglas Eernisse. There are good snorkeling localities near Two Harbors. Those wishing to snorkel, may either bring their own snorkeling gear, or rent it from the dive shop at Two Harbors.

Santa Catalina Island, the largest of the Southern Channel Islands, features diverse subtidal ecosystems along its coast as well as a rich human pre-history. The Tongva people had established settlements on Catalina island, leaving behind numerous midden piles dominated by mollusk shells and shell fragments. Today, thanks to the Marine Protected Areas along the Santa Catalina coastal regions (https://www.cccarto.com/catalina/protected/), mollusks are able to continue flourishing along the shoreline of Santa Catalina Island.

ABSTRACTS FOR ORAL PRESENTATIONS

In alphabetical order by first author

TOXICITY OF ESSENTIAL OILS TO THE PEST SLUG, ARION CIRCUMSCRIPTUS, IN LABORATORY BIOASSAYS

Alzahrani, Fares A.[1], Richart, Casey H. [1], and Mc Donnell Rory J. [1]

[1]*Department of Crop and Soil Science, Oregon State University, 3050 SW Campus Way, Corvallis, OR 97331, USA, fares.alzahrani@oregonstate.edu |casey.richart@oregonstate.edu | rory.mcdonnell@oregonstate.edu*

The white-soled slug (*Arion circumscriptus*) is an important pest of field crops (e.g. grass grown for seed) in Oregon. Management relies heavily on three chemical compounds: metaldehyde, sodium ferric EDTA, and iron phosphate, all of which have variable efficacy. Metaldehyde is most commonly used, but it is also toxic to many non-target organisms including mammals. Growers are thus interested in new and less persistent treatments. Essential oils are a compelling alternative as they have known activity against other gastropod pests, are Generally Regarded as Safe by the FDA, and hence many are exempt from pesticide registration and residue tolerance requirements under federal law. In this study, we investigate twenty essential oils in laboratory toxicity bioassays with adult *A. circumscriptus*. We test oils mixed into aqueous emulsions at a 1:2 ratio with the surfactant Tween 80 over a range of concentrations. We expose slugs to treatments for 24 hours in 9 cm ventilated Petri dishes, which contained a single filter paper, moistened with 1 ml of the oil emulsion. The most toxic essential oils were determined by calculating LC50 values in SPSS using probit regression. Garlic and clove oils were the most lethal to *A. circumscriptus* with LC50 values of 0.318 and 0.383% (v/v) respectively. Both of these oils are currently being tested in a greenhouse microcosm to 1) confirm their mortality to *A. circumsciptus*, 2) assess the extent of crop protection afforded by the oils and 3) investigate potential phytotoxicity effects of using garlic and clove oils at concentrations that kill slugs.

NUDIBRANCHS & SEA SLUGS OF THE EASTERN PACIFIC: EASTERN PACIFIC NUDIBRANCHS UPDATED

Behrens, David W.[1], Fletcher, Karin[2], Hermosillo, Alicia[3], Jensen, Gregory C.[4]

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[2]*PO Box 1074, Port Orchard, WA 98366, USA, karin@milltech.com*

[3]*197 Durango Rd Unit 3b, Destin, Fl, USA, 32541, aliciahmckowen@gmail.com*

[4]*School of Aquatic and Fishery Sciences, University of Washington, Fisheries Box 355020, Seattle, WA 98195, USA, gjensen@uw.edu*

After 16 years, an updated and revised version of the Eastern Pacific Nudibranchs: A Guide to Opisthobranchs from Alaska to Central America book is nearing completion. This edition, Nudibranchs & Sea Slugs of the Eastern Pacific, places more emphasis on species identification for the intertidal beach surveyor or recreational scuba diving naturalist with updated descriptions, more detailed photos, photos of color variations and egg ribbons, listings of similar species, species size and range as well as typical habitats for each species. Every species name has been updated to reflect either the most recently published morphological and molecular conclusions as noted in WoRMS or conclusions drawn from comparisons of CO1 sequences of eastern Pacific specimens from BOLD and GenBank. The book will be available in both print-on-demand and e-book formats.

LADIES OF THE SEAS: FEMININE EPONYMS HONORING WESTERN SOCIETY OF MALACOLOGISTS MEMBERS

Bertsch, Hans[1], Groves, Lindsey T.[2] and Vendetti, Jann[3]

Malacology Department, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007, USA, [1]hansmarvida@sbcglobal.net | [2]lgroves@nhm.org | [3]jvendetti@nhm.org

The history of science details not just with the advances in our knowledge, but with the people who made those contributions. This talk gave an overview of 21 women of our society who have had species and/or genera named in their honor. As of summer 2022, the list of eponyms included 136 total entries. This included 118 valid species of mollusks, one crab and one foraminiferan, 36 species of fossil mollusks, six valid genera and nine synonymized species. Representative pictures of the women and their eponyms were presented.

Figure 1. Crawford and Jean Cate, A. Myra Keen and Elsie M. Chace; AMU-PD Meeting, San Diego, 1965. Photo by Eugene V. Coan.

Figure 2. Twila Bratcher, Carole M. Hertz, Kirstie L. Kaiser and Billee Dilworth. Undated photo in the SDSC archives; possibly 1987 WSM meeting.

Figure 3. Carole Hickman, Jann Vendetti, Corinne (with butterflies) and Nadia Vendetti-Kwon, Gene Kwon and Judith Terry Smith; banquet WSM meeting, Los Angeles, 22 June 2017. Photo by Hans Bertsch.

SPECIAL PRESENTATION

NOTES ON THE NATURAL AND CULTURAL HISTORY OF MOLLUSKS AND INDIGENOUS PEOPLES OF THE CALIFORNIAS, ARIZONA Y SONORA

Bertsch, Hans

Research Associate in Malacology, Natural History Museum of Los Angeles County, Mailing address: 192 Imperial Beach Blvd. #A, Imperial Beach, CA 91932, USA, hansmarvida@sbcglobal.net

The 55th Annual Meeting of the Western Society of Malacologists was held on the campus of Pasadena City College. As is most of the Los Angeles basin, it is on land formerly inhabited by the Tongva-Gabrieleño people (Fig. 1). The Tongva lived in Los Angeles and Orange Counties, in the main part of the most fertile lowland of southern California. Their lands included a stretch of sheltered coast, giving them access to abundant marine and terrestrial food resources. Pre-European contact, there were about 5,000 people living in nearly 100 villages. According to their tradition, Povuu'nga was their place of emergence; it is located east of present-day California State University at Long Beach. Their culture has been documented in thousands of archeological sites in the area, and by the ongoing efforts of their modern descendants.

Figure 1. Map of Gabrieleño-Tongva villages in the Los Angeles, CA, basin. From the website of the Gabrieleño-Tongva Band of Mission Indians: https://www.gabrieleno-nsn.us/maps.

Within a broader geographic and temporal context, the interactions of the Indigenous Gabrieleño-Tongva people with mollusks are part of a rich human tradition that has connected cultural and natural biodiversity across multiple ecosystems.

The seas of northwest México and southern California (the Cortezian and Californian marine faunal provinces) are rich in marine biodiversity. These marine resources have been used for millennia by coastal and inland peoples.

Archaeological investigations and ethnohistories show the importance of mollusks as food and ornamental objects (both sacred and everyday artifacts), and as tools. Excavations of midden mounds show that mollusks were consumed by the inhabitants of San Miguel Island (southern California) approximately 11,500-12,000 years B.P., and by the pre-Cochimi in the region of San Quintin-El Rosario (Baja California) from 7000 years ago. There are literally thousands of coastal midden mounds throughout this area (Figures 2-5).

Figure 2. Wendy Enright, Nora Foster, and Kelvin Barwick walking the middens along the shoreline of the estuary at La Salina, Baja California (BC). En route to the 49th Annual Meeting of the WSM, held at Ensenada, BC. (Photo by HB, 6 July 2016)

Figure 3. In foreground, midden overlooking small bay just north of Krutsio, BC. (Photo by HB, 23 October 2007)

Figure 4. *Cryptochiton stelleri* valves found in the midden alongside the agricultural fields south of La Bocana Santo Tomás, BC. (Photo by HB, 16 April 2016)

Figure 5. *Mytilus* middens at Fraser Point, Santa Cruz Island, CA. (Photo by Douglas Eernisse, 8 May 2016)

Different inland groups obtained this material through trade routes or by village collecting trips to coastal sites. A jewelry-making tradition at Snaketown (Arizona) continued over 1700 years, using shells they collected from the upper Gulf of California and others obtained by trade from the Pacific coast. The most commonly used species throughout the Californias, Arizona and Sonora were gastropods and bivalves, especially, *Haliotis* spp., *Olivella* spp.,

Glycymeris gigantea (Reeve, 1843), *Laevicardium elatum* (Sowerby, 1833), and *Pinctada mazatlanica* (Hanley, 1856) (see Figures 6-10).

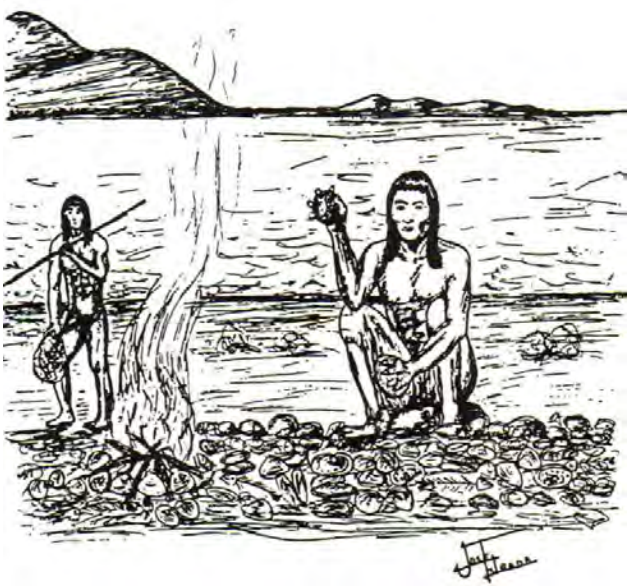

Figure 6. Abalone cookout on the beach. (Drawing by José Estrada of Ensenada, BC)

Figure 7. Necklace of *Olivella* and *Conus* shells, made by Señora Ramona Bartlett, Comcáac artisan of Punta Chueca, Sonora. Modeled by Señorita Adriana Ivette Cadena. (Photo by HB, 13 August 2015)

Figure 8. Stages in the making of a *Glycymeris* clam bracelet. From the museum display at Cerros de Trincheras archaeological site, Sonora. (Photo by HB, 8 November 2014)

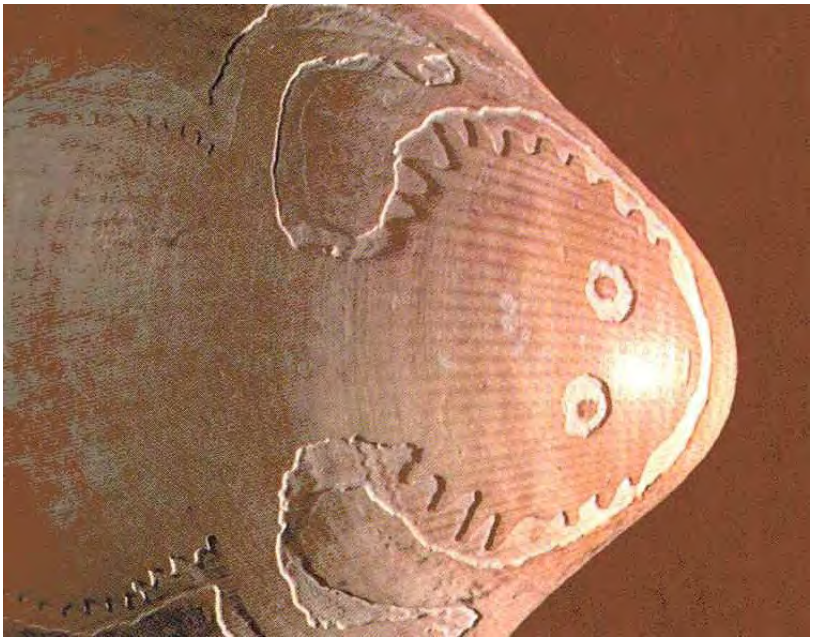

Figure 9. Design of *llorasangre* (horned lizard) etched on a *Laevicardium* valve, using cactus acid. Found during excavations at the Hohokam Snaketown site, Arizona. (Photo from Haury, 1976)

Figure 10. Funerary breastplate ornament of *Pinctada mazatlanica* shells found in grave (pre-1200 C.E.) on Isla Magdalena, Baja California Sur. (Photo by Carlos Cáceres Martínez)

Information and illustrations during my talk documented these uses by the Chumash, Tongvan, Kumeyaay, Cochimí, Guaycura and Pericú, Hohokam, and Seri nations. Modern artisanal practices demonstrate the continuing preservation of cultural traditions by extant nations (Figures 11-12). Notes on the biology of the mollusks, including their natural histories and distributions, were also presented.

Figure 11. Kumeyaay woven tray with rattlesnake design. From display at the Museo Comunitario de Tecate, BC. (Photo by HB, 17 June 2016)

Figure 12. Kumeyaay basket with acorns. From display at the Museo Comunitario de Tecate, BC. (Photo by HB, 15 August 2011)

Acknowledgments

This project results from many years of journeys and research. Numerous people have helped me, either working with me in the field, allowing me to use their photographs, or providing information. I am very grateful to all of them. Among these friends and colleagues are Luis E. Aguilar Rosas, Carlos Cáceres Martínez, Adriana Ivette Cadena, Rosa del Carmen Campay Villalobos, Douglas Eernisse, José Estrada, Carlos Figueroa Beltran, Cathy Moser Marlett, Miguel Tellez Duarte and Paul Valentich-Scott. The Comcáac (Seri) people at Punta Chueca, Sonora, were especially accepting and generous. Useful were the exceptional museum displays in Tecate, Baja California (Museo Comunitario), and Trincheras, Sonora (Cerro de Trincheras Archaeological Zone, overlooking the Río Magdalena).

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DIVERSITY AND POPULATION CONNECTIVITY OF ATLANTID GASTROPODS IN THE TROPICAL EASTERN PACIFIC

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Holoplanktonic organisms are usually widely distributed and are generally characterized by high levels of geneflow and population connectivity. Pelagic gastropods are no exception, with many species distributed throughout ocean basins. Despite significant taxonomic and population genetic research focusing on these groups in the open ocean, the pelagic gastropod fauna of the Tropical Eastern Pacific, especially in coastal waters, remains largely un-explored. To document the diversity of pterotracheoids from the coastal waters of the Bay of Panama, we collected, photographed, and sequenced fragments of mitochondrial cytochrome c oxidase subunit I (COI) and 16S ribosomal DNA for 60 atlantids, 3 carinariids and 6 pterotrachids. Our results include the first published 16S sequences for these groups. We uncovered 11 operational taxonomic units (OTUs), 9 in the genus *Atlanta*, 1 *Carinaria* and 1 *Firoloida*. We confirm the presence of *Atlanta oligogyra*, *Atlanta turriculata*, *Atlanta lesueurii*, *Atlanta helicinoidea*, *Atlanta frontieri* through comparisons between our sequences and previously published sequences. We did not find *Atlanta gaudichaudi*, *Atlanta inclinata*, *Atlanta tokiokai*, *Atlanta gibbosa*, *Atlanta peronii*, *Oxygyrus inflatus*, which have been reported from the region based on museum collections. Examination of haplotype networks for the species with the largest sample sizes showed that some species show population differentiation across the tropical Pacific.

HOOF LIMPETS (HIPPONICIDAE) IN CALIFORNIA AND BEYOND: DNA HELPS RESOLVE RELATIONSHIPS

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The phylogenetic affinities of Hipponicidae Troschel, 1861, or hoof limpets, are obscure within the incredibly diverse assortment of caenogastropod lineages. In my own and collaborative studies, we have analyzed mitochondrial 16S and *cox1* gene regions to help delimit species and estimate phylogeny for this interesting case of snails adopting a sedentary limpet lifestyle. As in other reports, we have found that widespread species that have turned out instead to be cryptic species complexes, either allopatric or sympatric. One case supports the opposite conclusion; tropical East Pacific or Hawaii nominal species are apparently instead the same species. Adding to the challenge of adequately representing widespread lineages, we need to determine which of the extant hoof snail lineages coincides with the type species of *Hipponix* Defrance, 1819 which, by subsequent designation, is a fossil shell from the Paleogene Paris Basin; important because most hoof limpet species in WoRMS are currently placed in *Hipponix*. Another challenge for hoof limpet phylogenetic analysis has been to identify the most proximal outgroups within caenogastropods, for improving rooting of the ingroup and to help reconstruct ancestral character states. Bandel and Riedel (1994), Simone (2002) and others used shell, reproductive, and anatomical traits to group the three similar appearing limpet-like caenogastropod families, Hipponicidae, Calyptraeidae Lamarck, 1809, and Capulidae J. Fleming, 1822. Preliminary molecular studies from Collin (2003) and later have instead reported these three as far apart from each other. More recent grouping of Hipponicidae and Vanikoridae Gray, 1840 has not been supported either, but this classification is still used in GenBank. I recently assembled and analyzed non-redundant 16S and *cox1* sequences available for downloading together with our own unpublished mitochondrial sequences across all relevant caenogastropods. I likewise found no evidence for close affinities of Hipponicidae with Calyptraeidae, Capulidae, or Vanikoridae, but this taxon-inclusive approach revealed surprisingly high support for affinities between Calyptraeidae and Capulidae. Results support the currently accepted WoRMS classification with Hipponicidae in its own superfamily, with a lingering mystery of hoof limpet affinities unresolved.

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FISHERY MANAGEMENT OF THE PACIFIC CALICO SCALLOP (*ARGOPECTEN VENTRICOSUS*) AND SPASMODIC STOCKS PULSE OF ABUNDANCE IN MAGDALENA BAY, MEXICO

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Abstract

This study reports population changes of the scallop *Argopecten ventricosus* and examines the impact of harvesting strategies applied during the last strong El Niño event (2015-2016). Based on landings statistics and literature reports on the fishery in Magdalena Bay, Baja California Sur, Mexico, management recommendations are proposed. Over the past 10 years, there have been two periods with landings exceeding 12,000 metric tons (live weight): 2010-2011 and 2018-2019. From 2010, landings declined steadily until the fishery closure in 2014 but returned in 2018 (16,000 t). The fishing season occurs from April to May in the shallow areas of Almejas Bay, and during the subsequent months, the harvest moves toward Magdalena Bay, reaching areas with depths of approximately 25 m. The scallop stock benefited from warm water conditions due to a possible increase in larval production and dispersal. Extinct beds were recolonized, and new habitats formed during these periods, although most became extinct shortly thereafter. Unfortunately, in 2020, the catch also declined to 690 t, without any apparent principal reason.

Introduction

The Pacific Calico scallop or Catarina scallop is an important fishery resource in Magdalena Bay, exploited for many decades in the state of Baja California Sur. Also known as Catarina scallops, Mexican Bay scallops *Argopecten ventricosu*s (Sowerby, 1842) ranges along the east coast of the Pacific from Santa Barbara, USA, along the peninsula of Baja California, throughout the Gulf of California, to Piura, Perú. Records from Monterey, California are probably from settlement during “El Niño” periods (Bertsch & Aguilar, 2016). Bay scallops are typically found in shallow (1–180 m) mud and sandy bottoms with shell or eelgrass underneath. These scallops have fast growth rates, short time to maturity (less than 1 year), short lifespans (2–3 years), high fecundity, and a broad species range (Félix-Pico 2006).

A federal law mandates that the National Fisheries Institute (Instituto Nacional de Pesca, INAPESCA) is responsible for performing surveys and stock management, distributing geographically specified permits, and setting annual quotas for this fishery (Norma Oficial Mexicana NOM-004-SAG/PESC-2015). Biomass levels and catch quotas refer to targets of 40–60% and legal size 56 mm. Harvesting during the spawning season, from December 15 to March 31, is prohibited. Catching is done using a semi-autonomous or "hookah" diving method from a 22' boat with an outboard motor. According to Mexico's National Fishing Chart (2018), overfishing is occurring in Baja California Sur, and it is recommended not to increase the fishing effort.

Scallop fisheries are notoriously variable, going through boom-and-bust phases, so the high variability in catch is not unusual. Variability in the abundance of harvested scallops may be due to environmental variability or changes in the recruitment patterns. Variations in the abundance of harvested scallops may be attributed to environmental variability or changes in recruitment patterns. Several studies have indicated that the continuing trend of warming coastal waters and significant changes in water quality will likely contribute to the decline of scallop populations in Magdalena Bay; population levels are favored by La Niña events (Jiménez-Quiroz et al. 2021).

Methods

Study area: Magdalena Bay is divided into three fishing zones with 20 banks, and the abundance of scallops appears to be related to depth and proximity to the bay mouth (Fig. 1).

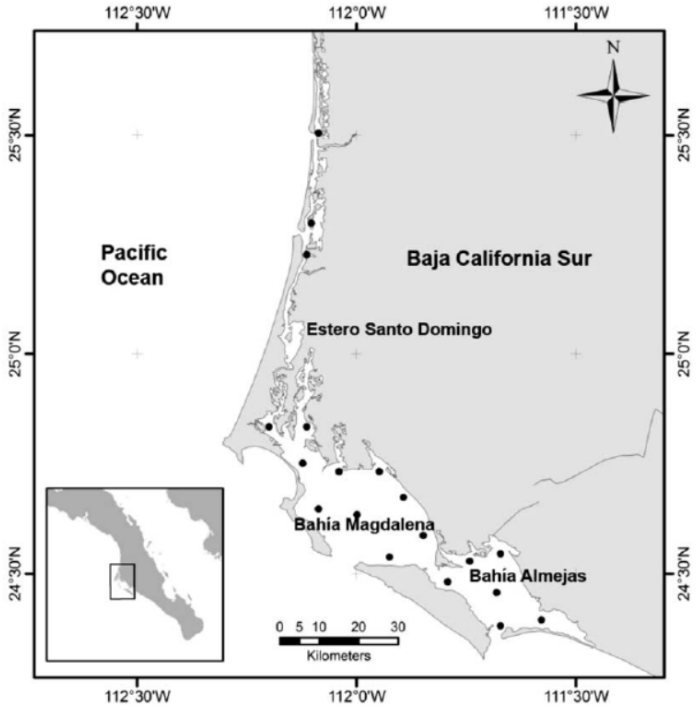

Figure 1.- Locations of commercial stocks of Catarina scallops in Magdalena Bay.

The objective of this study is to evaluate environmental factors that influence the potential productivity of scallop populations. This includes analyzing unusual environmental events and examining landing records from 2000 to 2020 obtained from the Comisión Nacional de Acuacultura y Pesca (CONAPESCA). The historical series of data include landed catch, value, catch per boat, per zone, and per day, month, and year. Water quality data consists of monthly averages of sea surface temperatures (obtained from Satellite Modis Aqua with a 1.1 km resolution) and Chl-a pigmentary concentration (obtained from Satellite SeaWiFS with a 1.1 km resolution).

Results

Historical data reveals the development of an emerging fishery in the early 1970s, characterized by short periods of high catches followed by three short periods of resource "collapse" or absence. Major landings of Catarina scallop occurred in 1989 and 1990, with 25,000 t and 24,000 t (whole weight), respectively. From 1992 to 2020, the data shows three distinct periods. The first period, from 1992 to 2000, had catch values around 900 t, with a peak of 14,400 t in 1996. In 2001 and 2002, only 105 t were recorded per year. The second period, from 2001 to 2013, witnessed an increase in catch, reaching an average of 14,800 t from 2004 to 2008, followed by a decrease to 1,500 t in 2013. From 2014 to 2016, the resource became scarce or did not appear, leading to the closure of the fishery. The third period, from 2017 to 2020, began with a catch of 900 t, but in 2018, it reached 15,000 t. Subsequently, it declined rapidly, and in 2020, only 691 t were recorded. The latest news for 2021 indicates a scarcity of the resource (Fig. 2).

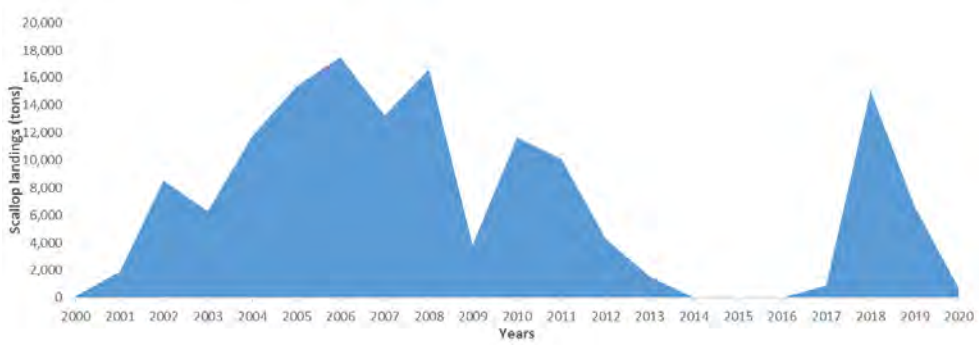

Figure 2.- Annual production (metric tons) of Pacific Calico scallop fishery in Magdalena Bay.

Sea surface temperature in Magdalena Bay has shown a gradual increase from 2000 to 2020. A significant decrease in landings was observed in 2015, likely attributed to the impacts of warming events such as "El Niño" and "The Blob" (a large mass of warm water in the Pacific Ocean) in the region (Fig. 3).

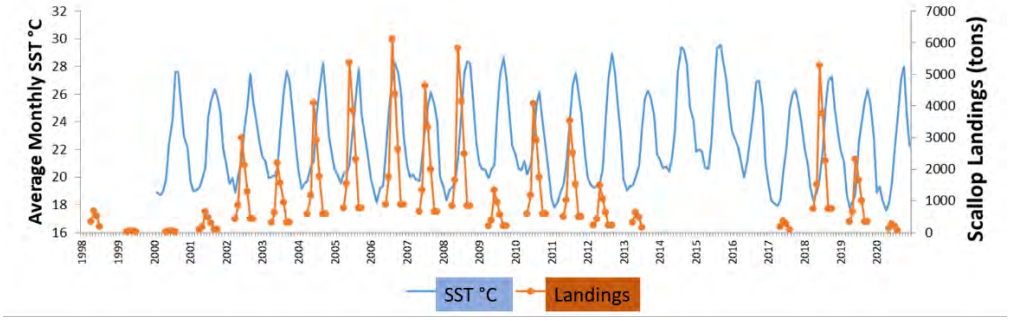

Figure 3.- Landings (whole weight in metric tons) of *Argopecten ventricosus* in Bahia Magdalena vs. monthly average sea surface temperatures from 2000 to 2020.

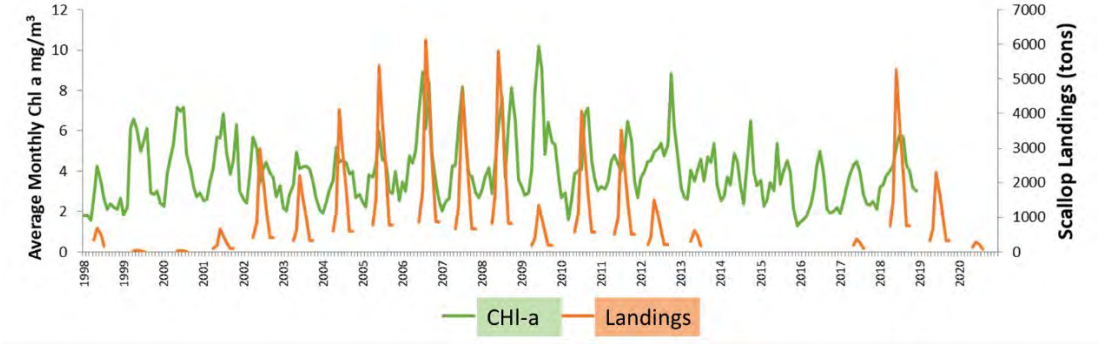

Figure 4.- Monthly landings (whole weight tons) (1998-2020) of *Argopecten ventricosus* in Magdalena Bay and Chl-a values from 1998 to 2018.

During warm periods, the strength of upwelling and nutrient influx into the bay diminishes, altering the seasonal pattern of chlorophyll-a (chl-a). The variations in chlorophyll-a suggest a decreasing trend in food availability, which likely played a role in most of the observed collapses (Fig. 4).

Conclusions

The catch trends of the Pacific Calico scallop are closely related to resource availability in major fishing regions, but the reasons for their declines, whether short or long-term, have yet to be explained. While the scallop catch volumes were favored by La Niña conditions in the past, recent signals are unclear. The scallop stock has reached such low abundance levels that the fishery has been closed. Consequently, some fishermen are collaborating with the government to use spat collectors to enhance recruitment through repopulation efforts. Other fishermen have opted to participate in the growing tourist industry of sport fishing and whale watching.

Acknowledgements

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INTRODUCED TERRESTRIAL MOLLUSCS OF SOUTHERN CALIFORNIA

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The California Floristic Province, which stretches from northern Baja California to southwestern Oregon, has a Mediterranean climate and is one of the world's best known biodiversity hotspots. Due to its agreeable climate, it also supports Homo sapiens (Mammalia < Chordata < Animalia) in large numbers. Many organisms have been purposefully or accidentally introduced into California by human activities. These organisms impact the existing biodiversity negatively by competition with the native taxa, and marginally positively by adding new taxa. Southern California has a large percentage of introduced molluscs, with 43 of the approximately 112 species (38%) not native to the area. A summary of mollusks not native to Southern California is presented, with a focus on taxonomy and biogeography of their native distribution.

HERE TO STAY? A REVIEW OF INTRODUCED FRESHWATER MOLLUSKS IN SOUTHERN CALIFORNIA

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Invasive species are non-native to the ecosystem whose introduction causes or is likely to cause economic and/or environmental harm or harm to human health. They also refer to a species that rapidly reproduces and spreads outside their point of origin. At least thirteen species of introduced freshwater mollusks are documented from southern California. This includes the gastropods *Cipangopaludina chinensis malleata* (Reeve, 1863), *Melanoides tuberculata* (Müller, 1774), *Pomacea bridgesii* (Reeve, 1856), *P. canaliculata* (Lamarck, 1822), *P.* cf. *P. paludosa* (Say, 1829), *Potamopyrgus antipodarum* (Gray, 1843), *Pseudosuccinea columella* (Say, 1817), *Radix auricularia* (Linnaeus, 1758), and *Tarebia granifera* (Lamarck, 1816) and the bivalves *Corbicula fluminea* (Müller, 1774), *Dreissena bugensis* Andrusov, 1897, and *Utterbackia imbecillis* (Say, 1829). The notorious Zebra mussel, *Dreissena polymorpha* (Pallas, 1771), has thus far only been reported from San Justo Reservoir and a golf course lake in Hollister both in San Benito County, central California and is mentioned here due to its potential to become an invasive species. *Planorbella duryi* (Whetherby, 1879) has recently been reported from San Bernardino County and various Los Angeles County localities. All of the aforementioned introduced species tend to outcompete native species and the gastropods may provide potential parasite vectors and the bivalves are fowling organisms. *Pomacea bridgesii* and *Utterbackia imbecilis* are known only from single occurrences and are unlikely to become established.

OVERVIEW OF THE CAREER OF LOUELLA R. SAUL AND HER NUMEROUS CONTRIBUTIONS TO THE STUDY OF WEST COAST FOSSIL MOLLUSKS

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LouElla (Lou) Rankin Saul passed away on June 21, 2021 at age 93. She received a B.S. in Music in 1947 and a M.A. in Geology, both from UCLA, in 1959. Her M.A. thesis was on the paleontology of the Late Cretaceous (Senonian) Chico Formation in Butte County, northern California. She was a sweet person and a brilliant paleontologist who was always happy to share her knowledge with beginners and seasoned veterans alike. LouElla was Curator of Invertebrate Paleontology and Recent Invertebrates at UCLA from 1965 to 1985 when the UCLA collections were transferred to the Natural History Museum of Los Angeles County, and she became first Collection Manager of LACMIP. Unfortunately, she was a victim of a series of layoffs from the museum in 1993 ... undaunted, she continued on as a Research Associate in IP until she was physically unable to visit the museum.

LouElla's presence at UCLA was fortuitous for the significant advancement of molluscan paleontology. Her mentor and friend at UCLA was Willis ("Parky") Popenoe, professor of paleontology, who initiated a method that relied on his own large collections of fossils, which were stored and well-curated by him and his mentoree LouElla. This method relied on careful collecting, recording of precise geographic and stratigraphic position, and accurate identifications. Furthermore, Parky and LouElla perfected the technique of selecting a number of specimens to represent each major formation in which they occur and carefully cleaning the hinges of the bivalves and the apertures of the gastropods. These careful cleaning techniques, eventually perfected by LouElla, clearly showed that information about critically important morphologic details and allowed for a much better basis for the systematic placement of taxa. Combined with detailed biostratigaphic information, they could more accurately show lineages of species and their evolutionary trends.

LouElla published numerous papers on Cretaceous and Paleogene mollusks primarily from California. At least 15 taxa were named in her honor, including two Cretaceous cypraeoidean species: *Eocypraea louella* Groves, 1990 and *Bernaya* (*Protocypraea*) *louellasaulae* Groves, Filkorn, and Alderson, 2011. Her late husband, geologist Richard B. (Dick) Saul, often referred to "Lou" as his favorite paleontologist. She is sorely missed by those of us who cherished our time with her.

REVISION OF NORTHEAST PACIFIC PALEOGENE CYPRAEOIDEAN GASTROPODS (MOLLUSCA), INCLUDING RECOGNITION OF THREE NEW SPECIES: IMPLICATIONS FOR PALEOBIOGEOGRAPHIC DISTRIBUTION AND FAUNAL TURNOVER

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The Paleogene cypraeoidean fauna of the northeast Pacific region (NEP), extending from Vancouver Island, British Columbia, Canada to Baja California Sur, México, consists of 12 genera, 20 named species (three of which are new), six species in open-nomenclature, one cf. species, one indeterminate cypraeid as to genus and species, and four *nomina dubia*. Species reassigned at the genus level are: *Protocypraea*? *simiensis* (Nelson, 1925) and *Luponovula maniobraensis* (Squires and Advocate, 1986). Improved documentation of known NEP species include *Propustularia kemperae* (Nelson, 19925), *Grovesia castacensis* (Stewart, 1926 [1927]), *G. mathewsonii* (Gabb, 1864), and *Eratotrivia crescentensis* (Weaver and Palmer, 1922). The three new species, *Subepona* n.sp., *Bernaya* n.sp., and *Eocypraea* n.sp. are all from the middle Eocene Llajas Formation of Simi Valley, Ventura County and Devil Canyon, Los Angeles County. Six open-nomenclature species need better preserved material; they are *Bernaya*? sp., *Gisortia* sp., two *Protocypraea*? sp., *Eocypraea* sp., *Cypraedia* sp., as does an indeterminate cypraeid from the Lodo Formation of central California. *Nomina dubia* are "*Bernaya*" *fresnoensis* (Anderson, 1905), "*Eocypraea*" *bayerquei* (Gabb, 1864), "*Sphaerocypraea*" *martini* (Dickerson, 1914), and "*Sulcocypraea*" *oakvillensis* (Van Winkle, 1918). *Eratotrivia mackini* (Durham, 1944) is herein assigned to the synonymy of *Grovesia mathewsonii* (Gabb, 1869).

The NEP Paleocene cypraeoidean fauna consists of four genera, a cypraeid of unknown generic affinity, and two *nomina dubia*. The early Eocene "Capay Stage" cypraeoidean fauna is comprised of eight genera, which coincided with the Early Eocene Climate Optimum (EECO), the warmest time of the Paleogene. At the end of "Capay" time, biodiversity abruptly decreased, and this trend continued because of the deterioration of the warm climate. Continued global cooling caused the disappearance of the thermophilic Paleogene NEP cypraeoideans before the beginning of the Oligocene. Most of the NEP cypraeoidean fauna is very similar morphologically to species found in the Tethys region of Europe, especially France, Italy, and Ukraine. These similar species are indicative that the introduction of most of the NEP cypraeoidean genera into the NEP region was via a westward-directed, warm-water current originating in the ancient Tethys Sea region of western Europe. The point of origin of the Paleocene *Propustularia* is unknown, and the late Eocene *Nucleolaria* most likely arrived in the NEP region via a Pacific Ocean route.

Keynote Presentation

MOLLUSCAN CONSERVATION IN THE ANTHROPOCENE

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There remains considerable debate over when exactly we demarcate the beginning of the Anthropocene, the current geologic epoch characterized by the overwhelmingly dominant influence of humans on biodiversity and the environment. However, there is little doubt about the devastating impacts of human actions on all other species and the ecosystems on which life relies. While all of life on Earth is suffering severe losses in the face of habitat alteration, climate change, and the diseases exacerbated by both, molluscs have the dubious distinction of accounting for the most recorded extinctions since 1500 and are often touted as the most threatened taxonomic group in the world. This may reflect biases in biodiversity studies more than underlying reality, yet the statistics still paint a grim picture for molluscs. Although the true numbers of extinctions during the last five centuries may never be known, we continue to witness species losses at an alarming rate and are confronting a biodiversity crisis that is leading to the sixth mass extinction. Despite this, there remains some hope that there is a way forward for conservation of molluscs in the Anthropocene, and still time to save some of this extraordinary diversity. This will require increased capacity for biodiversity discovery, taxonomy, and a shift from species focused conservation to ecosystem approaches, to gain a fuller understanding of biocultural diversity and all it entails. We will continue to lose many species, but if we revitalize traditional natural history and taxonomic approaches, combine them with modern ecosystem level considerations, and prioritizing those most at risk, we may be able to develop conservation and management plans that can slow extinctions and allow us to begin repairing some of the damage we have caused. Here I present research on Hawaiian land snails that illustrate some of the ways in which we can begin slowing the extinction of the most critically endangered species and manage to save others in the process. It is my hope that lessons learned from a wide diversity of species can help improve molluscan conservation in the Anthropocene.

REASSESSING THE CONSERVATION AND TAXONOMIC STATUS OF HAWAII'S LYMNAEIDAE: UNDERSTUDIED, UNDERESTIMATED, AND ENDANGERED

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Although freshwater ecosystems account for less than 1% of the Earth's surface, 10% of all species inhabit them, and all life is dependent upon their services. One in three freshwater species are threatened with extinction, and wetlands are disappearing three times faster than forests. About 30% of 1500 assessed mollusc species are threatened with extinction, a probable underestimate given data deficient species, and that only 25% of all freshwater molluscs have been assessed. Freshwater snails native to Hawaii belong to two families, Neritidae, comprising three species, and the Lymnaeidae with four recognized species. The taxonomic framework for the Hawaiian Lymnaeidae dates to the 1950s. *Erinna newcombi*, protected under the US Endangered Species Act, is the only lymnaeid in Hawaii assessed in the last 100 years, but none of the Hawaiian taxa have been evaluated using modern species concepts. Hubendick recognized five Hawaiian *Lymnaea* species, considering all widespread on multiple islands, except *L.* (*Erinna*) *newcombi*. Others recognized two species in the genus *Erinna* and two in *Lymnaea*. To update the taxonomic framework necessary for developing effective conservation assessments we are undertaking surveys across the main Hawaiian Islands and analysing historical and recently sampled material in an integrative taxonomic framework. Phylogenetic analysis indicates that there are at least six, and possibly as many as ten endemic lymnaeids, including two wholly sinistral species. There are four non-native lymnaeids established in the islands, which continue to spread. In contrast, many of the native species are geographically restricted, and in some cases consist of only a handful of individuals. For example, fewer than 15 of the sinistral *Pseudisidora producta* have been recorded in the last 20 years. Hawaiian lymnaeids inhabit ephemeral 'vertical wetlands' in waterfalls and seeps. Diminishing water supply and the spread of invasive species are likely to extirpate populations, driving extinction to a diverse fauna that remains poorly understood.

BIOSTRATIGRAPHY OF SOUTHERN CALIFORNIA FAUNAL AND FLORAL ASSEMBLAGES OF THE SAN DIEGO MIDDLE EOCENE: 4S RANCH AND WESTVIEW HIGH SCHOOL

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The middle Eocene marine formations of western San Diego County, California are often abundantly fossiliferous, yielding rich marine invertebrate faunas, and less often, terrestrial vertebrate and/or terrestrial or aquatic plant assemblages. In the unincorporated 4S Ranch residential community west of Rancho Bernardo and at Westview High School in Rancho Peñasquitos, sediments of the informal upper member of the Friars Formation have yielded composite assemblages that are particularly significant biostratigraphically due to their mixed combination of terrestrial and aquatic vertebrates, terrestrial and aquatic plants, and terrestrial and aquatic mollusks (Kennedy & Shiller, 2003, 2010). These mixed assemblages thus provide the only well dated benchmark for comparison of biostratigraphic geochronologies based on different suites of organisms (vertebrates, invertebrates, and plants). Based on dated stratigraphic ranges of the terrestrial vertebrate assemblage in the upper member (or "tongue") of the Friars Formation, the faunas represent the early part of the early Uintan NALMA of Walsh (1996) and Walsh et al. (1996) and date to ~45 Ma (million years). This finite timeline can thus be used in refining and correlating non-vertebrate biostratigraphic chronologies lacking geochronologic marker horizons, such as locally for the associated molluscan faunas and paleofloras. The two vertebrate faunas from the upper Friars Formation member comprise the newly proposed 4S Ranch and Westview local faunas (l.f.).

Geographically, the middle Eocene fossiliferous sediments at 4S Ranch were deposited in a protected coastal embayment formed by topographic highs consisting of Cretaceous granitic and metavolcanic rocks, limiting the maximum transgressive extent and sea level high stand of the middle Eocene in the San Diego region. The final "as graded" geologic map (Langpap & Evans, 1997, fig. 2) of the southern part of 4S Ranch (i.e., Neighborhood One) differs considerably from that mapped by Kennedy and Peterson (1975). Mapped exposures of the "Mission Valley Formation" and "Stadium Conglomerate" are now assigned to the upper sandstone and middle conglomerate members of the Friars Formation of Walsh et al. (1996). Some of the original "Friars Formation" outcrops in La Jolla Valley were simply deeply weathered metavolcanics.

The site of Westview High School, southwest of 4S Ranch, is located up to 2 km from the the topographic highs that formed the middle Eocene shoreline. The sediments here were previously mapped as the "Mission Valley Formation" and "Stadium Conglomerate" (Kennedy & Peterson, 1975). However, based on the lithostratigraphy exposed during mass grading projects to the west of the school site (unpublished data), and the vertebrate revelation that the so-called "Mission Valley Formation" sediments were too old and more appropriately assignable to the expanded Friars Formation of Walsh (1996) and Walsh et al. (1996), the stratigraphic section is now interpreted to consist (in ascending order) of the Delmar Formation, Torrey Sandstone, Scripps Formation, and Friars Formation (Kennedy & Shiller, 2003).

INVERTEBRATES (Table 1)

The middle Eocene marine invertebrate faunas of western San Diego Co., which are dominated by bivalve and gastropod mollusks, are locally extensive, deserve monographic treatment, and, being geographically well south of coeval faunas in Ventura and Los Angeles counties, differ somewhat in both depositional environment and faunal makeup from those farther to the north. At 4S Ranch they make up an important part of the mixed faunal and floral assemblage from the brackish lagoonal to estuarine siltstones and silty sandstones assigned to the upper member (or "tongue") of the Friars Formation of Walsh et al. (1996). The invertebrate fauna at 4S Ranch includes on the order of 35-40 species of bivalve and gastropod mollusks (Table 1), as well as sponges (*Cliona*-like borings), bryozoans (unidentified encrusting forms), and crustaceans (Kennedy & Shiller, 2010).

The primary invertebrate fauna at Westview High School (Kennedy & Shiller, 2003) is assigned to the more open water, but still shallow nearshore, marine conditions of the Scripps Formation. The fossiliferous marine sandstones are stratigraphically overlain by estuarine and mudflat facies with abundant razor clams (*Solena subverticala* Vokes, 1939). It was unclear, however, if the estuarine/mud flat sediments represented the uppermost Scripps Formation sediments or belonged to the overlying Friars Formation, but they graded upward into coastal dune sediments, which in turn graded upward into the vertebrate-bearing beds, all without an evident stratigraphic break. The contact between the two formations was thus arbitrarily placed where the sediments transitioned from marine to terrestrial. The coastal dune deposits have yielded large planispiral land snails that are reminiscent of the modern chestnut shell, *Glyptostoma* n*ewberryanum* (Binney, 1858), and of a *Macrocyclis* described from the Colorado Eocene.

Middle Eocene lithostratigraphic units in western San Diego County have previously been assigned to one of three Pacific Coast provincial "stages," being the "Domengine," "Transition," and "Tejon" on the basis of their molluscan faunas (Givens & Kennedy, 1979). In their review of local "stage" assignments, the Friars Formation and upper part of the underlying Scripps Formation were assigned to the "Transition stage" on the basis of their molluscan faunas. However, no defining molluscan species are known to be restricted to the "Transition stage," which locally is characterized by the overlapping lowest stratigraphic ranges of "Tejon" species and highest stratigraphic ranges of "Domengine" species (Givens & Kennedy, 1979, p. 87). Additionally, none of the species used to define the local "Transition stage" is present in the recovered fauna from 4S Ranch, which may be due to the estuarine/lagoonal nature of the assemblage in that depositional environment. Although the local faunas can now be placed into a biostratigraphic succession, the absolute geochronologic ages of these faunas is still undergoing investigation. In one previous summary, Squires (2003, fig. 2.1) assigned an age of 46 to 47 Ma to the "Transition stage" in southern California.

VERTEBRATES (Table 2)

The vertebrate fauna (Table 2) from the upper member of the Friars Formation exposed along Deer Ridge Place in 4S Ranch is dominated by crocodilian and soft-shelled turtle remains, but also includes cartilaginous and bony fish, cheloniid turtles, lizards, snakes, birds(?), and typical early Uintan terrestrial mammals (early primates, rodents, carnivore, brontothere, tapir, rhinoceras and small deer-like browsers). This mixed aquatic and terrestrial assemblage is here named the 4S Ranch local fauna (l.f.). The early Uintan NALMA age of the assemblage supports a numerical age of approximately 45 million years (Ma) for the 4S Ranch local fauna.

According to Walsh (1996), the early Uintan/late Uintan boundary in southern California can be characterized by the extinction of a number of early Uintan genera, including the small brontothere *Metarhinus*. The beginning of the early Uintan has also been defined and characterized by the presence of the rhinoceratoid genus *Amynodon* and the small deer-like artiodactyl *Leptoreodon*. Although the vertebrate fauna from the estuarine-marine beds at 4S Ranch is dominated by aquatic vertebrates, the most abundant terrestrial mammals are *Metarhinus pater, Leptoreodon*

marshi, and an unidentified *Leptoreodon*, thus solidifying the early Uintan age assignment of the 4S Ranch vertebrate fauna.

The Westview l.f. (Table 2), also from the upper member of the Friars Formation in Rancho Peñasquitos, differs in that it is mainly represented by smaller terrestrial mammal groups (opossum, apatothere, "hedgehog," "shrew," bat, lemur and/or tarsier, and rodent), in addition to tapir and a deer-like browser (Walsh, 2003). At least 24 species of mammals were recovered from Westview High School and comprise the newly proposed Westview local fauna. The school site has yielded a significant mammal assemblage fairly typical of the upper part of the Friars Formation in the Rancho Peñasquitos area. The assemblage is dominated by the insectivore *Crypholestes vaughni* and the rodents *Microparamys* cf. *M. minutus* and *Sciuravus powayensis*. Also common are the marsupial *Peratherium* cf. *P. knighti,* the tarsiiform primate *Washakius woodringi*, the tiny primate(?) *Uintasorex montezumicus*, and the eomyid rodent *Metanoiamys agorus*. Unusual is the apparent absence of the artiodactyls *Leptoreodon* and *Protoreodon*, which are common in most other well sampled localities in the upper part of the Friars Formation.

The Westview assemblage is clearly early Uintan in age, based on the presence of *Crypholestes vaughni*, *Patriolestes novaceki*, *Washakius woodringi*, *Microparamys* cf. *M. minutus*, *Sciuravus powayensis*, *Metanoiamys agorus*, *Merycobunodon littoralis*, and the absence of typical late Uintan taxa such as *Sespedectes*, *Proterixoides*, and *Simimys*. The early Uintan NALMA age of the assemblage supports a numerical age of approximately 45 million years (Ma) for the Westview local fauna.

PLANTS (Table 3)

Paleobotanically, the 4S Ranch and Westview High School floral assemblages, even when considered together, are only moderate in size. Included among them are plant structures analogous to water-lily pads and rhyzomes, but whose taxonomic placement is uncertain and needing definition. They are common at Westview High School, but also occur in the Mount Soledad Formation (lower conglomerate member), and in the Friars? and Scripps Formations. Another important discovery is of *Neomeris*, a lime secreting Dasycladoceran green alga (Chlorophyta) from the upper Friars Formation member at 4S Ranch, and in the Scripps Formation, at Westview High School and at additional localities above San Clemente Canyon. *Neomeris* is common in the Lutetian middle Eocene in the Paris Basin of France and in North Africa, but previously unknown in California.

The leaf-dominated paleofloras from 4S Ranch and Westview High School grew along the edges of fresh or brackish water coastal lagoons. Compositionally and vegetatively the floras are similar to the previously described fluviodeltaic Torrey Flora near Del Mar (Myers, 1991), elements of which reflect a dense multi-tiered broadleaved evergreen rainforest growing under humid paratropical climatic conditions with a mean annual temperature of > 20° C. [68° F.] and without a significant dry season.

The overall paleofloras from 4S Ranch and Westview High School are correlative with the lowermost "Franklinian" and "Fultonian" [paleobotanical "stages"] assemblages of the Puget Group, Washington (Wolfe, 1968) that grew near sea level, share floristic elements with San Diego area floras, and have been K/Ar dated at ~45 Ma by Turner et al. (1983) (Myers, 2003, 2010). Temporally equivalent, or slightly younger, floras from the Pacific Coast interior include the 44.5 to ~43.5 Ma Clarno Flora of central Oregon and the ~45 Ma Chalk Bluffs Flora of the central Sierra Nevada (MacGinitie, 1941), both of which grew on the seaward facing slope of the Paleogene Cordillera at elevations of ~1,000 m.

Table 1: Preliminary list of molluscan fossils from the informal upper member of the Friars Formation in the vicinity of Deer Ridge Place, in Neighborhood One of the 4S Ranch residential community, unincorporated San Diego County, California. Collections at LACMIP, identified by G. L. Kennedy.

Mollusca: Bivalvia

Acesta sp., or Anomiidae, indet.
Acutostrea idriaensis (Gabb, 1869)
Barbatia morsei Gabb, 1864
Brachidontes cowlitzensis (Weaver & Palmer, 1922)
Claibornites diegoensis (Dickerson, 1916)
Corbicula sp.
Cuneocorbula torreyensis (Hanna, 1927)
? Lucinidae, indet.
Miltha packi (Dickerson, 1916)
Neotrapezium californicum Squires, 1999
Ostrea [*s.l.*] sp., indet.
Pachyperna goniglensis (Hanna, 1927)
Panope torreyensis (Hanna, 1927)
Pelecyora aequilateralis (Gabb, 1869)
Phygraea stewarti (Hanna, 1927)
Tellinidae, indet. (several species)
Bivalvia, indet. (several species)

Mollusca: Gastropoda

"*Ampulospira" luda* (Hanna, 1927
Calyptraea diegoana (Conrad, 1855)
Cerithiidae, indet.
Crepidula pileum (Gabb, 1864)
Crepidula sp., new?
? *Crommium andersoni* (Dickerson, 1914), or ? *Ampullella schencki* Vokes, 1839
? Fusinidae, indet.
Marinula sp., new
Naticidae, indet.
Nerita kennedyi Squires & Saul, 2002
Nerita triangulata Gabb, 1869
Pulmonata, indet. (heliciform in shape)
Pulmonata, indet. (small, planispiral in shape)
Pyrgulifera lajollaensis (Hanna, 1927)
Siphonalia vistaensis Givens & Kennedy, 1976
Terebra californica Gabb, 1869
? *Tympanotonos californicus* Squires, 1999
Umpquaia oregonensis Turner, 1938
? *Zachrysia fraterna* Roth, 1988
Gastropoda, indet. (including microgastropods)

Table 2: Preliminary list of vertebrate fossils from the upper member of the Friars Formation in the vicinity of Deer Ridge Place, in Neighborhood One of the 4S Ranch residential community (4S Ranch local fauna), and at Westview High School in Rancho Peñasquitos (Westview local fauna), San Diego County, California. Collections at UCMP, identified by S. L. Walsh (mammals), D. P. Whistler (mammals, reptiles), J. D. Stewart (fish remains), and I. D. Browne (mammals, birds).

	4S Ranch l.f.	Westview l.f.
Chondrichthyes (cartilaginous fish)		
cf. *Myliobatis* sp. (bat ray caudal spine; teeth)	x	x
Osteichthyes (bony fish)		
Unidentified vertebra	x	-
Unidentified cycloid and ctenoid scales	x	x
Reptilia (reptiles [snakes, lizards, turtles, crocodiles])		
Squamata (snakes & lizards)		
Boidae, unidentified	x	x
Unidentified snake	-	x
Xantusiidae (night lizards)		
Palaeoxantusia sp.	-	x
Anguidae (aligator lizards)		
Melanosaurus or related form	-	x
Glyptosaurus or related form	-	x
Testudines (turtles)		
Cheloniidae, unidentified	x	-
Trionychidae (soft-shelled turtles)		
Apalone sp. (common)	x	-
Crocodylia (crocodiles)		
Unidentified teeth, misc. bones & dermal scutes	x	-
Aves (birds)		
Unidentified wading? bird(s), unidentified toe bones	x	-
Mammalia (mammals)		
O. Marsupialia (marsupials)		
Peritherium cf. *P. knighti* McGrew, 1959 (small opossum)	-	x
Peritherium cf. *P. innominatum* Simpson, 1928 (smaller opossum)	-	x
Peradectes sp. (even smaller opossum)	-	x
O. Apatotheria (apatotheres)		
Aethomylos simplicidens Novacek, 1976 (aye-aye)	-	x
Aethomylos sp., new small species	-	x
O. Insectivora (insectivores)		
Crypholestes vaughni (Novacek, 1976) (small “hedgehog”)	-	x
Patriolestes novaceki Walsh, 1998 (larger “hedgehog”)	-	x
Scenopagus cf. *S. priscus* (Marsh, 1872) (small hedgehog)	-	x
Centetodon aztecus Lillegraven, McKenna & Krishalka, 1981 (“shrew”)	-	x
Centetodon cf. *C. bembicophagus* L.., M. & K., 1981 (smaller “shrew”)	-	x
Batodonoides powayensis Novacek, 1976 (tiny “shrew”)	-	x
cf. *Nyctitherium* sp. (small “shrew”)	-	x

	4S Ranch l.f.	Westview l.f.
O. Chiroptera (bats)		
cf. Chiroptera (bat)	-	x
O. Primates (primates)		
Cantius actius (Gunnell, 1995) (small lemur)	-	x
Washakius woodringi (Stock, 1938) (small tarsier)	-	x
Stockia powayensis Gazin, 1958 (small tarsier)	-	x
Uintasorex montezumicus Lillegraven, 1976 (tiny ?primate)	-	x
Unidentifed teeth of early lemur or tarsier-like primate	x	-
O. Rodentia (rodents)		
Microparamys cf. *M. minutus* (Wilson, 1937) (small “squirrel”)	-	x
cf. *Pseudotomus* sp. (large “squirrel”)	-	x
Ischyromyidae, indet.	-	x
“Leptotomus” caryophilus Wilson, 1940	x	-
Sciuravus powayensis Wilson, 1940 (rat-sized rodent)	-	x
Metanoiamys agorus Chiment & Korth, 1996 (mouse-sized rodent)	-	x
Family uncertain, unidentified femur, other? bones	x	-
O. Carnivora (carnivores)		
Carnivora, indet. (unidentified teeth)	x	-
O. Perissodactyla (odd-toed ungulates)		
Hesperaletes walshi Colbert, 2006 (tapir)	-	x
Metarhinus pater Stock, 1937 (brontothere)	x	-
O. Artiodactyla (even-toed ungulates)		
Leptoreodon marshi Wortman, 1898	x	-
Leptoreodon sp., unidentified	x	-
Merycobunodon littoralis Golz, 1976 (primitive camel)	-	x
Artiodactyla, indet. (unidentified teeth & bones)	x	-

Table 3: Preliminary list of fossil plant remains from the upper member of the Friars Formation in the vicinity of Deer Ridge Place, in Neighborhood One of the 4S Ranch residential community, unincorporated San Diego County, California. Collections at UCMP, macroscopic remains identified by J. A. Myers.

Chlorophyta: Ulvophyceae
Neomeris sp. (lime secreting green alga)
Pteridophyta: Pteridopsida (ferns)
Unidentified fern pinna
Magnoliophyta: Liliopsida (flowering plants: monocots)
Narrow leaf of rush or reed
Sabalites sp. (palmetto-like palm)
Magnoliophyta: Magnoliopsida (flowering plants: dicots)
Anacardiaceae, indet. (leaves, sumac/poison oak family)
Magnoliaceae, indet. (leaves, magnolia family)
Phytocrene sordida (Lesquereux, 1878) (leaf, vine)
"*Terminalia*" sp. (fruiting structure)
Unidentified leaf material (terrestrial shrubs and/or trees)
Woody plant material
Nondescript vegetative plant debris
Impression of nut or fruit?

_____

Note: Plant remains from additional plant horizons at both 4S Ranch and Westview High School (Myers, 2003, 2010) are not listed in Table 3 because they were not directly associated with the vertebrate assemblages at Westview High School nor in the estuarine/lagoonal sediments at 4S Ranch that yielded the composite mixed vertebrate, invertebrate and floral assemblage.

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PHYLOGENOMIC RESOLUTION OF THE PANPULMONATE RADIATION: NEW INSIGHT INTO THE EVOLUTION OF AIR BREATHING

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Transitions to terrestriality have been associated with several major animal radiations, including land snails and slugs in Stylommatophora. With >20,000 described species, stylommatophorans comprise the most successful lineage of 'pulmonates,' a traditional but non-monophyletic assemblage of air-breathing gastropods. However, phylogenomic studies have failed to robustly resolve relationships among groups historically recognized as 'pulmonates' and affiliated marine lineages that together comprise clade Panpulmonata (Mollusca, Gastropoda). Two key taxa that have proven especially difficult to place are Sacoglossa, a group including photosynthetic sea slugs, and Siphonarioidea, intertidal limpet-like snails with a non-contractile pneumostome (a narrow opening to a vascularized pallial cavity). Given that the pneumostome may have been a pre-adaptation to fully terrestrial life, resolving the placement of Siphonarioidea is critical to clarify the evolutionary history of the panpulmonate radiation. We performed phylogenomic analyses on datasets of up to 1,160 nuclear protein-coding genes for 110 gastropods, including 40 new transcriptomes for Sacoglossa and Siphonarioidea. All 18 analyses recovered Sacoglossa as the sister group to a clade we named Pneumopulmonata, within which Siphonarioidea was sister to the remaining lineages in most analyses. Comparative modeling indicated shifts to marginal habitat (estuarine, mangrove or intertidal zones) preceded and accelerated the evolution of a pneumostome, which was recovered as present in the pneumopulmonate ancestor along with a one-sided plicate gill. These findings highlight key intermediate stages in the evolution of air-breathing snails, supporting the hypothesis that adaptation to marginal zones played an important role in major sea-to-land transitions.

DO NEW HIGHER RESOLUTION MAPS OF SOUTHERN CALIFORNIA KELP FORESTS IMPROVE OUR HABITAT SUITABILITY MODELS OF PINTO ABALONE (HALIOTIS KAMTSCHATKANA)?

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In 2016 (Ostrowski et al. 2019), we constructed a GIS-based multivariable habitat suitability model for San Diego County, California populations of pinto abalones (*Haliotis kamtschatkana* Jonas, 1845). The model incorporated a field-collected subtidal survey data set from depths of 13-30 m that was obtained in a separate study by one of us (Bird 2018); this included not only abalone transect surveys conducted by a team of scuba divers but also included their characterization of substrate type, kelp coverage, and bathymetry for each pinto abalone found. Our preliminary results implied that modeling habitat rugosity alone was surprisingly effective in predicting the presence of the rather sparsely distributed pinto abalones, but we also concluded that the then-available bathymetry GIS data sets for this region and for the subtidal range of depth were quite limited in their resolution, and this could have influenced the support for the observed association. Now, in 2022, one of us (EO) has been working as a GIS-based professional and has witnessed a steady improvement in the resolution for the sort of data sets we had used. NOAA now has a combined topographic and bathymetric (topobathy) Digital Elevation Model (DEM) available at 1-meter resolution, improved from the 9-meter resolution DEM we used previously. Here we will present our conclusions from repeating our modeling with the same field-collected data set with the improved DEM and using slightly newer analysis approaches. We are evaluating whether this difference has led to an improved model of habitat suitability for pinto abalones in kelp forests off San Diego County. These results could have implications for those interested in the conservation and restoration efforts for this and other abalone species in California, a group whose populations have been decimated by a combination of over-collection coupled with recent epidemics specific to abalones. Our study could also have more general implications for modeling kelp forest subtidal habitat suitability for other specific species or entire communities in California and beyond.

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MORTALITY OF DEROCERAS RETICULATUM AND ANNUAL RYEGRASS CROP PROTECTION CONFERRED BY THREE SPECIES OF PHASMARHABDITIS NEMATODES

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The nematode *Phasmarhabditis hermaphrodita* is a commercially available biological control agent for pest slugs in Europe, and the congeners *Ph*. *papillosa* and *Ph*. *californica* cause mortality in various pest slug and snail species. The Gray Fieldslug (*Deroceras reticulatum*) is one of the most damaging invasive gastropod species in the world. In Oregon, this species causes an estimated $100 million worth of annual damages to the grass seed industry. Here, we evaluate Annual Ryegrass (*Lolium multiflorum*) crop protection conferred by three species of *Phasmarhabditis* nematodes on *D. reticulatum* in a microcosm. We compare crop protection to a common chemical molluscicide (liquid metaldehyde), as well as to positive control (no slugs) and negative control (only slugs). We report a significant difference in slug mortality between nematode treatments throughout much of the experiment duration. All nematode treatments resulted in significantly higher slug mortality than metaldehyde and negative control treatments throughout most of the experiment. Mortality in the metaldehyde treatment did not significantly differ from the negative control throughout this research. All treatments conferred more crop protection than the negative control. That amount of crop protection conferred by *Ph. hermaphrodita*, *Ph. papillosa*, and liquid metaldehyde did not significantly differ from each other or from the positive control for the majority of this experiment; all three of these treatments conferred more crop protection than *Ph. californica* throughout most of the experiment. These data highlight the potential for using *Ph. hermaphrodita* and *Ph. papillosa* as biological control agents. However, before an informed decision can be made on their use in pest management it will be critically important to conduct comprehensive host range testing incorporating native gastropod species.

BROADSCALE DISTRIBUTION, ABUNDANCE AND HABITAT ASSOCIATIONS OF THE INVASIVE ASIAN CLAM (*CORBICULA FLUMINEA*) IN THE LOWER COLUMBIA RIVER, USA

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The Asian clam, *Corbicula fluminea*, is an invasive freshwater bivalve that has established populations across the globe and is known to have deleterious effects on natural and human systems. Yet, despite being present in the Columbia River (CR) for nearly a century, little is known about this invader's basic biology and ecology in this large river system. Thus, we undertook a field study to assess its i) broadscale distribution and abundance, and ii) associations with habitat characteristics in the lower CR. During 2019-20, *C. fluminea* were collected from 27 shore-based stations spanning 481 river kilometers of the lower CR, along with several habitat characteristics (bank slope, temperature, dissolved oxygen, pH, salinity, conductivity, chlorophyll-*a* concentration, and sediment composition and % organic matter). *C. fluminea* abundance ranged from 0-430 ind. m^{-2}. Most sites with abundances >100 ind. m^{-2} were located downstream of Bonneville Dam, while most sites with abundances < 100 ind. m^{-2} were located upstream. Generalized linear models predicting the abundance of *C. fluminea* indicated significantly positive correlations with water temperature and % sand, and negative correlations with bank slope and sedimentary % organic matter. We also reviewed the global literature on abundance and habitat associations of *C. fluminea* and compared this with our own results. Our investigation represents the greatest spatial extent at which *C. fluminea* has been studied in the CR and our results provide a better understanding of the basic biology and ecology of this global invader, as well as provide natural resource managers with information on habitat conditions favorable for this invasive bivalve within temperate river ecosystems.

NEW RECORDS OF THE FOSSIL BIVALVE GENERA *ACESTA* (FAMILY LIMIDAE) AND *MALLETIA* (FAMILY MALLETIIDAE) FOR THE EOCENE OF SAN DIEGO COUNTY, CALIFORNIA

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Introduction

Two bivalve genera, *Acesta* and *Malletia*, were collected from compact, greenish-gray shales of the Ardath Shale of the middle Eocene La Jolla Group during mitigation activities for a private residence on the western slope of Mount Soledad in La Jolla, San Diego, California (Figure 1). Three internal and external mold part-counterpart specimens of single *Acesta* valves were obtained from one field site, TW-Amin-06, from San Diego Society of Natural History (SDSNH) locality 7687. These specimens are relatively large and include an 84 mm long complete left valve internal mold. More than four dozen specimens of *Malletia* were discovered from all field sites of SDSNH locality 7687 and only one poorly preserved specimen was found from SDSNH locality 7686. This bivalve is relatively small, averaging about 20 mm in size. A search of the San Diego Natural History Museum fossil collection database and a review of the literature (Moore, 1987; Groves and Squires, 2021) indicate *Acesta* and *Malletia* are new to Eocene rocks in San Diego County.

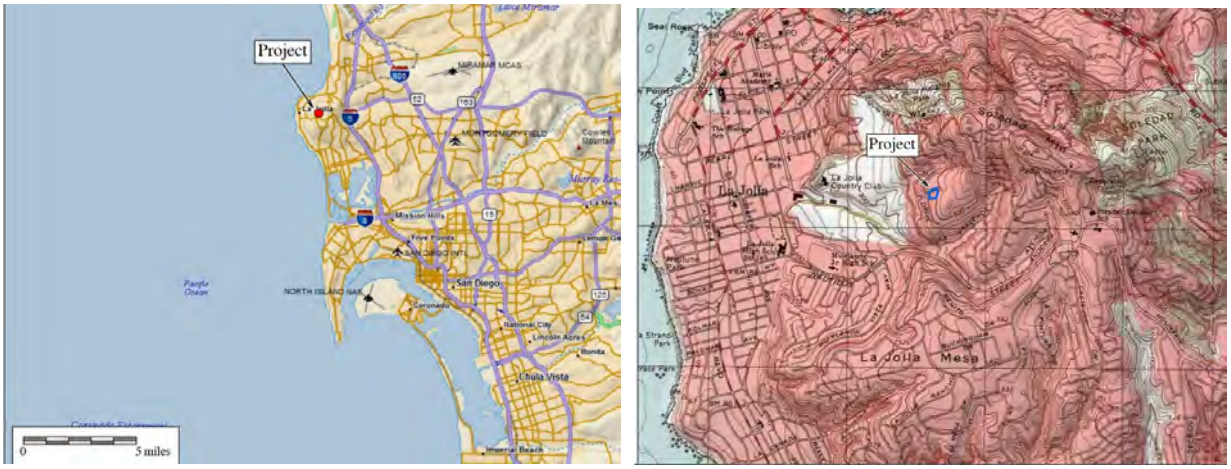

Figure 1: Project site

Associated Fauna and Environmental Setting

The new bivalves are associated with a rich invertebrate fauna including a foram, solitary coral, annelid worm, mollusks (gastropods, bivalves, scaphapods, and a nautiloid), arthropods (ghost shrimp) and echinoderms (heart urchin). These taxa indicate a mix of deeper shelf and shallower nearshore marine environments. Mollusk species that likely inhabited the deepest part of the shelf include the bivalves *Portlandia rosa*, *Cardiomya israelskyi*, and the scaphapod *Cadulus* sp., and indicate a depth range of around 50 to 150 meters. Living *Acesta* and *Malletia* can be found at even greater depths. A European species of *Acesta* lives to 2,635 meters (Abbott and Dance, 1982), and

Malletia is reported to live at a depth as great as 2,930 meters (Keen and Coan, 1974). Most of the other species are invertebrates that lived in more shallow water depths of around 10 to 50 meters, including the gastropods *Architectonica* sp. cf. *A. cognata*, *Calyptraea diegoana*, and *Turritella uvasana* sensu lato, and the bivalves *Nemocardium linteum*, *Miltha packi*, and *Plicatula juncalensis* (Squires, 1987). These species and numerous others correlate to species and genera of the upper transition zone of the lower Eocene Juncal Formation, with the exception of *P. juncalensis* from the mudstone facies at the base of the formation (Squires, 1987). Since described by Squires (1987), three additional specimens of *P. juncalensis* have been collected from the Ardath Shale in La Jolla, San Diego County, including the two from SDSNH locality 7687, and one other from the Torrey Pines Golf Course, SDSNH locality 7366.

Fragmentary remains of two ghost shrimp (Callianassidae) species, *Neocallichirus rhinos* and possibly *Vegarthron santiago* were recovered from SDSNH localities 7686 and 7687 as internal and external molds of claws and pincers. Previously, primarily fossil molds and exoskeleton shell remains of claws and pincers from un-named Callianassids have been known from the shelf deposits of the Ardath Shale and Scripps Formation of the La Jolla Group of central coastal San Diego County. Species of ghost shrimp were named from shallow marine to nearshore estuarine deposits of the Santiago Formation in the northern coastal region of the county (Schwietzer and Feldmann, 2002), with one species, *Neocallichirus rhinos*, also described from the Ardath Shale, from SDSNH locality 4529, with four specimens, including three whole bodies. Extremely few invertebrate fossil species are shared in common between the coeval La Jolla Group shelf deposits and the estuarine deposits of the Santiago Formation as a result of the paleoenvironmental differences between the two. But the ghost shrimp species they share indicate Callianassids thrived as well in the fine–grained continental shelf sediments as well as the very fine- to more coarse-grained estuary sediments.

a.  b. 

Figure 2. *Acesta* sp. New species of Limid bivalve, new record for San Diego County. The large specimen (a) includes a complete internal mold (on the left). The smaller, partial specimen (b) exhibits a much better preserved hinge area. On this specimen, the angular cuts of the carbide rod blade can be clearly seen on the surrounding matrix block. Very careful cutting, and luck, made it possible to extract these specimens.

a.  b. 

Figure 3. *Malletia* sp. New record for San Diego County. A small, fragile clam of order Nuculoida with many hinge teeth; a row of more than two dozen can be counted in the photo of the internal mold valve (a). The internal mold pair (b) shows that this Eocene species has a moderately inflated shell. Lengths of internal molds: 15 mm (a) and 12 mm (b).

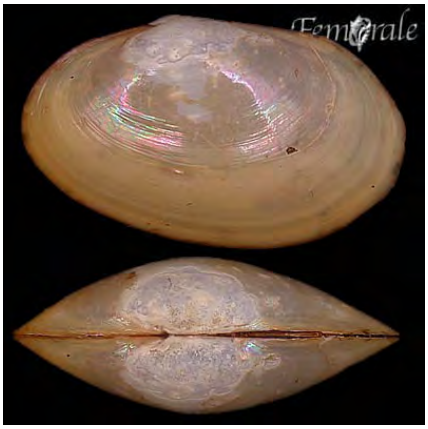

Figure 4. *Malletia talama*. A species living today. This specimen, > 14mm, was dredged by a research boat at 1,260 meters in the Catalina Basin, California (photo compliments of Marcus Coltro of Femorale).

Figure 5. *Portlandia rosa.* A smooth-shelled Nuculoid clam with a bluntly rounded posterior end that lived near the surface of marine sediments in deeper water. This species, along with *Periploma eodiscus* and *Tellina rosa* is more common in the Ardath Shale than the Scripps Formation. The black stains on the specimens are unusual. Orange color of the sandstone is caused by oxidation. Specimen is 14 mm in length.

a.  b. 

Figure 6. cf. *Vegarthron santiago.* If complete, this claw would be triangular in shape, strongly suggesting this species. The far more easily identified *Neocallochirus rhinos*, with a characteristically square claw (due to a larger space between the pincers) is also common in the Ardath Shale. Specimen lengths: (a) 12 mm and (b) 8 mm.

Figure 7. *Fusinus* sp. External mold of a large unidentified species.

a.  b. 

Figure 8. *Plicatula juncalensis.* A small, ornate species of bivalve characteristic of shallower nearshore depths. A living species of the southeast region of the United States is the Kitten's Paw, *Plicatula gibbosa*. Specimens 1 cm in length.

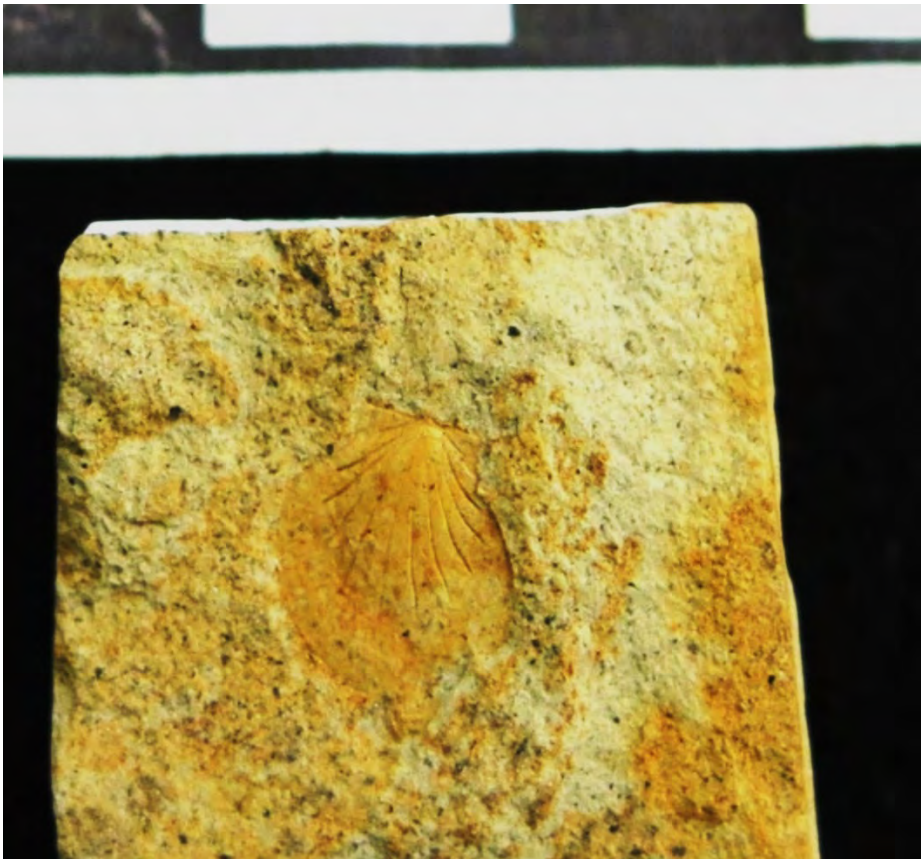

Figure 9. Propeamussidae. A family of deep water scallops with very thin valves having thickened radiating ribs that provide strength to the shell.

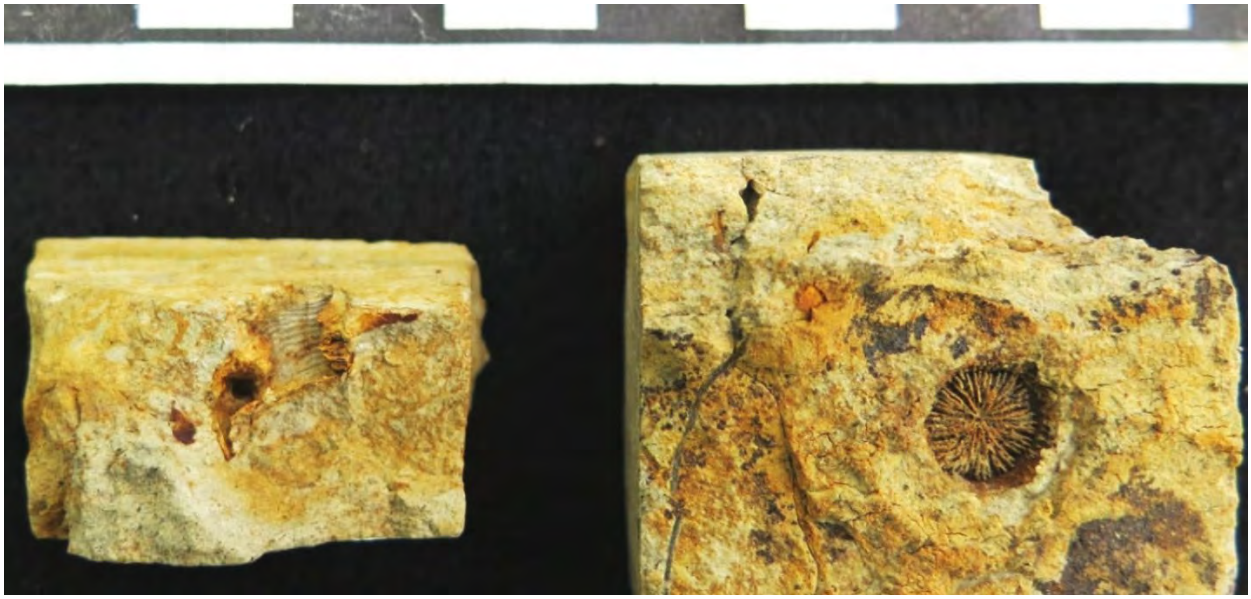

Figure 10. (Order) Scleractinia. A species of solitary coral. A top view of one calyx, and cross-section of another.

Geology

The Ardath Shale represents predominately fine-grained sediments deposited in a deep-marine, off-shore, continental shelf environment (Kennedy and Moore, 1971; Kennedy, 1975), although submarine channel fill deposits consisting of mudstones and cross-cutting sandstones characterize the formation along Black's Beach, north of the localities, as well (Campion et al., 1996). The Ardath Shale, along with the conformably underlying basal Mount Soledad Formation, are the only formations of the La Jolla Group mapped as bisected by the Rose Canyon fault zone, a major right-lateral strike-slip feature within San Diego (Kennedy, 1975). At the parcel, the Ardath Shale consisted of two blocks displaced by a fault of uncertain offset and slip direction. Fossils were collected from both sides of the fault, representing the two localities, both being derived from similar fossiliferous shales with some interbeds of very fine-grained sandstone. West of the fault, the shales were overlain by an unfossiliferous, homogeneous, silty clay of the Ardath Shale.

Significance

This report is likely the first publication treating Ardath Shale fossil localities occurring west of the Rose Canyon fault zone since Hanna (1926, 1927) listed just two gastropods at his locality 3984, underscoring a dearth of paleontological research for a significant areal portion of the formation.

Notes on Preparation

The large specimens of *Acesta* sp. were removed by very carefully noting the orangish coloring (from oxidation) along the internal/external valve mold edge, estimating the position of the specimen in the matrix and cutting precisely at the angle of the specimen with a carbide rod blade mounted on a hacksaw handle. The angle of the saw cuts can be clearly seen on the block with the partial valve external mold in Figure 1a. The specimens of *Malletia* were simply removed by breaking pieces of the shale until the internal and external molds of valves were revealed. The groove in which the molds of teeth occur protects these, and care was taken to leave the sides of the grooves relatively high for this reason.

Table 1: Number of specimens of each species from the Middle Eocene Ardath Shale recovered from the Mount Soledad Project.

Taxon Taxonomic identifications by N. Scott Rugh	**SDSNH Locality No.**		
	7686	**7687**	
		TW-Amin-06	**All others**
Foraminifera			
Nodosaria sp.	—	—	1
Anthozoa: Scleractinia			
Solitary coral, indet.	—	1p	1pf, 5f
Annelida: Polychaeta (marine worms)			
Rotularia tejonense (Arnold, 1910)	—	—	2
Mollusca: Bivalvia (clams and scallops)			
Acesta sp. (3 lots)	—	3pf	—
Acila sp.	—	1	1
Cardiomya israelskyi (Hanna, 1927)	—	—	2f
Cuneocorbula torreyensis (Hanna, 1927)	—	1	—
Glycymeris rosecanyonensis Hanna, 1927	1p, 2f	—	—
cf. *Glycymeris* sp.	—	1	1
Glyptoactis sandiegoensis (Hanna, 1927)	2f	1pf, 7f	4p, 4f
Malletia sp.	1f	1p, 13	3p, 33
Miltha packi (Dickerson, 1916)	—	—	1p
Myrtucina roseburgensis (Turner, 1938)	—	—	1p, 1
Family Mytilidae?	—	1f	—
Nemocardium linteum (Conrad, 1855)	2f	—	3, 1f
Ostrea idriaensis Gabb, 1869	—	1f	2p, 1, 2f
cf. *Ostrea* sp.	1	—	—
cf. *Pitar* sp., cf. *P. avenalesis* Vokes, 1939	—	1	1p, 8f
Plicatula juncalensis Squires, 1987	—	1p	1
Portlandia rosa (Hanna, 1927)	6	2f	3p, 19, 7f
Family Propeamussidae	—	1	—
Pycnodonte stewarti (Hanna, 1927)	—	—	1pp
Nuculana (*Saccella*) *gabbi* (Gabb, 1869)	—	—	1p
Tellidorella mclellani (Hanna, 1927)	—	—	1p, 1
Tellina vorbei Hanna, 1927	—	—	1
Bivalvia, indet. (internal & external molds of unidentified clams)	1, 1f	—	1f
Mollusca: Gastropoda (snails)			
cf. *Alvania* sp.	—	1f	—
Architectonica sp. cf. *A. cognata* Gabb 1864	—	2f	1p
cf. *Arene mcleani* Squires, 1988	—	—	1f
Calyptraea diegoana (Conrad, 1855)	—	3	1p, 1

Taxon Taxonomic identifications by N. Scott Rugh	**SDSNH Locality No.**		
	7686	**7687**	
		TW-Amin-06	**All others**
Cerithium cliffensis Hanna, 1927	6	—	—
Conus hornii Gabb, 1864	—	—	1, 1f
cf. *Crommium* sp.	—	—	2f
cf. *Drillia cliffensis* Hanna, 1927	—	—	1p, 1
Fusinus sp.	1, 1f	—	3f
Gemmula tumata Hanna 1927	—	1p, 1f	1f
Natica (Carinacca) rosensis Hanna, 1927	—	—	1f
Family Naticidae	2f	1f	—
Sassia sp.?	—	1p, 3f	1pf, 8f
Scaphander costatus (Gabb, 1864)	—	—	2f
Surcula lindavistaensis Hanna, 1927	1f	—	—
cf. *Terebra* sp.	—	—	1
Tornatellaea rosa Hanna, 1927	—	—	1f
Family Trochidae?	—	1	2
Turritella uvasana (*s.l.*)	1p, 7	5f	1pf, 27f
Turritella sp.	—	1f	—
Gastropoda, indet.	1f	3f	1pf, 5f
Mollusca: Scaphopoda (tusk shells)			
Cadulus sp.	—	1	—
Dentalium sp.	—	1	2, 1f
Mollusca: Cephalopoda			
Order Nautiloidea (chambered nautilus)	1pf	1pf	2pf, 3f
Arthropoda: Crustacea: Malacostraca (crabs and relatives)			
Family Callianasidae, ghost shrimp	—	1f	—
Neocallichirus rhinos Schweitzer and Feldmann, 2002	1pf, 3f	—	—
Vegarthron santiago Schweitzer and Feldmann, 2002	—	—	1pf, 1f
Order Decapoda, indet.	1pf	—	1pf, 2f
Echinodermata			
Class Ophiuroidea, brittle stars	—	1p, 2f	—
Schizaster diabloensis Kew 1920	—	3f	1pf, 3f
Chordata: Osteichthyes (bony fish)			
Fish scale	1p	1p	—
Fish vertebrae	—	—	2pf, 1f
Plantae: Magnoliophyta (Angiosperms) (flowering plants)			
cf. *Terminalia* sp.	1pf	—	—
Magnoliophyta, slender leaf	—	—	1p
Leaf debris	—	1pf	—
Plant debris	1pf	—	—

Taxon Taxonomic identifications by N. Scott Rugh	SDSNH Locality No.		
	7686	7687	
		TW-Amin-06	All others
Ichnofossil (trace fossils)			
Diopatrichnus roederensis Kern 1978	6f	—	—
Coprolite?	—	2f	1pf, 1f

Abbreviations:
cf. – conferre (fragmentary specimen[s] compare to) indet. – indeterminate
f – fragment
p – part and counterpart present pp – three counterparts present
s.l. – *sensu lato*, in the broad sense sp. or spp. – species (unidentified)

Specimen numbers:
SDSNH loc. 7686 (field locs. TW-Amin-02, 03, 04, and 05): specimen numbers 160241 – 160262
SDSNH loc. 7687 (field loc. TW-Amin-06): specimen numbers 160169 – 160195 and 160263 – 160269
SDSNH loc. 7687 (field locs. TW-Amin-01, 07, 08, and 09): specimen numbers 160196 – 160240 and 160270 – 160272

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HYPERCALCIFICATION IN PERMIAN CIRCUMPOLAR SEAS: NOT WHAT YOU EXPECT

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The evolution of maximum body size is an enduring area of investigation for biologists and paleobiologists (Heim et al., 2015). To a first approximation, maximum body size in shelled molluscs is proportional to geological age so that few Paleozoic shells are as large as their Mezozoic and Cenozoic descendants (Fig. 1). The Permian shells of circumpolar Gondwana are exceptional in this respect.

Figure 1. LouElla R. Saul (1927-2021) with some big shells, Mesozoic and Modern. From a photograph taken by Takeo Suzuki at UCLA when LouElla was Museum Scientist in the Department of Earth and Space Sciences.

Ever since Robert Etheridge, Jr. and W. S. Dun carried out the first in-depth study of the iconic Gondwanan bivalve *Eurydesma*, its massively thickened shells have seemed anomalous for circumpolar conditions: “The umbonal region of the valves in *Eurydesma* is of extraordinary thickness, and it is interesting to note, as Mr. Charles Hedley has pointed out, that all recent bivalves comparable in valve thickness occur in tropical waters.” (Etheridge and Dun, 1910, p. ix). In addition, several species of eastern Australian bivalves, including *Eurydesma*, some gastropods, and many brachiopods are relative giants for Paleozoic seas, even at lower latitudes (Heim et al., 2015). *Eurydesma* grew to a maximum size of 15 cm, with umbones up to 6 cm thick. The unrelated but co-occurring anomalodesmatan bivalve *Myonia corrugata* achieved similar sizes and valve thicknesses (Runnegar, 1979). One specimen of the inoceramiform pteriomorph, *Aphanaia* de Koninck, is 40 cm in length, and 35 species of bivalves, gastropods and brachiopods were larger than 10 cm in length (Runnegar, 1984).

Modern polar bivalves tend to be small and thin-shelled (Nicol, 1967). If body volume in cubic millimeters is expressed logarithmically, then the big 35 eastern Australian Permian shells exceeded a logarithmic volume of 5 (100 ml), compared with only a single extant species of Antarctic bivalve. Likewise, modern polar taxa are drab in color, whereas at least three Australasian Permian species, including *Eurydesma cordatum* (Fig. 2D), were brightly colored (Percival et al., 2012; Runnegar, 1979; Waterhouse, 1963). To the degree that temperature is responsible for the differences in size and color, these observations together suggest that the early Permian high southern latitudes were not as cold as they are today. Indeed, the Miocene may represent a reasonable analog, as some Miocene

Antarctic bivalves are strikingly similar to common Permian ones, e.g., the Miocene scallop *Australochlamys anderssoni* (Beu and Taviani, 2014) and the comparable Permian one, *Deltopecten illawarensis* (Fig. 2B).

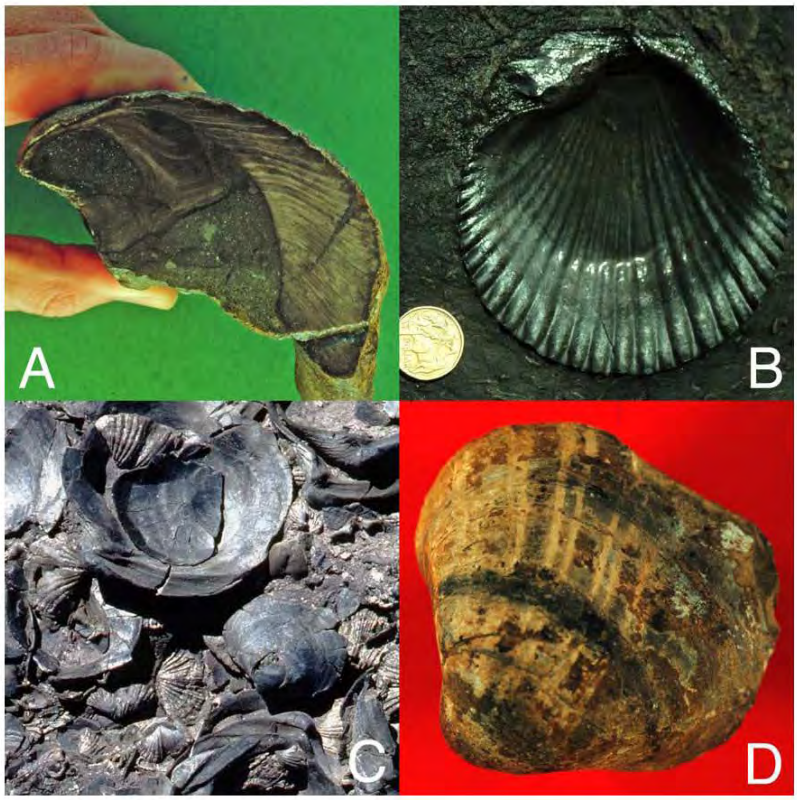

Figure 2. Examples of large, thick-shelled, and brightly colored bivalves from circumpolar latitudes in the eastern Australian Permian. A, *Myonia corrugata* Fletcher 1932, Port Kembla, NSW; B-C, *Deltopecten illawarensis* (Morris) 1845 and *Eurydesma hobartense* (Johnston) 1877, respectively, Maria Island, Tasmania; D, *Eurydesma cordatum* Morris 1845, Allandale, NSW. Coin in B is 2 cm in size, C is X0.5, D is X0.9. After Beard et al. (2015, fig. S4).

Is this an early example of polar gigantism, a phenomenon long attributed to the increased availability of dissolved oxygen in cold, high-latitude environments (Chapelle & Peck, 1999; Woods & Moran, 2020)? As metabolic rates drop with temperature, ambient temperature has a profound effect on maximum body size (White et al., 2022). In *Eurydesma*, shell calcification took place during the warmer seasons (Ivany & Runnegar, 2010; Beard et al., 2015) when particulate food was abundant and ocean waters were still cool enough to lower oxygen demand. Furthermore, unlike Antarctic waters which are highly corrosive, circumpolar Gondwanan seas were supplied with calcium and other cations by continental-scale rivers, and the fresh water they delivered may have enhanced oxygen availability. There is also evidence that cold conditions may promote individual and taxonomic longevity. Perhaps, in Charles Dickens's words, "it was the best of times" when circumpolar Gondwana was a haven for large and long lived calcitic and aragonitic "gentle giants"?

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THE COST OF ADAPTATIONS: RATE OF PARENTAL GROWTH OF THE POECILOGONOUS SPECIES ALDERIA WILLOWI (GASTROPODA: SACOGLOSSA: LIMAPONTIIDAE), AS A FUNCTION OF PRODUCING LECITHOTROPHIC VERSUS PLANKTOTROPHIC EGGS

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Natural selection can function on multiple hierarchical levels, including the pressure for individual survival. Differential survival and fitness of an individual influences the evolution of its population and species. This research project is to better understand the cost of an adaptation to individuals, therefore informing the influence of these adaptations in evolutionary contexts. The adaptations of interest are two different categories of eggs commonly made by marine invertebrates. Making eggs is energetically expensive and directly relates to fitness. Many marine invertebrates produce planktotrophic ("self-feeding") or lecithotrophic ("yolk-fed") larvae. Even sister species may make one or the other type. Individual species typically produce only one form. A poecilogonous species, able to make multiple forms of larvae, presents an opportunity to compare parental investment in these differing life-history strategies, which remains largely unexplored. This study of *Alderia willowi*, a hermaphroditic sea slug with seasonal poecilogony, compares within-species energy expenditure and parental growth rates between these two common types of larvae made. Most individuals produce large, lecithotrophic larvae in the summer with some adults laying small, planktotrophic larvae in the winter. Adult *A. willowi* specimens were field-collected, then kept in a lab environment. This controlled for confounding variables relating to inter-species and inter-population differences or environmental conditions. Egg production (number and type) was measured as a function of parental growth rates (change in area). Previous research between related cone snail species (genus *Conus*) revealed lecithotrophic-producing species allocated more effort to reproduction annually than the planktotrophic-producing species. Contrary to those results, *A. willowi* in this study had no consistent pattern suggesting one reproductive type was correlated with a different growth rate of the parent. The results suggested an equivalent reproductive effort between planktotrophic and lecithotrophic-producing adults. There was a significant relationship between growth and total number of eggs laid. This project contributes a detailed approach to our understanding of reproductive adaptations and the evolution of life-history trade-offs, examining unrecognized alternative offspring provisioning strategies.

PLEISTOCENE FOSSIL ASSEMBLAGES FROM PONTE VISTA, SAN PEDRO, CALIFORNIA: CONTRIBUTIONS FROM MITIGATION PALEONTOLOGY

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Applied EarthWorks, Inc. (*Æ*) provided construction monitoring for paleontological resources (fossils) during excavations for the Ponte Vista Development Project in San Pedro, California from 2016–2018. Throughout the course of the monitoring program, nearly 9,000 invertebrate fossils and over 60 vertebrate fossils were recovered from multiple Pleistocene units exposed in the study area. These include the Lomita Marl, the San Pedro Sand, and the Palos Verdes Sand. Working in collaboration with *Æ* for the Project, the Invertebrate Paleontology Department of the Natural History Museum of Los Angeles County identified at least 115 species of mollusks including bivalves, gastropods, and scaphopods, as well as various other invertebrates such as corals, bryozoans, barnacles, and sea urchins. From the vertebrate fossils, *Æ*'s paleontologists identified sharks, rays, various bony fishes, turtle, camel, and whale. With the exception of a few rarely preserved and significant taxa, the fauna identified from this investigation are typical of those found in middle to late Pleistocene marine strata of the region. However, the abundance and high quality of the fossils recovered from the project represent a significant contribution to the documentation of biodiversity and paleoecology in the Pleistocene of the Los Angeles basin.

In addition to protecting an irreplaceable natural heritage, monitoring of excavations for land development projects provides paleontologists the opportunity to examine ephemeral and often large-scale settings that might be inaccessible or otherwise unknown to paleontologists. The Ponte Vista assemblage adds to the growing number of fossils collected from monitoring programs that are currently housed at the Natural History Museum of Los Angeles County. The increasing availability of paleoenvironmental and biostratigraphic data provided by these contributions demonstrates the importance of mitigation paleontology within the broader scope of the science.

PACIFIC ISLAND LAND SNAIL BIODIVERSITY REPOSITORY (PILSBRY); DOCUMENTING AN IMPERILED FAUNA

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Pacific Islands harbor more than 6,000 species of land snails, most of which are narrow-range, single island endemics. Although extraordinarily diverse, Pacific Island land snails (PILS) are threatened by habitat destruction and invasive species and are among the most imperiled animals existing today, accounting for almost half of all documented animal extinctions since the 1500s. Unfortunately, most data on PILS species, and their past and present distributions are scattered, not digitized, and not easily available, masking the true magnitude of this crisis and hindering conservation efforts. However, much of this information can be obtained from specimens and associated data housed in museum collections. In 2019 a coalition of six museums holding the majority of PILS information in the US was established to make the data more widely accessible for research, education, and conservation. Consequently, the Pacific Island Land Snail Biodiversity Repository (PILSBRy) web portal was developed, mobilizing these valuable digital resources for use by researchers, organizations, and citizen scientists. Efforts are underway to digitize museum specimen data and georeference specimen localities. Data for 3,681,279 specimens across 375,951 collecting events are now publicly available, significantly contributing to biodiversity and systematic assessments. A comprehensive taxonomic authority file and a Pacific Island wide gazetteer are in development and will facilitate synthesis of data from across all collections. Images of type material, original labeling, ledger pages, field notebooks and other associated metadata are now linked to specimen records. This quick sharing of accurate, reliable data is necessary if we are to make effective decisions regarding PILS conservation and understand the evolution of this group across the Pacific Islands.

HOW OLD IS BAJA CALIFORNIA SUR'S SALADA FORMATION AND WHY IS THIS IMPORTANT?

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The Salada Formation crops out on the western Magdalena Plain, southern BCS, México. Named and described for a rancho above Arroyo La Salada by Arnold Heim (1922), the section was visited in the 1860's by W.M. Gabb, in 1921 by Carl Beal, then forgotten until 1982 when the author found Tertiary-Caribbean mollusks in the formation. Subsequent trips in 1985 and 2011 led to Schwennicke et al. (2000). Later authors applied "Salada" to any yellow-colored, mostly Pliocene marine sediments as distant as San Felipe in the northern Gulf of California. Current studies indicate it is middle or late Miocene, ~14 – 12 Ma, only found on the southwestern peninsula and nowhere in the Gulf. Its fossils are poorly preserved internal molds or impressions in reworked concretionary slabs, a facies Heim referred to as "The great *Pecten* beds." Some taxa are found in Arroyo La Purisima in sediments overlain by a 14.5 ± 1.2 Ma basalt flow (Hausback, 1984). Representative Tertiary-Caribbean bivalve genera include *Amusium*, *Clementia*, *Cyathodonta*, *Interchlamys*, and the gastropods *Cancellaria* (*Pyruclia*), *Turritella*, and *Vasum*. Species, many described from the Caribbean, Ecuador, and Perú, are being reviewed and updated following the two-year pandemic closure of the USNM. Largely index taxa, they are dispersed north from Central American seaways, permitting correlations between Baja California and formations from Panamá to Trindad, W.I., the Dominican Republic, Ecuador and Perú.

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SHALLOW-MARINE THERMOPHILIC GASTROPOD AND BIVALVE GENERA ENDEMIC TO THE NORTHEAST PACIFIC DURING LATEST CRETACEOUS AND PALEOGENE TIME

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Endemism refers to organisms being native to a single geographical area. This study is the first comprehensive determination of the number of endemic genera of shallow-marine tropical to subtropical (thermophilic) gastropods and bivalves known in the northeast Pacific (NEP) region [= Alaska Peninsula southward to Baja California Sur, México] from uppermost Cretaceous and Paleogene strata.

Nine endemic genera were detected in the literature: eight gastropods and one bivalve. The gastropods are (with family names in parentheses): *Perissitys* (Perissityidae) and *Reptipirula* (Volutidae) are Late Cretaceous to Paleocene; *Saxituberosa* and *Perrilliata* (both Fasciolariidae) are Paleocene; *Umpquaia* (Buccinidae), *Tejonia* (Naticidae), and *Intaglicollina* (Turbinidae) are early to middle Eocene; and *Oleqauhia* (Ranellidae) is early to late Eocene. They were mostly carnivorous neogastropods, and most consist of a single species. The only bivalve, *Saulella* (Tellinidae), is a single species of an infaunal-burrower, which is late Paleocene to early middle Eocene.

The eight endemic gastropod genera represent 3.5 percent of the 226 genera of thermophilic gastropods, and the single endemic bivalve genus represents 0.8 percent of the 117 thermophilic genera of thermophilic bivalves. Such low endemism is best explained by pulses of large influxes of genera (with planktotrophic larvae that could survive long distances of transport) from western Europe (the ancient Tethys Sea), the Gulf Coast of the United States, Kamchatka, and, to a lesser degree, Japan.

A well-documented turnover of gastropods and bivalves took place in the NEP region at the end of the middle Eocene "Tejon Stage," 36.5–37 million years ago, when newly arrived cool-water (temperate) genera, including those that could live in bathyal and chemosynthetic habitats, began to arrive and mix with the thermophilic taxa. Mixing continued during late Eocene through Oligocene time, with only 31% (69/226) of the thermophilic gastropod genera and only 19% (22/117) of the thermophilic bivalve genera persisting.

[Presentation given by Lindsey Groves.]

EPONYMS OF WOMEN AMONG CRETACEOUS MOLLUSKS OF CALIFORNIA: THE SPECIAL CASE OF LOUELLA SAUL

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Eponyms, as scientific names, may refer to any person or persons chosen as meaningful by the species author. Examples include those influential within a research community, a friend, or a mentor. Louella Saul was all of these and is honored by several eponyms among Cretaceous mollusks. To assess the division of eponyms by gender (i.e., those that refer to women and men) within Cretaceous and extant mollusks, several species datasets were analyzed and the etymology of species names was determined. Of 615 Cretaceous mollusk species from California, nearly 28% were eponymous. Of these, 88% (n=151) referred to men and 12% (n=21) referred to women. More female eponyms honored LouElla Saul than any other woman. When compared to datasets of 615 extant mollusk species from eight locations around the world, the disparity between male and female eponyms was similar; 89% (n=550) honor men, 11% (n=65) honor women. This gender asymmetry within molluscan eponyms will be discussed, as will the contributions to Cretaceous paleontology that made LouElla Saul uniquely eponymous.

FIRST REPORT OF MEGAFOSSILS FROM THE TOURMALINE SURFING PARK OUTCROP OF THE EOCENE MOUNT SOLEDAD FORMATION, LA JOLLA, CALIFORNIA

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Marine invertebrate megafossils from the Eocene Mount Soledad Formation forming the seaside bluff at Tourmaline Surfing Park in La Jolla, San Diego, California (Kennedy and Moore, 1971) were previously unknown. Recent collections made during paleontological mitigation investigations have yielded a marine invertebrate fauna of at least 32 species represented by internal and external molds of mostly bivalve, gastropod, and scaphopod mollusks, as well as at least two species of crustaceans, at least one species of echinoid, and trace fossils. The moderately to well-preserved molds, predominately in siltstone with minor very fine-grained sandstone, exhibit little to no abrasion, with some bivalves still articulated, indicating limited to no post-mortem transport. Individual fossils are generally scattered; no evidence of shell beds or lags was observed.

Bivalves are dominated by multiple specimens of the nuculanids *Nuculana* (*Saccella*) *gabbi* Conrad (ms.) of Gabb and *Portlandia rosa* (Hanna), with lesser numbers of *Myrtucina roseburgensis* (Turner), *Periploma eodiscus* Vokes, and *Tellina* sp. aff. *T. vorbei* Hanna. Bivalves represented by intact single specimens include cf. *Modiolus* sp., *Pitar joaquinensis* Vokes, and *Thracia sorrentoensis* Hanna. Fragmentary bivalve specimens include *Callista* sp., aff. *C. domenginica* Vokes and *Pitar uvasanus* (Conrad). Almost all the gastropods consisted of single specimens and include *Natica rosensis* Hanna, *Sinum obliquum* (Gabb), *Cylichnina tantilla* (Anderson and Hanna), and cf. *Phos* sp. Scaphopods are relatively numerous, represented by unidentified species of *Dentalium* and *Cadulus*. Identifiable decopod crustaceans include the ghost shrimps *Vegarthron santiago* Schweitzer and Feldmann and *Neocallichirus rhinos* Schweitzer and Feldmann, and the crab cf. *Palaeopinnixa* sp. The heart urchin *Schizaster diabloensis* Kew is the identifiable echinoderm.

A “Domengine” provincial molluscan “stage” (late early Eocene – early middle Eocene of Squires, 2003) is assignable to the fauna based on the restricted stratigraphic ranges of the bivalves *Portlandia rosa* and *Periploma eodiscus*, and the gastropod *Natica rosensis*; the highest stratigraphic occurrence of *Pitar joaquinensis*; and the lowest stratigraphic occurrence of *Thracia sorrentoensis* (Givens and Kennedy, 1979; Squires, 2008). The depositional environment for the Tourmaline Surfing Park outcrop of the Mount Soledad Formation has been variously interpreted as submarine fan overbank deposits in a middle to upper continental slope facies (Kies and Abbott, 1982; Link and Abbott, 1991), as an abandoned deep-water channel overlain by a levee complex in a continental slope (May and Warme, 1991; Campion et al., 1996), and most recently as a series of stacked channel deposits within a larger scale submarine slope canyon or valley (Power et al. 2014). The composition of the fauna, in conjunction with the depositional setting, suggests the sediments of the Tourmaline Surfing Park outcrop of the Mount Soledad Formation may be, in part, coeval with the continental shelf deposits of the early middle Eocene Ardath Shale.

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HAWAII'S NON-MARINE GASTROPOD INVASION STORIES: FRUSTRATING CRYPTIC SPECIES COMPLEXES, UNKNOWN SPECIES IDENTIFICATIONS, AND NEW INTRODUCTIONS

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Invasive species negatively impact natural resources, agriculture, and human health. Up-to-date surveys of introduced species are crucial for the development of effective biosecurity plans as they provide data necessary to understand taxonomy, distributions, and potential impacts. Knowledge of species identities and distributions informs conservation and invasive species management and permits the prioritization of control efforts. In 2008, 38 non-native, non-marine species were reported as established in Hawaii and a decade later, that number had grown to 52 species. Through a combination of *ad hoc*, opportunistic, and targeted surveys since we last reported numbers in 2018, we have documented an additional 21 species, bringing the total to 73 established non-natives species. This includes at least four cryptic species complexes and eight unidentified taxa that are genetically distinct from other species recorded in Hawaii. Two notable new records include *Otala lactea* and *Zachrysia provisoria*, highly invasive species that were recorded within the last few years. *Zachrysia provisoria* is now established in the islands and will continue to spread without immediate action. A combination of ongoing surveys combined with integrative taxonomic approaches and assessment of vouchered material from museums is providing a clearer picture of introductions into Hawaii and revealing the extent of undetected establishments by sleeper populations and cryptic species. Early detection is critical for effective control before spread and establishment, which is why continued surveys and taxonomic studies are necessary to strengthen biosecurity and to develop preventive measures aimed at reducing the potential impacts of invasive species.

REDUCING THE RATE OF EXTINCTIONS: HAWAIIAN LAND SNAIL CONSERVATION EFFORTS FROM REDISCOVERING SPECIES TO MANNING THE LIFEBOATS

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Hawaiian land snails have been important components of Hawaiian culture and lore and instrumental in the development of our understanding of speciation and island biogeography. Unfortunately, habitat destruction, impacts of invasive species, and climate change have reduced the highly endemic fauna to about 300 species out of an estimated 759. Of the remaining species, about 100 are estimated to go extinct within the next decade. In 2020, Bishop Museum (BPBM), the Hawaii State Department of Land and Natural Resources - Snail Extinction Prevention Program (SEPP) and the Honolulu Zoo established a collaborative network of captive propagation facilities to create redundant populations of highly threatened species with the aim to reduce the risk of extinction, share captive rearing techniques, and increase capacity for land snail conservation. Collectively, these programs currently rear 48 species and at the end of 2020, more than 6,000 snails from 10 species from the network were re-introduced into protected areas in the wild. Despite this initial success, captive rearing remains a stop-gap measure and is not a sustainable, long-term solution to the extinction crisis. Multiple integrated actions need to simultaneously occur to ensure the survival of the remaining snails which includes the development of research aimed at answering questions needed to carry out effective conservation, restoring native ecosystems, characterizing life history and ecological requirements for threatened species, and advancing techniques to mitigate and reduce threats (e.g. impacts of invasive species, disease, climate change). Immediately, efforts to survey for persisting species and populations must be scaled up before it is too late, and small habitat segments across islands must be protected with predator control and exclusion so that snails can both remain and be returned to the landscape. All of these actions require a comprehensive and updated taxonomic framework upon which all other conservation decisions rely.

ABSTRACTS FOR POSTER PRESENTATIONS

In alphabetical order by first author

IMPACT OF THE PELAGIC RED CRAB PLEURONCODES PLANIPES (DECAPODA, MUNIDIDAE) ON BENTHIC MOLLUSCAN COMMUNITIES OFF SAN DIEGO, SOUTHERN CALIFORNIA.

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During the 1992, 1998, and 2015 El Niño-Southern Oscillation (ENSO) events, large populations of *Pleuroncodes planipes* (red crabs) were observed in the City of San Diego's Ocean Monitoring Program (OMP) trawl samples off the coast of Point Loma in San Diego, California. These animals are usually found in ocean waters to the south off the coast of Baja California del Sur, Mexico. In video footage obtained in 2017 by remotely operated vehicle (ROV), these animals were observed in high-density aggregations disturbing the sediments in the OMP sampling area, presumably feeding. Ocean temperature fluctuations associated with these events varied, as did the duration of the red crab incursions. During the 1992 and 1998 events, red crabs were observed in trawl samples over a 1–2 year period. However, following the 2015 event, high densities were present in trawl samples through the summer of 2020. The impacts of these different incursions on the native molluscan soft bottom infauna community were examined using univariate, multivariate, and time series analyses. Initial analyses focused on phylogenetic class-level changes through time, but more detailed trends were evaluated utilizing characteristic species obtained from multivariate results, which incorporated additional physical and chemical data. The city of San Diego's long-term ocean monitoring program encompasses a continuous semi-annual site-revisit dataset, including oceanographic water quality constituents as well as sediment chemistry data. This allows comparisons across decades, as well as a mechanism to control for physical processes that may impact infauna community structure.

[Poster not presented.]

WE WERE NOT FIRST: NEWS THAT A EULIMID SNAIL PARASITIC ON BRITTLESTARS IN SOUTHERN CALIFORNIA WAS DISCOVERED 50 YEARS AGO

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Collectively, we have twice updated our progress to correctly identify an apparently overlooked eulimid snail in southern California (Patron et al. 2018; LaFollette et al. 2019). Although tiny, its orange color and typically firm attachment to an arm of the banded brittlestar, *Ophionereis annulata* (Le Conte, 1851) seemed to us a paradox. We found it at multiple localities and have by now found over 20 specimens, so how did this interesting association escape not only the notice of legions of private collectors in southern California, but especially the post-1960s mass picking and sorting of small snails by curators and volunteers at the Natural History Museum of Los Angeles County? The snail's mostly tropical family, Eulimidae Philippi, 1853, is well known to be parasitic on echinoderms, but eulimids are uncommon and mostly offshore in California and we have found no museum specimens or published reports on this intertidal eulimid from California or Mexico. Dr. James Carlton suggested it might be a recent anthropogenic introduction to California, and that hypothesis gained attraction when eulimid expert, Dr. Anders Warén, identified it to the genus, *Ersilia* Monterosato, 1872, with a Mediterranean type species, *Ersilia mediterranea* (Monterosato, 1869). We agree with his generic assignment and have noted slight but consistent differences between *E. mediterranea* and California specimens, implying it is likely an undescribed species. The few species of *Ersilia* have unusually stout shells for eulimids; Monterosato first misclassified its type species as a *Lacuna* (Littorinidae). Perhaps it was similarly misclassified by those who sorted California snails in previous decades. In January 2020, we received the surprising news of a surviving 1974-75 manuscript by George E. Radwin (d. 1977) and Ann Muscat; muricid expert Radwin had found one specimen, then received two snails on banded brittlestars for identification by Muscat, who was a Scripps' graduate student working on brittlestars. It soon became clear to us that they had discovered our snail 50 years earlier. Muscat has since kindly provided us with their manuscript and figures and has encouraged us to pursue the snail's description. We are thus undertaking a first published description of this new California eulimid and further plan to name it in their honor.

References

Patron, C., LaFollette, P.I., and Eernisse, D.J. 2018. First records for California and discovery of the brittlestar host for the parasitic eulimid snail, *Stilapex cookeana* (Bartsch, 1917) [abstract]. Program and Abstracts for the 2018 Meeting of the American Malacological Society and Western Society of Malacologists, Honolulu, Hawaii, June 2018, p. 108, downloaded on 31 May 2022 at: https://ams.wildapricot.org/resources/Documents/2018%20Meeting%20Docs/AMS%20Program%20and%20Abstracts%20Final.pdf

LaFollette, P.I., Patron, C., and Eernisse, D.J. 2019. Tiny orange eulimid snails on brittlestar arms: A new species of *Stilapex* Iredale, 1925 in southern California on a common intertidal ophiuroid host [abstract]. Abstract Volume: World Congress of Malacology 2019 Pacific Grove, California, p. 256, downloaded on 31 May 2022 at: https://www.calacademy.org/sites/default/files/final_abstract_volume_2019_1.pdf

HOOF LIMPET UNDER-ROCK BLISS IN LA: A BROODER, HER HAREM OF MALES, AND THEIR CRAWL-AWAY SNAIL HATCHLINGS.

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Hipponicidae are little-studied marine gastropods known as hoof limpets because their highly-modified foot becomes an attachment organ, and this leaves a prominent horseshoe-shaped muscle scar observable on their limpet-like beach shells. C.M Yonge (1953, 1960) completed one of the first-ever reproductive studies for hoof limpets while visiting Monterey, California. He identified them (using current spelling) as *Hipponix antiquatus* (Linnaeus 1767), a species now considered to be a Caribbean endemic, distinct from similar species in the East Pacific and elsewhere belonging to the same undocumented species complex. Yonge only found females with still-immature embryos, but he predicted these would later emerge as crawl-away hatchlings. Earlier this year near Los Angeles, we found a female hoof limpet who was brooding embryos at a very late stage, attached to the underside of an intertidal rock together along with nine smaller non-brooders. If these were the same species that Yonge studied, then our observations help confirm his prediction that hatchlings emerging from brooders remain benthic. We employed SEM and light microscopes to compare the "larval" shells of the late-stage brooded embryos with the protoconch shell portion that we found in the least-eroded hoof limpets from the same rock. These corresponded closely in size and appearance, implying that settlement soon follows hatching. A ready-for-release "larva" resembles a tiny snail, not a limpet, so early crawling away is likely its only opportunity to locate a permanent residence near a potential mate. As in most hoof limpets, this species attaches to a lower secreted shell cemented to the rock, feeding on detritus with an extended proboscis. We found some of the smaller hoof limpets had a penis, as illustrated by Yonge (1960), and this is consistent with his proposal of sequential hermaphroditism. We predict that male access to females is limited by both proximity and penis length. The details of copulatory behavior, competition between males, sperm storage, and avoidance of inbreeding by early dispersal, will remain a challenge to study at least in their natural habitat. Our study has better characterized the earliest hatchling stages before they emerge as "hoof snails" and settle into "hoof limpet-hood."

References

Yonge, C. M. (1953) Observations on *Hipponyx antiquatus* (Linnaeus). *Proceedings of the California Academy of Sciences*, 4th Ser., 28: 1-24.

Yonge, C. M. (1960) Further observations on *Hipponyx antiquatus* with notes on North Pacific pulmonate limpets. *Proceedings of the California Academy of* Sciences, 4th Ser., 31: 111-119.

SHAW'S COVE: AN ECOSYSTEM AT A GLANCE

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For most of my life, I have been terrified of fish. It wasn't until recently that this changed: I was coerced into snorkeling on a family vacation and had a chance sighting of an octopus. I managed to capture a video of the encounter. I was mesmerized by him: his rapid, effortless camouflage; the way he alternated between scurrying over coral and propelling himself with his siphon. Swimming with the octopus completely dispelled any unease I had in the water. Instead, I was fascinated by the ecosystem I observed.

In the course of the last six months, I have aimed to share the wonder I feel when exploring my favorite local dive site: Shaw's Cove in Laguna Beach, CA. I have created a YouTube channel as an educational resource showcasing the rich ecology of the reef. My videos are an informal survey of this ecosystem. Many videos include species identifications and highlight rare observations, such as abalone and starfish. I hope to develop my informal surveys into a proper scientific project and am currently in the exploration phase of this process. I am open to and appreciative of any and all feedback.

The abalone at Shaw's Cove are of particular interest to me. In the past six months I have observed a slight increase in the number of abalone I see per dive, but still the numbers are low and they are sparsely distributed throughout the reef. To further investigate the status of abalone populations in Laguna, I contacted Nancy Caruso, executive director of the organization Get Inspired, which aims to restore the green abalone at Orange County beaches (among other organisms, such as kelp and Pismo clams). After 100 years of over-harvesting, the abalone populations have dwindled significantly. The loss of Laguna's kelp forests for 25 years also greatly hurt the abalone. Without much to eat, they dispersed, feeding on mostly diatoms. Today, the greatest issue facing the abalone is that they are not aggregating, and thus researchers are not finding offspring, making restoration efforts that much more necessary.

I am grateful to the South Coast Divers group, whose members continue to educate me and help me form connections with experts in this field, and to Nancy Caruso for taking the time to discuss abalone and the work of her organization, Get Inspired, to restore the green abalone population.

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MINUTES FROM THE 2022 WSM EXECUTIVE TEAM MEETING

WSM Executive Team Meeting **June 23, 2022**

Meeting called to order at 6:33PM.

Executive Committee Members present: Kelvin Barwick, Wendy Enright (remote), Jann Vendetti, and Michael Vendrasco; Past Presidents in attendance: Hans Bertsch, Douglas Eernisse, and Esteban Fernando Felix Pico.

Secretary's report (Wendy Enright)

Catching up on past volumes:

The 2018 Annual Report is in review; 2019 will be submitted to Pat in the next week or two; 2020 is done (no meeting that year).

2021 & 2022 should be done by this Fall pending any "expanded" abstracts. [Note: the 2021 Annual Report was sent out in Summer, 2023.]

Doug moved to approve the Secretary's report for presentation at the WSM Business Meeting, Esteban seconded; motion approved.

Treasurer's report (Kelvin Barwick)

Kelvin Barwick (KB) had e-mailed the PDF of his draft of the Treasurer's report.

KB reported that the total funds for the WSM are approximately still the same as when he began serving as Treasurer.

There are currently 5 institutional members of the WSM, 37 paid (more might have paid as part of registration). In 2021, due to ongoing COVID, the affordable WSM membership fee of $20 ($8 for students) included access to the Annual Report. There were 93 attendees in 2021 at the fully online Annual Meeting.

$2000 in student grants came in.

KB proposed a modification to the categorization of WSM printing/shipping expenses. As of now, the payment of printing/shipping for the annual reports has been counted against the conference expenses, whereas it should be considered a general expense. With this change, more $$ can therefore be sent to the student grant fund – overages on what the conferences take in. Hans Bertsch moved to bring this modification forward to the WSM Business meeting; Doug Eernisse seconded the motion; and this motion was approved.

Doug Eernisse moved to approve the Treasurer's Report for presentation at the WSM Business Meeting; Hans Bertsch seconded and the motion was approved.

Officer nominations for next year – Discussion ensued

2023 – Still no nominees. Wendy will email Vanessa Delnavaz at the SBNHM (citing the "rare opportunity"); Hans Bertsch will reach out to the San Diego shell club; Doug Eernisse suggested Rick Harbo in British Columbia (of the Royal BC Museum) and Rory McDonnell at Oregon State. An ad-hoc nominating committee was created, chaired by Michael Vendrasco to pass on other suggestions going forward.

2024 – Christine Parent is on board for 2024; need to approve at the WSM Business meeting.

WSM Student grants

James McLean award – Jann Vendetti reported that Alejandro Mendeville from Peru will get $2000 to look at specimens at LACNHM & work with Angel Valdez at Cal Poly Pomona. His proposal was: "Taxonomic review of Aplysia (Mollusca: Heterobranchia) from the eastern Pacific."

WSM Student Research Grants – two were awarded this year:

- $1000 to Emily Kunselman, UCSD, for her project "Impact of increasing temperature on Ostreid Herpesvirus in natural *Crassostrea gigas* spatfall from San Diego Bay"
- $985 to Bailey McCann from Humboldt State, for his project "Does climate warming amplify the effect of a range-expanding marine gastropod, *Acanthinucella spirata*?"

WSM Student awards

Two best student presentation awards will be given.

The ad-hoc committee will consist of Hans Bertsch, Esteban Fernando Felix Pico, and Michael Vendrasco who will serve as judges. Michael will provide scoresheets and a list of students to the other committee members.

Other Items

Doug Eernisse was wondering about our old reports on the Biodiversity Heritage Research Library – right now it only goes until 2015/2016. It was decided that we should ask Patrick LaFollette for info – there might be a more formal procedure for getting our volumes into the site.

Michael Vendrasco solicited agenda items for the upcoming WSM Business Meeting.

Doug moved to thank Michael for putting together such a great meeting even after the world ended. Kelvin seconded and others approved.

Meeting adjourned 7:08 PM.

MINUTES FROM THE 2022 WSM BUSINESS MEETING

WSM Business Meeting **June 25, 2022**

Meeting called to order at 3:35PM.

Executive team present: Kelvin Barwick, Wendy Enright (remote), Jann Vendetti, and Michael Vendrasco. Many other WSM members were also present.

Pasadena City College acknowledgment read:

"Before we begin, we believe it is important to open our meeting by acknowledging the indigenous land that we share. Pasadena City College is a learning community within the indigenous homelands of people who have been known as the Gabrieliño Band of Mission Indians of the Sisitcanongna [pronounced "Shesh-i-i-kuan-ga") Village and Kizh (pronounced "Keech") Nation. We acknowledge the painful history of genocide and forced removal from this land on which we gather. We honor all indigenous people past, present and future and their continued survival and contributions to our society. We also honor the legacy of the African diaspora and recognize that this country would not exist without the free enslaved labor of black people. We share these acknowledgments to raise awareness about histories that are too often erased or forgotten, to recognize our place in this history and to affirm our commitment to social justice, systemic change and anti-racism."

OFFICER'S REPORTS

Secretary's report – back issues of the WSM Annual Reports (Wendy Enright)

Wendy Enright provided an update on the status of WSM Annual Reports from 2018-present.

Kelvin Barwick moved to approve Secretary's report, Hans Bertsch seconded and motion approved.

Treasurer's report – current state of finances (Kelvin Barwick)

Kelvin Barwick (KB) presented a summary of current WSM finances, updated even since the WSM Executive Board meeting a few days prior.

KB reported on dues received, interest, t-shirt sales, and student grant donations. Expenses included publication costs and t-shirt production. $2000 in student grants came in last year.

KB proposed an adjustment be made to the categorization of WSM funds. He proposed that costs associated with printing and shipping of the Annual Report should be considered part of the WSM general business expenses rather than meeting expenses. Doug Eernisse moved to approve this proposal, Hans Bertsch seconded and motion approved.

KB reported that the total funds for the WSM are approximately still the same as when he began serving as Treasurer.

There are currently 5 institutional members of the WSM, 37 paid (more might have paid as part of registration). In 2021, due to ongoing COVID, the affordable WSM membership fee of $20 ($8 for students) included access to the Annual Meeting. There were 93 attendees in 2021 at the fully online Annual Meeting. However, membership has been down since then.

Hans Bertsch formally congratulated Kelvin Barwick on the great work he's doing as Treasurer, and everyone agreed.

Doug Eernisse moved to approve the Treasurer's Report, Patrick Krug seconded and motion approved

Officer nominations for next few years

2023 – There were no current nominees for next year's President. Wendy Enright has emailed Vanessa Delnavaz w/ SBNHM and is awaiting her response; Hans Bertsch will reach out to the San Diego Shell Club; Doug Eernisse suggested Rick Harbo in British Columbia (of the Royal BC Museum) and Rory McDonnell at Oregon State. An ad-hoc nominating committee was created, chaired by Michael Vendrasco to pass on other suggestions going forward.

2024 – Christine Parent was approved as First Vice President

2025 – There were no current nominees for 2nd Vice President. Hans Bertsch and Esteban Fernando Felix Pico will inquire with our Mexican colleagues.

WSM Student Research Grant Awards for 2022

- $1000 was awarded to Emily Kunselman, UCSD, for her project "Impact of increasing temperature on Ostreid Herpesvirus in natural *Crassostrea gigas* spatfall from San Diego Bay"
- $985 was awarded to Bailey McCann from Humboldt State, for his project "Does climate warming amplify the effect of a range-expanding marine gastropod, *Acanthinucella spirata*?"

James McLean Grant Award for 2022

- $2,000 was awarded to Alejandro Mendivil from Peru, for the proposal, 'Taxonomic review of *Aplysia* (Mollusca: Heterobranchia) from the eastern Pacific'. He plans to visit the collections of the Natural History Museum of Los Angeles County collections as well as those at Cal Poly Pomona.

Best Student Presentation Awards for this WSM Annual Meeting 2022

Winners of the Best Student Presentations for this meeting each received $100 cash hand delivered by Kelvin Barwick plus a free one-year membership in the Western Society of Malacologists. The best presentations were:

- "Broadscale distribution, abundance and habitat associations of the Asian clam (*Corbicula fluminea*) in the lower Columbia River, USA", Salvador Robb-Chavez, Washington State University, Vancouver, WA.
- "The cost of adaptations: Rate of parental growth of the poecilogonous species *Alderia willowi* (Gastropoda: Sacoglossa: Limapontiidae), as a function of producing lecithotrophic versus planktotrophic eggs", Mariah S. Scott, University of Chicago.

Other Business

Judith Smith put forth the proposal for a historical photo archive/repository; she asked if the WSM could put the photos on our website categorized by year (or something); and she was wondering who might be able to do that. Hans Bertsch proposed that all photos have a minimum of description associated with the file.

A question was asked about the location of Jody Woolsey's photo binders containing photographs from past WSM annual meetings. A possible location is at the archive at SBMNH, and it was suggested reaching out to Paul Valentich Scott and/or Hank Chaney at the SBMNH.

There was discussion about technical issues associated with adding content to the website. Kelvin Barwick uses WordPress for the current WSM website. Doug Eernisse has a website that features photos from previous WSM Annual Meetings. Patrick LaFollette suggested integrating the AMS info; Hans Bertsch was skeptical since it would add so many years.

An informal committee was formed to gather photos and information. We may need to pay someone to get it onto the website since our in-house expertise for this is limited; Hans Bertsch will start gathering the materials together. Photos could be solicited as part of the meeting follow-up communications, perhaps using a DropBox repository. The overall goal is to have more historical photos of WSM members, in particular meeting photos, freely accessible online.

One proposal was to include photos into the Annual Report itself. There was some concern with additional publishing costs if more photos are incorporated into annual report. The consensus was to make the institutional copies color, and those for general members black & white to mitigate costs, with a color PDF available to all. Michael Vendrasco agreed to do a test run for this year's meeting, integrating more meeting photos into the Annual Report.

Doug moved to thank Michael for a fantastic meeting, Kelvin seconded. Michael thanked everyone and gave a big thanks to Doug and Kelvin who had assisted at many stages of meeting planning and preparation.

Meeting adjourned at 4:05 PM.

WSM CASH FLOW: June 26 2021 to June 18, 2022

In-flows

Membership		$2,279.94
Interest earned		$2.20
Student grant donations (available balance $6,594.85)		$2,465.00[1]
2021 Conference t-shirt		$52.80
	Total in-flow	$4,429.94

Out-flows*

2017 Annual Report		-$640.75
2020 Annual Report		-$147.28
Office supplies		-$26.93
2021 Conference t-shirt		-$50.75
Office supplies		-$117.92
State of California Nonprofit register		-$25.00
	Total out-flow	-$981.70
	Net	**$3,448.24**

**PayPal cost not realized above (2.9% plus $0.30 per transaction): -$89.22*

Cash on hand as of June 18, 2022:

Checking	$14,889.53
Savings	$13,194.98
Credit card	$0.00
Total	**$28,084.51**

MEMBERSHIP TOTALS

Individuals	37
Institutional	5

[1] *Includes $370 proceeds from auction held June 24, 2022.*

MEETING PHOTOS

At the reception desk were Pasadena City College volunteers Sophia White (left), Hannah Aguilar (center), Rebecca Wilcox (right), and Sabrina Blankinship (not pictured). *Photograph by Hans Bertsch.*

Doug Eernisse led an enthusiastic discussion about specimen photography. *Photograph by Michael Vendrasco.*

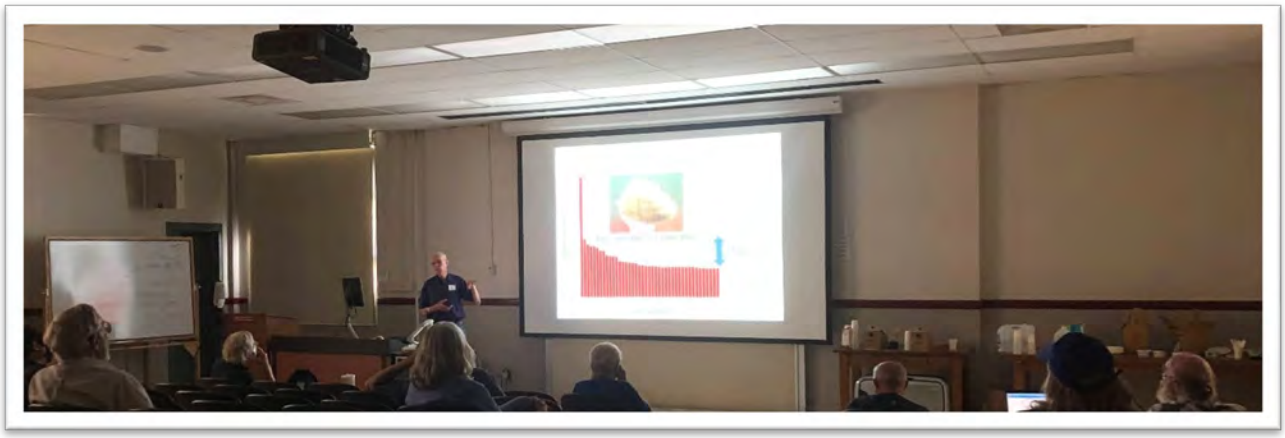
Poster session. In the foreground, Patrick LaFollette discusses his poster with Judith Smith. *Photograph by Rebecca Wilcox.*

Kenneth Hayes gives his Keynote Presentation on molluscan conservation. *Photograph by Michael Vendrasco.*

Top: Hors d' oeuvres and more before the auction. *Photograph by Esteban Fernando Félix Pico.*

Right: One of the items put up for auction at the WSM student grant fundraiser. The auction raised approximately $400. *Photograph by Hannah Aguilar.*

Below: Hans Bertsch convenes the auction with his unique and energetic style. *Photograph by Sophia White.*



Bruce Runnegar describes surprises about cold-water fossil mollusks at the LouElla Saul special session. *Photograph by Sophia White.*

Hans Bertsch directs the group photograph for the LouElla Saul session speakers. *Photographs by Hannah Aguilar (left) and Kelvin Barwick (below).*

At the post-meeting dinner, including (from left to right) Casey Richart, Doug Eernisse, Kelvin Barwick, Judith Smith, Michael Vendrasco, Patrick LaFollette, and Mariah Scott. *Photograph by Casey Richart.*

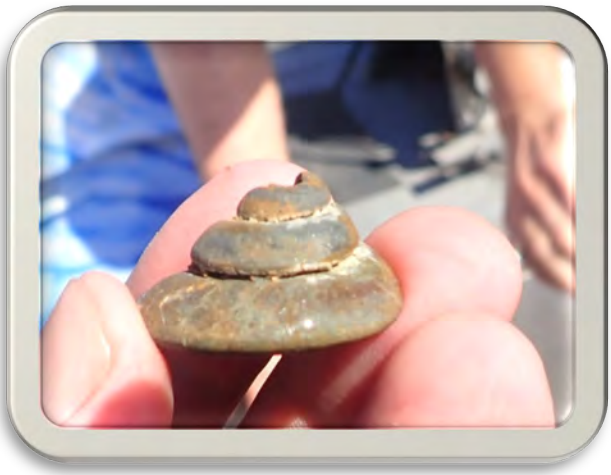
View of the Port of Los Angeles as we depart in the early morning for the field trip to Santa Catalina Island.

Kelvin Barwick (left) and Casey Richart (right) on the way to Santa Catalina Island.

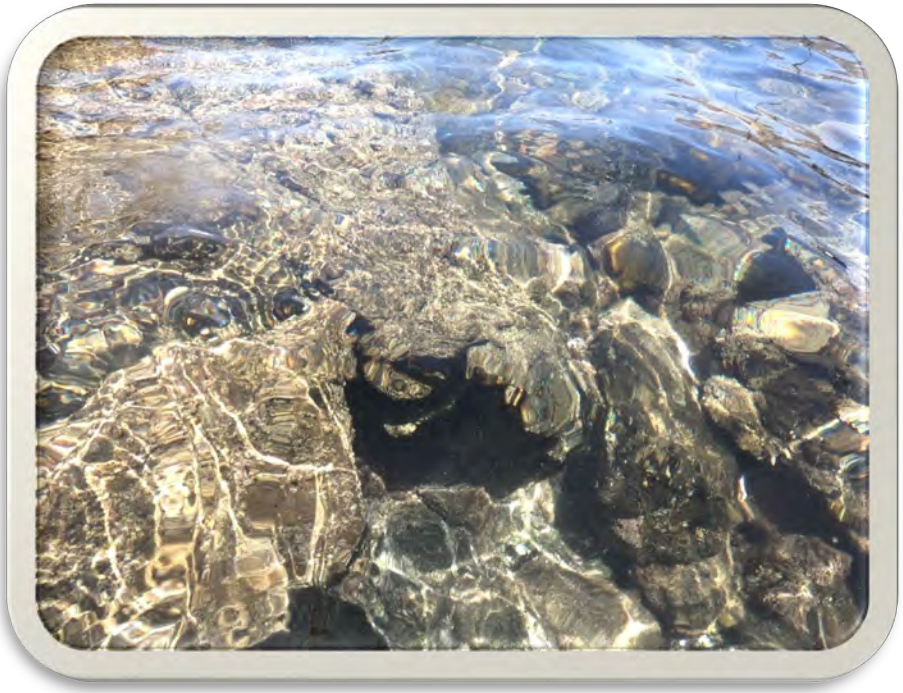
Right Kelvin Barwick and Rebecca Wilcox hold specimens from the dredge. Samantha Nambu, Casey Richart, Patrick LaFollette, and Doug Eernisse look on.
Photographs by M. Vendrasco

Left Kelvin Barwick extracts an elongate polychaete (not a mollusk, but arguably just as fascinating) while Samantha Nambu and Doug Eernisse look on.

Below Left: Rock containing modern and fossil mollusks and their traces. In the center of the photograph is a composite internal and external mold of a gastropod. Below Right: Closeup of the internal mold.



Our arrival at Two Harbors, Santa Catalina Island. *Photograph by Sophia White.*



Visibility was great for snorkeling along the northern edge of Isthmus Cove.

Intensely folded Miocene Monterey Formation at the point between Isthmus Cove and Fourth of July Cove reveal deep water sedimentary rocks that have been significantly uplifted.

Patrick LaFollette explores the tidal flat. *Photograph by Casey Richart.*

Doug Eernisse talks with his students on the return trip home.

There are still more surprises in the dredge tank, as discovered by diehards Patrick LaFollette (center back), Kelvin Barwick (left), Doug Eernisse (center front), and Casey Richart (right).

Shipping vessel loaded with shipping containers full of stuff and things. Classic Port of LA!

Above: a small isopod crawls over sediment. Below right: a mysterious egg case.

Other photos and videos from the meeting and field trip can be found at:

(1) http://biology.fullerton.edu/biol317/ftm/ft_su22_wsm_6_23-26_22.html

(2) https://photos.app.goo.gl/ECyRc8nLzWW5HfAW6

Videos of snorkeling during the field trip can be found at:

(3) https://www.youtube.com/playlist?list=PLOmQexPRgPKR6AlzDyqVCtRrNW0MYWGzn

(4) https://www.youtube.com/watch?v=7zMDK4Y28wQ

OR USE THE QR CODES BELOW TO ACCESS THE WEBPAGES:

1. 2. 3. 4.

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IN MEMORIAM

LouElla Rankin Saul

JULY 28, 1927 – JUNE 21, 2021

LouElla R. Saul (ca. 2008) at the LACM Invertebrate Paleontology facility. *Photograph by Harry F. Filkorn.*

FOSSIL MOLLUSCAN PAPERS IN MEMORY OF LOUELLA R. SAUL

Cretaceous mollusk specialist LouElla (Lou) Rankin Saul passed away in June 2021 at the age of 93. In her honor, Lindsey Groves convened a memorial session on fossil mollusks as part of the 55th Annual Meeting of the Western Society of Malacologists at Pasadena City College on Saturday, June 25, 2022.

See herein for an overview of LouElla's career and contributions by Lindsey Groves and Richard Squires (p. 39). These authors have also completed a more detailed biography of LouElla in *The Nautilus* that includes a complete list of publications and named species (Groves and Squires, 2023).

Groves, L.T and R.L. Squires. 2023. LouElla Rankin Saul (1928-2021): Her remarkable career and numerous significant contributions to Cretaceous and Paleogene molluscan paleontology. *The Nautilus* 137(2): 63-78.

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