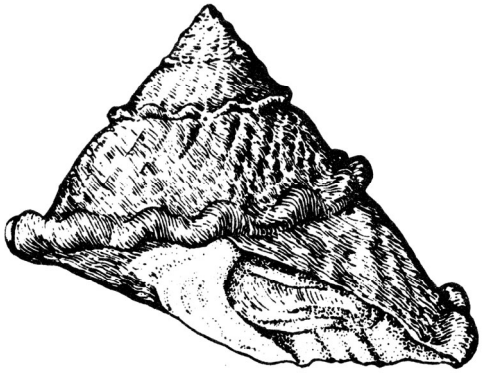


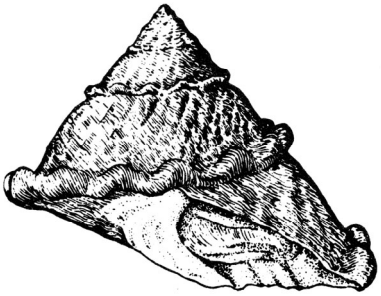
THE WESTERN SOCIETY OF MALACOLOGISTS

Annual Report
For 2017

Volume 50
October 2020

Abstracts and papers from the 50th annual meeting of the
Western Society of Malacologists

Natural History Museum of Los Angeles County and
University of Southern California,
Los Angeles, CA, USA
June 19-23, 2017



CONTENTS

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; Kbarwick@ocsd.com.

Western Society of Malacologists

Executive Board 2016-2017

President	Jann Vendetti
First Vice President	Rebecca Johnson
Second Vice President	Miguel Angel del Rio Portilla
Secretary	Wendy Enright
Treasurer	Kelvin Barwick
Members-at-large	Shawn Wiedrick, Alvin Alejandrino

STUDENT AWARDS

A: WSM James H. McLean Student Grant in Collections-Based Research for 2017

1) *Michael Malloy, UC Merced:* Landmark-based geometric analysis of morphological variation in a common marine gastropod species, *Californiconus californicus* , in the age of the Anthropocene ($951)

2) *Shawn G. Wiedrick, Cal State Fullerton:* Morphological and genetic analysis of the predatory species in the genus *Ocinebrina* Jousseaume, 1880 from the Eastern Pacific ($700)

B: WSM 2017 Student Research Grants in Malacology

1) Scott Gabara, UC Davis: Ocean acidification and subtidal marine communication: Does low pH reduce red abalone's ability to detect and respond to predators? ($1000)

2) Alyssa Frederick, University of California, Irvine: Determining disease resistance markers in abalone, ($750)

C: Best student oral presentation for the 2017 meeting ($200)

1) Linscott, T. Mason and Parent, C.E. P hylogenomics of lower Salmon River Oreohelicidae

D: Best student posters for the 2017 meeting ($150 each)

1. Aziz, Javaria, Hendy, A. J. W. and Estes-Smargiassi, K. Biodiversity and paleoecology of Plio-Pleistocene marine molluscs, Carpinteria, Santa Barbara County, California

2. Chávez-Viteri Yolanda E. and Ward S. Combined effects of ocean acidification and warming on embryos and larvae of sea hares (Mollusca: Opisthobranchia) in the Great Barrier Reef, Australia

3. Alvarez-Cerrillo Laura R., Avila-Poveda O.H., Kawamoto-Camacho N.A., Rodríguez-Domínguez G., Pérez-González R., and Ramírez-Pérez J.S. Erosion facing size and latitude in a dominant herbivore polyplacophoran widely distributed in the intertidal rocky shore of the Mexican tropical Pacific

4. McIntyre, Stacey L., Zacherl, D.C., and Walter, R.P. Transcriptomic response to reduced salinity and increased temperature in oysters *Ostrea lurida* and *Crassostrea gigas*

Welcome from the President

On behalf of the WSM executive board and past presidents, **WELCOME** to the 50th Annual Meeting of the Western Society of Malacologists! It is an honor to host this year's meeting and a privilege to bring together such talented researchers for special sessions highlighting molluscan paleontology, terrestrial gastropods, mollusks and climate change, marine heterobranchs, and WSM history. As always, myriad other molluscan topics complement these sessions as talks and posters.

On this, WSM's auspicious golden anniversary, we are hosted by two exceptional Southern California institutions: The Natural History Museum of Los Angeles County and the University of Southern California. Our Los Angeles neighborhood of Exposition Park features diverse and outstanding museums, gardens, entertainment, and restaurants. Just further afield are gems of the city including the La Brea Tar Pits & Museum, LACMA, and NHMLA's Invertebrate Paleontology collection.

In 1968, WSM held its first annual meeting in Pacific Grove, California from June 19-22. A. Myra Keen gave the opening address and stressed the society's "resolve to include students interested in the field of malacology." This tradition continues. At this 2017 meeting, 32 student participants make up a third of all registrants. As was also part of its mission, WSM has been and continues to be instrumental in supporting and encouraging professional and avocational malacologists. For some perspective, the 1974 WSM meeting in Pomona, California included, among others, Hans Bertsch, Carole Hickman, George Kennedy, Pat LaFollette, Chris Kitting, and Michael Ghiselin. Louie Marincovich chaired the paleontology symposium, Twila Bratcher chaired the nominating committee, and the amount of the student research grant was $500. In 1985, Tim Pearce and Sally Walker won for best presented papers. The list goes on. In deference to you, reader, I won't attempt any kind of comprehensive review here, but, as many of you know, simply thumbing through WSM Annual Reports of years past becomes an exercise in who's who in North American malacology.

At the Society's remarkable half-century commemoration we are also compelled to reflect on WSM history, sponsored scholarship, and scientific achievements, as well as envision the future of the Society. It is also a time to particularly appreciate and strengthen cross-border partnerships between WSM members, especially those between the United States and Mexico, that make WSM unique and relevant.

It has been an honor to serve as WSM President and it would be an understatement to say that I learned a lot. I can't absolutely know that malacologists make the most generous colleagues, but I suspect so. There are many people to thank for making this meeting happen, and to all of you please know that your efforts (big or small) were indispensible and greatly appreciated. Professor David Bottjer of the University of California made the beautiful Mudd Hall of Philosophy room at USC available to WSM, and we are indebted to him for his efforts.

In closing I can't help but share with you a non-comprehensive list of witty talk and poster titles presented at WSM through the years. Is wit and the appreciation of puns a particular characteristic of malacologists (I'm thinking of Gary Vermeij) or a trait of taxonomists and systematists in general? Regardless, I hope that this WSM tradition endures at least another 50 years. Enjoy the following:

Is there double trouble in marsupial clams?

– Eugene V. Coan (1974)

Looking up the wrong end: Anatomical characters of freshwater bivalves

– Arthur E. Bogan (1992)

Remains of the prey — recognizing the midden piles of Octopus dofleini

– Rebecca Dodge and David Scheel (1997)

Who says it's not easy to get around in LA: Palos Verdes peninsula is an ineffective genetic barrier for chitons and limpets

– A. Rodriguez, R.P. Kelly and Doug Eernisse (2006)

Will the real Gymnodoris alba *please stand up?*

– Vanessa Knutson and Terrence Gosliner (2013)

How the southern shield limpet's rocky journey leads to a mid-life crisis

– Chrystal Johnson et al. (2011)

Midden mounds of Baja California: Trash dumps with a view

– Hans Bertsch (2010)

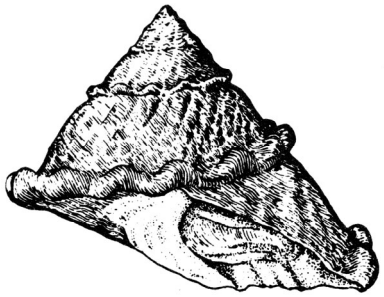
Finally, I would like to conclude with a bit of California trivia, or is it *Pseudopusula californiana* (Gray, 1827)?

Have a wonderful meeting!

Jann Vendetti

WSM President 2016-17

Los Angeles, 2017



Meeting Program

Western Society of Malacologists

50th Annual Meeting

Los Angeles, California

June 2017

Meeting hosted by

Natural History Museum of Los Angeles County

&

University of Southern California

June 19-23, 2017

NATURAL HISTORY MUSEUM
LOS ANGELES COUNTY

UNIVERSITY OF SOUTHERN CALIFORNIA 1880

June 19, 2017: Monday

1:00—3:00 PM, **Registration**, Natural History Museum of LA County (NHMLA), north entrance off Exposition Blvd. near the Museum's Nature Gardens (see map 1)

3:30—5:00 PM, **WSM Executive Board meeting**, Grill at NHMLA (ground floor)

5:30 PM, Icebreaker at **Mercado La Paloma**, within walking distance of NHMLA (see map 2)

* Indicates a student presenter who is eligible for WSM oral presentation award

June 20, 2017: Tuesday, 3709 Trousdale Pkwy, Mudd Hall of Philosophy, room 101, USC campus

9:15—9:30 AM, **Conference welcome**: Jann Vendetti

Morning Session: Topics in Marine Malacology, chair: Wendy Enright

9:30—9:45 AM,*Neu, Alex T., Allen, E. E., and Roy, K. *Diet, biogeography, and the marine gastropod microbiome*

9:45—10:00 AM, *Wiedrick, Shawn G. and Eernisse, D.J. *Phylogenetic and morphological analyses of the eastern Pacific genus* Ocinebrina *Jousseaume, 1880*

10:00—10:15 AM,*Cruz-Flores, Roberto, Muñoz-Flores M. and Cáceres-Martínez J. *Hyperparasitism and abalone withering syndrome, their role in sudden mass mortalities of abalone in Baja California, México*

10:15—10:30 AM,*Coombs, Kim M. and Eernisse, D.J. *When they go low, we go high: Is the southern* Lottia conus *displacing* Lottia scabra *in southern California?*

10:30—10:45 AM, **Coffee break**

10:45—11:00 AM, Santana-Flores, Pablo and Aldana-Aranda, D. *New contributions on the egg-laying of the Queen Conch*, Lobatus gigas *(Gastropoda: Strombidae)*

11:00—11:15 AM,*Ostrowski, Eric, Bird, A. and Eernisse D.J. *Predictive habitat model of pinto abalone in San Diego County, California*

11:15—11:30 PM, Foster, Nora, Valentich-Scott, P. and Iken, K. *Baffling bathyl bivalves and others from the Chukchi borderlands*

11:30—11:45 PM, Wicksten, Mary K. *Monoplacophorans, slit shells, and escaping mollusks*

11:45—12:00 PM, Lafarga De La Cruz, F., Vargas Peralta, C.E., Farfan, C. and del Río-Portilla, Miguel A. Tivela stultorum*: the complete mitochondrial genome of the Pismo clam by using next generation sequencing*

Lunchtime Workshop: 12:10—1:40 PM, **Citizen Science Training with iNaturalist**, lunch provided.

Afternoon Mini-Session: Mollusca and Climate Change, chair: Doug Eernisse

1:45—2:00 PM,*Clare, Xochitl S., Contolini, G. M., Palkovacs, E. P. and Raimondi, P. T. *The effects of ocean acidification on local adaptation in a keystone intertidal predator,* Nucella emarginata

2:00—2:15 PM,*Contolini, Gina M., Palkovacs, E.P, Raimondi, P.T. and Kroeker, K. J. *What drives drilling? Patterns of prey selectivity among populations of predatory snails*

2:15—2:30 PM, **Coffee break**

2:30—2:45 PM, *Alma, Lindsay, Fiamengo, C., Holtgrieve, G. and Padilla-Gamino, J.L. *Effects of ocean acidification and warming on the physiology of purple-hinge rock scallops: A multi-stressor and multi-method approach*

2:45—3:00 PM, Félix-Pico, Esteban F., Ramírez-Rodríguez, E. M. and Ortega-García, S. *On the probable causes of the Pacific Calico scallop fishery collapse in Magdalena Bay, Baja California Sur, México*

3:00—3:15 PM, *Bullard, Elizabeth M., Yanes, Y. and Miller, A.I. *Quaternary land snails from Tenerife (Canary Islands) preserved in a scoria deposit*

3:15—3:30, **Remembrance of Bill Emerson**

3:30—4:00 PM, **Student and Honorary Award announcements & group photo for all attendees**

4:05 PM: drop off of any items to be auctioned in Mudd Hall of Philosophy, room 101

7:00—9:00 PM, **Auction**, proceeds to benefit the student award fund, NHMLA, Times Mirror Room (see map), bring your checkbook! **Auctioneer:** Hans Bertsch

June 21, 2017: Wednesday, Mudd Hall of Philosophy, room 101, USC campus

Symposium: Current Research in Fossil Mollusca, chair: Lindsey Groves

9:00—9:20 AM, **Opening remarks and tribute**: Lindsey Groves

9:20—9:35 AM, Smith, Judith T. *Tertiary-Caribbean and AnaVent basin mollusks, late Oligocene – Miocene marine embayments, southwestern California, USA and Baja California Sur, México*

~~9:35—9:50 AM, *Ditmar, Jolene and Bonuso, N. *A paleoecology of late Pleistocene oyster beds, San Pedro, California*~~

9:50—10:05 AM, Vendrasco, Michael J., Checa, A. G. and Squires, R.L. *Unaltered mollusk shell microstructures from the Pennsylvanian Buckhorn Asphalt of Oklahoma* (*307 ma*)

10:05—10:20 AM, Stanton Jr., Robert J. and Alderson, J. *Paleontology of the Conejo Volcanics, Miocene, Santa Monica Mountains, California*

10:20—10:35 AM, **Coffee break**

10:35—10:50 AM, Muhs, Daniel R., Simmons, K.R., Groves, L.T. and Schumann, R.R. *Quaternary sea-level history on the Pacific coast of North America: Effects of low uplift rate and glacial isostatic adjustment processes on the marine terrace fossil mollusk record*

10:50—11:05 AM, Hickman, Carole S. *Revisiting the Pliocene opening of the Bering Sea gateway and invasion of Pacific molluscan taxa recorded in fossil shellbeds at Tjörnes, Iceland*

11:05—11:20 AM, Kennedy, George L., Rockwell, T.K. and Haaker, E.C. *Paleontology and the Pleistocene marine terrace record of U.S. Marine Corps base camp Joseph H. Pendleton, northern San Diego County, California*

11:20—11:35 AM, Squires, R.L., Lipman, Paul J. and Nyborg, T. *A rare glimpse of early Paleocene (late Danian) northeast Pacific mollusks and arthropods: A new locality, north side of Simi Valley, Ventura County, southern California*

11:35—11:45 AM, **Group photo for all presenters in this session**

Lunchtime Poster Session: 11:45 AM—1:30 PM, Mudd Hall of Philosophy courtyard, USC

Symposium (continued): Current Research in Fossil Mollusca, chair: Austin Hendy

1:30—1:45 PM, Eernisse, Douglas J. and Vendrasco, M.J. Ochmazochiton *is a Permian Chitonida crown group imposter*

1:45—2:00 PM, Clites, E.C., Pearson, Lillian K., Hendy, A. and Marshall, C.R. *Eastern Pacific invertebrate communities of the Cenozoic (EPICC): Digitizing millions of fossil mollusks*

2:00—2:15 PM, Smith, Judith T. *Tertiary-Caribbean mollusks in the ancient Gulf of California*

2:15—2:30 PM, **Coffee break**

2:30—2:45 PM, DeVries, Thomas J. *An early Eocene brackish-marine molluscan fauna from the East Pisco Basin* (*southern Peru*)

2:45—3:00 PM, *Anderson, Brendan M. and Allmon, W.D. Turritella abrupta: *The bizarre biology and ecology of the largest known turritellid gastropod*

3:00—3:30 PM, Groves, Lindsey T. *An unusually preserved suite of invertebrate fossils from the late Pleistocene, Hancock Park, Los Angeles County, California*

3:30—4:10 PM, **Remembrance of James McLean and Twila Bratcher**

June 22, 2017: Thursday, Mudd Hall of Philosophy, room 101, USC campus

Symposium: Terrestrial Gastropods, chair: Shawn Wiedrick

9:00—9:15 AM, **Opening remarks**: Shawn Wiedrick

9:15—9:30 AM, *Linscott, T. Mason and Parent, C.E. *Phylogenomics of lower Salmon River Oreohelicidae*

9:30—9:45 AM, *Richart, Casey H., Chichester, L. F., Boyer, B. and Pearce, T.A. *Rediscovery of the southern California endemic American Keeled Slug* Anadenulus cockerelli *(Hemphill, 1890) after a 71-year hiatus*

9:45—10:00 AM, *Wiedrick, Shawn G., Ostrowski, E.G. and Eernisse, D.J. *California desert land snails through the eyes of David Quammen*

10:00—10:15 AM, Nekola, Jeff *A phylogenetic overview and revision of the California Vertiginidae* 10:15—10:30 AM, Parent, Christine E. *Adaptation and speciation in Galapagos* Naesiotus *snails*

10:30—10:45 AM, **Coffee break**

10:45—11:00 AM, Meyer III, W. Marty, Yeung, N. and Hayes, K. *Rapoport's rule as a tool for understanding distributions of non-native species on tropical islands in multiple ecological contexts*

11:00—11:15 AM, Drost, Charles A., Roth, B., Pearce, T.A., and Nekola, J. *Land snails and slugs of the California Channel Islands: Current inventory and assessment*

11:15—11:30 AM, Kitting, Chris L. *Three species of freshwater invasive apple snail shells, found dead, on shores of California's upper delta, and two reservoirs upstream*

11:30—11:45 AM, Pearce, Timothy A. *Review of the endemic land snail genus* Micrarionta *on four California islands plus Guadalupe Island, with a re-evaluation of* M. maxima

11:45 AM—12:00 PM, Gilbertson, Lance and Goodward, D. *A comparison of selected desert helminthoglyptid taxa (Helicoidea: Helminthoglyptidae) with an emphasis on reproductive anatomies*

12:00—12:15 PM, Gilbertson, L., Goodward, D., Vendetti, J.E., Wiedrick, S.G., McIntyre, S.L. and Eernisse, D.J. *First phylogeny estimates for the California Helminthoglyptidae Project (CHP)*

12:15—12:25 PM, **Group photo for all presenters in this session**

Lunchtime Session: 12:25—1:25 PM, **50 years of WSM: A Retrospective**, chair: Patrick J. Krug

Afternoon Session: Marine heterobranchs: biodiversity & phylogenetics, chair: Ángel A. Valdés

1:30—1:45 PM, Bertsch, Hans *Structure and biodiversity of three heterobranch (Mollusca: Gastropoda) communities at Bahía de los Ángeles, Baja California, México, with inter-provincial comparisons*

1:45—2:00 PM, Valdés, Ángel *Speciation on the fringes, alternate facts, and biodiversity of sea hares*

2:00—2:15 PM, Krug, Patrick J., Ellingson, R.A., Pimentel, V., Nakata, N., Medrano, S., McCarthy, J.B., Awbrey, J., Medina, M., Vendetti, J.E., Trowbridge, C.D. and Valdés, A. *A five-gene phylogeny of 282 species overturns conventional systematics of* Sacoglossa*, and reveals surprising niche conservation at the species level*

2:15—2:30 PM, *Medina, Melanie and Krug, P.J. *Integrative species delimitation supports 12 taxa in the* Elysia tomentosa *complex (Heterobranchia:* Sacoglossa*), including seven cryptic species in the Indo-Pacific*

2:30—2:45 PM, **Coffee break**

2:45—3:00 PM, *Green, Brenna and Gosliner T.M. *A tale of two? Slugs: Cryptic speciation and morphological variation in northeastern Pacific* Flabellina

3:00—3:15 PM, Krug, P. and *Sherman, Ariel *Clarifying the boundaries between sea slug species: Resolving the* Elysia ornata *species complex*

3:15—3:30 PM, Bertsch, Hans and Hoover, C. *Comparative natural histories of* Doriopsilla bertschi *and* D. davebehrensi*, and* Tambja abdere *and* T. eliora *(Heterobranchia: Nudibranchia) at Bahía de los Ángeles, Gulf of California, México*

3:30—4:30 PM, **WSM Business Meeting**, members please stay to establish a quorum

6:30—9:00 PM, **WSM Banquet**, NHMLA, Foyer. **Speaker:** Carole S. Hickman, *WSM turns 50 –*

Celebrating great moments and people in left coast malacology

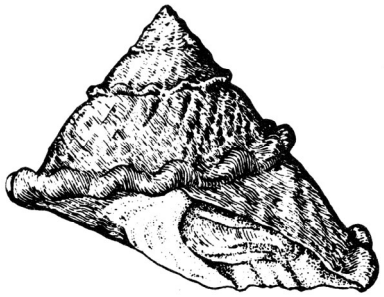
June 23, Friday, Field Trips: meet at 9:15 at NHMLA car park

- Madrona Marsh: 9:15 AM – 1:30 PM
- Pleistocene of Palos Verdes: 9:15 AM to about 4:30 PM. Field trip begins with a visit to the NHMLA invertebrate paleontology collections (off-site)

Fieldtrips: Please meet near the NHM car park (open green circle in Map 2, above) at 9:15 AM for either field trip. Vans will leave promptly. Please be advised of time changes, which may be announced during the meeting. ***Please bring water and wear comfortable shoes.***

Madrona Marsh (meet at 9:15 AM at the NHM car park, lunch provided). Edited from the website www.friendsofmadronamarsh.com: "The Madrona Marsh Preserve is one of the last remaining vernal freshwater marshes in Los Angeles County. Since the arrival of Europeans, development has removed virtually all regional wetlands. The Preserve is a mix of dune, coastal prairie, alkali margin, vernal pool, and vernal marsh within the El Segundo Sand Dune System."

Pleistocene of Palos Verdes (meet at 9:15 AM at the NHMLA car park, lunch provided) The Palos Verdes Peninsula is composed of Middle Miocene and younger sediments lying unconformably on Mesozoic-aged Catalina Schist, through which volcanism has introduced basalt and tuff. The Palos Verdes Peninsula is remarkable for its record of Pleistocene marine terraces (some richly fossiliferous), spectacular geomorphology, whale watching, and the most beautiful views in Southern California.



Oral Presentations

Alphabetical by First Author

Effects of ocean acidification and warming on the physiology of purple-hinge rock scallops: A multi-stressor and multi-method approach

*Alma, Lindsay, Fiamengo, C., Holtgrieve, G. and Padilla-Gamino, J.L.
University of Washington, School of Aquatic and Fishery Sciences, 1122 NE Boat St., Seattle, WA 98105 USA
lalma@uw.edu, cfiamengo1@gmail.com, gholt@uw.edu, jpgamino@uw.edu

In 2015, the atmosphere surpassed 400 ppm of CO^2 for the first time in recorded history. The consequences of elevated CO^2 are increased ocean temperatures and ocean acidification, which are expected to affect the physiology of marine organisms. This project seeks to explore the interactive effects of pH and temperature on the acclimation capabilities of shellfish, allowing us to understand effects on macromolecular physiology when faced with multi-stressor treatments. I will be using the purple-hinge rock scallop (*Crassadoma gigantea*) as a model organism because *C. gigantea* is widely distributed across the North American Pacific, and of interest in the aquaculture industry. The objectives of this study are to quantify treatment differences in shell integrity, total lipids, fatty acid content, and presence of sub-lethal protein expression using shot-gun proteomic analysis. The results will contribute to our still limited understanding of the effects multiple environmental stressors on calcifying species under changing climate scenarios. Understanding how *C. gigantea* will be affected by climate change will help us foresee how other shellfish will be impacted and will be important to forecast future viability of this species in the aquaculture industry.

***Turritella abrupta*: The bizarre biology and ecology of the largest known turritellid gastropod**

Anderson, Brendan M.[1,2], Allmon, W.D.[1,2]
[1]*Department of Earth and Atmospheric Sciences, Snee Hall, Cornell University, Ithaca, NY 14853 USA;* [2]*Paleontological Research Institution, 1259 Trumansburg Road, Ithaca, NY 14850 USA*
brendan.m.anderson@gmail.com, wda1@cornell.edu

The Miocene turritellid *Turritella abrupta* (synonyms including *T. bosei, fredeai,* many specimens assigned to *robusta*, and potentially *ocoyana*) can exceed 20 cm in length and is also among the thickest-shelled turritellid species, fossil or Recent. This thick shell appears to confer protection against drilling and peeling predators, as the species has higher rates of breakage-repair than most other turritellids. Despite producing a shell at least twice as thick as other turritellids for similar sized whorls, and completely filling their apices with shell material, they appear to grow at a similar rate as other turritellids, as indicated by oxygen isotopic sclerochronology; a shell 11 cm (approximately 13 cm, if the missing distance to the apex is included) long is estimated to be no more than 2 years old. Unlike many turritellid species, furthermore, they are not abundant anywhere, and are usually rare components of fossil assemblages where they occur, even where turritellids are generally common, which may indicate a trade-off between successful defense and reproductive output. *Turritella abrupta*, however, appears to have ranged from Southern California (Rincon Formation) to Ecuador and Peru, and as far east as Colombia, an impressive geographic distribution for a species with low reproductive output. (Unfortunately, the protoconch is unknown.) Additionally, they exhibit a growth pattern unique within the group, in which the coiling axis appears off-set, flattening one side of the shell, perhaps serving to allow it greater stability on the bottom. In summary, this species shows numerous unusual features that appear to be the result of its relative giantism within its clade.

Structure and biodiversity of three heterobranch (Mollusca: Gastropoda) communities at Bahía de los Ángeles, Baja California, México, with inter-provincial comparisons
(**Extended from original program submission**)

Bertsch, Hans
Instituto de Investigaciones Oceanológicas, UABC, Ensenada, Baja California, México
hansmarvida@sbcglobal.net

Analyzing the taxonomy of the species found at Bahía de los Ángeles during 30+ years of ongoing investigations, reveals three distinct heterobranch communities, characterized by different species' compositions and physical oceanographic conditions:

1. Cuevitas, 20 km north of town (shore entry site 29º 03.39' N; 113º 32.37' W).
2. Punta la Gringa, 16 km north of town (shore entry at 29º 02.561' N; 113º 32.28' W).
3. Islas, including Puerto Don Juan (sunken ship reef [SSR] between Islas Ventana and Cabeza de Caballo, 28º 59.427' N; 113º 29.697' W).

Different relative abundances of the 12 most common heterobranch species define these three communities at BLA. Doriopsilla bertschi (Hoover, Lindsay, Goddard & Valdés, 2016) and Histiomena convolvula (Lance, 1962) are the dominant species at Cuevitas. Eight different species were most abundant at Punta la Gringa: Elysia diomedea (Bergh, 1894), Berthellina ilisima (Marcus & Marcus, 1967), Doriopsilla davebehrensi Hoover et al., 2016, Anteaeolidiella chromosoma (Cockerell in Cockerell & Eliot, 1905), Dendrodoris sp., Phidiana lascrucensis Bertsch & Ferreira, 1974, Discodoris ketos (Marcus & Marcus, 1967), and Phestilla lugubris (Bergh, 1870). At the Islas site SSR, Tambja eliora (Marcus & Marcus, 1967) and T. abdere Farmer, 1978, were predominant.

Taxonomic diversity (as measured by both H' and Evenness indices) for Nudipleura was highest at Punta la Gringa, and lowest at Cuevitas and Islas (Table 1). These taxonomic differences are explained by differences in the feeding biodiversity at these sites (Table 2), due to the super abundance of a few species.

The quantitative use of a time-search method by different investigators allows for comparisons between the densities and diversity indices from sites in different faunal provinces (Bertsch & Hermosillo, 2007; Bertsch, 2011). Taxonomic composition of spongivores, cnidarivores and bryozivores from the BLA sites and communities in Oregon, central California, Bahía de Banderas and Hawaii are contrasted to illustrate differences and similarities in feeding biogeography of heterobranch communities across marine provinces and temperature regimes.

Table 1. Total taxonomic biodiversity (as measured by the H' and Evenness indices) of Heterobranchia and Nudipleura at the three communities in Bahía de los Ángeles (data from 1984-2010).

	# Species	**Specimens**	**H'**	**Evenness**
HETEROBRANCHIA				
Punta la Gringa	82	6571	2.6378	0.5986
Cuevitas	64	2236	2.1489	0.5167
Islas	55	1013	2.46	0.6141
NUDIPLEURA				
Punta la Gringa	64	3741	2.9907	0.7191
Cuevitas	51	1738	1.659	0.422
Islas	44	948	2.2534	0.5955

Table 2. Totals of species and specimens observed (including numbers, percentages, and densities), and H' and evenness (J') values for feeding preferences of Nudipleura at the three Bahía de los Ángeles heterobranch communities. Site totals are for all Nudipleura specimens observed, including all prey items and those with unknown prey. Low H' (<1.5) and/or Evenness (<0.5) indices are indicated by * and **bold** text. Br: bryozoan feeders; Cn, cnidarian feeders; Sp, sponge feeders.

Location/Prey	**Species**	**Specimens**	**%**	**H'**	**Evenness**
Punta la Gringa	64	3741		2.9907	0.7191
			(11.55/hr)		
Br (0.97/hr)	13	313	8.4%	2.091	0.8152
Cn (4.25/hr)	20	1377	37%	2.0984	0.7005
Sp (6.26/hr)	28	2029	54.6%	2.0308	0.6094
Cuevitas	51	1738		1.659	0.422
			(15.86/hr)		
Br (0.54/hr)	9	59	3.4%	1.7837	0.8118
Cn (3.54/hr) *	**16**	**388**	**22.2%**	**1.2251**	**0.4419**
Sp (11.74/hr) *	**21**	**1287**	**74.4%**	**0.8417**	**0.2764**
Islas	44	948		2.2534	0.5955
			(9.69/hr)		
Br (5.84/hr) *	**10**	**571**	**62.6%**	**0.9901**	**0.4299**
Cn (0.97/hr)	12	95	10.4%	1.9883	0.8002
Sp (2.51/hr)	19	246	27%	1.6175	0.5493

References

Bertsch, H. 2011. Nudibranch feeding biogeography: Ecological network analysis of inter- and intra-provincial variations. Thalassas 27: 155-168.

Bertsch, H., & Hermosillo, A. 2007. Biogeografía alimenticia de los opistobranquios del Pacífico noreste. Estudios sobre la Malacología y Conquiliología en México: 73-75.

Comparative natural histories of *Doriopsilla bertschi* and *D. davebehrensi*, and *Tambja abdere* and *T. eliora* (Heterobranchia: Nudibranchia) at Bahía de los Ángeles, Gulf of California, México
(**Extended from original program submission**)

Bertsch, Hans[1] and Hoover, C.[2]
[1]*Instituto de Investigaciones Oceanológicas, UABC, Ensenada, Baja California, México;* [2]*Dept. Biological Sciences, California State Polytechnic University, Pomona, CA 91768 USA*
cahoover@cpp.edu, hansmarvida@sbcglobal.net

Members of the three Heterobranch communities of Bahía de los Ángeles, *Doriopsilla bertschi* Hoover, Lindsay, Goddard & Valdés, 2016, and *D. davebehrensi* Hoover et al., 2016, are most abundant at Cuevitas (70.1% of individuals) and Punta la Gringa (82.7%), respectively, whereas the two *Tambja* species occur at Islas (96.4%). *Doriopsilla bertschi* is found almost exclusively on or near its prey sponge *Cliona californiana* (de Laubenfels, 1932) (88.6%), has an annual life cycle from August-July (maximum densities found in spring), and lays large eggs (89% found in May and June) in flat coils with direct development, usually on nearby algae, never on its sponge prey (Bertsch, 2002). To date, this species has only been reported from the Bahía de los Ángeles region (Bertsch & Aguilar Rosas, 2016). *Doriopsilla davebehrensi* usually is found out in the open or under rocks

(89.8%), far less often on possible sponge prey (10.2%), with an annual life cycle from July-June (maximum densities in summer), lays typical dorid upright ribbon egg masses (76% found in February and March), on various substrates, including prey sponge.

Both *Tambja* species feed on *Sessibugula translucens* Osburn, 1950, and a branching cream-yellow bryozoan; they lay pinkish egg ribbons. At the sunken boat reef, *T. abdere* Farmer, 1978, tends to occur deeper (75.5% below 20') than *T. eliora* (Marcus & Marcus, 1970) (70.1% shallower than 20').

References

Bertsch, H. 2002. The natural history of *Doriopsilla gemela* Gosliner, Schaefer and Millen, 1999 (Opisthobranchia: Nudibranchia), at Bahía de los Ángeles, Baja California, México. Western Society of Malacologists, Annual Report 33: 7-8.

Bertsch, H. & Aguilar Rosas, L. E. 2016. Invertebrados Marinos del Noroeste de México / Marine Invertebrates of Northwest Mexico. Universidad Autónoma de Baja California, Instituto de Investigaciones Oceanológicas, Ensenada, México. xxxii + 432 pp.

Hoover, C., Lindsay, T., Goddard, J. H. R., & Valdés, Á. 2015. Seeing double: pseudocryptic species in the *Doriopsilla albopunctata-Doriopsilla gemela* species complex of the north-eastern Pacific. Zoologica Scripta doi:10.1111/zsc.12123.

Quaternary land snails from Tenerife (Canary Islands) preserved in a scoria deposit

*Bullard, Elizabeth M.[1,2], Yanes, Y.[2] and Miller, A.I.[2]

[1]*Department of Biological Sciences, Section of Ecology, Behavior, and Evolution, University of California at San Diego, 9500 Gilman Dr, La Jolla, CA 92093 USA;* [2]*Department of Geology, University of Cincinnati, 345 Clifton Ct., Cincinnati, OH 45221, USA*

embullar@ucsd.edu, yurena.yanes@uc.edu, arnold.miller@uc.edu

Fossil assemblage faunal compositions may vary through space and time in response to climatic and/or taphonomic factors, but these relationships can be difficult to diagnose and disentangle. A Pleistocene land snail rich scoria sequence was studied to determine if it was influenced by taphonomic bias, climate change, or both, using a multifaceted approach that combines taphonomic, ecological, body size, and stable isotope data. Shell assemblages were sampled from two layers (Units A and B) in a cinder cone volcano of southern Tenerife (Canary Islands), dated to the glacial interval MIS 8 (~299-302 ka). The two units differed in taphonomy, species composition, and abundance, with the upper unit B showing higher diversity, abundance, and lower alteration than the lower unit A. Unit A was characterized by larger bodied species (length > 10mm) that were better preserved than smaller species (length < 10mm) whereas Unit B was dominated by well-preserved smaller species. The mismatch between the two layers likely resulted from physical differences in the sediment matrix surrounding the fossils, with larger scoria grains of Unit A enhancing destruction rates and thus favoring preservation of larger (more durable) taxa than smaller scoria grains of Unit B which enhanced shell preservation. Comparisons with modern assemblages from the coastal scrub, the plant biome in which the Pleistocene site currently resides, indicates that no modern analogue exists for these fossil assemblages within this biome. Shell oxygen isotope values reveal that the local climate was colder/wetter during MIS 8 than at present, which also may explain variations in species composition through time. These data suggest that both taphonomic and climatic factors appear to have induced temporal variations in taxonomic composition, but it is difficult to determine which of these has more significantly influenced the observed results.

The effects of ocean acidification on local adaptation in a keystone intertidal predator, *Nucella emarginata*

*Clare, Xochitl S., Contolini, G.M., Palkovacs, E.P., Raimondi, P.T.
University of California, Santa Cruz, Long Marine Lab, 115 McAllister Way, Santa Cruz, CA 95060 USA
xclare@ucsc.edu, gcontolini@ucsc.edu, epalkova@ucsc.edu, raimondi@ucsc.edu

Apex predators maintain the top-down structure of trophic relations. Information on marine top predators is often difficult to obtain due to limitations of observing organisms that forage at sea. Intertidal zones offer a platform for observing responses of top predators to environmental stress in an accessible spatial range. Increased atmospheric carbon dioxide has caused a slow decline in the pH of the world's oceans described as "ocean acidification" (OA). Environmental stress has been shown to affect animal behavior by causing alterations in chemoreception, including predatory cue responses. These effects may induce evolutionary changes in populations at local scales. This study investigates local adaptation to OA in the drilling sea snail, *Nucella emarginata*, foraging on its prey, the California mussel. Predation on mussels by snails from three sites was observed under low and ambient pH for 60 days. Mussel size was used to determine how snail drilling differs in each treatment. We found evidence of behavioral variation at each site, which could imply local adaptation to OA. Since human induced environmental change can create selective pressures on organisms, it is urgent that we begin to understand how this could alter community structure.

Eastern Pacific invertebrate communities of the Cenozoic (EPICC): Digitizing millions of fossil mollusks

Clites, E.C [1]., Pearson, Lillian K.[1], Hendy, A.[2], Marshall, C.R.[1,3]
[1]University of California Museum of Paleontology, 1101 Valley Life Sciences Bldg., Berkeley, CA 94720 USA; [2]Natural History Museum of Los Angeles County, 900 Exposition Blvd, Los Angeles, CA 90007 USA; [3]University of California, Berkeley, Department of Integrative Biology, 3040 Valley Life Sciences Bldg., Berkeley, CA 94720 USA
eclites@berkeley.edu, lkpearson@berkeley.edu, ahendy@nhm.org, crmarshall@berkeley.edu

Eastern Pacific Invertebrate Communities of the Cenozoic (EPICC) is a National Science Foundation sponsored Thematic Collections Network (TCN), affiliated with the Integrated Digitized Biocollections (iDigBio). The geographic and taxonomic scope of the TCN is the last 66 million years of Earth's history along the eastern Pacific coast, the longest continuous coastline in the world. The TCN's goal is to make data for 1.6 million fossil invertebrates available online. Nine natural history museums are partnered in the EPICC project: The California Academy of Sciences, John D. Cooper Center, National Museum of Natural History, Natural History Museum of Los Angeles County, Paleontological Research Institute, University of Alaska Museum, University of Oregon Museum of Natural and Cultural History, University of Washington Burke Museum with the University of California Museum of Paleontology as lead institution. EPICC is in its second of four years and has digitized 665,378 specimens, photographed 21,460 specimens and georeferenced 13,575 localities to date.

In addition to the capturing specimen data and imagery, EPICC project participants are compiling a taxonomic concordance for eastern Pacific fossils. This concordance is based on an assembly of taxonomic data for Recent and Quaternary mollusks, which provides a robust taxonomic framework for the introduction of taxonomic names from older fossil literature. The project is also developing stratigraphic concordances for the eastern Pacific, as well as compilations of eastern Pacific collecting localities showing equivalence across different museums. Virtual Field Experiences (VFEs) will transport students, teachers and the general public to well-known fossil collecting localities such as Pleistocene marine terraces of southern California. These digital records, data products, and outreach components will serve as a rich resource for better understanding the ecological and evolutionary processes that have shaped the Pacific biota and for communicating this research to the public.

What drives drilling? Patterns of prey selectivity among populations of predatory snails

*Contolini, Gina M., Palkovacs, E.P, Raimondi, P.T. and Kroeker, K.J.
University of California, Santa Cruz, Long Marine Lab, 115 McAllister Way, Santa Cruz, CA 95060 USA
gcontoli@ucsc.edu, epalkova@ucsc.edu, raimondi@ucsc.edu

Dogwhelks are intertidal snails that feed by drilling through the shells of sessile prey. On the west coast of North America, *Nucella* spp. dogwhelks are important predators that consume large quantities of a habitat-forming species, the California mussel. Because these predators have very low dispersal, I am studying how populations of *Nucella* may be adapted to local mussel phenotypes and seawater conditions. My main questions are: (1) Do mussel traits such as size and thickness vary throughout the dogwhelks' range? (2) Are dogwhelks selectively drilling mussels based on these traits? (3) Do environmental variables explain differences in selectivity? I measured drilled and non-drilled mussels at 8 sites in Oregon and California, compared selectivity for thickness and size among sites, and tested for effects of pH, temperature, and chlorophyll-*a* using an environmental dataset (OMEGAS). The mean size and thickness of drilled and available mussels varied significantly among sites. On average, dogwhelks tended to drill mussels larger (more energetically rewarding) and thinner for a given length (easier to handle) than what was available. At sites where this pattern was more prominent, selection to choose the most optimal prey may be stronger. After running models with combinations of measures of pH, temperature and chlorophyll-*a*, the models that best described thickness and length selectivity included terms for the frequency of low pH events. This implies that dogwhelk prey selectivity is more sensitive to ephemeral but extreme drops in pH rather than changes in the mean. Additionally, median chlorophyll-*a* was the most significant term in the model for thickness selectivity, meaning dogwhelks are choosing thinner prey when seawater is more productive, perhaps because mussels are growing thicker and the dogwhelks must be more discriminate. In our era of climate change, it is important to understand climate-mediated effects on these predators since they can alter community diversity by preying on foundational mussel beds.

When they go low, we go high: Is the southern *Lottia conus* displacing *Lottia scabra* in southern California?

*Coombs, Kim M.[1] and Eernisse, D.J.[1,2]
[1]Department of Biological Science, California State University, Fullerton, 800 N. State College Blvd., Fullerton, CA 92831 USA; [2]Research Associate, Malacology Department, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA
kcoombs@csu.fullerton.edu, deernisse@exchange.fullerton.edu

The limpets, *Lottia scabra* and *Lottia conus,* are common in rocky intertidal habitats along the southern California coast, where they are exposed to stressors such as temperature fluctuations, wave exposure, and desiccation. These limpets form a north/south pair and overlap broadly in their range and habitat within southern California, but only *L. scabra* is known from central to northern California, whereas our lab has found that *L. conus* is surprisingly abundant, and often mistaken for *L. scabra,* in at least the southern portions of southern California. In 2016, an El Niño event resulted in prolonged anomalous warming of coastal seawater, which may have impacted the vertical and latitudinal distribution of these two species. Prior to this study, our lab's studies on this species pair have mostly been qualitative to date. Here we quantitatively estimated distribution patterns of *L. conus* and *L. scabra* using a PCR-based assay, which is reliable in providing unambiguous identification. Quadrat sampling was completed at nine sites in central to southern California at various heights above chart datum, recording the number and size of collected limpets. Our studies were designed to test two hypotheses. First, we predicted a gradient in their relative vertical distribution wherever the two species co-occur in southern California, with the southern *L. conus* expected to be more abundant high on the shore, where thermal stress is higher, and *L. scabra,* conversely, more abundant on the cool lower shore. Second, we predicted that *L. conus* will be more abundant with decreasing latitude (and increasing

temperature), away from Point Conception. Our results confirm how common the little studied *L. conus* is at present throughout southern California. Being susceptible to temperature changes make limpets a good indicator species for detecting regional climate change in their habitat. Limpets are a potentially valuable empirical test case for tracking changes in species distribution of rocky intertidal inhabitants. Our first estimates could provide an important baseline in the event that the 2016 warming trends continue or reverse, dynamically affecting the relative distribution of these similar appearing species.

Hyperparasitism and abalone Withering Syndrome, their role in sudden mass mortalities of abalone in Baja California, México

*Cruz-Flores, Roberto[1], Muñoz-Flores, M.[1], and Cáceres-Martínez, J.[1,2]
[1]Centro de Investigación Científica y de Educación Superior de Ensenada, (CICESE), Carretera Ensenada-Tijuana No. 3918, Zona Playitas, 22860, Ensenada, Baja California, México; [2]Instituto de Sanidad Acuícola, A.C. (ISA), Calle de la Marina S/N, esq. Caracoles, Fraccionamiento Playa Ensenada, 22880, Ensenada, Baja California, México
rocruz@cicese.edu.mx, munozf@cicese.edu.mx, jcaceres@cicese.mx

Abalone Withering Syndrome (WS) is a disease that is highly lethal for black abalone (*Haliotis cracherodii*) from the coastal waters of central and southern California, USA. This disease is considered as one of the main causes for the closure of the abalone fishery in the US during the 90´s. The etiological agent of WS is a Rickettsiales-like bacteria called *Candidatus* Xenohaliotis californiensis (*C*Xc), that is also found in black abalone from the waters of Baja California and by analogy it is considered responsible for the disappearance of this species in México in the mid 90´s. Additionally, it has also been detected in cultured red abalone (*Haliotis rufescens*), wild blue abalone (*Haliotis fulgens*) and wild yellow abalone (*Haliotis corrugata*) from Baja California and it has been proposed that *C*Xc is associated with massive mortalities of these species in cultured and wild populations. However, it is common to find abalone that are highly infected by *C*Xc that show no signs of the disease and survive. On the contrary, abalone with signs of the disease and light infections have been found to die. This disease has been proven to be chronic and this contradicts the acute profile of WS. Recently, a bacteriophage hyperparasite that is lethal for *C*Xc has been detected. This bacteriophage alters the development of WS and appears to be a natural interaction that could help explain the contradicting observations on the development of WS. In this study a molecular and histopathological survey of cultured and wild abalone populations was carried out to monitor *C*Xc and its bacteriophage to better understand the development of WS. Our results suggest that due to the chronic progression of this disease, *C*Xc can hardly be considered responsible for the mass mortalities observed in the peninsula of Baja California; these are most likely associated with sudden environmental changes that affect infected and uninfected abalone.

An early Eocene brackish-marine molluscan fauna from the East Pisco Basin (southern Peru)
(**Extended from original program submission**)

DeVries, Thomas J.
Burke Museum of Natural History and Culture, University of Washington, Box 353010, Seattle, WA 98195 USA. Corresponding address: Box 13061, Burton, WA 98013 USA
tomdevrie@aol.com

The East Pisco Basin of south-central Peru **(**Figure 1a**)** is an emergent forearc basin that contains hundreds of meters of Cenozoic marine sedimentary strata assigned to four depositional sequences and eponymous formations: the Paracas (middle to upper Eocene), the Otuma (uppermost Eocene to lowermost Oligocene), the Chilcatay (uppermost Oligocene to middle Miocene), and Pisco (middle Miocene to Pliocene) (Dunbar et al., 1990; DeVries, 1998; Figure 1b**)**. These bioclastic sandstones and tuffaceous and diatomaceous

silty sandstones are well known for their vertebrate fauna, which includes archeocete, odontocete, and mysticete cetaceans; seals and sea lions; penguins and seabirds; sharks; and crocodiles. The bioclastic sandstones also contain a diverse molluscan fauna (e.g., DeVries, 2007).

The Caballas depositional sequence, which underlies the Paracas sequence, was previously perceived solely as a non-marine deposit. The sequence is prominently exposed as floodplain red beds in beach escarpments facing Puerto Caballas and along cliffs flanking the lower Río Grande valley. That perception has been overturned by the discovery of shell beds interfingering with the upper part of the red beds (DeVries, 2017), part of a succession of strata that began with an accumulation of 70 meters of gravelly alluvium and culminated with poorly sorted floodplain siltstones **(**Figure 2**)**.

The shell beds' fauna, the oldest known Cenozoic molluscan fauna in the East Pisco Basin, is dominated by small oysters, which are assigned to the northern Peruvian Eocene species, *Ostrea buski* Woods, 1922 (Figure 3). Many of the small oysters are articulated; a few exhibit impressions of tree twigs. Other epibenthic or semi-infaunal bivalves include four byssate taxa: a mytilid, *Brachidontes euglyphus* (Woods, 1922), an anomiid, *Carolia parinensis* Olsson, 1928, and two noetiid arcoids, *Samanoetia* sp. and another similar to *Sheldonella*. Infaunal bivalves include venerids and an unidentified species of the cyrenid *Polymesoda*.

As abundant as the oysters are cerithioid gastropods, represented by a modest diversity of genera, including *Batillaria*, *Bittium*, *Melanatria*, *Pachychilus*, *Potamides*, *P*. (*Potamidopsis*), and *Turritella* (Figure 4). Less commonly encountered gastropods include the naticid-like *Ampullina woodsi* Hanna and Israelsky, 1925 (Figure 4T), one undescribed species of *Nerita*, and rare unidentified neogastropods.

Molluscan species in common with the fauna of the Talara Basin of northern Peru Olsson, 1928, 1929, 1931) include *B*. *euglyphus*, *C*. *parinensis*, *A*. *woodsi*, *Turritella* aff. *T*. *keswickensis*, and "*Potamides*" *occidentalis*; they point to an age of late early Eocene to early middle Eocene. A more precise age cannot be determined, absent radiometrically dated ashes or microfossils associated with the shell beds. Ash beds in the Otuma sequence have returned early Priabonian ages and radiolarians and coccolithophorids in overlying Paracas siltstones have yielded early Bartonian ages (Dunbar et al., 1990; DeVries et al., 2006). Caballas continental deposition is inferred to have commenced following the Incaic I tectonic phase (59-55 Ma) and marine and floodplain deposition to have terminated prior to the Incaic II tectonic phase (43-42 Ma) of Benavides (1999). Hence, the age of the Caballas shell beds is probably about 46 Ma, i.e., early Lutetian, and likely no older than late Ypresian.

The cerithioid-oyster fauna is characteristic of brackish-marine environments (Squires, 1991, 1999; Kowalke, 2001), as is the presence of *Polymesoda*. Disseminated carbonized leaf debris in sandstone beds and twig molds on oyster valves are consistent with the presence of brackish water-adapted woody plants, e.g., mangroves, as are inverted V-shaped trace fossils that may be mangrove stilt roots (Figure 5). To date, however, no pollen of any kind has been recovered from Caballas rocks.

The Eocene brackish waters at Puerto Caballas were inhabited by marine vertebrates, including sharks and sea turtles. Of special note is the discovery in the brackish-water strata of a caudal vertebra of an archeocete whale, perhaps the oldest cetacean discovered in South America, older than basilosaurids from the lower Paracas sequence (Uhen et al., 2011) and as old or older than a cetacean from Seymour Island, Antarctica (Reguero et al., 2011).

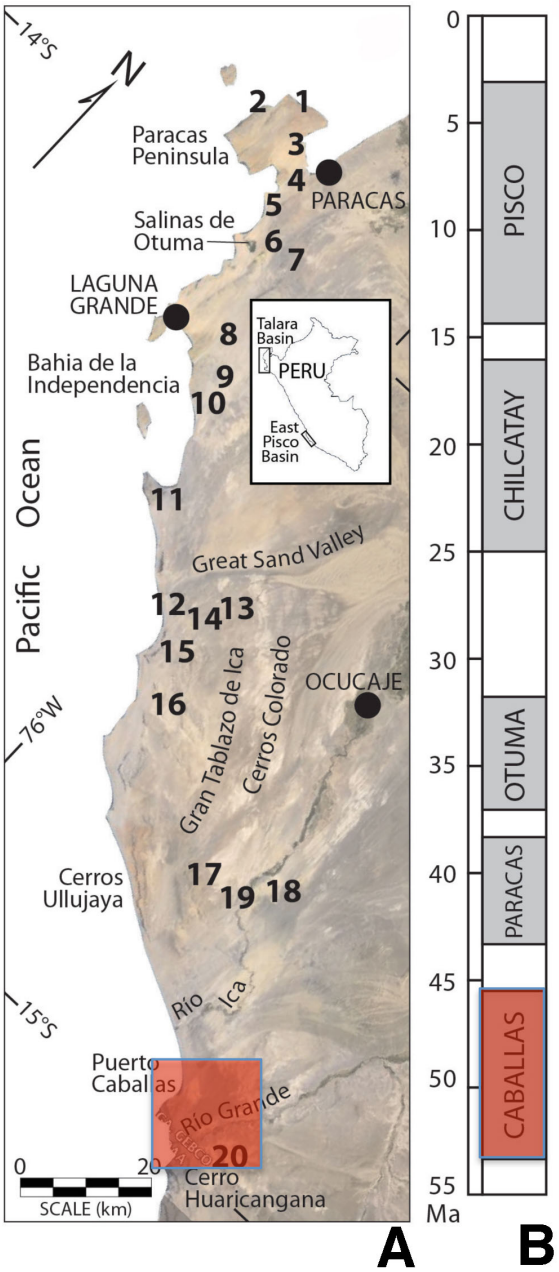


Figure 1. The East Pisco Basin, southern Peru. A. Google Earth imagery of the East Pisco Basin from Paracas to Cerro Huaricangana and the location of outcrops of the Caballas Formation (rose-colored square). B. Stratigraphic column of Cenozoic sedimentary strata in the East Pisco Basin, including the lower to lower middle Eocene Caballas Formation (rose-colored).

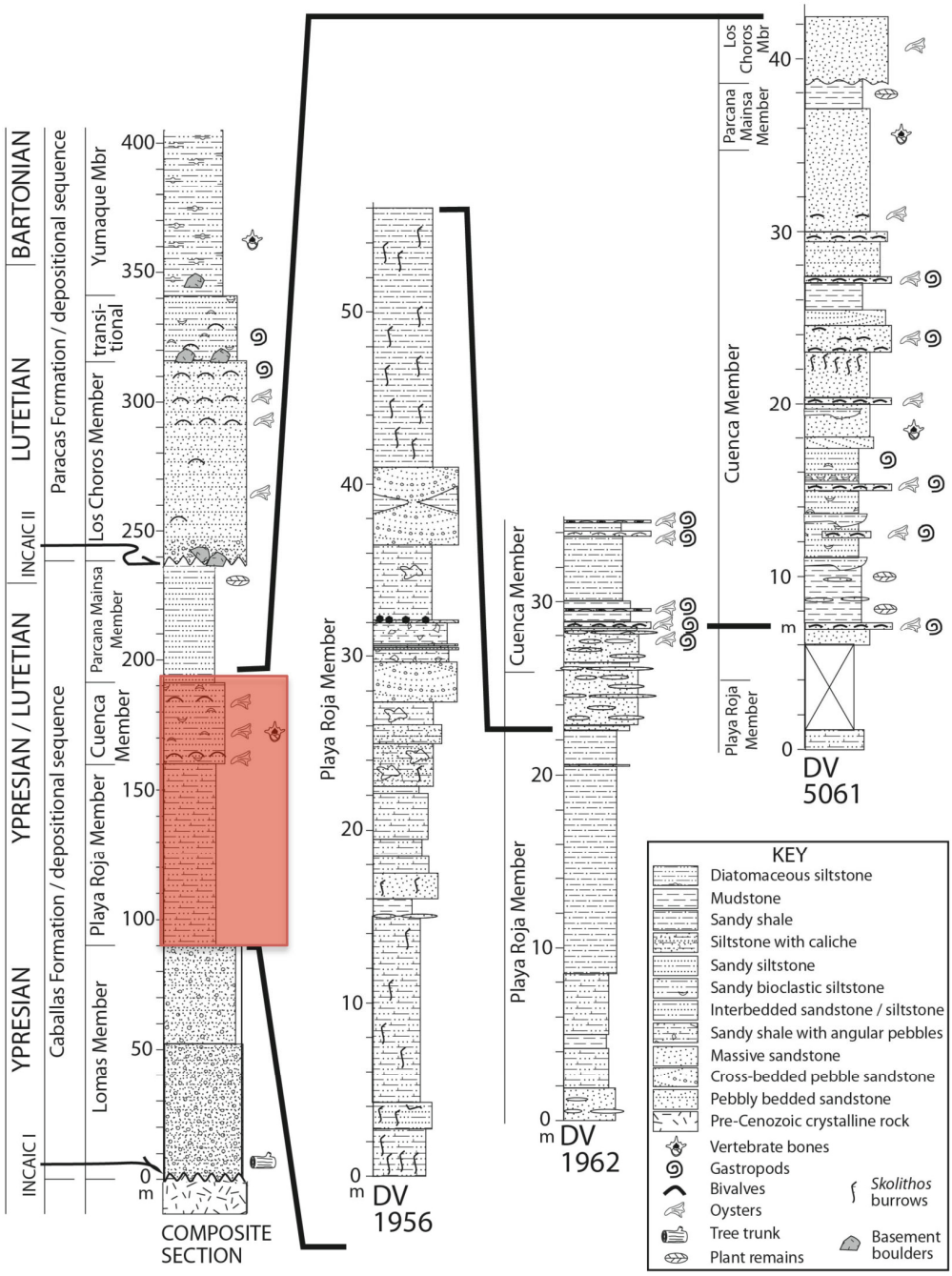


Figure 2. Stratigraphic column of the Caballas Formation / depositional sequence and the overlying Paracas Formation / depositional sequence, including named members of both formations. Red beds and overlying estuarine mollusk-bearing beds are rose-colored.

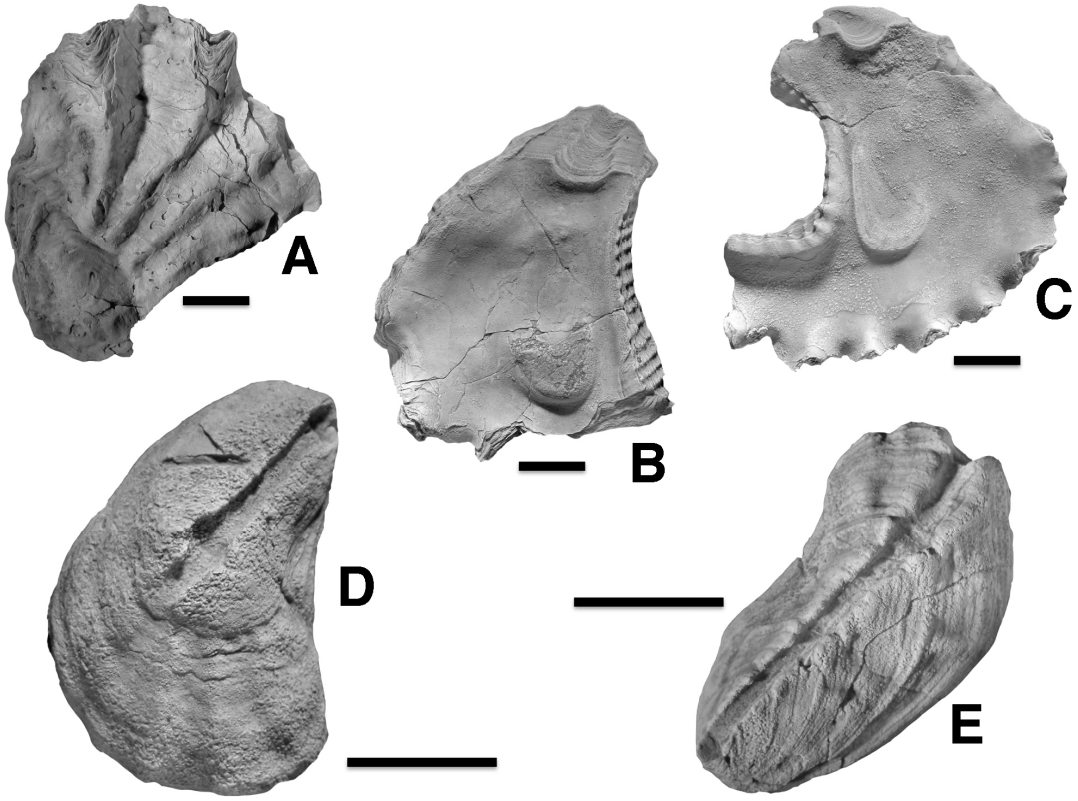


Figure 3. *Ostrea buski* Woods, 1922, which is abundant in the estuarine beds of the Caballas Formation. A. Exterior, upper valve. B. Interior, upper valve. C. Interior, attached valve. D. Exterior, attached valve with twig impression. R. Exterior, attached valve with twig impression.

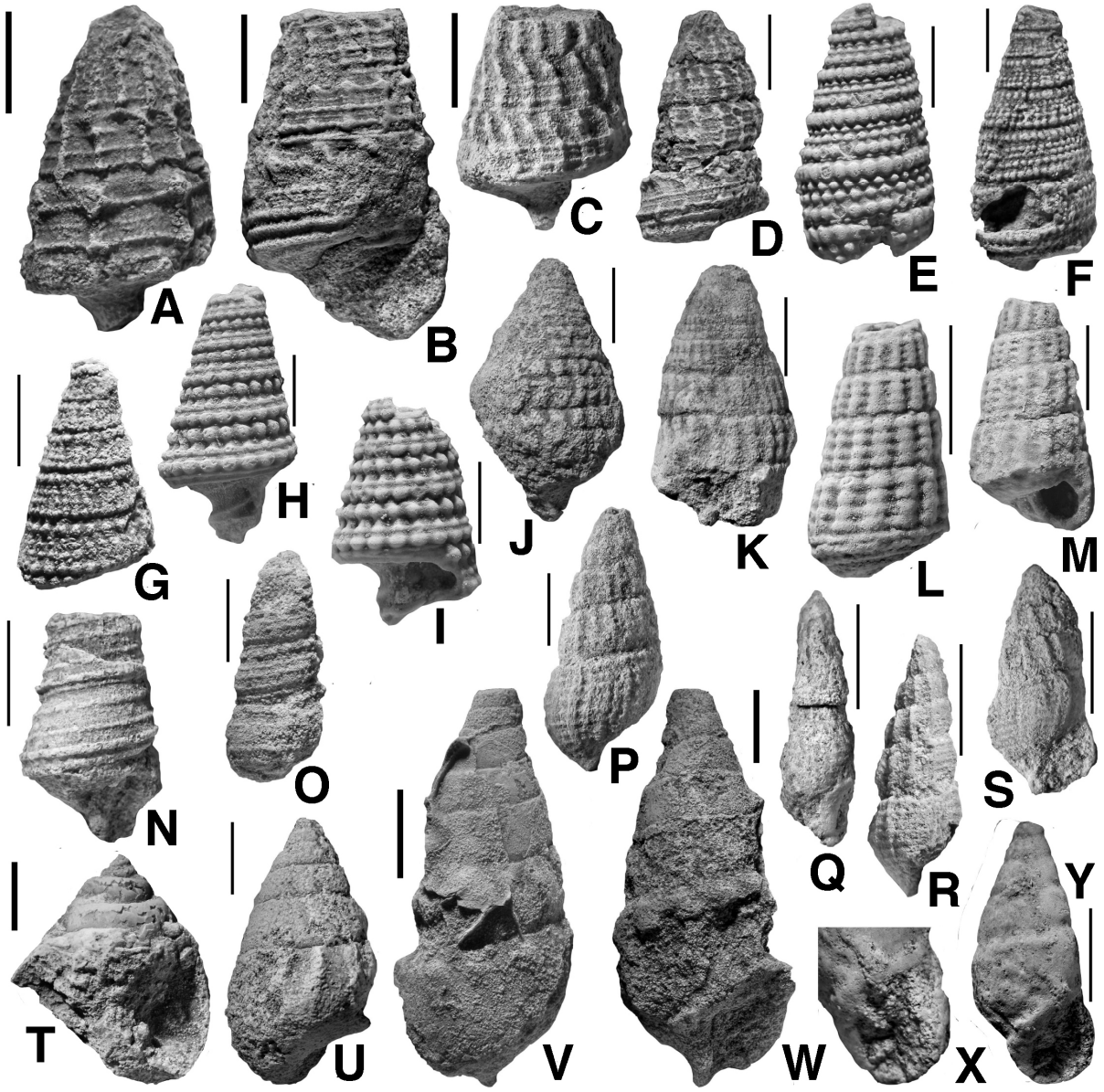


Figure 4. Gastropods of the estuarine beds, Caballas Formation. A-D. *Potamides* (*Potamidopsis*) *occidentalis* Woods, 1922. E. *Potamides* sp. 1. F. *Potamides* sp 2. G. *Potamides* sp. 3. H, I. *Potamides* sp. 4. J, K. *Potamides* sp. 5. L, M. *Batillaria* sp. N, O. *Turritella* aff. *T. keswickensis* Olsson, 1928. P, S. Cerithioid sp. Q, R. *Bittium* sp. T. *Ampullina woodsi* Hanna and Israelsky, 1925. U-W. *Melanatria* sp. X, Y. Cerithioid sp. Thick scale bars are ten millimeters; thin scale bars are 5 millimeters.

Figure 5. Trace fossils in carbonaceous sandstones of estuarine strata, Caballas Formation. Inverted V-shaped traces may be mangrove stilt roots.

References

Benavides C., V. 1999. Orogenic evolution of the Peruvian Andes: the Andean cycle. In: Geology and ore deposits of the Central Andes; Skinner, B.J. (ed.), SEPM Special Publication, v. 7, p. 61-107.

DeVries, T.J. 1998. Oligocene deposition and Cenozoic sequence boundaries in the Pisco Basin (Peru). Journal of South American Earth Sciences, v. 11, p. 217-231.

DeVries, T.J. 2007. Cenozoic Turritellidae (Gastropoda) from southern Peru. Journal of Paleontology, v. 81, p. 331-351.

DeVries, T.J. 2017. Eocene stratigraphy and depositional history near Puerto Caballas (East Pisco Basin, Peru). Boletín de la Sociedad Geológica del Perú, v. 112, p. 39-52.

DeVries, T.J., Narváez, Y., Sanfilippo, A., Malumian, N., Tapia, P. 2006. New microfossil evidence for a late Eocene age of the Otuma Formation (southern Peru). XIII Congreso Peruano de Geología, Lima, Peru, October, 2006. Sociedad Geológica del Perú, Publicación Especial, v. 7, p. 615-618.

Dunbar, R.B., Marty, R.C., Baker, P.A. 1990. Cenozoic marine sedimentation in the Sechura and Pisco basins, Peru. Palaeogeography, Palaeoclimatology, Palaeoecology, v. 77, p. 235-261.

Kowalke, T. 2001. Cerithioidea (Caenogastropoda: Cerithiimorpha) of Tethyan coastal swamps and their relations to modern mangal communities. Bulletin of the Czech Geological Survey, v. 76, p. 253-271.

Olsson, A.A. 1928. Contributions to the Tertiary paleontology of northern Peru. Part 1, Eocene Mollusca and Brachiopoda. Bulletins of American Paleontology, v. 14, 155 p.

Olsson, A.A. 1930. Contributions to the Tertiary paleontology of northern Peru. Part 3, Eocene Mollusca. Bulletins of American Paleontology, v. 17, 73 p.

Olsson, A.A. 1931. Contributions to the Tertiary paleontology of northern Peru. Part 4, The Peruvian Oligocene. Bulletins of American Paleontology, v. 17, 124 p.

Reguero M.A., Tambussi, C., Mörs, T., Buono, M., Marenssi, S., Santillana, S. 2011. Vertebrates from the basal horizons (Ypresian to Lutetian) of the Cucullaea I Allomember, La Meseta formation, Seymour

(Marambio) Island, Ant-arctica. 11th International Symposium on Antarctic Earth Sciences (ISAES), Edinburgh, Scotland.
Squires, R.L. 1991. A new middle Eocene potamiid gastropod from brackish-marine deposits, southern California. Veliger, v. 34, p. 354-359.
Squires, R.L. 1999. Middle Eocene brackish-marine mollusks from the Matilija Sandstone at Matilija Hot Springs, Ventura County, southern California. Contributions in Science, Natural History Museum of Los Angeles County, v. 480, 29 p.
Uhen, M.D., Pyensen, N., DeVries, T.J., Urbina, M., Renne, P.R. 2011. New middle Eocene whales from the Pisco Basin of Peru. Journal of Paleontology, v. 85, p. 955-969.

Paleoecology of late Pleistocene oyster beds, San Pedro, California

*Ditmar, Jolene and Bonuso, N.
Department of Biological Science, California State University, Fullerton, 800 N. State College Blvd., Fullerton, CA 92831 USA

Oyster diversity steadily declined from four species in the Cenozoic (Miocene?) to two species in the Pleistocene. Currently only one native species remains: *Ostrea lurida*. Biologists attribute the decline of oyster beds to industrialization and urbanization of southern California. Restoration efforts continue within southern California, but researchers lack the deep-time perspective of oyster bed community history. An oyster paleocommunity was examined to better understand pre-human habitats. This was accomplished by documenting fossil content from the late Pleistocene Palos Verdes Sand on Knoll Hill, San Pedro, California and comparing results with that of Vreeland (2014). Two samples were wet sieved, sorted, and all usable fossils were identified to the species level and counted. Length and width measurements of all oyster specimens were recorded. *Ostrea lurida* accounted for 11.6 % of all taxa recovered from the first sample. It is the most abundant taxon present, with 86.5 individual specimens. Oyster specimens from the second sample only accounted for 6.7% of the total taxa determined. Average oyster size differences from both samples are less than one millimeter. The addition of the late Pleistocene San Pedro locality oyster sizes disproves the hypothesis that oyster size decreases through the Quaternary. However, oyster diversity data from the late Pleistocene San Pedro locality supports the hypothesis that oyster diversity has decreased in the post-Miocene.

Reference

Vreeland, K. K., 2014, A paleoecological reconstruction of oysters from Orange County, California: Understanding the past to help restore the future [M.S.: CALIFORNIA STATE UNIVERSITY, FULLERTON, 140 p.]

Land snails and slugs of the California Channel Islands: current inventory and assessment

Drost, Charles A.,[1] Roth, B.[2], Pearce, T.A[3]., and Nekola, J.[4]
[1]U.S. Geological Survey, Southwest Biological Science Center, 2255 N. Gemini Drive, Flagstaff, AZ 86001 USA; [2]745 Cole Street, San Francisco, CA 94117 USA; [3]Carnegie Museum of Natural History, 4400 Forbes Ave, Pittsburgh, PA 15213 USA; [4]C., Department of Biology, University of New Mexico, Albuquerque, NM 87131 USA
charles_drost@usgs.gov, barry_roth@yahoo.com, pearcet@carnegiemnh.org, jnekola@unm.edu

The land snails and slugs have the highest rate of endemism among all major animal groups on the eight Channel Islands located off the southern California coast; approximately 75% of the species are confined to one or more of the eight islands. We present a comprehensive overview of the land mollusk fauna of the Channel Islands, bringing together historical information and the results of recent and ongoing inventory studies. We

document a total of 36 native and 11 introduced species on the islands. For the islands with complete or nearly complete inventories, numbers of native terrestrial and semi-aquatic mollusks range from seven species on 1.6 sq. km Santa Barbara Island, to 13 species on both San Clemente Island (146 sq. km) and Santa Catalina Island (193 sq. km). Recent surveys have doubled the number of known species on some of the islands. The most striking find from recent surveys is an apparently new *Trilobopsis* species from Santa Cruz Island in the northern group. There are distinct biogeographic differences between the northern and southern islands (e.g. *Helminthoglypta* species on the northern, vs. *Micrarionta* and *Xerarionta* species on the southern islands), as well as apparent differences among the southern islands. Our surveys suggest a strong link between the recovery of native vegetation on the islands, and the population status of land snails and slugs, with substantially larger populations of native mollusks on those islands that have been free of non-native mammals the longest. We are extending the island studies to genetic comparisons with related groups on the mainland, particularly for *Haplotrema* and *Trilobopsis* species.

Ochmazochiton is a Permian Chitonida crown group imposter

Eernisse, Douglas J. [1] and Vendrasco, M.J.[2]
[1]*Department of Biological Science, California State University, Fullerton, 800 N. State College Blvd., Fullerton, CA 92831 USA;* [2]*Department of Geology, Pasadena City College, Pasadena, CA 91106 USA*
deernisse@fullerton.edu, mvendrasco@pasadena.edu

The crown group of Chitonida (Mollusca: Polyplacophora), which includes most of the about 1,000 extant chiton species, has recently been claimed to have originated during the Late Paleozoic, based in part on “slits” in the valves of fossil *Ochmazochiton* Hoare and Smith 1984 from the Permian Glass Mountains of West Texas. Members of Chitonida (chitonids) can be diagnosed by lateral extensions of the articulamentum layer of the intermediate valves, which anchor them firmly in the muscular girdle, and these so-called insertion plates have distinctive deep lateral slit rays where nerve bundles pass to the multitude of aesthete sensory organs in the exposed dorsal tegmentum layer of the valves. Related to a detailed study by one of us (MJV) of a larger sample of *Ochmazochiton* or related fossils (ochmazochitonids) from the Glass Mountains, has revealed that slit-like impressions in the valves to be fundamentally different from the slit rays of modern chitonids. Notably, the “slits” in ochmazochitonids are shallow and radially arrayed over a broad region including the sutural laminae whereas in modern chitons the slits are deep and occur singly or doubly along only the lateral margin. Also, the slits in ochmazochitonids are produced via a radial array of large horizontal aesthete channels whereas in modern chitons the slits are produced via a line of smaller vertical canals (corresponding to the slit ray). Other chitons in the Permian assemblage show grooves on the sutural laminae, and in general it seems that grooves and slits in their articulamentum extensions could have more to do with anchoring the valves than with nervous innervation of the tegmentum, and similar grooves or pectinations on the articulamentum margin have originated many times independently in the Polyplacophora. In contrast, the unique pattern of nervous innervation through well-defined articulamentum slit rays has not yet been demonstrated for pre-Cretaceous fossils. These new observations about ochmazochitonids and the lack of other compelling evidence for derived features associated with living or pre-Cretaceous chitonids imply that the Chitonida crown group could be much younger than current dogma suggests. Other extant chitons, grouped as Lepidopleurida, appear to lack anything like the shell-based apomorphic features noted for chitonids, so similar claims that their fossil record extends to the Paleozoic are even more difficult to justify.

On the probable causes of the Pacific Calico scallop fishery collapse in Magdalena Bay, Baja California Sur, México

Félix-Pico, Esteban F., Ramírez-Rodríguez, E. M. and Ortega-García, S.
Centro Interdisciplinario de Ciencias Marinas del Instituto Politécnico Nacional. Av. IPN s/n, Col. Playa Palo de Santa Rita, La Paz, Baja California Sur, 23090, México
efelix@ipn.mx, mramirr@ipn.mx, sortega0408@gmail.com

The Pacific calico scallop (*Argopecten ventricosus*) fishery was very important in the Magdalena Bay region of the central Pacific coast of Baja California Sur. The maximum capture happened in 1989 with 25,290 t. Then few records were reported, but from 1992 through 2012 the fishery operated at around 6,500 t, with some important fluctuations. In 2013 the catch declined markedly and since 2014 the government closed the fishery. The causes of this decline have not yet been established but may include overfishing, disease, and climatic variations. In this work we present results on possible relationships among time series of catch, sea surface temperature, chlorophyll *a* concentration, and fishing effort. In general, environmental change is related with catch fluctuations and negative temperature anomalies favored high captures. Fishing activities were high and poorly regulated, with intense poaching on top of the legal catch quota per season. The role of diseases on the population abundance remains unknown. In order to complement these results and because large oscillations in scallop stocks have occurred in other countries, we compiled information on the catch fluctuation causes reported from other scallop fisheries and the actual state of those stocks compared with the one in Mexico.

Baffling bathyal bivalves and others from the Chukchi borderlands

Foster, Nora,[1] Valentich-Scott, P.[2] and Iken, K.[3]
[1]NRF Taxonomic Services 2998 Gold Hill Road Fairbanks AK 99709 USA; [2]Santa Barbara Museum of Natural History 2559 Puesta del Sol Santa Barbara, CA USA; [3]School of Fisheries and Ocean Sciences University of Alaska Fairbanks P.O. Box 757220, Fairbanks, AK 99775-7220 USA
norarfoster@gmail.com, pvscott@sbnature2.org, kbiken@alaska.edu

In August 2016 biologists aboard the U.S. Coast Guard Cutter *Healy* surveyed marine fauna north of the Chukchi Sea shelf, to 77°N, and in depths of 498 to 3037 m. The mollusks collected by trawl, box core or ROV and made available to authors was very small: 14 specimen lots. Species identification is in progress, and we have determined 10 taxa: 6 bivalves, 3 gastropods, and one aplacophoran. For the two gastropods, described from Scandinavian waters, the Chukchi represents westward extension of their documented north Atlantic distribution. Of the 6 bivalves, 4 were described from the Arctic, and two from the abyssal northeast Pacific. The aplacophoran is tentatively identified as *Proneomenia sluiteri* described from north Atlantic waters.

A comparison of selected desert helminthoglyptid taxa (Helicoidea: Helminthoglyptidae) with an emphasis on reproductive anatomies

Gilbertson, Lance[1] and Goodward, D.[2]
[1]Museum Associate in Malacology, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA; [2]Grand Terrace, CA USA

An overview of helminthoglyptid species groups from the desert regions of southern California is presented. Comparisons between taxa are made with special regard to the organs and structures of their hermaphroditic reproductive systems. Photos taken of freshly dissected specimens and of subsequent stained slide preparations are used to show characteristic features. These include the dart sac and associated mucus glands found in many helminthoglyptids.

A major desert helminthoglyptid species group found in southern California is genus *Eremarionta* (*s.s*. and

Eremariontoides). Several species of *Eremarionta* and a related genus, *Cahuillus*, from the Coachella Valley and Mojave Desert are illustrated and compared. In these two genera (and a monotypic relative, *Chamaearionta*) the dart sac and mucus glands are seated directly on the vagina. All species are dart bearing except *Eremarionta* (*Eremariontoides*) *argus* and *Cahuillus fultoni*.

The *Helminthoglypta* subgenus *Coyote* is found on slopes along the northern and western edges of the Mojave Desert. Species of *Coyote* differ anatomically from other groups by aspects of their lower epiphallus and short, wide verge (papilla). In addition, they exhibit a dart sac seated atop an atrial sac and have a single mucus gland tube entering beneath the dart sac. *Sonorelix*, *Mohavelix*, and *Herpeteros* show a dartless condition. In addition, these genera exhibit a well-developed verge which is robust in *Herpeteros*. These characters are also found in the speciose southwestern genus *Sonorella*.

First phylogeny estimates for the California Helminthoglyptidae Project (CHP)

Gilbertson, L.,[1] Goodward, D.,[2] Vendetti, J.E.,[1] Wiedrick, S.G.,[3,1] McIntyre, S.L.,[3] Eernisse, Douglas J.[3,1]
[1]Natural History Museum of Los Angeles County, 900 Expo Blvd., Los Angeles, CA 90007 USA; [2]Grand Terrace, CA USA; [3]Department of Biological Science, California State University, Fullerton, CA 92834 USA
lngilbert@gmail.com, davegoodward@earthlink.net, jvendett@nhm.org, shawnwiedrick@hotmail.com, staceymc@csu.fullerton.edu, deernisse@fullerton.edu

The helicoid family Helminthoglyptidae Pilsbry, 1939, includes fairly large land snails called shoulderbands that are endemic to many of California's varied coastal, mountain, and desert habitats. They can be locally common but typical species have a surprisingly restricted geographic range that reflects their isolation within patchy suitable habitat separated by barriers to dispersal. The few California land snail specialists, whose numbers have steadily decreased from attrition, have warned that anthropogenic habitat destruction and species introductions are already posing an escalating threat to California's land snail fauna. There are approximately 110 recognized species, plus many subspecies, of Helminthoglyptidae reported as present in California. Few of these species or subspecies have been studied since the monumental 1939 monograph for terrestrial North American mollusks north of Mexico by Henry A. Pilsbry. Even fewer have any DNA sequences represented in GenBank. One challenge is that Pilsbry's extensive descriptions relied on anatomical features, as revealed by his expert dissections. Few today can perform comparably skillful specimen preparation, so that accurate identifications are challenging to obtain. Intraspecific variation in reproductive anatomy and shell morphology introduce additional challenges. Our own integration of DNA sequence analysis combined with dissections has produced enticing results, but we are still at an early stage of study. To promote further progress, we have formed an informal CHP working group and encourage contributions from others. Our goals are as follows: 1) document species that are still present, either thriving or imperiled; 2) assess their distribution compared to historical records; 3) provide selected mitochondrial and nuclear gene region sequences of representative expert-identified vouchered material for each species or subspecies; and 4) use these sequences to conduct phylogenetic analyses and to document DNA barcodes. A phylogenetic estimate can be useful for species delimitation, for testing the monophyly of recognized genera or subgenera, and for revealing biogeographic affinities of different regions within California and between parts of California and adjacent regions. In our presentation, we will summarize what we have learned with most of our focus so far on those species found in southern California.

A tale of two? Slugs: Cryptic speciation and morphological variation in northeastern Pacific *Flabellina*

*Green, Brenna and Gosliner T.M.
Department of Invertebrate Zoology and Geology, California Academy of Sciences, 55 Music Concourse Drive, San Francisco, CA 94118 USA
bgreen@calacademy.org, tgosliner@calacademy.org

Molecular analysis of the nudibranch genus *Flabellina* Gray, 1833 in the temperate northeastern Pacific has revealed a more complex picture of the genus than previously recognized. The most commonly encountered species in the region, *Flabellina trilineata*, has been described as exhibiting a wide degree of variation in color throughout its range. Molecular studies using the COI, 16S, and H3 markers indicate that *F. trilineata* is a complex of three species. Further complicating this picture, some specimens previously identified as *F. trilineata* are shown by molecular evidence to belong to the closely related species *Flabellina cooperi*. Additional specimens with a variety of color patterns have also been identified by molecular analysis as *F. cooperi*, suggesting that this species, traditionally considered rare, may actually be somewhat common but frequently misidentified.

An unusually preserved suite of invertebrate fossils from the late Pleistocene, Hancock Park, Los Angeles County, California

Groves, Lindsey T.
Malacology Department, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA
lgroves@nhm.org

An exploratory shaft for a future MetroRail Purple Line station at Wilshire Blvd. and Ogden Dr., Hancock Park, Los Angeles Co. yielded at least 103 taxa of fossil invertebrates including mollusks, echinoderms, arthropods, bryozoans, and annelids. Preservation of these specimens is highly unusual as they are coated with asphalt similar to Rancholabrean age (late Pleistocene) fossil specimens collected at the nearby La Brea tar pits. Specimens were recovered from 50 to 95 feet below the surface and are considered typical of the marine San Pedro Formation (~330,000 ka) (Quinn*, et al*., 2000; Scott *et al.* 2014). Mollusks include 45 gastropod taxa, 51 bivalve taxa, and two scaphopod taxa. All species are extant with the exception of a single broken specimen of the gastropod *Crepidula princeps* Conrad, 1856. The bivalve fauna is dominated by a growth series of the mactrid bivalve *Tresus nuttallii* (Conrad, 1837), which is indicative of a shallow muddy bottom from middle intertidal zone to 80 m depth in a bay very similar to that of modern Santa Monica Bay. A similar but smaller fauna reported by Lipps & Valentine (1970) from a construction site just east of the MetroRail site and probably from the same stratigraphic horizon, has been lost. Specimens identified in Quinn *et al.* (2000), from Hancock Park are from a similar horizon but have yet to be examined.

References

Lipps, J.H. and Valentine, J.W. 1970. Marine fossils at Rancho LaBrea. Science 278:277-278, fig. 1.

Quinn, J.P., Ponti, D.J., Hillhouse, J.W., Powell, II, C.L., McDougall, K., Sarna-Wojcicki, A.M., Barron, J.A., & Fleck, R.J. 2000. Quaternary chronostratigraphic constraints on deformation and blind fault activity, northern Los Angeles Basin. Final Technical Report 1434-HQ-98-GR-00055, 33 p., figs. 1-10.

Scott, K., Richards, C, & Gust, S. 2014. Purple line extension exploratory shaft project, Los Angeles, Los Angeles County, California. Cogstone Resource Management report, 124 p., figs. 1-22.

Revisiting the Pliocene opening of the Bering Sea gateway and invasion of Pacific molluscan taxa recorded in fossil shellbeds at Tjörnes, Iceland

Hickman, Carole S.
University of California, Museum of Paleontology, Berkeley, CA 94720–4780 USA
caroleh@berkeley.edu

Ocean gateways have played a fundamental geophysical role in the history of global climate change by

transporting or blocking massive transfers of heat energy. At the same time, gateways have played a fundamental biological role in faunal exchange, migration and invasions that have dramatically changed marine molluscan faunas. Pliocene opening of the Bering Strait resulted in an asymmetric exchange of gastropods and bivalves through the Bering Sea. The invasion of Pacific taxa is most strikingly recorded in the Tjörnes shellbeds in northeastern Iceland in a 1,200 m thick sequence exposed in seacliffs. Cold-water taxa appear abruptly at 3.6 Ma at the boundary between the *Mactra* Zone and the *Serripes* Zone.

The Tjörnes outcrops and fossils have been studied over a period of > 250 years, not only by Icelandic and Danish scientists, but also by paleontologists in Western North America. The Trans-Arctic Invasion is documented in 36 drawers of specimens in the UC Berkeley Museum of Paleontology, made in 1964 by David M. Hopkins of the U.S. Geological Survey and identified and studied by F. Stearns MacNeil and J. Wyatt Durham. An expedition to revisit the faunal transition was undertaken with the objective of relocating specific horizons and key invading taxa *in situ* to test the efficacy of returning to the field to obtain data left behind at the time of original collection. Three boreal-subarctic mollusks of Pacific origin were chosen for intensive search effort: the bivalve *Serripes groenlandicus*, abundant carnivorous naticid gastropods and the buccinid genus *Sipho*. We relocated these and other invading taxa in situ and photographically documented details in shellbeds above and below the zonal boundary. Images record taphonomic change as well as depositional change from a high-energy, open coastal environment to a deeper, more sheltered setting. Our observations confirm the value of Tjörnes as a field archive for the study global change and museum collections as archives directing future research.

Paleontology and the Pleistocene marine terrace record of U.S. Marine Corps base camp Joseph H. Pendleton, northern San Diego County, California

Kennedy, George L.,[1] Rockwell, T.K.[2] and Haaker, E.C.[3]
[1]Brian F. Smith and Associates, Inc., 14010 Poway Road, Poway, CA 92064 USA; [2]Department of Geological Sciences, San Diego State University, San Diego, CA 92039 USA; [3]G3Soilworks, Inc., 350 Fischer Avenue, Costa Mesa, CA 92626 USA
gkennedy@bfsa-ca.com, trockwell@geology.sdsu.edu, ehaaker@g3soilworks.com

Pleistocene marine terraces are a dominant geomorphic feature along the coastal strip of Camp Pendleton in northernmost San Diego County, California. Terraces are particularly well preserved between the mouth of the Santa Margarita River, in the south, and the mouth of San Onofre Creek, in the north, but have received little scientific attention probably due to their location on an active military base. In response to a proposed model of an offshore blind thrust fault beneath coastal San Diego County, a study of the marine terraces in Camp Pendleton was initiated in 2012. A sequence of at least 16 marine terraces extend to elevations of 380 meters or more, most of which are cut across a bedrock of San Onofre Breccia, and to a lesser extent, across softer marine sediments of the San Mateo and Capistrano Formations. The marine origin of these abrasion surfaces is confirmed by the presence of well-rounded pebble and cobble gravels that overlie the abraded bedrock surfaces, some with pholadid bivalve borings.

Except for three isolated outcrops with exposed rock-boring bivalve holes at higher terrace levels, the only fossils encountered were on the lowest terrace along the bluffs just south of San Onofre State Beach. The composite faunal assemblage comprises more than 150 invertebrate species and is dominated by bivalve and gastropod mollusks, as well as one scaphopod, at least six chitons (additional specimens remain unidentified), clionaid sponge borings, perhaps three species of marine polychaete worms, and a few small decapod crustacean pieces (*i.e.*, crab claws). Notably absent from the collections were any corals, bryozoans, brachiopods, barnacles, or echinoid (sea urchin and sand dollar) remains. Based on the geomorphic position of the terrace, and the cool-water zoogeographic signature of the fauna, the terrace and its faunal assemblage are assigned an age of about 80,000 years BP, correlative with marine oxygen isotope ($d^{18}O$) substage 5a (MIS 5.1) and the cool, latter part of the last interglacial complex.

Three species of freshwater invasive apple snail shells, found dead, on shores of California's upper delta, and two reservoirs upstream
(**Extended from original program submission**)

Kitting, Chris L.
Department of Biological Sciences, Cal State Univ. Hayward, CA 94542 USA
chris.kitting@csueastbay.edu

Unusually large freshwater snails, mainly *Pomacea canaliculata* (Lamarck, 1819) and other invasive snail species, threaten California's other agriculture and ecology. Several of such invasive apple snails, from the Amazon, already are established in parts of southern California, and elsewhere, including Southeast Asia. They are reportedly amphibious at night, unusual in having a gill AND lung, although they are not pulmonates. Reportedly, apple snail populations cannot persist at < 10 degrees C.

During late September 2015, during freshwater sampling, I found and imaged such a large, empty shell, 5 cm long at 0.7 ppt (freshwater salinity) at the mouth of San Joaquin River, flowing tidally into the River's Stockton Ship Channel, near Stockton, CA. Its shell morphology (see Figure next page) does not quite resemble well known apple snails, including *Pomacea diffusa* (Reeve, 1856) *(= P. bridgesii,) P. canaliculata* (Lamarck, 1819)*, P. haustrum* Reeve, 1858), nor *P. insularum* (D'Orbigny, 1839). Immediate and subsequent searching associated sediment, invasive water hyacinth, and *Egeria densa* (Planch, 1849) pondweed, I found no further apple snails nor eggs in that region. We have been unable to isolate and analyze DNA from dead shells.

During late May 2016, my similar observations yielded a 4 cm, different apple snail's empty shell just above the shore at Oroville Reservoir, Feather River, 180 km north, in Sierra foothills. Then during early August 2017, my similar observations yielded a 5 cm, still different apple snail's empty shell just above the shore at Don Pedro Reservoir on Tuolumne River in Sierra foothills, 100 km east of the first observation. Further observations above and below water yielded no other dead nor live invasive aquatic snails, such as New Zealand mud snail, *Potamopyrgus antipodarum* (Gray, 1853)*,* at any of these areas, nor further up San Joaquin River, in mid August 2016, at Millerton Reservoir, on San Joaquin River, 180 km southeast in Sierra foothills. However, previous reports by others showed New Zealand mud snail further NE in the California Delta watershed. Widespread *Physella gyrina* (Say, 1821) and *Helisoma anceps* (Menke, 1830), pulmonate gastropods and other apparently native snails continue to be found throughout this region, particularly on underwater vegetation.

Repeated possible introductions of these conspicuous non-natives upstream are likely, although these recently observed animals might not be viable, thus far. Many apple snails such as *Pomacea diffusa* (Reeve, 1856) in Ampullariidae remain readily available through pet supply sources. Any major increases in temperature probably increases such vulnerabilities to invasive species, often originating from closer to Earth's equator. Californians keep interconnecting their bodies of fresh water, often warming, with major economic, ecological, and other risks. Sooner or later, we may have to just say no to our rapid overexploitation and of our dwindling resources, especially water.

If it is so valuable to modify a habitat, we can demand that some of that value repair and restore our related natural resources as habitats, as sustainable native conditions.

A five-gene phylogeny of 282 species overturns conventional systematics of Sacoglossa, and reveals surprising niche conservation at the species level

Krug, Patrick J.,[1] Ellingson, R.A.,[1] Pimentel, V.,[1] Nakata, N.,[1] Medrano, S.,[3] McCarthy, J.B.,[3] Awbrey, J.,[1] Medina, M.,[1] Vendetti, J.E.,[2] Trowbridge, C.D.,[3] and Valdés, A.[4]
[1]Department of Biological Sciences, California State University, Los Angeles, CA 90032-8201 USA; [2]Natural History Museum of Los Angeles County, 900 Expo Blvd., Los Angeles, CA 90007 USA; [3] Oregon Institute of Marine Biology, Charleston, OR 97420 USA; [4]Department of Biological Sciences, California State Polytechnic University, Pomona, CA 91769 USA
pkrug@csula.edu (corresponding author)

Sea slugs in clade Sacoglossa are variously studied for their photosynthetic ability, potential use in anticancer drug discovery, for biocontrol of invasive algae, or due to their pivotal evolutionary position at the base of the pulmonate radiation. We developed a phylogenetic hypothesis for Sacoglossa using sequence data for five genes from 282 species and tested for monophyly of traditional genera and higher groups. We then modeled the evolution of algal host use and tested how host association altered diversification rates across slug lineages. Cryptic diversity was high, as 120 sampled species were likely undescribed. Alternative classification schemes proposed by Marcus, Jensen and Gascoigne based on morphological traits were all rejected by AU tests for monophyly of major proposed groups. Systematics of the shelled Oxynoacea was challenged by genetic evidence that three genera are synonyms of *Berthelinia*, and that *Cylindrobulla* is a sacoglossan sister to the rest of Oxynoacea, despite having a radula with multiple teeth per row and not eating *Caulerpa*. The superfamily of cerata-bearing slugs, Limapontioidea, is non-monophyletic, within which two of three families and 10 genera were also non-monophyletic, and four lineages await description as new genera. Ancestral character state reconstructions of major algal host groups support recurring transitions from Halimedinae to Bryopsidinae to Cladophorales to a range of derived hosts; the effects of algal calcification, chemical defense, and host group on slug diversification rate will be discussed. Although host use showed high evolutionary lability across family Plakobranchoidea, remarkable niche conservation was inferred at the species level in *Elysia*, with little evidence for recent ecological speciation via host shifting.

Clarifying the boundaries between sea slug species: Resolving the *Elysia ornata* species complex

Krug, P. and *Sherman, Ariel
Department of Biological Sciences, California State University, Los Angeles, 5151 State University Drive, Los Angeles, CA 90032-8530 USA
pkrug@calstatela.edu, asherma@calstatela.edu

Historically, identification and differentiation of shell-less gastropods have been difficult because these animals lack obvious countable (meristic) or continuous morphological traits; thus, similar-looking but evolutionarily distinct species have often been grouped under one name. The *Elysia ornata* complex is a group of morphologically similar, colorful species of sea slugs that contain kahalalides, anti-cancer compounds currently being tested in clinical trials. Despite the potential importance of *Elysi*a species to drug discovery work, much of their taxonomic status is unclear. The two Pacific names *E. marginata* and *E. grandifolia* have been applied inconsistently due to vague original descriptions, and the nominal species *E. ornata* was reported from multiple ocean basins. To resolve the number and identity of species in this complex, one mitochondrial and one nuclear gene were sequenced from 58 specimens sampled from three Caribbean locations and eight sites spanning the Indo-Pacific. Molecular phylogenetic and species-delimitation methods supported nine distinct species: *E. ornata* (Caribbean), the morphologically distinct *E. rufescens* (Pacific), and seven cryptic Pacific species. All candidate species are being morphologically characterized by quantitative analysis of dorsal vessel networks, radular traits, and penial characters; trait data will be used in integrative species delimitation analyses to test species hypotheses based on genetic data. Taxonomic research on the *Elysia ornata* complex should guide future drug discovery work by determining which species contain known kahalalides, versus which species have not been chemically characterized and may therefore contain new, medically useful compounds.

***Tivela stultorum*: the complete mitochondrial genome of the Pismo clam by using next generation sequencing**

La Farga De La Cruz, F., Vargas Peralta, C.E., Farfan, C. and del Río-Portilla, Miguel A.
Departamento de Acuicultura, CICESE. Centro de Investigación Científica y de Educación Superior de Ensenada, Carretera Ensenada-Tijuana #3918. Zona Playitas. Ensenada Ensenada, Baja California, México

The pismo clam, *Tivela stultorum*, inhabits the coasts of Baja California, and is commercially fished, but it is a poorly studied species. Nowadays, the next generation sequencing techniques have help to investigate, from a genetic point of view, non-model species, since it is not necessary to have previous knowledge of the DNA sequences. The main objective of this study was to obtain the complete mitochondrial genome of the pismo clam. A gill sample was fixed in 95% ethanol and DNA was extracted with a commercial kit and sent for pair mate Illumina sequencing. Fastaq files were processed and analyzed with CLC Genomics Workbench and a total of 339054 contigs were obtained. The largest contig was found to be its mitochondrion genome. Annotation was carried out with DOGMA and Mitos software and by comparison with other Veneridae species. The mitogenome comprises a total of 18629 nucleotides, with a rich A+T feature (66%). Twenty-two tRNAs, two ribosomal RNA, and 13 genes were found and their order was similar to other Veneridae species. Here, we discuss the potential use of this information for phylogeny and fishery studies of this and other Veneridae species.

Phylogenomics of lower Salmon River Oreohelicidae

*Linscott, T. Mason and Parent, C.E.
Dept. of Biological Sciences, University of Idaho, 875 Perimeter MS 3051, Moscow, Idaho 83844-3051 USA, Mason.linscott@gmail.com, ceparent@uidaho.edu

Mountainsnails (*Oreohelix*) of lower Salmon River form one the most striking assemblages of monogeneric

snail diversity in North America. However, the ecological specialization of these snails to small islands of limestone outcrops in montane ecosystems makes them vulnerable to extirpation from anthropogenic activity and climactic shifts. Many historical colonies of *Oreohelix* subspecies at lower elevations are vanishing and many co-occurring undescribed species may also be vulnerable. While conservation and taxonomic experts of this group have focused on differences in shell shape and color as a criterion of species delimitation, little to none is known of the concordance of these phenotypic characters with the genetic variability or evolutionary history of this group. Utilizing restriction enzyme associated sequencing, we present a preliminary phylogeny of the group and discuss the discordance between previously proposed taxonomic relationships based on shell morphology and the genomic signatures we observe.

Integrative species delimitation supports 12 taxa in the *Elysia tomentosa* complex (Heterobranchia: Sacoglossa), including seven cryptic species in the Indo-Pacific

*Medina, Melanie and Krug, P.J.
Department of Biological Sciences, California State University, 5151 State University Dr., Los Angeles, CA 90032 USA, mmr318@gmail.com, pkrug@calstatela.edu

Sacoglossan sea slugs in the '*Elysia tomentosa*' complex are large-bodied consumers of the highly invasive and ecologically devastating "killer algae", *Caulerpa taxifolia* and *C. racemosa*, but are taxonomically challenging. Only two names have been proposed for Pacific complex members (*E. tomentosa*, *E. expansa*) but diverse morphotypes and prior molecular surveys suggested several cryptic species. The Caribbean species *E. subornata* was proposed as biocontrol, given its non-dispersive larval development, but its feeding behavior was not effective for controlling *C. taxifolia*. As a better understanding of the identity and biology of all complex members may facilitate biocontrol efforts, we sought to resolve long-standing uncertainty about the number of species in this group. Molecular species delimitation of 183 specimens supported seven candidate species in the tropical Indo-Pacific (at least 5 undescribed), as well as five in the Caribbean (two newly described, one undescribed). One allopatric species pair (from the Philippines and Bahamas, respectively) were minimally divergent (3.4% at COI) for *Elysia*, and were lumped together in delimitation analyses, but analyses of radular and penial anatomy support all candidate species as distinct. Ecological data moreover indicate some species prefer different *Caulerpa* spp., with significance for control of introduced algae. However, variation in penial armature in the *E. tomentosa* complex suggests sexual selection contributed to the divergence of sympatric sister species, consistent with work on other sacoglossan groups where host use is conservative.

Rapoport's rule as a tool for understanding distributions of non-native species on tropical islands in multiple ecological contexts

Meyer III, W. Marty[1], Yeung, N.[2] and Hayes, K.[3]
[1]Pomona College, 333 N. College Way, Claremont, CA 91711 USA; [2]University of Hawaii, Center for Conservation Research and Training, 3050 Maile Way, Gilmore 408, Honolulu, HI 96822 USA; [3]Howard University, Department of Biology, 415 College Street NW, EE 332 Washington, DC 20059 USA
Wallace.Meyer@pomona.edu, nyeung@hawaii.edu, kenneth.hayes@howard.edu

To protect the remaining land snail diversity on tropical islands it is important to predict the elevation ranges of non-native species. Rapoport's Rule – a positive correlation between latitude and range size – may provide insight into the outcome of introductions of species from various latitudes along an elevation gradient. To examine the efficacy of Rapoport's Rule in predicting land snail distributions in Hawaii, we used survey data from two studies that examined land snail communities in two ecological contexts: (1) sites along elevation gradients on the eastern (windward) side of the island of Hawaii, and (2) low (below 500 m) and high (above 500 m) nurseries throughout the Hawaiian archipelago. We tested the hypotheses that non-native temperate species are more likely to become established at higher elevations and to extend over larger elevation ranges than non-

native tropical species. In both contexts, non-native tropical species were primarily found in sites at or below 500 m and occupied small elevation ranges, whereas species introduced from temperate regions occupied wide elevation ranges and were the primary component of the land snail fauna at sites above 500 m. Because temperate species have wide elevation distributions and dominate land snail faunas at high elevation, on many tropical islands the last refuges of the native species, preventing introduction of temperate species should be a conservation priority. This is counter to the widespread assumption that tropical islands are more susceptible to establishment and spread of tropical species. Application of Rapoport's Rule to invasion processes provides insight to understanding distributions of non-native snails introduced from different latitudinal regions. In this case, it highlights that temperate species and high elevation nurseries which are primarily composed of temperate species and at elevations that increase probability of establishment outside nurseries represent significant threat to the remaining land snail fauna of Hawaii.

Quaternary sea-level history on the Pacific coast of North America: Effects of low uplift rate and glacial isostatic adjustment processes on the marine terrace fossil mollusk record

Muhs, Daniel R.,[1] Simmons, K.R.,[1] Groves, L.T.[2] and Schumann, R.R.[1]
[1]U.S. Geological Survey, MS 980, Box 25046, Federal Center, Denver, CO 80225 USA; [2]Malacology Department, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA
dmuhs@usgs.gov, ksimmons@usgs.gov, lgroves@nhm.org, rschumann@usgs.gov

Along coastal California, some of the best records of fossil mollusks come from marine terrace deposits. In this region, each landform in a flight of marine terraces has long been thought to represent a single past high-sea stand. However, the last interglacial period of the late Pleistocene is often recorded on a single terrace by deposits containing fossils dating to two high separate high-sea stands dated by uranium-series on coral to both the ~100,000-year-old high-sea stand (marine isotope stage or MIS 5c) and the ~120,000-year-old high-sea stand (MIS 5e). Glacial isostatic adjustment (GIA) processes and a modest uplift rate explain much of this fossil reworking. Coastlines of North America are susceptible to GIA effects because of the nearby presence of large ice sheets during glacial periods: local paleo-sea levels are higher than what would be expected from a purely eustatic sea level rise. It is hypothesized that pre-MIS 5 marine terraces should be similarly affected, particularly those of early Pleistocene age, a time dominated by the ~41 ka obliquity cycle. On San Nicolas Island, the 3rd, 4th, 5th, 6th, 8th, and 10th terraces have strontium isotope ages on mollusks correlating these deposits to MIS 11, 15, 17, 19, 21, and 31, respectively. The 5th, 8th, and 10th terraces host mixtures of warm-water and cool-water species of mollusks, analogous to the mixture of warm (120 ka) and cool (100 ka) species on the 2nd terrace. Thus, each terrace likely contains fossils from both a warm-water high-sea stand and a cool-water high-sea stand. Thus, the role of GIA processes on coastlines such as California may explain the observations of what have been called "thermally anomalous" fauna (mixtures of warm-water and cool-water species in the same deposit) in the molluscan fossil record. The combination of low uplift rate and GIA effects indicates that a complex marine terrace record on the Pacific Coast is expected, and a simple, one-terrace-per-high-sea-stand scenario for the Quaternary is unlikely.

A Phylogenetic overview and revision of the California Vertiginidae

Nekola, Jeff C.
Biology Department, University of New Mexico, Albuquerque, NM, 87131 USA
jnekola@unm.edu

As previously understood, the Vertiginidae (Gastropoda: Pulmonata: Orthurethra) of California constituted *Columella, Gastrocopta, Nearctula, Sterkia*, and *Vertigo*. DNA sequence analysis of the 28S nuclear ribosomal RNA region documents that *Columella* is a chondrinid while *Gastrocopta* is a separate family-level

branch within the Orthurethra. Additionally, *Nearctula* and *Sterkia* are best recognized as junior synonyms of *Vertigo*. Consensus pattern observed across nDNA sequence (ITS1 and ITS2), mtDNA sequence (CytB and 16S), conchology, and ecological preference documents 17 specific or subspecific-level entities within California *Vertigo* – with another 3 putative taxa awaiting analysis – making it the fourth most diverse land snail genus in the state. More than 70% of these are members of *Vertigo* (*Staurodon*), which extends from the Central and North American Pacific coast through Madeira to South Africa. *Vertigo* (*Staurodon*) in California can be organized into two informal taxonomic groups: Nearctula (*californica, californica longa, catalinaria, cupressicola, dalliana, diegoensis, rowellii, trinotata*) and Sterkia (*calamitosa, clementina, hemphilli, pimuensis*). This deviates considerably from prior taxonomic approaches by: (1) recognizing seven – rather than three – species level entities within California Nearctula group members; (2) reinstating *californica* and *rowellii* to their authors original – and unambiguous – usage, based on critical reanalysis of type material; and (3) recognition of Santa Catalina island Sterkia group populations as a new species. Most California *Vertigo* (*Staurodon*) taxa are limited to areas within the maritime fog belt, with some never straying more than a few kilometers from the shore. California *Vertigo* (*Staurodon*) members also possess the most limited documented ranges in the genus, in particular *V. pimuensis* (endemic to Santa Catalina island), *V. cupressicola* and *V. trinotata* (both with global ranges < 20 km).

Diet, biogeography, and the marine gastropod microbiome

*Neu, Alex T.,[1] Allen, E. E.[2] and Roy, K.[1]
[1]Section of Ecology, Behavior and Evolution, University of California San Diego, 9500 Gilman Drive, La Jolla, CA 92093 USA; [2]Section of Molecular Biology, Division of Biological Sciences and Scripps Institution of Oceanography, University of California San Diego, 8522 Kennel Way, La Jolla, CA 92037 USA
aneu@ucsd.edu, eallen@ucsd.edu, kroy@ucsd.edu

The rocky intertidal habitat harbors a rich molluscan community characterized by a variety of life histories and ecologies. However, very little is known about the microbial taxa associated with intertidal molluscan species. Intertidal gastropods exhibit substantial species and phylogenetic diversity as well as a variety of feeding ecologies, thus providing an excellent system for studying how host-microbe interactions evolve and how they impact the functioning of ecological communities. Here we present the first analysis of the microbial diversity associated with intertidal gastropods in two different biogeographic provinces along the California coast. We sampled six common gastropods (*Lottia gigantea*, *Mexacanthina lugubris*, *Littorina plena*, *Littorina keenae, Chlorostoma eiseni* and *Chlorostoma funebralis*) from two sites in the Californian province (San Diego County) and one site in the Oregonian province (Santa Barbara County). These sites were chosen to explore spatial variations in gastropod-associated microbial community composition along a major oceanographic gradient. Individuals of *L. gigantea*, *M. lugubris, C. eiseni* and *C. funebralis* were dissected to sample the intestine and digestive gland, which have been shown to harbor diverse and unique microbial communities in other animals; the *Littorina sp*ecies were processed as whole organisms with shells removed. We extracted bulk DNA from each sample and sequenced the V4 region of the 16S rRNA gene, which is highly variable and a reliable taxonomic marker for Prokaryotes, using the Illumina MiSeq platform. Results show that the host-microbe specificity may be low in intertidal gastropods, with multiple hosts harboring similar microbial communities. Such broad sharing of microbial taxa suggests that the dynamics of microbial communities associated with intertidal mollusks may be very different from that documented for terrestrial invertebrate and vertebrate species.

Predictive habitat model of pinto abalone in San Diego County, California

*Ostrowski, Eric, Bird, A. and Eernisse D.J.
Department of Biological Science, California State University, Fullerton, 800 N. State College Blvd., Fullerton, CA 92831 USA
ostrowski.e@gmail.com, amanda.bird@csu.fullerton.edu, deernisse@fullerton.edu

We have developed a geographic information systems (GIS) suitable habitat model for the pinto abalone, *Haliotis kamtschatkana* Jonas, 1845, for subtidal habitats in San Diego Co., California USA, based on a field-collected data set completed in 2014 by one of us (AB). Habitat variables selected for use in this study were implemented as rasters, which are images containing elements of habitat characteristics associated with observational data. Habitat preference parameters were then established, and a spatial analyst tool set inside of a GIS was used to highlight preferable habitat characteristics. Using the Benthic Terrain Modeling extension, created by ESRI and NOAA for ArcGIS, three habitat variables were calculated and exported as rasters. After all the variables were selected, the raster images were imported into the Raster Calculator for ArcGIS. The variables were then combined and the resulting calculation produced a map of estimated habitat preference. Acquiring a high-resolution bathymetric data set was difficult; however, the Sea Floor Mapping Lab at California State Monterey Bay provided accurate 2 meter resolution bathymetry. Analyzing the 2 meter bathymetric data set resulted in a habitat model that gives AB the ability to refine her survey locations and survey previously unknown locations of suitable habitat. This study presents a practical application of analyzing bathymetry by itself to create an initial habitat suitability model for surveying a benthic species.

Adaptation and speciation in Galapagos Naesiotus snails

Parent, Christine E.
Department of Biological Sciences, 875 Perimeter Dr., University of Idaho, Moscow, ID 83844-3051 USA, ceparent@uidaho.edu

Ecological opportunity, brought about for example when organisms colonize a new environment, is widely thought to promote adaptive radiation by generating conditions that will favor diversifying selection. My research group studies the evolutionary process of diversification resulting from organisms colonizing new environments. Island systems are ideal laboratories for such studies since the sequentially formed islands can be viewed as a series of snapshots of the evolutionary processes taken over time. We have established Galapagos endemic land snails as a model system to study diversification, adaptation, and speciation on islands. Galapagos land snails of the genus *Naesiotus* form the most species-rich adaptive radiation on these islands. The great majority of species are single-island endemics and their distributions are limited to single vegetation zones. Importantly, the Galapagos *Naesiotus* are incredibly diverse in morphology, and this variation seems to be associated with the diversification of species in a wide range of habitats. I will present how our research group is using molecular and morphological tools and capitalizing on this ongoing natural experiment to infer how evolutionary diversification proceeds on island systems.

Review of the endemic land snail genus *Micrarionta* on four California islands plus Guadalupe Island, with a re-evaluation of *M. maxima*

Pearce, Timothy A.
Carnegie Museum of Natural History, 4400 Forbes Avenue, Pittsburgh, PA 15217 USA
pearcet@Carnegiemnh.org

Micrarionta is a genus of land snails in the family Helminthoglyptidae. They are endemic to the four

southern California Channel Islands plus Guadalupe Island, Mexico. Although Pilsbry (1939) included four subgenera in the genus *Micrarionta*, three of the subgenera were moved out of *Micrarionta*; Bequart & Miller (1973) elevated *Eremarionta* and Miller (1981) elevated *Plesarionta* and *Xerarionta* to full genus. Roth (1975) described *M. opuntia*, bringing the number of taxa recognized by Pearce (1990) to 11: *M. beatula* and *M. rufocincta* (Catalina Id.), *M. facta* and *M. intermedia* (Santa Barbara Id.), *M. feralis, M. micromphala, M. opuntia*, and *M. sodalis* (San Nicolas Id), *M. feralis, M. gabbi,* and *M. maxima* (San Clemente Id), and *M. guadalupiana* (Guadalupe Id). *M. feralis* is known from two islands, the rest are single island endemics. *M. intermedia, M. micromphala, M. sodalis,* and *M. maxima* are extinct.

Analysis by Pearce (1990) using 49 characters hypothesized a monophyletic *Micrarionta*, with *M. micromphala, M. opuntia*, and *M. sodalis* forming a monophyletic subgroup. A morphomentric analysis using eight characters supported those three as distinct species. Pearce (1993) showed that *M. sodalis* is the most ancient of those three species, occurring before 120,000 years ago, and became extinct less than 3430 years ago.

A cladistic analysis by Roth (1996a) divided *Micrarionta* into two subgroups; he named subgenus *Nicolenea* for *M. micromphala, M. opuntia*, and *M. sodalis* on San Nicolas Island.

An impression exists of a large and a small form on some of the islands. Pearce's (1990) cladistic hypothesis grouped the larger *Micrarionta* species into a single sub-clade, implying an ancestral large form dispersed among the islands.

Roth's (1996b) removed size characters from Pearce's (1990) dataset and concluded that the large forms did not form subclade. He concluded that colonization of the California Channel Islands was likely a single dispersal event within the last 950,000 years, and suggested that *M. intermedia* might be the ancestor.Roth & Sadeghian (2003) synonymized *M. maxima* under *M. gabbi*. Current work is re-evaluating whether *M. maxima* should be considered a distinct species.

References

Bequaert, J.C. & Miller, W.B. 1973. The Mollusks of the Arid Southwest, with an Arizona Check List. University of Arizona Press: Tucson. xvi + 271 pp.

Miller, W.B. 1981. *Helminthoglypta reederi* spec. nov. (Gastropoda: Pulmonata: Helminthoglyptidae) from Baja California, Mexico. Veliger 24:46-48.

Pearce, T.A. 1990. Phylogenetic relationships of *Micrarionta* (Gastropoda: Pulmonata) and distinctness of the species on San Nicolas Island, California. Malacological Review 23:1-37.

Pearce, T.A. 1993. *Micrarionta* (Gastropoda: Pulmonata) on San Nicolas Island, California. Evolutionary relationship among the species. Malacological Review 26:15-50.

Pilsbry, H.A. 1939. Land Mollusca of North America (north of Mexico). Academy of Natural Sciences of Philadelphia, Monograph 3, part 1(1):i-xvii, 1-573.

Roth, B. 1975. Description of a new terrestrial snail from San Nicolas Island, California (Gastropoda: Stylommatophora). Bulletin of the Southern California Academy of Sciences 74:94-96.

Roth, B. 1996a. Homoplastic loss of dart apparatus, phylogeny of the genera, and a phylogenetic taxonomy of the Helminthoglyptidae (Gastropoda: Pulmonata). Veliger 39: 18-42.

Roth, B. 1996b. The fossil land snail *Micrarionta (Micrarionta) intermedia* Pilsbry (Gastropoda: Pulmonata): insular phylogeny revisited. Veliger 39: 204-212.

Roth, B. & Sadeghian, P.S. 2003. Checklist of the land snails and slugs of California. Santa Barbara Museum of Natural History, Contributions in Science 3:1-81.

Rediscovery of the southern California endemic American Keeled Slug *Anadenulus cockerelli* (Hemphill, 1890) after a 71-year hiatus

*Richart, Casey H.[1], Chichester, L. F.[2], Boyer, B.[1] and Pearce, T.A.[3]
[1]*Department of Biology, San Diego State University, 5500 Campanile Drive, San Diego, CA 92182 USA;* [2]*209 Chestnut Springs Way, Williamston, SC 29697 USA;* [3]*Section of Mollusks, Carnegie Museum of Natural History, 4400 Forbes Avenue, Pittsburgh, PA 15213 USA*
pileated@gmail.com, lfchichester@charter.net, pearcet@carnegiemnh.org

We report the first records of the southern California endemic American Keeled Slug *Anadenulus cockerelli* (Hemphill, 1890) in 71 years. Due to the restricted range of this species and lack of recent detection, it has received a NatureServe conservation status of "Critically Imperiled" or "Imperiled". This species has always been difficult to detect and will likely continue to be. This may be the result of genuine rarity or may be the result of being cryptic and occurring in a microhabitat only ephemerally accessible to human researchers. We create a Species Distribution Model for *A. cockerelli*, which strongly predicts its occurrence where it is known, and where it is currently unknown, such as in the northern Peninsular Ranges and in the San Bernardino Mountains. With many threats in southern California including human encroachment and habitat loss, hotter and drier climate change, increased fire frequency, beetle infestation and oak death, as well as introduced species, *Anadenulus cockerelli* should be surveyed and monitored in order to better understand its distribution and level of conservation concern.

New Contributions on the Egg-Laying of the Queen Conch, *Lobatus gigas* (Gastropoda: Strombidae)

Santana-Flores, Pablo and Aldana-Aranda, D.
Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional. Km 6, Antigua Carretera a Progreso, C.P. 97310, Mérida, Yucatán, México
pablo.santana@outlook.com, daldana@cinvestav.mx

The reproductive activity of *Lobatus gigas* (Linnaeus, 1758) was studied using non-invasive methods. Fortnightly observations were made from February to December 2013, between the hours of 0800-1800, in the small bay of Xel-Ha, Quintana Roo, México. Using the mark-recapture method, a precise accounting of egg-laying activity was obtained. A total of 424 egg-laying events were recorded from June to September, with a maximum of 40 in one day. Egg laying was most common at 10:00 h (89 events) and at 11:00 h (115 events), and then repeated in the evening, resulting in two peaks during a daily cycle. The frequency of egg laying by a female varied from one (63.7%) to five times (0.3%), within an interval of 1-32 days. The duration of egg-laying, from beginning to end, was observed in 71 females, averaging a total time of 7.2 hrs ± 7.4, with a minimum of 0.06 hr and a maximum of 31.3 hrs. Based on these results, we conclude that *L. gigas* has specific periods for egg laying, i.e., in the morning. In general, the females of this species deposit one mass of eggs per season; however, an egg laying may be partial, can take some 10 hours, and even be interrupted for several days, after which they again continue their egg laying. These findings show the reproductive effort involved in the egg-laying process for this species.

Tertiary-Caribbean and AnaVent basin mollusks, late Oligocene – Miocene marine embayments, southwestern California, USA and Baja California Sur, México

Smith, Judith T.
U.S. National Museum; 2330 14th St. N., #401, Arlington, VA 22201-5867 USA
Redcloud1@earthlink.net

To make sense of Oligo-Miocene species distributions in southwestern California and Baja California Sur

(BCS), both taxonomy and the understanding of their tectono-stratigraphic context needs updating. From Mesozoic to Oligocene time a forearc basin lay parallel to the Peninsular Ranges northwest of San Diego and northern Baja California; it included a NW-SE–oriented block known as the western Transverse Ranges. In the middle Miocene (~15 Ma) the southern part, known as the AnaVent Basin, rotated clockwise nearly 90° and attached on its north and east sides to North America. This change is known as The Incredible Miocene Rotation (Fritsche, 1998). Miocene marine molluscan species from embayments in this part of California and western BCS include wide-ranging Tertiary-Caribbean taxa such as *Turritella abrupta* Spieker and *Clementia dariena* (Conrad) together with index species described from the Santa Cruz Mountains, northern La Panza Range, Temblor basin, northern Channel Islands, and Orange County. Subsidence beginning in the early Miocene allowed marine deposition of the rocks that contain the AnaVent faunas; to the north a second large basin received sediments known as the Vaqueros and Rincon formations and the deeper water Saltos Shale in the La Panza area, Temblor and Santa Ynez ranges. Correlative units in BCS crop out in the Vizcaíno embayment (middle Miocene Tortugas Formation), Purísima-Iray basin (early to middle Miocene Isidro Formation) and the Magdalena embayment (late Oligocene El Cien and Miocene Salada formations). The AnaVent Basin and the embayments in western BCS contain a fauna of mixed affinities: the Caribbean taxa *Turritella abrupta* Spieker, *Clementia dariena* (Conrad), *Lindapecten falconensis* (F. & H.K. Hodson) [=*Pecten sancti-ludovici* Anderson & Martin in the La Panza Range] and the AnaVent taxa *Melongena californica* Anderson and Martin*, Rapana imperialis* Hertlein, *Turritella temblorensis* Wiedey, *T. carrisaensis* Anderson and Martin, and *Lyropecten catalinae* (Arnold), *L. pretiosus* (Hertlein), among others.

Reference

Fritsche, A. E., 1998, Miocene paleogeography of southwestern California and its implications regarding basin terminology. *International Geology Review* 40(5):452-470.

Tertiary-Caribbean mollusks in the ancient Gulf of California

Smith, Judith T.
United States National Museum, 2330 14th St. N., #401, Arlington, VA 22201-5867 USA
Redcloud1@earthlink.net

Tertiary-Caribbean mollusks lived in the ancient Gulf of California in the late Miocene (~ 7 Ma), but the earliest marine incursion was middle Miocene (no later than 11.6 Ma, Helenes *et al.*, 2009), documented by microfossils from the Consag and Tiburón basins. Late Miocene megafossils are found in western parts of these basins: San Felipe (San Felipe Diatomite, Boehm, 1982), Puertecitos (Matomí Member, Puertecitos Formation), Boleo (basal Boleo Formation), Loreto (La Vinorama Conglomerate), on southwestern Isla Tiburón, and in the Salton Trough as far north as the Fish Creek/Vallecito Mountains, San Diego Co., CA. Many of the same species are found farther north near San Gorgonio Pass and the Indio Hills, Riverside Co., CA but these were transported by faults active before the initiation, ca. 5 Ma, of the San Andreas Fault (Powell, 1993). Reports of 12.9 Ma marine mollusks on Isla Tiburón (Gastil *et al.,* 1999) were based on inaccurate radiometric dates on associated volcanic rocks (Bennett *et al.,* 2015). Microfossils indicate an early gulf less than 200 m deep with normal ocean water, not the narrow, brackish arm of seawater postulated by early reports (Helenes *et al.* (2009). Tectonic modelers working in the northern gulf have been reluctant to recognize a marine incursion older than 6 Ma, but more recent multi-channel seismic studies across the southern gulf support seawater as early as 14 – 11 Ma (Sutherland *et al.*, 2012). Wide-ranging late Miocene Caribbean taxa from the ancient gulf include *Anadara patricia* (Sowerby), *Dosinia grandis* Nelson, *Leopecten gatunensis* (Toula), *Murexiella (Subpterynotus) textilis* (Gabb), *Turritella altilira* Conrad [= *T. imperialis* Hanna auctt.], and *Strombus gatunensis* Toula. Gulf species such as *Euvola beali* Hertlein and *Strombus obliteratus* Hanna were found, unidentified, in Venezuelan collections at the Paleontological Research Institution, Ithaca, NY; more taxa of unrecognized Caribbean affinity are anticipated.

References

Bennett, S., Oskin, M., Dorsey, R., Iriondo, & Kunk, M. 2015, Stratigraphy and structural development of the southwest Isla Tiburón marine basin: Implications for latest Miocene tectonic opening and flooding of the northern Gulf of California. Geosphere 11(4): 1-33.

Boehm, M. C. F. 1982. Biostratigraphy, lithostratigraphy, and paleoenvironments of the Miocene-Pliocene San Felipe marine sequence, Baja California Norte, Mexico [unpub. M.S. thesis]: Stanford, California, Stanford University, 325 p.

Gastil, R.G., Neuhaus, J., Cassidy, M., Smith, J.T., Ingle, J.C., & Krummenacher, D. 1999.Geology and paleontology of southwestern Isla Tiburón, Sonora, Mexico. Revista Mexicana de Ciencias Geológicas 16 (1):1–34.

Helenes, J., Carreño, A.L., & Carillo, R.M. 2009. Middle to late Miocene chronostratigraphy and development of the northern Gulf of California. Marine Micropaleontology 72(1):10–25.

Powell, R.E. 1993, Balanced palinspastic reconstruction of pre-late Cenozoic paleogeography, southern California: Geologic and kinematic constraints on evolution of the San Andreas fault system. *In:* Powell, R.E., Weldon, R. J., II &, Matti, J.C (eds.), The San Andreas fault system: Displacement, palinspastic reconstruction, and geologic evolution. Chapter 1. Geological Society of America Memoirs 178:1-106.

Sutherland, F.H. Graham, M.K, Alistar, J.H., Umhoefer, P.J., Driscoll, N.W., Lizarralde, Fletcher, J.M., Axen, G.J., Holbrook, W.S. González-Fernández, A, & Lonsdale, P. 2012. Middle Miocene to early Pliocene oblique extension in the southern Gulf of California. Geosphere 8(4):752-770.

A rare glimpse of early Paleocene (late Danian) northeast Pacific mollusks and arthropods: A new locality, north side of Simi Valley, Ventura County, southern California

Squires, Richard L.[1], P.J. Lipman[2], and T. Nyborg[3]
[1]*Research Associate, Invertebrate Paleontology, Natural History Museum of Los Angeles County, 900 Exposition Boulevard, California 90007 USA;* [2]*Wesierski & Zurek LLP, 1000 Wilshire Boulevard, Suite 1750, Los Angeles, California 90017 USA;* [3]*Department of Earth and Biological Sciences, Loma Linda University, Loma Linda, California 92350 USA*
richard.squires@csun.edu, PLipman@WZLLP.com, tnyborg06g@llu.edu

Abundant shallow-marine mollusks, a few arthropods, and some petrified wood were found recently in the lower Santa Susana Formation, near Mt. Sinai Memorial Park, north side of Simi Valley. Prior to installment of landscaping and sprinklers at the locality, the developer kindly gave permission to collect fossils, which weathered out from a thin, poorly exposed *Turritella*-rich storm bed near the top of a low hill of gray siltstone. Preservation is good although many specimens are incomplete. They underwent post-mortem transport, probably by turbidity currents emanating from shallower marine depths. Distance of transport of the shells was relatively short based on absence of abrasion. Identifiable gastropod species are: *Turritella peninsularis* Anderson & Hanna, *T. peninsularis qualeyi* Saul, *T. reversa* Waring, ***Serratocerithium usanium*** Compton, ***Drepanochilus exilis*** (Gabb), **Brachysphingus gibbosus* Nelson, ****Pegocomptus howardi*** (Dickerson), ****Sycostoma burroensis*** (Nelson), ****Saxituberosa titan*** (Waring), **Heteroterma gabbi* Stanton, **H. trochoidea* Gabb, ****Volutocorbis virginea*** Zinsmeister, and ****Turricula waringi*** Nelson. *Tornatellae* n. sp. is represented by a single specimen. Identifiable bivalve species are: *Cucullaea mathewsonii* Gabb, "*Crassatella" branneri* (Waring), and (in wood) ***Paramartesia tolkieni*** (Kennedy). The non-molluscan material consists of a raninid crab (*Raninoides* n. sp.), and a spiny lobster (*Linuparis* sp.). The assemblage is determined to be early Paleocene (Danian) in age, on the basis of the geologic ranges of *T. p. qualeyi*, *T. reversa*, *H. gabbi*, and *H. trochoidea*. The presence of a few specimens of *T. peninsularis s. s.,* which intergrade with *T. p. qualeyi*, help refine the age as late Danian. This study is significant because it 1) provides new information about the poorly known taxonomic composition of early Paleocene faunas, which are rare in the northeast Pacific, 2) allows for the geologic age

ranges of the species (listed above in bold type) to be revised downward to include the late Danian, 3) shows that neogastropods (indicated above by an asterisk) were diverse, and 4) reveals that *Raninoides* n. sp. may represent the oldest occurrence of this genus in the northeast Pacific.

Paleontology of the Conejo Volcanics, Miocene, Santa Monica Mountains, California

Stanton Jr., Robert J. and Alderson, J.
Research Associate, Malacology Department, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA
stanton.robertj@gmail.com, jjalderson@live.com

The Conejo Volcanics consists of basaltic to andesitic volcanic flows and hyaloclastic breccias cut by dikes of diverse composition. The thickness of the Conejo Volcanics is greatest in the western Santa Monica Mountains at about 1800 m, decreasing to several hundred m in the central Santa Monica Mountains. The Conejo Basin formed as a result of plate motion in the early Miocene. Accumulation began in the western Santa Monica Mountains probably during the Relizian benthic foraminiferal stage (bfs) and continued through the Luisian (bfs), filling the basin with marine and then terrestrial volcanic deposits. Accumulation in the central Santa Monica Mountains began later, during the Luisian (bfs), and deposition was at bathyal depths. Based on a paleomagnetic reversal near the top of the Conejo Volcanics in both the western and central Santa Monica Mountains, accumulation of the Conejo Volcanics ended contemporaneously throughout the area, near the end of the Luisian (bfs), at approximately 16 Ma.

A diverse and rich fauna within the Conejo Volcanics occurs in lenticular limestone and sandstone deposits overlying flows and in Neptunian dikes within flows. It consists of mollusks, articulate and inarticulate brachiopods, barnacles, bryozoans, and regular echinoids that lived on the outer shelf at a depth of 50 to 200 m before being redeposited onto the basin floor at bathyal depths. The mollusks are typical of the "Temblor" California provincial molluscan stage (cpms), but a larger number than were anticipated are commonly associated with the older, "Vaqueros" (cpms). The marine climate in which the fauna lived was similar to that off the southeastern coast of Baja California today, but it is difficult to describe in detail because of uncertainties in the geography at that time and the water depth at which the organisms lived.

Speciation on the fringes, alternate facts, and biodiversity of sea hares

Valdés, Ángel
Department of Biological Sciences, California State Polytechnic University, 3801 West Temple Avenue, Pomona, California 91768, USA
aavaldes@cpp.edu

The Indo-Pacific tropics in general, and the Coral Triangle in particular, are considered the global centers of marine biodiversity. Morphology-based species catalogues of sea slugs have confirmed that in almost every group there are more tropical Indo-Pacific species than representatives from any other region of the world. More recently, molecular data have revealed unexpected levels of cryptic and pseudocryptic diversity in the temperate Eastern Pacific and the Atlantic Ocean. Conventional wisdom suggests that applying similar techniques to the Indo-Pacific biota will unveil even more species. Here, we put this hypothesis to the test using sea hares, a relatively small group of sea slugs including several morpho-species with pantropical distributions. Molecular data revealed that all pantropical sea hare morpho-species studied to date are species complexes with distinct Atlantic and Indo-Pacific taxa. But surprisingly, more species are found in the Atlantic than in the Indo-Pacific. Moreover, Indo-Pacific species display low levels of genetic diversity and apparent lack of genetic structure, suggesting panmixia is rampant in this region. While these results are probably not applicable to other groups of sea slugs, they raise intriguing questions about diversification of these important grazers in the tropics.

Unaltered mollusk shell microstructures from the Pennsylvanian Buckhorn Asphalt of Oklahoma (307 Ma)

Vendrasco, Michael J.,[1,2] Checa, A. G.[1] and Squires, R.L.[3]
[1]Departamento de Estratigrafía y Paleontología, Universidad de Granada, Facultad de Ciencias, Avenida Fuentenueva s/n, 18002 Granada, Spain; [2]Current address: Department of Geology, E-215, Pasadena City College, 1570 E Colorado Blvd, Pasadena CA 91106-2003 USA; [3]Department of Geological Sciences, California State University Northridge, Northridge, CA 91330-8266 USA
mvendrasco@pasadena.edu, acheca@ugr.es, richard.squires@csun.edu

Original aragonite crystals and associated organic inclusions are preserved in shells from the Buckhorn Asphalt of Oklahoma. Field Emission Scanning Electron Microscopy (FE-SEM), Electron Backscatter Detection (EBSD), and Atomic Force Microscopy (AFM) confirmed the striking high fidelity of preservation of the shells of a cephalopod, gastropod, and bivalve mollusk. These fossils preserve the oldest unaltered nacre tablets, showing original nanometer textures like vermiculations within the nacre tablets. The data also reveal crystallographic and other ultrastructural differences in nacre among different mollusk lineages. The compiled shell microstructure data for mollusks in the Paleozoic Era show that, by the Pennsylvanian Period, nacre and crossed lamellar were the dominant shell microstructures in the inner shell layer of the Mollusca. Loosely-organized horizontal bundles of aragonite fibres were common among Cambrian mollusks and problematic lophotrochozoans (e.g. hyoliths). These were replaced by the more fracture-resistant shell microstructures nacre and crossed lamellar at multiple times during the early Paleozoic. This evolutionary pattern reflects the importance of crossed lamellar and nacre in deterring predation and helped paved the way for molluscan success during the Mesozoic and Cenozoic Eras.

Monoplacophorans, slit shells, and escaping mollusks
(**Extended from original program submission**)

Wicksten, M.K.
Department of Biology, Texas A&M University, College Station, TX 77843-3258 USA
Wicksten@bio.tamu.edu

During 2016-2017, The NOAA ship *Okeanos Explorer* deployed the remotely operated vehicle *Deep Discoverer* to depths of over 5000 m in new marine life refuges in the north central to western Pacific. The vehicle, equipped with high resolution video and still cameras, can take photos to within 0.3 m of a subject, with zoom magnification. The resulting photographs show in-life views of marine life ranging from large sharks to very tiny crustaceans. Among the most interesting views are those of a living monoplacophoran, *Neopilina* sp., showing the oral velum, gills and mantle undisturbed; a close-up view of a slit shell (Pleurotomariidae, see photo and tentative ID on following page), the previously unknown escape response of the gastropod, *Gaza* cf. *daedalus*, tumbling over the sea floor; and a cirrate octopus swimming.

Slit shell, perhaps *Mikadotrochus gotoi*, previously reported from the Philippine Islands. Off Pagan, Marianas, 411 m. Identification by David Berschauer, photo courtesy of U.S. NOAA Office of Ocean Exploration and Research.

Phylogenetic and Morphological Analyses of the Eastern Pacific genus *Ocinebrina* Jousseaume, 1880

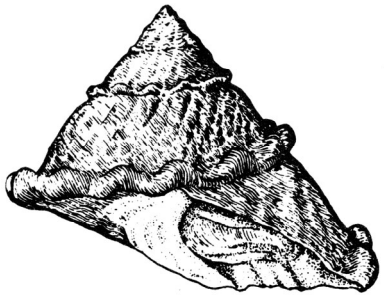
*Wiedrick, Shawn G. [1,2] and Eernisse, D.J.[1,2]
[1]*Department of Biological Science, California State University, Fullerton, 800 N. State College Blvd., Fullerton, CA 92831 USA;* [2]*Research Associate, Malacology Department, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA*
shawnwiedrick@hotmail.com, deernisse@fullerton.edu

Ongoing collaborative research with European malacologists, and our own separate analyses, have revealed that the northeastern Pacific "*Ocinebrina*" we have been studying have little to do with the European type species, *Ocinebrina aciculata* (Lamarck, 1822) and other species of Atlantic *Ocinebrina* in its vicinity. Together, the Atlantic species are supported as a monophyletic group that is quite distant from any North Pacific muricid gastropods. If the northeastern Pacific "*Ocinebrina*" are instead part of one or more endemic North Pacific clade(s), the closest affinities are more likely to be found in the northwestern Pacific, but these affinities remain to be investigated. We have analyzed shell features of northeastern Pacific "*Ocinebrina*" alongside of a new combined mitochondrial 16S + COI sequence analysis, as most species sequences from this region have lacked availability in GenBank. Our results are still preliminary, but our sampling of northeastern Pacific nominal species has revealed a similar complex situation to the better-studied northeastern Atlantic case. Some DNA sequence results favor fewer species than have been recognized based on shell morphology, while there could also be unanticipated species distinctions between populations of snails with only cryptic differences in their shells. Despite similar high levels of shell-based diversity in both regions, the northeastern Pacific "*Ocinebrina*" are only at an early stage of study, and adding multiple nuclear markers will likely be necessary to test the monophyly of North Pacific "*Ocinebrina*." Our molecular studies should help us delimit multiple species complexes, and partially resolve some of them. Likewise, the quite extensive fossil record associated with this apparently North Pacific species radiation needs to be reconsidered together with new molecular results.

California desert land snails through the eyes of David Quammen

*Wiedrick, Shawn G.,[1,2] Ostrowski, E. G.[1] and Eernisse, D.J.[1,2]
[1]*Department of Biological Science, California State University, Fullerton, 800 N. State College Blvd., Fullerton, CA 92831 USA;* [2]*Research Associate, Malacology Department, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA*
shawnwiedrick@csu.fullerton, ostrowski.e@csu.fullerton.edu, deernisse@fullerton.edu

A Cal State Fullerton Environmental Studies course assignment that focused on endangered habitats prompted a study of Mojave Desert and Channel Island land snails. The assignment required students to undertake a project with parallels between David Quammen's book, *The Song of the Dodo*, and a chosen southern California habitat or group of organisms. Students were tasked with drawing correlations of island biodiversity to the anthropogenically altered landscape found in the southern portion of the state. Our project led to this presentation, which includes a basic introduction to terrestrial snail life histories, paleontology, invasive species, and a brief synopsis of our chosen taxa, the relatively large native land snails grouped as Helminthoglyptidae Pilsbry, 1939. We also present the results of a rapid assessment of distribution patterns based on more than 3,500 specimens of Helminthoglyptidae at the Natural History Museum of Los Angeles County. We specifically emphasized species from the western Mojave Desert, which inhabit this severely arid region. Reported localities, transcribed from voucher labels, were updated, when feasible, with global positioning system (GPS) coordinates in our compiled database. These data were used to generate geographic information systems (GIS) maps of species distributions, abundance and biodiversity. Our contribution has significance because multiple species within Helminthoglyptidae in the region are faced with conservation concerns, especially being vulnerable to habitat loss.



Poster Presentations

Alphabetical by First Author

Are SoCal natives leaving town? Current status of southern California helicoid land snails in genus, *Helminthoglypta* Ancey, 1887, in Los Angeles and Orange Counties

*Abney, C.J. [1], Vendetti, J.E.[2], Eernisse, D.J. [1]
[1]*Department of Biological Science, California State University, Fullerton, 800 N. State College Blvd., Fullerton, CA 92831 USA;* [2]*Malacology Department, Natural History Museum of Los Angeles County, 900 Exposition Blvd, Los Angeles, CA 90007*
jabney1993@gmail.com, jvendett@nhm.org, deernisse@exchange.fullerton.edu

The land snail genus, *Helminthoglypta* (Helminthoglyptidae), accounts for about 24 percent (68 of 284) of recognized native California terrestrial gastropod species. Despite patterns of endemism along California's coast, this genus has been relatively ignored in the wake of Henry Pilsbry's extensive and influential 1939 monograph. Notably, there have been almost no DNA-based studies for *Helminthoglypta*, not uncommon among North American land snail genera. Morphological studies and species delimitation can be challenging because the diagnoses of Pilsbry and others rely on subtle anatomical and shell differences, while specialists who are adept at differentiating these species have long been in decline. In this study, an attempt was made to assemble *Helminthoglypta* species collected from the heavily urbanized Los Angeles and Orange Counties by cooperating snail experts, with the same and other experts consulted for their reliable identification alongside of DNA sequencing. Unfortunately, a multi-year drought made finding active snails difficult, so relatively few snails were found during the study period. In addition to our ongoing sequencing for the relatively few specimens found in this region, we have focused on summarizing type localities and habitat ranges by compiling records of identified snails from this region within the collections of the Natural History Museum of Los Angeles County and the Santa Barbara Museum of Natural History. We are relating these historical records to current maps of natural areas, geo-referenced iNaturalist website reports with reliable identifications, and other recent collections of specimens reported to us, as a first step toward estimating current habitat availability. This survey will assist in assessing the impact of urbanization on members of *Helminthoglypta*, and targeting imperiled species for future conservation efforts. In addition, we hope to use this survey, in conjunction with ongoing sequencing efforts, to make the study of the genus more accessible to non-experts.

Erosion facing size and latitude in a dominant herbivore polyplacophoran widely distributed in the intertidal rocky shore of the Mexican tropical Pacific

Alvarez-Cerrillo L.R.[1*], Avila-Poveda O.H.[1,2], Kawamoto-Camacho N.A.[1], Rodríguez-Domínguez G.[1], Pérez-González R.[1], and Ramírez-Pérez J.S.[1]
[1]*Facultad de Ciencias del Mar, Universidad Autónoma de Sinaloa, Mazatlán, Sinaloa, México, 82000;* [2]*Dirección Cátedras-CONACyT, CONACyT, Ciudad de México, México, 03940*
letgopvd@gmail.com, oavila@uas.edu.mx, kirin_murasaki@hotmail.com, guirodom@yahoo.com.mx, raulp@uas.edu.mx, jsramirezp@gmail.com

The rocky intertidal communities are subjected to physical and biological processes that erode them, so species require robust armor for their protection. The chitons have an articulated natural armor that provides them protection and robustness; however erosion on its plates has been observed, which can affect their fitness condition and mobility. In order to test the hypothesis that the erosion in chiton plates is directly correlated with the increases in size of the adult population, since the biggest chitons (oldest) have been exposed for more time to environmental factors, herein is used *Chiton articulatus* (Mollusca: Polyplacophora), the largest dominant herbivorous (reaching 90 mm in length) in the rocky intertidal shore from the Mexican tropical Pacific (23°N to 15°N), where it is endemic. It is investigated whether for adult populations; the old adult chitons have greater coverage and degree of erosion than young adult chitons. Herein were analyzed 1357 adult specimens (< 40 mm in length, max = 86, min = 43) collected haphazardly monthly, from October 2015 to October 2016, in three sites: north (Sinaloa, 23°N), middle (Colima, 19°N) and south (Oaxaca, 15°N). Total length was measured with a Vernier

caliper (± 0.1 mm) on relaxed and fixed specimens. Area eroded was assigned according to coverage percentage of the worn plates; and erosion degrees by depth (none, moderate and deep). Erosion was presented in the 98% of the sampled chitons. Eroded area was highly erratic, with fluctuations between 0-74%. The major coverage of erosion (45% ± 29) was presented in the chitons from the north site, compared to the middle and south sites (23%±19 and 25%±20, respectively). The Spearman correlation coefficient between size and erosion coverage were weak (r<0.2) at the three localities. Erosion degree was *deep* (61%) at 23°N, *moderate* (53%) at 19°N and *deep* (57%) at 15°N. Contrary to expectations, erosion coverage and degree are independent from the adult length of the chiton. The erosion degrees, *moderate* and *deep*, show that the chitons are exposed to different factors that affect their plates, and in turn, can affect their fitness and other physiological processes, a hypothesis subject to additional testing.

Biodiversity and paleoecology of Plio-Pleistocene marine molluscs, Carpinteria, Santa Barbara County, California

*Aziz, Javaria,[1] Hendy, A.J.W.,[2] and Estes-Smargiassi, K.[2]
[1]*El Camino College* 16007 Crenshaw Blvd, Torrance, CA 90506 USA; [2]*Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA*
javariaaziz@yahoo.com, ahendy@nhm.org, kestes@nhm.org

The Rincon Hill section near Carpinteria (California) contains a sedimentary succession that is highly fossiliferous, with diverse bivalves and gastropods, among other marine invertebrates. It has been correlated with the Santa Barbara Formation, which is distributed more widely in the west of the Ventura-Santa Barbara Basin. The multiple shell beds and intervening mudstones exposed in this section appear to comprise several distinct faunal associations. Bulk samples (5 gallon) were collected from nearly 30 beds within the section (20 are analyzed here), providing insights into the species diversity, paleoecology, and taphonomy of each of these depositional events. More than 180 molluscan species are thus far recovered, including 61 bivalves and 121 gastropods. Of more than 16,000 specimens analyzed, *Cyclocardia occidentalis* (18%), *Lirobittium* sp. (12%), *Turritella cooperi* (6%), and the columbellids *Alia carinata* (10%) and *Astyris tuberosa* (10%) are most abundant. Despite uniform sample size, species richness varies considerably from bed to bed, with as many as 74 species (1452 specimens) and as few as 11 species (160 specimens) retrieved from any given sample. This is in part related to the skeletal packing of individual beds (post-mortem concentration), but may also reflect variations in the richness and evenness of contemporaneous biological communities.

These sediments have been mapped as Santa Barbara Formation, implying a Middle Pleistocene age. Nevertheless, it has been argued that these sediments belong to a distinct, and as yet unnamed, unit of Pliocene age (Powell et al., 2009). Few fossils have been identified from these samples that are undoubtedly Pliocene in age, and many of the distinctive species that typify other late Pliocene units in California are yet to be recognized at Rincon Hill. It is plausible that environmental factors bias against their presence in this section, or that it was indeed deposited during the early or middle Pleistocene and can be correlated with the Santa Barbara Formation in its type area.

Reference

Powell, C.L., II, Stanton, R.J., Jr., Vendrasco, M., and Liff-Grief, P., 2009, Warm extralimital fossil mollusks used to recognize the mid-Pliocene warm event in southern California: *Western Society of Malacologists Annual Report for 2008, 41*, 70-91.

Exploratory studies of chiton eye lenses: Their morphology and composition

*Balayan, Aleksandr[1], Vendetti, J.E.[2] and Celestian, A.[3]
[1]*Department of Biology, Glendale Community College, 1500 North Verdugo Road, Glendale, CA 91208 USA;* [2]*Malacology, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA;* [3]*Mineral Sciences, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA*
abalaya700@student.glendale.edu, jvendett@nhm.org, acelesti@nhm.org

Chitons are marine molluscs in the class Polyplacophora(1),which have eight dorsal valves as a protective armor (1). The valves of genera *Tonicia*, *Onithochiton* and *Acanthopleura* are embedded with hundreds of ocelli (eyes)(1), which have nerve endings called "aesthetes", (2) and are image forming organs (2). Ocelli are, generally, abundant on the anterior plate. Bands of ocelli may have regularly or irregularly arranged eyes extending from the outer edges of the valve towards the midline of the animal. Ocelli progressively decrease in number with the shortening width of the band (1). To better understand the external morphology and elemental composition of ocelli, multiple kinds of microscopy were used. Scanning electron microscopy (SEM) revealed, as expected, lenses of half-dome shape on the surface of the valves. The surface of the lenses appeared to be smoother than the surrounding shell material. In a few cases, a midline was observed on the lenses, although this feature was faint and could be an artifact of SEM imaging. To explore the chemical composition of these lenses, X-Ray Analytical Microscopy, Raman Microscopy and Energy-dispersive X-ray Spectroscopy (EDXS) were used. X-ray Analytical Microscopy and EDXS presented the bulk chemistry of the lenses. X-ray Analytical Microscopy indicated that calcium was in abundance with additional detected S, K, Mg, Cl, and Sr which can be attributed to the incorporation of these elements into the shell from sea water. EDXS indicates abundance of Ca, C and O, with trace amounts of Na, Mg, Al, S and Cl. Lastly, when looking at the lenses under Raman Microscopy, the spectrum obtained indicated aragonite.

References

Connors, M. J. (2014). Design of a Multinational Biomineralized Armor System: The Shell of Chitons. 39-66.
Speiser, D., Eernisse, D. & Johnsen, S. 2011. A Chiton Uses Aragonite Lenses to Form Images. *Current Biology* *21*(8), 665-670.

Urban biodiversity of terrestrial gastropods in Los Angeles: Investigating morphological diversity of jaws and radulae

Burnett, Emily R.[1] and Vendetti, Jann E.[2]

[1]*Department of Biological Sciences, Glendale Community College, 1500 N Verdugo Rd., Glendale, CA 91208 USA;* [2]*Malacology Department, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA*
eburnet072@student.glendale.edu, jvendett@nhm.org

Terrestrial snails and slugs are, overall, a vastly understudied group of mollusks. This is especially true in urban environments such as Los Angeles. To better understand (and inventory) both the native and introduced land gastropod species living in and around the cities of Los Angeles County, I prepared and examined jaws and radulae of specimens from the SLIME project (Snails and slugs Living In a Metropolitan Environment) collection at the Natural History Museum of Los Angeles County. SLIME is a citizen science initiative designed to compile online data records and collected specimens of slugs and snails from residents of Los Angeles County and greater Southern California. The radulae and jaws of various specimens collected through SLIME were extracted, prepared, and examined using scanning electron microscopy (SEM). For some species examined, such as newly

introduced *Cochlicella barbara* and *Arion hortensis*, this analysis marks the first time such morphology has been described from these taxa collected in Los Angeles County. For others, such as *Glyptostoma gabrielense*, this analysis marks the first time in nearly 70 years that its radula has been visualized. The aim of this investigation is to not only catalog the morphology of jaws and radulae in the malacofauna of Los Angeles County, but to investigate intraspecific and interspecific differences in morphology to gain a better understanding of the lifestyle and feeding habits of these poorly inventoried gastropods.

Combined effects of ocean acidification and warming on embryos and larvae of sea hares (Mollusca: Opisthobranchia) in the Great Barrier Reef, Australia

Chávez-Viteri Y. E.[1,2] and Ward, S.[1]
[1]*The University of Queensland School of Biological Sciences, Queensland Brisbane QLD 4072 Australia;* [2]*Universidad Península de Santa Elena. Facultad de Ciencias Marinas. Av. Principal La Libertad - Santa Elena, Ecuador*
yolanda.chavezviteri@gmail.com, selinaward@uq.edu.au

Marine mollusks are vulnerable organisms that play a crucial role in determining the composition and dynamics of an ecosystem. Intensified anthropogenic pressures, such as ocean acidification and warming, have altered the equilibrium of some ecologically and economically important marine communities. Our knowledge on the isolated effects of these stressors is increasing, however their interactions are poorly understood, particularly during early life stages. This study analyzed the combined effects of ocean acidification and temperature rise on the development of two sea hares, *Aplysia dactylomela* and *Dolabella auricularia*. Individuals were collected at Heron Island on the southern Great Barrier Reef, Australia. *In situ* experiments were performed to simulate six different scenarios of decreased pH and increased temperature, and to evaluate morphological and behavioral responses of embryos and larvae. We found that embryonic stages were less affected than larval stages, suggesting that the impacts of both stressors may only become evident after long periods of exposure. While results varied between species, the analysis revealed that pH and temperature could interact in several ways, ameliorating or exacerbating their isolated effects. In general, our results indicate that sea hare early life stages can tolerate moderate variations in pH and temperature, but that more severe conditions can produce serious detrimental effects. We suggest that analysis of the combined effects of multiple stressors is crucial in order to properly address climate change impacts, and to identify species stress thresholds along with possible adaptive responses.

Field experiment exploring community consequences of local adaption in dogwhelk drilling

Contolini, G.M., Palkovacs, E.P, Raimondi, P.T., *Traverso, S.E.
University of California, Santa Cruz, Long Marine Lab, 115 McAllister Way, Santa Cruz, CA 95060 USA
gcontoli@ucsc.edu epalkova@ucsc.edu raimondi@ucsc.edu stravers@ucsc.edu

Dogwhelks are predatory intertidal snails that feed by drilling holes in mussel shells. In western coast intertidal zones, the California mussels dominate the substrate, and provide secondary structure for habitat that support a wide variety of species. In this experiment we seek to understand the degree of local adaptions among *Nucella emarginata* (dogwhelk) and how that influences community structure. The objective is to test how dogwhelks with different drilling behaviors affect mussel bed structure and community. The main research questions are (1) Do the dogwhelks drill differently at their home site vs. a foreign site (i.e. are they locally adapted?) (2) If so, how might different mussel drilling behaviors affect intertidal community dynamics such as diversity and recruitment? We will test these questions in a reciprocal transplant experiment in two sites in California by measuring the effect of drilling on mussel beds and communities after two months of predation. We will set up cages with dogwhelks from both sites and standardized mussel beds with a variety of sizes in all

the treatments. This will take place in both sites. After two months we will record the size of the mussels that were drilled, and community diversity. Hypotheses for this experiement are (H1) Dogwhelk predation reduces mussel beds and therefore community diversity. (H2) Predation on larger mussels reduces the mussel beds more and therefore reduces community diversity more. (H3) Dogwhelks are locally adapted and drill larger mussels at their home site. (H4) Dogwhelks do not reduce mussel beds and therefore have no effect on community diversity. (H5) Dogwhelk predation increases community diversity if dead shells provide space for mobile fauna and infauna to live. The results of this experiment can provide insight on how intraspecific variation, regardless of its evolutionary origin, can have broad community effects.

A high throughput laboratory bioassay for testing potential attractants for terrestrial gastropods, demonstrated by identification of a highly attractive food for *Cornu aspersum* and *Deroceras reticulatum*

Cordoba, M.[1], Millar, J.[2] and Mc Donnell, R.[1]
[1]*Dept. of Crop and Soil Science, Oregon State University, Corvallis OR 97331;* [2]*Dept. of Entomology, University of California, Riverside, CA 92521*
maria.cordoba@oregonstate.edu, jocelyn.millar@ucr.edu, rory.mcdonnell@oregonstate.edu

Terrestrial gastropods cause economic damage to crops in a number of ways, including reducing yield due to consumption of seeds, seedlings, roots and aerial parts of mature plants, and decreased crop quality due to the presence of mucus and faeces. Control strategies are focused heavily on molluscicides, which are ineffective under certain conditions, and which can have serious non-target effects. Thus, there is an ongoing need to develop alternative management options. One such option is the development of novel attractants for use in traps and in attract-and-kill strategies. However, in contrast to insects, very little work has been done to explore the chemical ecology of gastropods, and what little work has been done has been relatively superficial, e.g. comparing attraction to various food sources, with little or no follow-up work to identify the attractive odors. However, even these preliminary studies have clearly shown that chemical cues play a major role in a wide range of gastropod behaviors, including feeding and predator avoidance. The goal of this study was to develop a generic bioassay method that can be used to identify novel attractants for any terrestrial gastropod species by high-throughput screening of a wide variety of foodstuffs and other possible attractant sources. The optimized method uses arrays of glass T-tubes with cameras positioned above them to record snail movement and choices. The concepts behind this bioassay design will be discussed. Using the bioassay, from the previously reported attractants and additional odor sources that were tested in >1500 choice and no-choice bioassays, cucumber was consistently the most attractive to *Cornu aspersum* and *Deroceras reticulatum*. Our results also showed that previous feeding influenced subsequent food choice for both species, but this conditioning was not absolute and could be broken. Future research will involve using our high-throughput method for bioassay-guided fractionation of active extracts of cucumber, with the goal of identifying individual compounds or blends of attractive compounds.

Evaluation of silver nanoparticles on the prevalence and intensity of *Candidatus* Xenohaliotis californiensis in cultured red abalone *Haliotis rufescens*

*Cruz-Flores R.[1], Juarez-Moreno K[2] and Cáceres-Martínez J[1,3]
[1]*Centro de Investigación Científica y de Educación Superior de Ensenada, (CICESE), Carretera Ensenada-Tijuana No. 3918, Zona Playitas, 22860, Ensenada, Baja California, México;* [2]*Centro de Nanociencias y Nanotecnología, Universidad Nacional Autónoma de México, Km. 107 Carretera Tijuana-Ensenada, Ensenada, Baja California, C.P. 22860, México;* [3]*Instituto de Sanidad Acuícola, A.C. (ISA), Calle de la Marina S/N, esq. Caracoles, Fraccionamiento Playa Ensenada, 22880, Ensenada, Baja California, México*
rocruz@cicese.edu.mx, kjuarez@cnyn.unam.mx, jcaceres@cicese.mx

Candidatus Xenohaliotis californiensis (*C*Xc) is a Rickettsiales-like bacteria that causes abalone Withering Syndrome a potentially lethal disease for all abalone species of North America. To date the only successful treatment for eliminating this pathogen from affected abalone is the use of antibiotics (Oxytetracycline) via bath or injections. Phage therapy has been reported to control and alter the development of WS but it does not eliminate the pathogen. Silver has been long known to exhibit a strong toxicity to a wide range of micro-organism; for this reason, silver-based compounds have been used extensively in many bactericidal applications. In this study the effect of three concentrations (10ng/µl, 20ng/µl and 40ng/µl) of silver nanoparticles administrated via intramuscular injections were evaluated in cultured red abalone (*Haliotis rufescens*) infected with WS agent *C*Xc. The prevalence of *C*Xc was determined by PCR and histology. The intensity of the infection was determined by histology. In the present work the obtained results are discussed.

Distribution of Lucinidae and Thyasiridae (Bivalvia) on the coastal shelf near San Diego, CA

Enright, W.
City of San Diego Ocean Monitoring Program, 2392 Kincaid Rd., San Diego, CA, 92101
wenright@sandiego.gov

Bivalves in the families Lucinidae and Thyasiridae are common and often abundant members of the soft bottom benthos on the coastal shelf of Southern California. Members of these families within this area are characterized by the presence of chemoautotrophic symbiotic bacteria and thus are able to thrive in areas of high organic enrichment, high sulfides, and/or oxygen minimum zones. Previous studies have shown these animals to exhibit a "halo" pattern surrounding point sources of organic enrichment such as sewage outfalls. In the nearshore area of San Diego, two sewage outfalls in the Point Loma and South Bay regions discharge an average of 165 and 40 million gallons of treated effluent into the ocean per day, respectively. The City of San Diego maintains an extensive monitoring program to ensure the environmental impact of these outfalls is minimal. In this study, molluscan population data were examined from randomly distributed coastal shelf stations (9–200m depth) sampled during July beginning in 1994. The distribution of bivalves in the Lucinidae and Thyasiridae were mapped and examined in relation to the two outfalls. Other univariate and multivariate community indices were also analyzed as well as grain size, total organic carbon, total nitrogen and total sulfides. Although common members of the molluscan community, no significant relationship was detected between these bivalves, distance to the outfalls, or sediment organic constituents.

The great scaphopod hunt: Finding forgotten fossils

Estes-Smargiassi, K., Hendy, A.J.W.
Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007
kestes@nhm.org, ahendy@nhm.org

The invertebrate paleontology collection at the Natural History Museum of Los Angeles County (LACMIP) is currently working on an NSF-sponsored Thematic Collections Network project, EPICC, which funds the digitization (cataloging, photography, georeferencing) of Cenozoic Eastern Pacific marine invertebrate fossils. Since the project's start we have digitally catalogued nearly 600,000 specimens, with a focus on the Pliocene and Pleistocene of Southern California. A digitization effort of this scale gives paleontologists and malacologists an opportunity to capture rare and chronically understudied taxonomic groups. As a test case, we are working to identify and digitize all the scaphopods in the LACMIP collection, beginning with the Pleistocene of California, with much of the digitization work being completed by student interns from traditionally underserved local community colleges and universities.

The nearly 27,000 fully cataloged California Pleistocene scaphopods in the LACMIP collection represent just five species (*Dentalium neohexagonum, Antalis pretiosa, Graptacme semipolita, Gadila aberrans, Gadila tolmiei*).

This seemingly depauperate diversity likely reflects both environmental and preservational biases on the fossil record of California and the relative abundance of these species in Pleistocene and modern faunas. These five species are common in shallow water settings, while most of the documented extant scaphopod diversity in the Eastern Pacific is found in deeper water environments. Additional shallow water Eastern Pacific species will likely be discovered in the collection as sampling is extended south of California. The LACMIP staff plans to use this digital data to collaborate with other scaphopod researchers to increase the understanding of these mollusks, including research on paleoecology (e.g., predation, biotic interactions), taphonomy (preservation biases), and investigating changes in the relative abundance of scaphopods throughout the fossil record. Digitization projects such as EPICC reveal the importance of understudied taxonomic groups, like scaphopods, making what was once dark data readily available and more accessible than ever before.

Radular and penile morphology of sacoglossan sea slug *Elysia diomedea* (Bergh, 1894) using scanning electron microscopy

Flamenco, R.,[1] Chávez-Viteri Y. E.,[2,3] and Vendetti, J.E.[4]
[1]*Department of Biological Sciences, Glendale Community College, 1500 N Verdugo Road, Glendale, CA 91208 USA;* [2]The University of Queensland School of Biological Sciences, Queensland Brisbane QLD 4072 Australia; [3]Universidad Península de Santa Elena. Facultad de Ciencias Marinas. Av. Principal La Libertad - Santa Elena, Ecuador; [4]Malacology Department, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA
reflamenco@yahoo.com, yolanda.chavezviteri@gmail.com, jvendett@nhm.org

Elysia diomedea is a sacoglossan sea slug found in the eastern Pacific from the Gulf of California (Sea of Cortez) in México to Ecuador. Notably, studies have described kleptoplastic ability in this species, but it has been the subject of little morphological work. The last time radular morphology was described in *E. diomedea* was in 1924 by MacFarland whose representations of the radular teeth lacked serration. The sister species of *E. diomedea* are *E. crispata* and *E. ellenae,* which both have minutely serrated radulae (Krug et al. 2016). Using the methods of Krug *et al.* 2016 as a guide, morphological features of the radula and penis of *Elysia diomedea* were identified by the authors. The radulae of 12 *E. diomedea* specimens were dissected out the animals, prepared, and viewed under a Hitachi S-3000N scanning electron microscope in the SEM Laboratory at the Natural History Museum of Los Angeles County. The penis of two *E. diomedea* specimens (LACM 70-9 and LACM 74-31) were also extracted, prepared, and imaged. The results indicate that in *E. diomedea*'s, 1) radular teeth have very tiny serrations or denticles like those in *E. ellenae* and *E. crispata*, and 2) the penis has a cuticular extension of the vas deferens (referred to as a stylet in Krug et al., 2016) much like that of *E. ellenae* but unlike *E. crispata*, which has no stylet. These results are the first of their kind for *Elysia diomedea* and have important implications for understanding the evolution of traits in the genus *Elysia*.

Reference

Krug, P., Vendetti, J., Valdes, A.. 2016. Molecular and morphological systematics of Elysia Tisso, 1818 (Heterobranchia: Sacoglossa) from the Caribbean region. Zootaxa 4148 (1): 1-137.

Morphological identification of monophyletic groups within *Elysia* (Sacoglossa: Plakobranchidae)

*Galvão Filho, Hilton C.[1] and Krug, P.J.[2]
[1]*Museum of Zoology of the University of São Paulo, 481 Av. Nazaré, Sao Paulo, SP 04206-000 Brazil;* [2]*Department of Biological Sciences, California State University, 5151 State University Dr., Los Angeles, CA 90032 USA*
hiltoncgf@gmail.com, pkrug@calstatela.edu

The genus *Elysia* contains about a third of the species in order Sacoglossa, and possibly even more due to the number of undescribed species recorded in publications, online databases and molecular surveys. These highly specialized marine herbivores live on macroalgae; within *Elysia*, some clades selectively feed on one algal genus, and slug species may specialize on one algal species. Also, *Elysia* is famous for the ability to sequester chloroplasts from algal cells and keep them functional in the digestive gland. It has been difficult, however, to determine synapomorphies in *Elysia*, especially because of the reliance upon external and radular characters for taxonomic description and identification for most species, leading to cycles of splitting and lumping within this nominal genus. We have sought to improve our understanding of relationships within *Elysia* by comparing results from molecular phylogenetic versus morphological analyses. Maximum Likelihood and Bayesian analyses were performed on concatenated DNA sequences representing portions of two mitochondrial (COI, 16S) and three nuclear (H3, 28S, 18S) genes for 122 species of *Elysia* and its related genera in family Plakobranchidae; results yielded significant support for numerous subclades within *Elysia*. External and detailed internal morphological traits were obtained from traditional dissection methods and scanning electron microscopy of 20 species, and compared among selected monophyletic groups. Morphological analysis yielded potential apomorphies and synapomorphies consistent with clades within *Elysia* that were supported by our molecular analyses. For instance, at least five morpho groups were inferred from reproductive characters, such as the position and number of hermaphrodite ampulla and absence/presence of gametic vesicles, genital receptacle and bursa copulatrix. However, examination of additional morphological traits is necessary to more comprehensively assess relationships within, and the evolution of, the most diverse group in Sacoglossa. (Financial support: FAPESP 2016/22035-9)

High-resolution paleoenvironmental analysis of a Plio-Pleistocene marine succession, Carpinteria, Santa Barbara County, California

Hendy, A. J. W.
Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA
ahendy@nhm.org

The Rincon Hill section near Carpinteria, California preserves a fault-bounded block of Plio-Pleistocene sediments, which have been correlated with the Santa Barbara Formation of western Ventura-Santa Barbara Basin. This sedimentary package is well known for its ease of collecting and high diversity, with 214 molluscan species reported by Powell et al. (2009), and more than 180 species obtained from exhaustive bulk sampling by Aziz et al. This study documents the results of high resolution (0.5 m stratigraphic intervals) faunal inventorying through the lower 90 m of the section. The objective was to do document fine-scale stratigraphic variations in faunal composition, sediment type, and taphonomic properties, such as packing density, fragmentation, and encrustation/bioerosion.

Faunal lists were collected from nearly 140 horizons, and this approach documented stratigraphic variations in the relative abundance of 105 species. It was observed that invertebrate fossils were most diverse in relatively few horizons that were characterized by densely packed, disarticulated and fragmented bioclasts in often sandy and conglomeratic sediments. Nevertheless throughout the lower 90 m of section most siltstones and mudstones contain some sparsely- or loosely-packed fossils. A basal contact with the Sisquoc Formation is delineated by channelized, redeposited coarse terrigenous sediments and bioclasts. The overlying 90 m of section contain three sedimentary sequences, each one bounded by a basal coquina, overlain by mudstone, and grading upwards into siltsone. These subtle lithofacies changes appear to correlate with shifts in biofacies composition.

The rich data obtained here have been analyzed using Detrended Correspondence Analysis (DCA) and Cluster Analysis. The cluster analysis identified four faunal associations, which were dominated by *Lirobittium* sp. (undetermined), *Nutricola tantilla*, *Cyclocardia occidentalis,* and *Chlamys opuntia*, respectively. DCA identified strong faunal gradients within the data, which are associated with paleobathymetry and sediment composition. When plotted against stratigraphic position, variations in DCA values appear to depict temporal fluctuations in

paleobathymetry and sediment flux at the Rincon Hill site.

Reference

Powell, C.L., II, Stanton, R.J., Jr., Vendrasco, M., and Liff-Grief, P., 2009, Warm extralimital fossil mollusks used to recognize the mid-Pliocene warm event in southern California: *Western Society of Malacologists Annual Report for 2008, 41*, 70-91.

Comparative study of molluscan abundance on the rocky intertidal and shallow zone of Espíritu Santo Archipelago, Gulf of California, México

Holguín-Quiñones O.E, Félix-Pico Esteban F. and García-Dominguez, F.A.
Centro Interdisciplinario de Ciencias Marinas del Instituto Politécnico Nacional. Av. IPN s/n, Col. Playa Palo de Santa Rita, La Paz, BCS, México 23090
efelix@ipn.mx, oholguin@ipn.mx, fdomin@ipn.mx

Samplings were made in April and June of 2002 and August and October 2013 in seven localities of the Archipelago Espíritu Santo. The purpose was to determine mollusk richness in intertidal and upper infralittoral rock surfaces. The abundance of the conspicuous benthic macromollucs (Gastropoda, Bivalvia, Polyplacophora and Cephalopoda) was estimated visually by free diving at 1-6 m depth along two band-transects parallel to the coastline. Each transect was 5 m wide and 50 m long, covering an area of 500 m^2 per site. Twenty five species were identified. The gastropods were the best represented group, with 14 species, nine bivalves, one polyplacophoran and one cephalopod. There were no significant differences in diversity, equitability and species richness among sampling years, though differences were found among sites ($P < 0.05$). The highest mean abundances were recorded for *Pinctada mazatlanica* (25.4 ± 43.77 ind.). A spatial diversity pattern was identified, with low values (0.69 bits ind^{-1}) for exposed shores and high values (2.3 bits ind^{-1}) for semi-protected areas. Except for slight changes in composition in number and presence or absence of species by localities, there was no evident alteration in the malacofaunistic structure eleven years after the implementation of the Management Program of the Archipelago Espíritu Santo of 2002.

Geographic an d vertical distribution of three species of the chiton genus, *Nuttallina*, along the California coast

*Hood, N.Z. and Eernisse, D.J.
Department of Biological Science, California State University, Fullerton, 800 N. State College Blvd., Fullerton, CA 92831 USA
nzhood2@csu.fullerton.edu, deernisse@fullerton.edu

Three species of the chiton genus *Nuttallina* (Mollusca: Polyplacophora: Lepidochitonidae) occur along the California coast. Although *N. californica* (Reeve, 1847), *N. fluxa* (Carpenter, 1864), and an undescribed species, *N.* sp. A, are commonly found in the rocky intertidal, not much is known about their microhabitat or geographic distribution. In fact, only the first of these is presently recognized as a valid species in the World Register of Marine Species (WoRMS), but these have subtle morphological and substantial genetic differences, and also differ in their geographic and microhabitat distribution. *Nuttallina fluxa* extends as far south as the Pacific coast of Baja California Sur, Mexico, and is extremely common in southern California up to Point Conception, whereas *N. californica* is extremely common north of Point Conception, but becomes relatively rare north of San Francisco Bay. The distributions of these species appear to approximately coincide with the Californian and southern portion of the Oregonian marine biogeographic provinces, respectively, however *N. californica* is occasionally also found in southern California and is somewhat common at cool exposed upwelling sites south of

Ensenada, Baja California, Mexico. From limited data, *N.* sp. A is known from relatively few localities in both southern and central California. Our study will investigate if there are observable differences in the morphology between the three species of *Nuttallina* and if there are any differences in microhabitat. Studies are underway to quantify and collect *Nuttallina* from central to southern California, emphasizing *Nuttallina* that are highest or lowest in the intertidal zone**.** Densities are being estimated and randomly selected individual are being collected for identification with a PCR-based DNA assay and subjected to a morphometric analysis of disarticulated valves. Our goal is to develop rapid reliable methods to identify individuals to species. This will also provide a useful system for investigating competitive and other interactions between these ecologically important intertidal species. Estimating current distributional patterns will establish a baseline dataset so that future changes can be assessed.

Seashells by the Salton Sea: Marine molluscs of the Middle Pleistocene Brawley Formation, Riverside County, California

*Huh, M.[1], Laguna, R.[2], and Hendy, A.J.W.[3]
[1]*University of Southern California, Los Angeles, CA 90089 USA;* [2]*Glendale Community College, 1500 N Verdugo Rd. Glendale, CA 91208 USA;* [3]*Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA*
meganhuhh@gmail.com, rlaguna249@student.glendale.edu, ahendy@nhm.org

Recent surveying of the Brawley Formation on the northeastern shoreline of the Salton Sea and Superstition Hills of Imperial County (California) have revealed many more species of marine bivalves and gastropods than previously documented. Extensive beds of the brackish-water bivalve *Rangia* have been noted for more than a century (Conrad, 1853). More recently Roeder & LaFollette (2015) reported the presence of beds containing *Tagelus* and undetermined Pectinidae. Our own field efforts have involved mapping out invertebrate-bearing beds along outcrops of Brawley Formation, exposed below weathered sediments from Holocene paleo-Lake Cahuilla. These beds comprise both monospecific and mixed assemblages of *Rangia lecontei, Tagelus californianus, Chionista fluctifraga,* and *Phrontis iodes*. Other notable records include less abundant *Cerithideopsis californica, Cyclinella subquadrata,* and an undertermined Lucinid bivalve.

Rangia inhabit low salinity brackish-water habitats, in areas of high turbidity and soft fine-grained sediments. *Chionista, Tagelus, Cerithideopsis*, and *Phrontis* are consistent with estuarine mud and sand flats, and coastal lagoons or sloughs. *Cyclinella subquadrata* and *Phrontis iodes* range into the northernmost Gulf of California (31.7°N), but are absent from the modern-day Pacific coastline of California. *Rangia lecontei* is extinct, but has been tentatively identified from the late Pleistocene of Newport Bay, and is widespread in Plio-Pleistocene deltaic deposits of the Imperial Valley and as far north as Mono Lake (Hersher & Jayko, 2009).

This growing faunal inventory and repeated stratigraphic occurrences of these fossils suggests that the Salton Sink was subjected to repeated marine incursions throughout the Middle Pleistocene (c. 600-700 ka), despite post-dating the progradation of the Colorado River delta to its present position during the Pliocene. These events may relate to Pleistocene high sea-level stands or reflect rapid changes in the morphology of the Rio Colorado delta.

References

Conrad, T.A. (1853). Descriptions of new fossil shells of the United States. *Journal of the Academy of Natural Sciences of Philadelphia 2*, 273–276.

Hershler, R., & Jayko, A.S. (2009). A Mactrid Bivalve from Pleistocene Deposits of Lake Russell, Mono Basin, California. *Journal of Paleontology 83(3)*, 496-499.

Roeder, M.A., & LaFollete, P.I. (2015). New fossil records from the Middle to Late Pleistocene Brawley Formation of Imperial and San Diego counties, southern California. *Southern California Academy of Sciences 108th Annual Meeting, May 15-16, 2015.*

Study on the morphological variability of genitalia and external characteristics of terrestrial slugs *Ambigolimax nyctelius* and *A. valentianus* and their distribution in Los Angeles County

*Lee, Cedric[1,2]
[1]*212 N McPherrin Ave Apt B, Monterey Park, CA 91754 USA;* [2]*Research Associate, Malacology Department, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA*
xxcedric@yahoo.com

The terrestrial slug *Ambigolimax valentianus* was first recorded in California in 1930 (Pilsbry 1948) while *A. nyctelius* was first recorded in California through mtDNA sequencing in 2016 (unpublished). In order to confirm the presence of *A. nyctelius* through morphology, genitalia dissection was conducted on *Ambigolimax* specimens collected in Los Angeles County. Genitalia dissection revealed that the two species cannot be confidently identified through external characteristics. In addition, the two species are both widely distributed in Los Angeles County, suggesting that *A. nyctelius* has been present in California for many decades.

Genetic structure and demographic history of *Humboldtiana durangoensis* based on microsatellite markers

López-López, B.[1], Gómez-Ortega R.[2] and Mejía O.[1]
[1]*Departamento de Zoología, Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional, Prolongación de Carpio y Plan de Ayala S/N, Colonia Casco de Santo Tomas, C.P. 11340 México;* [2]*Departamento de Toxicología, Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional (CINVESTAV-IPN), Av. Instituto Politécnico Nacional 2508, Col. San Pedro Zacatenco, C.P. 07360 México*
benjamin_end@hotmail.com, hmejiag@ipn.mx, mrgomez@cinvestav.mx

Phylogeographic studies of different mountain biological groups in Mexico have revealed complex patterns in a broad scale but an absence of genetic structure within local mountain systems such as the Sierra Madre Occidental. In this work, we estimate the genetic structure and demographic history of the endemic land snail *Humboldtiana durangoensis* within this mountain range. Nine polymorphic microsatellite loci in 178 individuals from 16 localities throughout the complete geographic distribution were analyzed. Strong deviations from Hardy -Weinberg equilibrium and low levels of heterozygosity were detected in the seven genetic clusters. The genetic flow between two of the main geographic regions (North and South) was symmetric (≈ 4 individuals). In addition, the analysis detected changes in the effective population size indicating that both geographic regions experienced a drastic reduction in their effective population size probably associated with the Pleistocene climatic changes.

Do water-borne cues mediate density dependent reproductive effects in the sea slug genus *Alderia*?

*Lugo, L.M. and Krug, P.J.
Department of Biological Sciences, California State University, 5151 State University Dr., Los Angeles, CA 90032, lisamlugo@yahoo.com, pkrug@calstatela.edu

Recent mating history, mating group size, and water-borne chemical signals can influence allocation between female versus male roles in hermaphrodites. Prior studies showed that more frequent mating and crowding decreased egg production by the hermaphroditic sea slugs *Alderia willowi* and *A. modesta* whereas egg masses stimulated oviposition; however, these effects could be due to dissolved pheromonal cues or physical contact. Theory predicts reallocation from egg production to male functions in larger mating groups, but hypodermic insemination could also decrease egg production as a cost of mating at higher densities. Egg masses could stimulate oviposition either by acting as a physical substrate for egg attachment, or by releasing peptide

pheromones as observed in other sea slug groups. To distinguish whether changes in egg production were due to chemical cues or physical access to mates/egg masses, paired slugs were exposed to chemical signals of slugs, egg masses, or both together. Water-borne cues from adults inhibited egg production in the absence of more frequent mating, suggesting cues indicating larger group size cause reallocation away from female functions as predicted by theory. Dissolved cues from other egg masses stimulated egg production, consistent with pheromonal induction. Concurrent exposure to cues from both slugs and egg masses changed egg output in a non-additive but inconsistent manner across trials. My research supports theoretical predictions of sexual selection on hermaphrodites, and provides insight into how chemical signaling mediates population ecology, and how reproductive interference between *Alderia* spp. May contribute to setting their respective range limits in northern California.

Morphological variations of a common marine gastropod species, *Californiconus californicus*, in the age of the Anthropocene

*Malloy, M., Ul-Hasan, S., and Sistrom, M.
University of California, 5200 N. Lake Rd., Merced, CA 95343
mmalloy2@ucmerced.edu, sul-hasan@ucmerced.edu, msistrom@ucmerced.edu

The California cone snail is a common, yet understudied, marine gastropod species found from the San Francisco Bay to Baja California Sur in the subtidal and intertidal. Its populations span three marine ecoregions and as a result is increasingly subject to anthropogenic impacts over time. Previous studies have demonstrated phenotypic variations in gastropod shell such as increased apertural diameter and globosity to be associated with adaptation. We measured the globosity, shell thickness, and aperture of over 1,800 *C. californicus* shells from museum collections (primarily from Los Angeles and the Channel Islands) collected to investigate potential correlations between *C. californicus* shell morphology and possible anthropogenic influences associated with urbanization of the Southern California coastline over the past 120 years. We hypothesize *C. californicus* responds to rising average temperatures similar to that of other marine mollusc species, exhibiting decreased shell thickness and narrower spires to release excess heat. We also hypothesize *C. californicus* follows Bergmann's rule, increasing in size as waters become colder northward. Lastly, we hypothesize both those trends are altered by urbanization along the coast, creating morphologically distinct variations within several distinct marine ecoregions. These variations may provide new definitions of eastern Pacific ecoregions as species respond to the ecological changes of the Anthropocene. The diagnosis of historical *C. californicus* shell variation, via measurement and abiotic factor analyses, may also serve as a strengthening component for multivariate models on marine invertebrate populations and long-term morphological radiation in response to human-caused climate change.

Transcriptomic response to reduced salinity and increased temperature in oysters *Ostrea lurida* and *Crassostrea gigas*

*McIntyre, S.L., Zacherl, D.C., and Walter, R.P.
Department of Biological Science (MH 282), California State University, Fullerton, 800 N State College Blvd, Fullerton, CA 92831 USA
staceymc@csu.fullerton.edu, dzacherl@fullerton.edu, rwalter@fullerton.edu

Global climate change presents substantial challenges to conservation and restoration managers whose task is to ensure the success of focal species and communities. In southern California, localized coastal restoration projects are underway directed at the native foundation species, the Olympia oyster (*Ostrea lurida*). Among the restoration challenges is the abundant co-occurrence of the non-native Pacific oyster (*Crassostrea gigas*), which can compete with native oysters for microhabitat. Establishing molecular responses to climate

change stressors in both species can provide valuable insight for the development of effective restoration strategies that strive to maximize native oyster recovery while minimizing non-native expansion. Here we conducted a common garden experiment coupled with RNA sequencing to examine within and between species differences in molecular responses to reduced salinity (20 ppt) and increased temperature (30℃) stressors. Following gene ontology (GO) enrichment analysis, approximately 95% of GO terms associated with biological processes (13137), molecular function (3877), and cellular components (1678) were shared between species. Furthermore, *O. lurida* showed 66 unique GO terms associated with stress genes versus 48 in *C. gigas*. Comparisons of gene expression profiles associated with both thermal and osmotic stress showed greater variation at high temperature in both species relative to the control treatment. In addition, reduced salinity showed less variation in *C. gigas* than *O. lurida*. These results represent the first comparative transcriptomics analysis between *O. lurida* and *C. gigas* in thermo-osmotic stress associated genes and may hold the potential for forecasting the trajectories of these two competing species to predicted climate change stress.

Protozoans associated with siphon lesions of the clams *Panopea generosa* and *Panopea globosa*

Pérez Bustamante I.S.[1], Cruz-Flores R.[2] and Cáceres-Martínez, J.[2,3]
[1]*Universidad Autónoma de Baja California, Carretera Ensenada-Tijuana, No. 3917, Colonia Playitas 22860, México;* [2]*Centro de Investigación Científica y de Educación Superior de Ensenada, (CICESE), Carretera Ensenada-Tijuana No. 3918, Zona Playitas, 22860, Ensenada, Baja California, México;* [3]*Instituto de Sanidad Acuícola, A.C. (ISA), Calle de la Marina S/N, esq. Caracoles, Fraccionamiento Playa Ensenada, 22880, Ensenada, Baja California, México*
a334537@uabc.edu.mx, rocruz@cicese.edu.mx, jcaceres@cicese.mx

The clams from the genus *Panopea* are bivalve mollusks that belong to the family Hiatellidae. In México there are two species, *Panopea globosa* and *Panopea generosa*. Both species are extensively fished due to the high demand in Asian, including China and Hong Kong where they are exported. In México and Canada dark spots in the siphon area and mantle have been observed. In the affected areas the periostract can easily be detached and it has an unhealthy appearance that affects its commercialization, additionally this appearance has been associated with unusual mortalities of *P. generosa* in México. In both cases these lesions have been associated with unidentified protozoans. The objective of this study was to determine if the lesions of *P. generosa* and *P. globosa* were associated with protozoans. The lesions in *P. generosa* were characterized and numerous protozoans in different stages of development were observed within the lesions. In *P. globosa* no histological evidence of the presence of protozoans was observed. However, the isolation and culture of the protozoan parasite *Uronema marinum* was achieved from lesions in the siphon. The identity of this parasite confirmed by PCR and product sequence analysis. In fish and other commercial bivalve species high mortality episodes have been attributed to this protozoan parasite. In this case it is still not possible to confirm *U. marinum* as the causal agent of the lesions in the siphon of *P. globosa*. More studies are necessary such as those of the Koch postulate to confirm the relationship between *U. marinum* and *P. globosa*. Furthermore, it is still necessary to identify the unknown protozoan in the siphon lesions of *P. generosa.*

Elemental composition analysis of *Cornu aspersum* shells from Los Angeles and Ventura counties

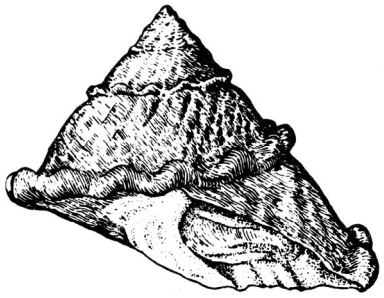
*Rostami, S.[1] , Vendetti, J.E.[2], and Celestian, A.[3]
[1]*Department of Biological Sciences, Glendale Community College, 1500 N Verdugo Rd. Glendale, CA 91208 USA;* [2]*Malacology Department, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA;* [3]*Mineral Sciences Department, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007 USA*
srostam581@student.glendale.edu, jvendett@nhm.org, acelesti@nhm.org

Cornu aspersum (Müller, 1774) is a widely dispersive introduced terrestrial gastropod found in many regions within Southern California. Four modern and recently collected specimens of this species from various localities in LA and Ventura counties (from the Natural History Museum of Los Angeles (NHMLA) malacology collection) were tested for significant differences in shell composition. NHMLA's Raman Spectrometer was used to measure frequency shifts of molecular compounds, and an X-Ray Analytical Microscope was used to determine elemental composition. Three samples came from Los Angeles Country as part of the NHMLA's Slime Project (Snails and Slugs Living in Metropolitan Environments) and another sample was collected from Ventura County. Results showed compositional differences within the shell specimens. Future directions include, 1) using the Energy Dispersive Spectroscopy on the Scanning Electron Microscope to verify previous results, 2) comparing samples of *Cornu aspersum* from previous decades within the same localities for evidence of changes through time 3) Obtaining samples from several different species to see if shell compositional differences are also present in species other than *Cornu aspersum*.

Digitizing the Cretaceous clams, snails, and cephalopods of California

Walker, L. J., Hendy, A.J.W., and Estes-Smargiassi, K.
Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007
lwalker@nhm.org, ahendy@nhm.org, kestes@nhm.org

The Invertebrate Paleontology collection (LACMIP) at the Natural History Museum of Los Angeles County (NHMLA) recently received an NSF Collections in Support of Biological Research grant to improve the curatorial quality and digital accessibility of the museum's extensive collections from the Cretaceous of California and Mexico (NSF DBI 1561429). These collections primarily include fossil bivalves and gastropods, as well as a large number of cephalopods (nautiloids and ammonites). Importantly, many specimens from these collections were the focus of 50+ taxonomic publications by scholars in California paleontology (Popenoe, Saul, Squires, et al.) and/or were collected from now inaccessible localities. Other components of this project focus on rehousing historic Plio-Pleistocene marine invertebrates in conjunction with a larger, ongoing digitization project (NSF DBI 1503065), and integrating collections from the Miocene from the Santa Monica Mountains into the LACMIP stratigraphic collections. Despite their immense research value, these specimens have remained largely inaccessible beyond the NHMLA. Therefore, in addition to rehousing and curating specimens, one of the most pressing goals of this project is to digitize (database, georeference, image) nearly 26,000 specimen lots and disseminate this information online via large biodiversity data aggregators by 2019. Much of this work will be accomplished by student interns from traditionally underserved local universities and community colleges. All data generated as part of this project will be made freely available online for the benefit of researchers and the public alike. Outreach efforts involve partnering with local educators and the avocational paleontology community, for whom we plan to develop print and online resources to facilitate their exploration of Cretaceous paleontology (fossils and localities) in California.



Meeting Minutes

Minutes, Executive Meeting, Western Society of Malacologists
Fiftieth Annual Meeting, 19 June 2017, Los Angeles, CA

Board members present: President Jann Vendetti; 2nd Vice President Miguel del Rio Portilla; Treasurer Kelvin Barwick; Secretary Wendy Enright; Members-at-large Shawn Wiedrick and Alvin Alejandrino; Past President Doug Eernisse; visiting scientist from OSU Maria Cordoba

The meeting was called to order by President Jann and introductions were made all around.

PRELIMINARY BUSINESS:

- ◊ Miguel expressed concern regarding institutional support for his meeting; tentatively scheduled to be held in Ensenada. Other officers shared suggestions regarding past meetings and successful strategies and offered their help.
- ◊ Doug suggested the potential of joining with the World Congress of Malacology in 2019 that will be held in Asilomar, CA August 11-16.
- ◊ Issues remain with obtaining visas for visiting students

OLD BUSINESS:

- ◊ The secretary neglected to bring the minutes of the 2016 meeting and will email them to the board at a later date
- ◊ Kelvin presented the Treasurer and Membership reports
    - ♦ Questions remain regarding the division of the 2016 registration money. Kelvin will speak with Tim Pearse of the AMS to try to get in communication with their treasurer and close that meeting out.
    - ♦ Kelvin has a "calendar of events" in his Treasurer's cookbook that could be modified for future presidents
    - ♦ Wendy moved to accept the Treasurer's report and Alvin made the 2nd.

NEW BUSINESS:

- ◊ Looking for a new webmaster; preferably one with experience in Word Press
- ◊ Annual Reports; Wendy promised to continue to badger Paul, Danielle and Carlos for documentation necessary to complete their reports
    - ♦ There is an agreement in place with the Biodiversity Heritage Library to publish the reports after 5 years

MISCELLANEOUS BUSINESS:

- ◊ The question was raised whether to make an official statement regarding the Paris climate accord
    - ♦ Discussion ensued; a final suggestion was to make a more general climate change statement
- ◊ Three McLean grant winners will be announced prior to the group photo
- ◊ Low attendance this year for the field trips
- ◊ Further discussion with Miguel regarding a future meeting dealing with issues of transportation, the banquet, the auction, dates and the possibility of having it much earlier in the year
- ◊ Shawn will work with Jann to coordinate the reprint sale that will be held the night of the auction

Doug moved to adjourn with Kelvin providing the 2nd.

Respectfully submitted

Wendy Enright

Wendy Enright

WSM Secretary

Minutes, General Meeting, Western Society of Malacologists
Fiftieth Annual Meeting, 19 June 2017, Los Angeles, CA

The meeting was called to order at 3:40 pm by President Jann Vendetti. About 30 members were present. All officers were in attendance.

President Jann Vendetti
Vice President Rebecca Johnson
2nd Vice President Miguel del Rio Portilla
Treasurer Kelvin Barwick
Secretary Wendy Enright
Members-at-large Alvin Alejandrino and Shawn Wiedrick

OLD BUSINESS:

- The minutes of the 2016 meeting were read and approved (Hans Bertsch moved; Alvin 2nd)
- President's message (text is at the beginning of the meeting program)
- Kelvin gave the Treasurer's report
  - Special thanks to Hans for the 50th anniversary gift
  - Kelvin will be in contact with PayPal to get the fee they charge us reduced in light of our status as a non-profit
  - Special thanks to Brent Raines for a generous donation to the McLean grant
  - The report was approved (Hans moved; Angel Valdes 2nd)

NEW BUSINESS:

- Angel Valdes proposed joining the 2019 WSM meeting with that of the World Congress of Malacology (UNITAS) to be held in Asilomar, CA
  - In order to preserve the next meeting in Ensenada, it was suggested that Miguel remain 2nd VP and hold his meeting in 2020 while a new candidate step in to be Vice President for 2018 and act as the liaison with the WCM (should the membership decide to participate in a joint meeting)

- Patrick Krug accepted his nomination
- Further discussion ensued about other nominees and whether it is appropriate to nominate students considering the obligations on their time and uncertainty in their future. Angel also clarified the contingent nature of the nomination.
- The nominations were then closed (Barry Roth moved, Pat LaFollette 2nd)

◊ Kelvin sent out a plea for a web master with some knowledge of WordPress

◊ Hans Bertsch was honored to receive a lifetime membership to the society

◊ Amendments to the WSM by-laws regarding gender-neutral language and the use of electronic mail were accepted (Shawn moved, Jann 2nd)

◊ The 2018 slate of officer nominations were presented and approved
- President Rebecca Johnson
- Vice President Patrick Krug (contingent upon joint meeting with WCM)
- 2nd Vice President Miguel del Rio Portilla
- Treasurer Kelvin Barwick
- Secretary Wendy Enright
- Members-at-large: Alvin Alejandrino and Shawn Wiedrick

PRESENTATION OF THE GAVEL TO INCOMING PRESIDENT REBECCA JOHNSON

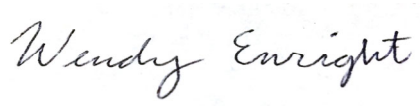
MISCELLANEOUS BUSINESS:

◊ Wendy moved to thank Jann for a great meeting, her hard work, and a wonderful tribute to the 50 years of the society (Doug 2nd)

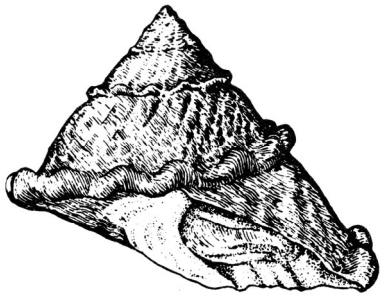
◊ Rebecca gave a brief presentation introducing herself and sharing some preliminary details on the 2018 meeting to be held jointly with AMS in Honolulu, HI
- Dates: June 17-20
- Field trips may include the Waikiki Aquarium and the Bishop Museum
- Possible symposia
  - Land snail conservation
  - Citizen scientists
  - Women in malacology

Hans moved to adjourn the meeting (Nora Foster 2nd)

Respectfully submitted,



Wendy Enright,
WSM Secretary



Treasurer's Report

Financial Report for WSM

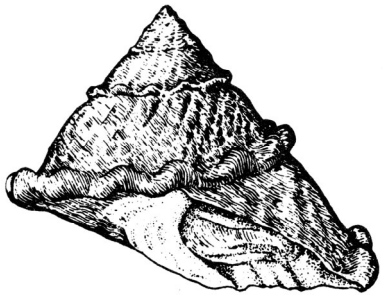
as reported by Treasurer Kelvin Barwick on June 19, 2017

In-flows	
Membership	$1,022.22
Interest earned	$3.95
Student grant donations (available balance $6371.52*)	$2,112.00
2017 Conference	$7,232.73
2016 Conference	$2,991.56
Total in-flow	$13,362.46
Out-flows	
2016 Conference	-$80.00
2017 Conference	-$2,587.01
50th Anniversary gift (advance)	-$1,500.00
IT security services	-$360.00
Office supplies	-$74.31
Total out-flow	-$4,601.32
Net	**$8,761.14**
*Does not include overages for 2016 conference.	

Cash on hand:	
Checking	$24,825.03
Savings	$13,144.62
Credit Card	-$2,437.01
Total	**$35,532.64**
PayPal cost* not realized above:	
Donations & Membership	$1,251.00
Fees	-$40.97
Net	**$1,210.03**

* 2.9% plus $0.30 per transaction

Kelvin Barwick
Treasurer



Meeting Highlights

Current Research in Fossil Mollusca Symposium Participants

Standing (L to R): Carole Hickman, Tom DeVries, Brendan Anderson, Judy Smith, Richard Squires, Paul LIpman, Jacob Lipman, Dan Muhs, Doug Eernisse, Mike Vendrasco, Lillian Pearson, Bob Stanton, George Kennedy.

Kneeling (L to R): Lindsey Groves, Austin Hendy.

Terresrial Gastropod Symposium Participants

Standing (L to R): Casey Richart, Lance Gilbertson, Jeff Nekola, Christine Parent, Marty Meyer III, Chris Kitting, Shawn Wiedrick, Doug Eernisse, Mason Linscott, Barry Roth.

Kneeling (L to R): Tim Pierce, Charles Drost.

WSM TURNS 50 – CELEBRATING GREAT MOMENTS AND PEOPLE IN LEFT COAST MALACOLOGY

INTRODUCTION AND DISCLAIMER

Here we are, celebrating 50 years and more of Left Coast Malacology. This is going to be a personal collection of thoughts on what has made for 50 great years. I am not an historian, and this is not the time for an historical account. This is an occasion to talk about unique interactions of people, place, and mollusks. It has not been fact-checked and there will be no slides. I am going to begin with a few early recollections and my own introduction to the Society.

MY FIRST WSM MEETING

My personal experience began with the 1974 annual meeting of WSM in Pomona, where I gave a paper based on my dissertation research as **Myra Keen**'s last student in the Department of Geology at Stanford. Miss Keen's other students who gave papers at the meeting included **Judy Terry Smith**, **Gene Coan**, and **Jim McLean**. Jim was president of WSM that year. There was an impressive contingent from Hawaii. This is where I met and began to get to know many of the wonderful avocational malacologists who have played such a vital role in WSM. It is where I first met **Stillman Berry**, and it resulted in an invitation to visit him at his legendary home in Redlands. **Clyde Roper** gave the Banquet Address.

I have two especially vivid memories of that meeting – first the other graduate students who gave papers. They included ***Mr.* Hans Bertsch**, ***Mr.* George Kennedy**, and ***Mr.* Chris Kitting**, who are now distinguished past presidents with long records of important contributions to WSM. ***Mr.* Jim Carlton** was also there, and Jim and I were both invited to publish our papers in the Annual Report. My second vivid memory is of the number of fellow paleontologists at the meeting. The WSM Award of Honor was made to **Katherine van Winkle Palmer**, Director of the Paleontological Research Institution, and the citation was read by **Myra Keen**. In addition to presentations by Judy Terry Smith and George Kennedy there were papers by **Louie Marincovich, Bill Zinsmeister**, **Jack Mount** and **Bob Rowland**. **Kiyotaka Chinzei** was there from Japan – Kiyo would later invite me to give a keynote address in a symposium at the 29th International Geological Congress in Kyoto in 1992. **Bill and Lois Pitt** were there with an exhibit of fossil mollusks from the Kettleman Hills. Bill and Lois did a lot of fossil collecting in Ecuador, and I would later make two paleontological expeditions to the Galápagos Islands with Bill and Lois. My graduate student **Matt James** was part of our first Galápagos paleontological expedition. Bill and Matt are also both past presidents of WSM. And so it seems to me that WSM has been about building a malacological family: a distinctive Left Coast malacological family. Let's explore this concept further.

DEFINING THE LEFT COAST

What do I mean by *left coast*? Looking at a map of the Americas, any proper map of the Americas, the Pacific Ocean is always on the left and the Atlantic Ocean is always on the right. I intend nothing political in referring to the left coast. But I do want to articulate what I think is a distinctive left coast malacological sense of place. It has three elements.

Geology and Tectonics

The first is geologic. The Pacific margin is tectonically active. The Atlantic margin is passive. Geologically our Pacific margin is at the boundary between the North American Plate and the Pacific Plate. Our continental shelf is narrow. We have some very unusual deep-water molluscan habitats close to shore. The San Andreas Fault moves two great plates past one another and has opened the Gulf of California. Farther to the north subduction and chains of active volcanoes link us to the entire North Pacific Rim – our high latitude Northeastern Pacific molluscan faunas have more in common with those of the Bering Sea, Chuckchi Sea, Sea of Okhotsk, and Japan than with the faunas of Atlantic coast. Alaska is part of this. We met in Alaska when **Nora Foster** was president of WSM. Here is Los Angeles, we are actually holding our celebration on the Pacific Plate, headed slowly northward toward subduction into the Aleutian Trench.

Part of our active margin history involves vertical movements of the land that have interacted with eustatic changes in sea level to produce a rich molluscan fossil record in Quaternary marine terraces.

Oceanography

The second distinct element is oceanographic. This is an upwelling coast with seasonally high productivity that supports major molluscan fisheries and aquaculture. We have squid. We have oysters. We have abalone. We have scallops. We have mussels. We have clams. We have growing conservation concerns associated with overexploitation, pollution and climate change. Our oceanographic sense of place transcends the borders between countries on the left coast.

Connection to Oceania

The third element is our Pacific connection to the islands of Oceania. The history of WSM interest in Hawaii and the Galápagos is not an accident. There is also a connection to continental islands, especially the California Channel Islands of the geologically complex borderland shared by southern California and Baja California, Mexico.

DEFINING WSM AS A SOCIETY

Our left coast malacological setting and the mollusks we study do not fully explain our unique WSM malacological culture and community – a community of people. In my experience there are eight themes that emerge from out our activities and friendships. These are what define us. I will tell you what they are, but we would be here all night if I attempted to elaborate on each of them. And there are others here who are better qualified to do so.

Eight Themes

•**Student awards, recognition, encouragement, and mentoring.** Our best students have stayed involved in WSM. Why? We might do well to consider the reasons, because this does not happen in many professional societies. I want to pay special recognition to the malacologists in the California State Universities – a system that is involving increasing numbers of students in WSM. California State University presidents of WSM include **Jim Nybakken**, **Vida Kenk**, **Matt James**, **Doug Eernissee**, **Chris Kitting**, **Daniel Zacherl** and future president **Pat Krug**.

•**Pacific Rim malacology.** We have a long record of collaboration with our Asian and Latin American colleagues and societies. We have held three of our recent meetings in Mexico, and the boundaries between our societies are increasingly indistinct.

•**Embracing avocational malacology, shell clubs, and their publications.** *The Festivus* is peer reviewed and publishes descriptions of new taxa. Avocational malacologists have assumed important positions on the WSM Board across the spectrum of officerships. Although there has been a decline in shell clubs and shell collecting, there is an increase in the number of citizens who want to be involved in science and new opportunities to involve them. We continue to be inclusive, not exclusive.

•**Molluscan aquaculture and fisheries.** This theme has become increasingly evident in recent years, and it has generated important basic biological data via intensive study of model species of economic significance. It assumes increasing significance as multiple factors contribute to the collapse of molluscan fisheries.

•**Role of our left coast Natural History Museums**. Our museum curators and volunteers have built important collections documenting left coast living and fossil mollusks. Our museums have published many of the large monographic treatments of molluscan taxa and faunas. Museums have taken a leading role in generating metadata, ranging from impressive faunal manuals to a broad range of databases. Collaboration among museums in producing metadata is on the increase, and we can expect to see much more. Museums have provided early encouragement to malacologically curious youngsters, including past WSM presidents **David Lindberg** and **Barry Roth**.

•**Role of expeditions involving academicians, museum scientists, graduate students and avocational malacologists** – **the whole left coast malacological family.** Add to this, our experiences with mollusks at field stations. There is a big fun component here. *Being in the field is a form of being fully alive and happy*.

•**Activism in molluscan conservation and environmental protection**. Threats from pollution, oil spills, and invasive species have been with us on the Pacific Coast for more than 50 years. **Gene Coan** began speaking out on conservation issues from the very beginning of WSM. We recognize the need for more activism in response to global climate change, ocean acidification, rising sea levels; and on land to desertification and human impact on our fresh water ecosystems.

•**Geological and Paleontological Malacology, with a strong Quaternary subtheme.** This theme

precedes WSM and is rooted in the deep history of the Eastern Pacific Margin. In addition to academic and museum research, there is the strong impact of the US Geological Survey in Menlo Park. As a paleontologist and geologist I shall elaborate briefly on this theme.

I think it is remarkable that seven of our WSM presidents have been paleontologists, beginning with **Bill Emerson** (our second President), **Myra Keen** (our third president) and continuing with **George Kennedy, Chuck Powell, Bill Pitt, Matt James**, and this year **Jann Vendetti**.

I hope it comes as no surprise that I refer to **Bill Emerson** and **Myra Keen** as paleontologists. Bill received his PhD in the Department of Paleontology at UC Berkeley. He published significant papers on Pleistocene molluscan faunas of California and Mexico including a paper in the Journal of Geology with **Jim Valentine** on environmental interpretation of Pleistocene marine species. His extensive work on scaphopods (the subject of his doctoral dissertation) included both fossil and living taxa. Myra Keen's academic career was in the Department of Geology at Stanford, and one of her major contributions to left coast paleontology was a method for quantitatively defining molluscan provinces using the midpoint of ranges for 1,948 species and a quantitative method for comparing molluscan faunules. Paleontologist Hubert Schenck was the first author on this paper, but it was Myra Keen's statistical and quantitative background in psychology (the field in which she received her PhD), that was essential to the contribution. Her checklist of California Tertiary Marine Mollusca, published with Herdis Bentson in 1944, continues to be an important contribution to our metadata. I can't write a paper about Tertiary marine mollusks without consulting it.

We regularly have had paleontology symposia and sessions at WSM annual meetings, some of them specifically honoring WSM paleontologists. These include recognition of **Ellen Moore**, **Lou Ella Saul**, and at this meeting ***Dick Squires***, to whom we confer the WSM Award of Honor. We also conferred the Award of Honor to paleontologists **Katherine Palmer** and **Chuck Powell**. **Lindsey Groves** has been especially active in organizing paleontology sessions at our meetings.

The United States Geological Survey has had a tremendous impact on WSM. USGS Professional Papers have been a major outlet for monographic work. In addition to **Ellen Moore**'s prodigious output of professional papers and metadata, there is the work on Cenozoic mollusks by **Warren Addicott**, **Louie Marincovich**, **Bob Rowland**, and ***Chuck Powell***. Survey collections from many field seasons and remote localities in Alaska have been crucial to our understanding of the evolution of high latitude faunas of the Pacific Rim. ***David Hopkins*** was a giant figure and is one of my heroes. And yes, he did contribute to WSM. I worked half time for the Survey while finishing my dissertation. It was as much a part of my education as it was a way to pay my bills at Stanford.

The list of paleontologists among us goes on and on, **Bob Stanton** and **Tom DeVries** have given papers at this meeting – in fact there are >30 names on papers and posters in the paleontology symposium at this meeting. I haven't really gotten into the whole Quaternary record of mollusks, climate, and sea level change. This is a research theme that goes back farther than our 50 years as a society and has been featured in papers at this meeting.

MY BEST EXPERIENCE IN WSM

I will end this with a personal recollection of joint meetings of AMU/AMS with WSM out here on our Left Coast. At the top of my list is joint meeting that **Paul Valentich-Scott** and I held on the UC Clark Kerr campus in Berkeley in 1992. **Hank Chaney** drove up from Santa Barbara with cases of fine wine that put everyone in the mood for the auction. Hank took turns as auctioneer with **Dick Petit** – they were a stellar duo, and we made a tidy sum of money for student support in both societies, combined with proceeds from the silent reprint auction that **George Kennedy** has organized for so any years. Paul and **Brian Morton** not only organized a magnificent international bivalve symposium for the Berkeley meeting, they also staged a post-meeting bivalve research workshop at the Moss Landing Marine Lab that included graduate students. Paul got us out to sea to dredge in the Monterey Canyon. The papers from the workshop were published in *The Veliger*. I abandoned the gastropods to participate in this workshop and almost defected totally into working on bivalves.

CONCLUSION

In conclusion, we have always been a society of professional and avocational malacologists and students in love with expeditions and fieldwork. Our finest experiences tend to be in the field together on ships or small boats, diving, working at marine laboratories (we share fond memories of those summer low tides at 5 am), wading in streams or camping in the desert, turning over rotten logs, sorting leaf litter, photographing and collecting fossil shell beds. So let's get out there in the field, and let's keep doing this for at least another 50 years.

Hans Bertsch being honored with Lifetime WSM membership by WSM secretary, Wendy Enright, WSM treasurer, Kelvin Barwick, and WSM president, Jann Vendetti

USC
HALL OF PHILOSOPHY

WSM 2017 Participants: (previous page)

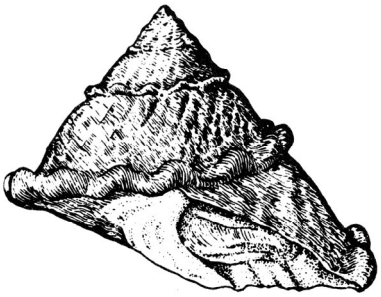
Front Row (L to R): Yolanda Chávez-Viteri, Xochitl Clare, Gina Contolini, Shelby Shapiro, Lindsay Alma, Jann Vendetti

Second Row (L to R): Stacey McIntyre, Elizabeth Bullard, Sandra Traverso, Kim Coombs, Kelvin Barwick, Carole Hickman, Laura Regina Alvarez-Cerrillo, Alyssa Frederick

Third Row (L to R): Paul Valentich-Scott, Miguel Angel Del Rio Portilla, Michael Malloy, Mary Wicksten, Robert Moore, Wendy Enright, Judy Smith, Hans Bertsch, Roberto Cruz Flores, Alvin Alejandrino

Forth Row (L to R): Lindsey Groves, Nora Foster, Pat LaFollette, Maria Cordoba, JoAnne Linnenbrink, Newton Hood, Esteban Fernando Felix Pico

Top Row (L to R): Shawn Wiedrick, Paul Tuskes, Dave Bottjer, Tom DeVries, Doug Eernisse, Casey Richart



Membership

Alvin Alejandrino
13702 Via Del Palma
Apt. H
Whittier, CA 90602
USA
aalejand@whittier.edu

Cristiana Antonino
485 Camino Laguna Vista
Goleta, CA 93117
USA
cantonino@sbnature2.org

Kelvin L. Barwick
16391 Del Oro Circle
Huntington Beach, CA 92649
USA
kbarwick@ocsd.com

Liz Bergy
Oklahoma Biological Survey/OU
111 E. Chesapeak Street
Norman, OK 73069
USA

Dr. Hans Bertsch
192 Imperial Beach Blvd., #A
Imperial Beach, CA 91932
USA
hansmarvida@sbcglobal.net

Justin Brundin
983 Birch Court
Auburn, AL 36830
USA
justin.brudin@gmail.com

Curtis Cash
412 Culver Blvd. #13
Playa del Ray, CA 90293
USA
curtis.cash@lacity.org

Dr. Eugene V. Coan
P.O. Box 420495
Summerland Key, FL 33042-0495
USA
genecoan@gmail.com

Dr. Tom Cockburn
7683 Colin Place
Saanichton, BC V8M 1N6
CANADA

Dr. Robert Cowie
Center Conser. Res. & Training
Univ. Hawaii
Honolulu, HI 96822
USA
cowie@hawaii.edu

Dr. Douglas J. Eernisse
Dept. Biol. Sci. MH282
California State Univ., Fullerton
Fullerton, CA 92834-6850
USA
deernisse@fullerton.edu

Wendy Enright
City of San Diego
2392 Kincaid Road
San Diego, CA 92101-0811
USA
wenright@sandiego.gov

Mr. Neil E. Fahy

Karin Fletcher
PO Box 1074
Port Orchard, WA 98366
USA
karin@milltech.com

Nora R. Foster
2998 Gold Hills Road
Fairbanks, AK 99709
USA
norafoster@gmail.com

Shoko Furuya
c/o Kitting Biow
Cal State U East Bay
Hayward, CA 94542
USA

Mr. Lindsey T. Groves
Natural History Museum of Los Angeles County
900 Exposition Blvd.
Los Angeles, CA 90007
USA
lgroves@nhm.org

Austin Hendy
744 Walker Ave. Apt. 4
San Pedro, CA 90731
USA
austin.hendy@gmail.com

Mr. and Mrs. Jules Hertz
3883 Mt. Blackburn Ave
San Diego, CA 92111
USA
jhertz@san.rr.com

Dr. Carole S. Hickman
University of California
Dept. of Integrative Biology
Berkeley, CA 94720-3140
USA
caroleh@berkeley.edu

Newton Hood
407 Primrose Ave.
Placentia, CA 92870
USA
nzhood2@gmail.com

Edward J. Johannes
Deixis Consultants
16827 51st Avenue
Seatac, WA 98188
USA
deixisconsultants@gmail.com

Rebecca Johnson
1763 Chestnut St.
San Francisco, CA 94123
USA
rjohnson@calacademy.org

Seth Jones
920 Rancheros Dr. Suite F-1
San Marcos, CA 92069
USA
seth@consultmts.com.com

Dae Wui Jung
kkc5816@naver.com

Dr. George L. Kennedy
8997 Moisan Way
La Mesa, CA 91941
USA
sdpaleo@cox.net

Dr. Christopher L. Kitting
Cal State University, East Bay
Hayward, CA 94542
USA
chris.kitting@csueastbay.edu

Michele Larson
2104 E. Hancock St. Aprt. 201
Laramie, WY 82072
USA
mlarson0938@hotmail.com

Dr. Janet Leonard
Univ. Calif. Santa Cruz
100 Shaffer Rd.
Santa Cruz, CA 95060
USA
jlleonar@ucsc.edu

JoAnne Linnenbrink
2035 Charlemagne Ave
Long Beach, CA 90815
USA
jlinnenb@gmail.com

Mason Linscott
725 Residence St.
MOSCOW, ID 83843
USA
mason.linscott@gmail.com

Sarah McAnulty
63 Oak St.
Willimantic, CT 6226
USA
sarahj.mack@gmail.com

Sabrina Medrano
26360 Nova Lane
Sun City, CA 92585
USA
sabrina.medrano@gmail.com

Michael D. Miller
4777 Ladner St.
San Diego, CA 92113-3544
USA
mdmiller@cts.com

Ms. Nancy Mountford
Cove Corporation
10200 Breeden Road
Lusby, MD 20657-2839
USA
covelab@chesapeake.net

Dr. Harold D. Murray
247 Pinewood Lane
San Antonio, TX 78216
USA
haroldmurray@msn.com

Mr. Michael A. Osborne
P. O. Box 388
Lincoln City, OR 97367
USA
cshelloz@aol.com

Terra Petry
3510 W. 229th Placea St.
Torance, CA 90505
USA
terrapetry@lacsd.org

Casey Richart
5500 Campanile Drive
San Diego, CA 92182
USA
pileated@gmail.com

Selin Rostami
230 N Belmont St #8
Glendale, CA 91206
USA
selinrost@gmail.com

Dr. Barry Roth
745 Cole St.
San Francisco, CA 94117
USA
barry_roth@yahoo.com

Paul Valentich Scott
Santa Barbara Museum of Natural History
2559 Puesta del Sol Road
Santa Barbara, CA 93105
USA
pvscott@sbnature2.org

Shelby Shapiro
1327 Sunset Ave
Arcata, CA 95521
USA
sjs672@humboldt.edu

Richard Shipps
7411 Kennedy Road
Sebastopol, CA 95472
USA
shipps@sonic.net

Dr. Judith Terry Smith
2330 14th St. N. #401
Arlington, VA 22201-5867
USA
Redcloud1@earthlink.net

Paul Tuskes
3808 Sioux Ave.
San Diego, CA 92117
USA
tuskes@aol.com

Dr Angel Valdes
California State Polytechnic University
3801 W. Temple Ave.
Pomona, CA 91768-4032
USA
aavaldes@cpp.edu

Mr. Ronald G. Velarde
Marine Biology Laboratory
San Diego, CA 92101
USA
rvelarde@sandiego.gov

Jann E Vendetti
424 Oak St. #122
Glendale, CA 91204
USA
jannvendetti@yahoo.com

Michael Vendrasco
Department of Geology
1570 E Colorado Blvd, E-215
Pasadena, CA 91106
USA
mjvendrasco@yahoo.com

Benjamin Weitzman
1801 Kepner Dr.
Anchorage, AK 99504
USA
bpweitzm@gmail.com

Laney Whitlow
California State Universtiy, Fullerton
Department of Biological Sciences
Fullerton, CA 92831
USA
laney.whitlow@gmail.com

Shawn Wiedrick
5351 Glenstone Drive
Huntington Beach, CA 92649
USA
shawnweidrick@csu.fullerton.edu

Ms. Mary Jo (Jody) Woolsey
3717 Bagly Ave. #206
Los Angeles, CA 90034
USA
m.woolsey@att.net

Ronald Zepeta
Campus Puerto Angel Ciudad Universtaria
San. Pedro Pochotla, Oxaca 70902
MEXICO
ronaldzepeta@hotmail.com

INSTITUTIONAL MEMBERS

Bibliotheque Malcologie
57 rue Curvier
Paris, 75005
FRANCE

Library of Chinese Academy of Sciences
=[Beijing Publishing]
P.O. Box 830470
Birmingham, AL 35283
USA

Field Museum of Natural History
1400 S Lake Shore Dr
Chicago, IL 60605-2827
USA

Harold A. Miller Library
Attn: Dr. Joseph G. Wible
Pacific Grove, CA 93950-3094
USA

Te Aka Matua Library
P. O. Box 467
Wellington,
NEW ZEALAND

University of Washington Libraries
Arcs-Serials
Box 352900
Seattle, WA 98195
USA