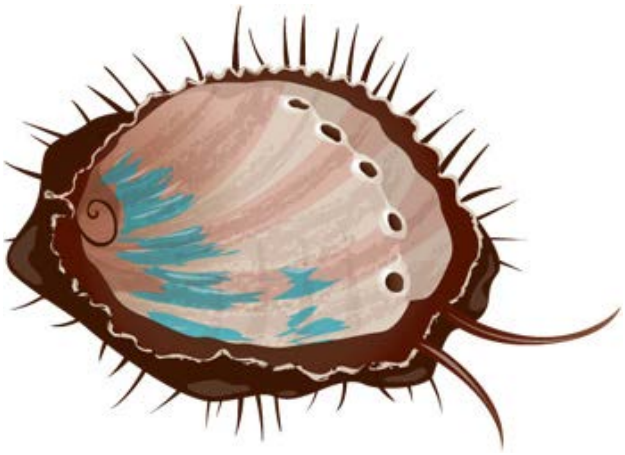
PROGRAM AND ABSTRACTS



WESTERN SOCIETY OF
MALACOLOGISTS

48th Annual meeting, Fullerton, CA, June 2015

California State University, Fullerton

June 25-28, 2015

CALIFORNIA STATE UNIVERSITY
FULLERTON™

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Welcome from the President

As the current President of the Western Society of Malacologists (WSM), and on behalf of the entire WSM Executive Board, it is my pleasure to welcome you to the 48th Annual Meeting of the Western Society of Malacologists here on the campus of California State University, Fullerton, California. Join us for registration on campus followed by a welcome reception in historic downtown Fullerton on the evening of Thursday, June 25th, followed by a stimulating schedule of symposia, contributed talks, and a poster session from Friday, June 26th to Saturday, June 27th. We are delighted that many of you will join us for a field trip to Catalina Island on Sunday, June 28th.

The Western Society of Malacologists (WSM) was born in 1948 as the Pacific Division of the American Malacological Union (AMU), now the American Malacological Society (AMS). The Pacific Division of the AMU held separate meetings on the west coast in years when the AMU met on the east coast. The WSM was established in 1968 as an independent society to improve our understanding of molluscs, and members include professional researchers, students, collectors, and other mollusk enthusiasts.

A primary goal of the WSM is to encourage students to enter into the field of malacology and to support their research via grants. We offer annual support in the form of **Student Research Grants in Malacology** and are pleased to announce three very deserving recipients in 2015:

Emily Ann Orzechowski , UC Berkeley, $1500, “The impact of reproductive & larval life history on invasion success & extirpation risk in marine bivalves and prosobranch gastropods.”

Arianna Tamvacakis, Georgia State University, $1000, “Investigating neural mechanisms controlling independently evolved swimming behaviors in Gastropods.”

Amanda Bird, CSU Fullerton, $500, “Determining population structure, reproductive potential and habitat associations of pinto abalone (*Haliotis kamtschatkana*) in southern California.”

The WSM Executive Board is also delighted to announce that our commitment to student success in Malacology extends to offering a **Best Student Paper** and a **Best Student Poster** award at this meeting. Winners will receive $100 each, deliverable at the Annual Business meeting on Saturday afternoon.

It has been a pleasure to serve as your president for the past year, and I look forward to many future years of service to the society once I step down as president.

Warmly,

Dr. Danielle Zacherl, President
Western Society of Malacologists

Acknowledgments

I thank my wonderful team of meeting planners - all industrious graduate students at CSU Fullerton - Kari Eckdahl, Christina Burdi, Chrystal Johnson and Joanne Linnenbrink. Their willingness to dive fearlessly into the planning of this meeting has kept us on schedule and organized. Symposium organizers Ángel Valdés, John Berriman, and Joanne Linnenbrink have organized a stimulating collection of talks. My fellow WSM officers and member-at-large Hans Bertsch have provided key support, and played critical roles in coordinating the judging of student talks and posters and in coordinating the annual WSM auction. Karen Lau in the Department of Biological Science and Yvonne Moar in the Office of the Dean of the Natural Sciences and Mathematics helped me reserve the venue space and connected me to the correct people University-wide. Derek at ZBolt Designs crafted up the logo for this year's meeting. I am especially grateful to past presidents Paul Valentich-Scott, Wendy Enright, and Doug Eernisse, and to Kelvin Barwick, our Treasurer, for countless pieces of precious advice and responsiveness to an endless series of questions.

Dr. Danielle Zacherl, President
Western Society of Malacologists

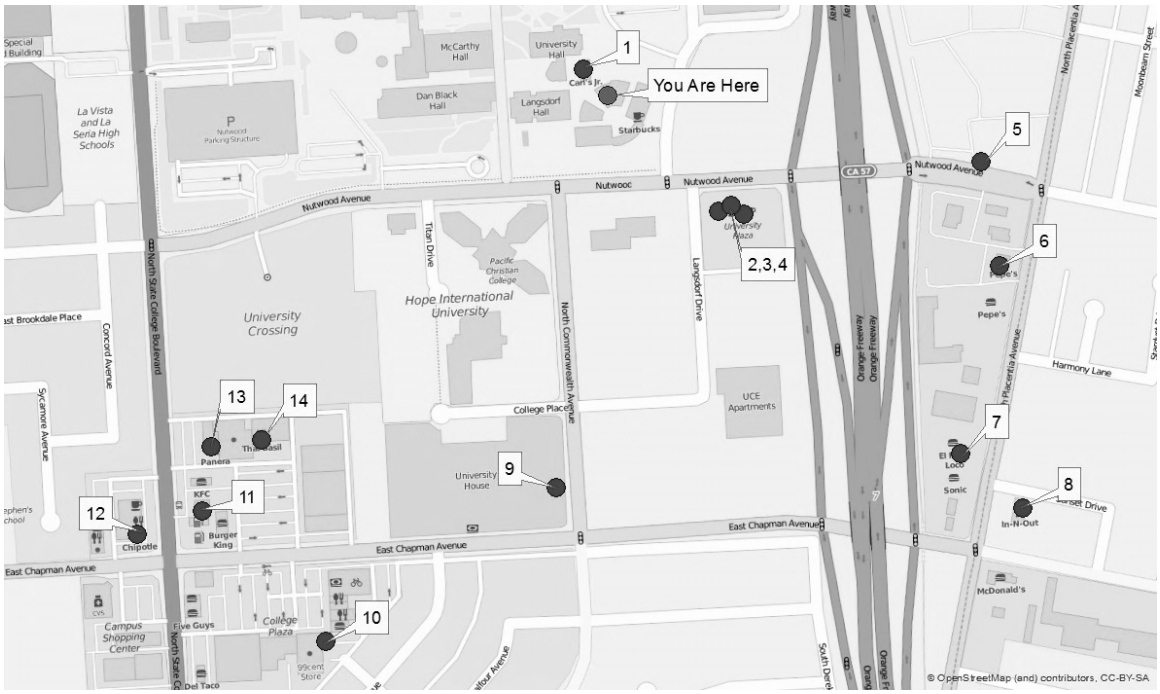
Western Society of Malacologists Executive Board 2014-2015

President	Danielle Zacherl
First Vice President	Carlos Figueroa Beltrán
Second Vice President	Jann Vendetti
Secretary	Brian Urbano
Treasurer	Kelvin Barwick
Members-at-large	Hans Bertsch & Maria Moreno-Alcántara

CSUF Campus Parking Information and Map

Talks will be held in **Steven G. Mihaylo Hall (SGMH) 1506** (**black star** indicates location below). Parking is available for $8/day (Thursday and Friday) in the following areas: Lot E and Eastside Parking Structure (EPS). Daily parking permits can be purchased in the Eastside Parking Structure. There is no cost for parking on Saturday and Sunday.

Restaurants near CSUF



Places within walking distance:

1. **Carl's Jr**. Fast-food burgers. Only open Friday until 1pm. On campus. $
2. **The Habit**. Burgers, sandwiches, fries. 2720 Nutwood Ave. $
3. **Flame Broiler**. Meat and veggie rice bowls. 2720 Nutwood Ave. $
4. **Which Wich**. Deli sandwiches. Can order online. 2720 Nutwood Ave. $
5. **Maru Sushi**. Japanese-inspired teriyaki, ramen and sushi. 2931 Nutwood Ave $$
6. **Pepe's**. Burritos, nachos, taco salads, burgers. Can be ordered online. Only takes cash or debit cards. 821 N Placentia Ave. $
7. **El Pollo Loco**. Fast-food burritos, quesadillas, chicken, and salads. 501 N Placentia Ave. $
8. **In N Out**. Burgers, fries, and shakes. 825 W. Chapman. $
9. **85° Bakery**. Taiwan-inspired bakery that serves coffees, teas, desserts, and breads. 535 N Commonwealth Ave. $
10. **Olivia's Bistro**. Pho, rice dishes, rice vermicelli. 2466 E Chapman Ave. $$
11. **Pieology**. Customized pizzas made to order. 516 N State College Blvd. $$
12. **Chipotle**. Customized burritos or taco salads. Can order ahead online. 516 N State College Blvd. $
13. **Panera Bread**. Café chain with sandwiches, soups, and salads. 516 N State College Blvd. $$
14. **Thai Basil**. Family-owned Thai restaurant with curries, noodles, and salads. 516 N State College Blvd. $$

*** **Note**: There are many more restaurants within the general area. Yelp is a good resource if you are looking for something in particular.

WSM 2015 Meeting Schedule

Thursday June 25th

5:00 – 7:00 pm	Registration and Load Talks (S.G. Mihaylo Hall 1506)
6:45 & 7:15	Shuttle Bus Departs CSUF for Opening Reception at Bootlegger's Brewery
7:00 – 9:00	Opening Reception (provided)
8:30 & 9:30	Shuttle Bus Departs Bootlegger's for return to CSUF

Friday June 26th

(All talks will be held in S. G. Mihaylo Hall 1506)

8:30- 10:30 am	**Symposium:** DNA AND SPECIES DIVERSITY: MOLECULAR ADVANCES IN SPECIES DELINEATION AND INTEGRATIVE TAXONOMY
8:30- 9:00	Ángel Valdés*, Tabitha Lindsey, Craig Hoover, and Jeffrey H. R. Goddard SEEING DOUBLE WITHOUT BOOZE: INTEGRATIVE TAXONOMY REVEALS UNEXPECTED NUDIBRANCH CRYPTIC SPECIATION IN THE NORTH PACIFIC
9:00- 9:30	Patrick J. Krug*, John S. Berriman, Jaymes Awbrey, Jennifer Retana, Jann E. Vendetti, and Ángel A. Valdés A BITING COMMENTARY ON SPECIES DELIMITATION: INTEGRATING MULTI-LOCUS DATA AND RADULAR CHARACTERS TO UNRAVEL CRYPTIC DIVERSITY IN SEA SLUGS
9:30-10:00	Douglas J. Eernisse CASES OF CRYPTIC CHITON AND LIMPET SPECIES PAIRS IN THE NORTH PACIFIC: WHAT DO THEY IMPLY ABOUT SPECIATION PROCESSES?
10:00-10:30	Panel Discussion
10:30- 10:45	**Break (snacks/ water/ coffee provided)**
10:45- 11:00	Shawn G. Wiedrick A BRIEF REVIEW OF SEVERAL CONOIDEAN TURRI-FORM GENERA (GASTROPODA) FROM THE INDO-PACIFIC BY MORPHOLOGICAL ANALYSIS
11:00- 11:15	Christina E. Burdi*τ and Douglas J. Eernisse YOU TOO CAN BE A MUCUS QUEEN: A USEFUL MUCUS-BASED PCR ASSAY FOR IDENTIFYING MORPHOLOGICALLY SIMILAR LIMPETS, *LOTTIA SCABRA* AND *LOTTIA CONUS*

11:15- 11:30	Sarah M. ChristianScher*τ and Ángel Valdés INVESTIGATION OF THE PHYLOGENETIC RELATIONSHIP BETWEEN *NAVANAX INERMIS* AND *POLYALPHOS* USING DNA AND PHOTOGRAPHIC ANALYSIS
11:30- 11:45	Richard Emlet* and Douglas J. Eernisse GREEN EGGS AND HULLS – LINKING SPAWNED EMBRYOS WITH ADULTS IN SOUTHERN AUSTRALIAN CHITONS
11:45- 12:00	Douglas J. Eernisse* and Erik M. Pilgrim SOUTHERN CALIFORNIA HAS THE REAL *BRACHIDONTES ADAMSIANUS* (MYTILIDAE)
12:00- 1:30	**Lunch (on your own)** **** Posters need to be set up during lunch**
1:30-1:45	Jennifer B. McCarthy τ THE SLUG WITHIN THE BIVALVE: RECONCILIATION OF SHELL-BASED TAXONOMY AND MOLECULAR DATA IN JULIIDAE (HETEROBRANCHIA: SACOGLOSSA)
1:45- 2:00	Sabrina Medrano τ UNDERSTANDING THE BIOGEOGRPAHY AND TAXONOMY OF TWO CALIPHYLLIDAE GENERA: *POLYBRANCHIA* AND *CYERCE* (GASTROPODA: HETEROBRANCHIA: SACOGLOSSA)
2:00- 2:15	Craig A. Hoover*τ, Jeff H. R. Goddard, Hans Bertsch, and Angel Valdes GENETIC DIVERSITY OF *FELIMARE CALIFORNIENSIS* IN SOUTHERN CALIFORNIA FOLLOWING REGIONAL EXTINCTION AND RECOVERY
2:15- 2:30	Clara J. King* and Ángel A. Valdés NORTHWARD MOVEMENT OF *PHIDIANA HILTONI*
2:30- 2:45	JoAnne M. Linnenbrink*τ, Ryan P. Walter, Danielle C. Zacherl, and Douglas J. Eernisse HOW MANY POPULATIONS ARE THERE? GENETIC POPULATION STRUCTURE OF THE OLYMPIA OYSTER, *OSTREA LURIDA*, IN SOUTHERN CALIFORNIA
2:45- 3:00	Miguel A. del Río-Portilla*, Carmen E. Vargas Peralta, Claudia Farfan, and Fabiola Lafarga De La Cruz COMPLETE MITOCHONDRION GENOMES OF MOLLUSK SPECIES BY NEXT GENERATION SEQUENCING: CHALLENGES AND PITFALLS
3:00- 3:15	**Break (snacks/ water/ coffee provided)**
3:15- 3:30	Charles L. Powell WESTERN UNITED STATES NEOGENE MOLLUSCAN PALENTOLOGY: PROSPECTIVE PROJECTS

3:30- 3:45	Kelly K. Vreeland and Nicole Bonuso* A PALEOECOLOGICAL RECONSTRUCTION OF OYSTERS FROM ORANGE COUNTY, CALIFORNIA: UNDERSTANDING THE PAST TO HELP RESTORE THE FUTURE
3:45- 4:00	Carlos Figueroa-Beltran*, Krystal M. Gutiérrez-Ortiz, José Luis Ferman-Almada, and Alejandro García-Gastelum TALES, IMAGES AND SHELL MIDDENS IN THE ENVIRONMENTAL HISTORY OF BAJA CALIFORNIA
4:00- 4:15	Hans Bertsch SLUG SIGHTS AND OTHER MOLLUSCAN INSIGHTS
4:15- 4:30	John Greenamyer and Michael Miller* OPISTHOBRANCHS OF PNG, SEEING IS BELIEVING!
4:30- 6:30	**Poster Session in the James D. Woods Grand Foyer (Snacks/ water/coffee provided)**

Saturday June 27th

8:30- 10:30 am	**Symposium** MOLLUSCAN TAXONOMY: CONTEMPORARY APPLICATIONS AND INCREASING STUDENT PARTICIPATION
8:30- 9:00	Lawrence L. Lovell I'VE GOT MY DEGREE, NOW WHAT DO I DO? APPLICATION OF TAXONOMIC SKILLS IN THE REAL WORLD. YOU TOO CAN BE A PAID TAXONOMIST!
9:00- 9:30	Jann E. Vendetti STUDENT RECRUITMENT & MENTORING: COUPLING COLLEGIATE TEACHING WITH MALACOLOGICAL MUSEUM COLLECTIONS
9:30-10:00	Ryan A. Ellingson THE IMPORTANCE OF STUDENT INVOLVEMENT IN PHYLOGENETIC SYSTEMATICS: FROM CSU TO UC AND BACK AGAIN
10:00- 10:30	Panel Discussion
10:30- 10:45	**Break (snacks/ water/ coffee provided)**
10:45- 11:00	Jann E. Vendetti LAND SNAIL COLLECTION AT THE NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY: GROWTH & POTENTIAL

11:00- 11:15	Brian Urbano* and Michel Hendrickx DIVERSITY AND DISTRIBUTION OF CEPHALOPOD CLASSES IN THE MEXICAN PACIFIC WATERS
11:15- 11:30	Paul Valentich-Scott A DEPAUPERATE MARINE BIVALVE FAUNA IN WESTERN SOUTH AMERICA?
11:30- 11:45	Carole S. Hickman MOLLUSCAN MONOGRAPHY IN THE DIGITAL AGE
11:45- 12:00	Christopher L. Kitting MOLLUSKS AMONG OTHER SURPRISING INVERTEBRATES LIVING AT THE BOTTOM OF SHIP CHANNELS OF CALIFORNIA DELTA
12:00- 1:30	**Lunch (on your own)**
1:30- 1:45	Paul M. Tuskes NESTING BEHAVIOR OF THE CHESTNUT COWRY, *NEOBERNAYA SPADICEA*
1:45- 2:00	Paul M. Tuskes* and Ann Tuskes OBSERVATIONS ON THE BIOLOGY OF THE MUREX *PTEROPURPURA TRIALATA*
2:00- 2:15	Esteban F. Félix-Pico*, Mauricio Ramírez-Rodríguez, Oscar E. Holguin-Quiñones, and César A. Ruiz-Verdugo FLUCTUATIONS IN THE PACIFIC CALICO SCALLOP (*ARGOPECTEN VENTRICOSUS*) FISHERY OF MAGDALENA BAY, BAJA CALIFORNIA SUR, MÉXICO
2:15- 2:30	Carlos Cáceres-Martínez* and Mariana Rodríguez-Trejo SPATIAL PATTERN OF DISTRIBUTION AND POPULATION ECOLOGY OF *SACCOSTREA PALMULA* FROM LA PAZ BAY, BAJA CALIFORNIA SUR, MEXICO
2:30- 2:45	Cristina M. Fuentes*τ, Alejandra Garcia, Terrance Champieux Christine Whitcraft, and Danielle C. Zacherl RECRUITMENT OF NATIVE AND NON-NATIVE OYSTERS ONTO A CONSTRUCTED BED IN ALAMITOS BAY, CA
2:45- 3:00	Michelle Ridgway, Nora R. Foster*, Ángel Valdés, and Angela Gravitt BIOGEOGRAPHY OF *BOREOBERTHELLA AUGUSTA* MARTYNOV AND SCHRODL 2009 IN PRIBILOF CANYON AND ZHEMCHUG CANYON, BERING SEA
3:00- 3:15	**Break (snacks/ water/ coffee provided)**
3:15- 3:30	Thomas F. Kroupa*τ, Tharadet D. Man, Luke P. Miller, Mark W. Denny, and Bengt J. Allen THERMAL DEFENSE STRATEGY DETERMINES LIMPET RESPONSE TO ACUTE TEMPERATURE STRESS ON ROCKY SHORES

3:30- 3:45	Elizabeth A. Duncan*τ, Luke P. Miller, Mark W. Denny, and Bengt J. Allen PREDICTING EFFECTS OF INCREASING ENVIRONMENTAL VARIABILITY ON THERMAL RISK TO BLACK ABALONE: COMBINING ECOMECHANICS WITH BEHAVIOR
3:45- 4:00	Kari A. Eckdahl* and Danielle C. Zacherl IT'S NOT EASY BEING SEEN: BLACK ABALONE (*HALIOTIS CRACHERODII*) ABUNDANCE AND HABITAT AVAILABILITY IN SOUTHERN CALIFORNIA
4:00- 4:15	Zahoor Pir ECOLOGICAL ASSESSMENT OF NARMADA RIVER WITH SPECIAL REFERENCE TO DIVERSITY OF MOLLUSCANS
4:30- 5:30	**Business Meeting (S. G. Mihaylo Hall 1506)**
6:45 & 7:15	Shuttle Bus Departs CSUF for Banquet and Auction at Café Hidalgo
9:30, 10:30, 11:30	Shuttle Bus Departs Café Hidalgo for return to CSUF

*= Presenting author

τ = Student is eligible for the best oral/ poster presentation

Field Trip to Catalina Island on the R/V Yellowfin - Information

Sunday, June 28th

Meeting place

Southern California Marine Institute (SCMI)
820 South Seaside Ave., Terminal Island, CA 90731
Phone: (310) 519-3172

Meeting time

7:15 am (Yellowfin departure time is at 7:30 am sharp)

Plan to leave Fullerton by 6:15 am. Sign up for a carpool at the conference registration desk on Thursday or Friday, June 26-27.

On the R/V Yellowfin, we will venture out to Catalina Island. The trip over to the island is about 2 hours. Once we arrive at the Wrigley Marine Institute in Two Harbors, you may choose to rent snorkeling gear or kayaks ($15 rental fee, plus $5 facility fee). We will be on the island for about 3 -4 hours and will plan to eat lunch at Wrigley. While on the Yellowfin, we plan an otter trawl and a plankton tow.

Bring: layers of clothing including windbreaker and other warm layer, warm hat, sun hat, sunscreen, sunglasses, water bottle, bathing suit, snorkeling gear

The field trip itself is FREE and there is an option to buy a catered lunch from Panera for $15, which includes bottled water, soda, a sandwich or salad, and a cookie.

DIRECTIONS FROM CSUF:

- Take **57 S** to **91W**
- Take **91W** to **I-710 S** (toward Long Beach)
- Take the **I-710** exit on the **left** towards **Piers S T/Terminal Island**
- Merge onto **W Ocean Blvd**
- Take the exit toward **Berths 301-305/Berths 401-406**
- Keep **right** at the fork in the ramp.
- Merge onto **Terminal Way.**
- Turn **left** to stay on **Terminal Way**.
- **Terminal Way** becomes **S Seaside Ave.**
- Destination is on the **left.**

HINTS FOR FINDING SCMI IF YOU GET LOST:

- Stay on Terminal Island – between the Vincent Thomas Bridge and the Gerald Desmond Bridge.
- The Terminal Island Correctional Institution, and the Coast Guard are past us on South Seaside Ave. So follow any signs to these that you see. If you reach them, you have gone too far. If you are lost ask for directions to these two landmarks!
- ***(Terminal Island is undergoing constant construction, with several detours and a few missing street signs. Leave yourself plenty of time to find us in case you get lost.)

TALK ABSTRACTS

In alphabetical order by first author

SLUG SIGHTS AND OTHER MOLLUSCAN INSIGHTS

Hans Bertsch

Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California, Ensenada
hansmarvida@sbcglobal.net

New data regarding Nudipleura from Bahía de los Ángeles, and remarks on book-in-progress, *Los Invertebrados Marinos.*

YOU TOO CAN BE A MUCUS QUEEN: A USEFUL MUCUS-BASED PCR ASSAY FOR IDENTIFYING MORPHOLOGICALLY SIMILAR LIMPETS, *LOTTIA SCABRA* AND *LOTTIA CONUS*

Christina E. Burdi* τ, Douglas J. Eernisse

Department of Biological Science, California State University Fullerton, Fullerton, CA 92834; christinaburdi@gmail.com; deernisse@fullerton.edu

Rocky intertidal grazers with similar morphologies and ecological habitats actively compete for food and space. Two of the most common intertidal limpets in southern California, *Lottia scabra* and *L. conus*, are almost indistinguishable in their morphology, and therefore the potential interactions between them remain unstudied. *L. scabra* and *L. conus* have overlapping ranges south of Point Conception. Despite both species being commonly found in southern California, there has been little published on *L. conus* since it was described in 1945 and, therefore, little published comparing *L. scabra* to *L. conus* to allow for accurate morphological comparisons. These species have been contrasted via shell and radula characteristics; however, dorsal shell plasticity contributes to inaccurate field identification when compared with all published descriptions. Because each species has distinctive mitochondrial 16S rDNA gene sequences, we developed species-specific primers that were used in four-primer combinations to identify individuals without costly sequencing. Our low-cost assay allowed us to contrast the published shell characteristics and test whether improved shell diagnoses are feasible for distinguishing *L. scabra* from *L. conus*. We further adapted techniques for extracting DNA from foot mucus and have perfected a non-lethal sampling method for species identifications. This can later be used to quantify the distributions and abundance of each species, so that the potential ecological interactions between *L. scabra* and *L. conus* can be studied. This method has limitless potential for a variety of molluscan studies while reducing organism mortality and will be especially useful for ecological or genetic studies on endangered species.

SPATIAL PATTERN OF DISTRIBUTION AND POPULATION ECOLOGY OF *SACCOSTREA PALMULA* FROM LA PAZ BAY, BAJA CALIFORNIA SUR, MEXICO

Carlos Cáceres-Martínez*, Mariana Rodríguez-Trejo

Departamento de Ingeniería en Pesquerías Universidad Autónoma de Baja California Sur, Mexico; ccaceres@uabcs.mx; paralabrax@hotmail.com

Saccostrea palmula has a permanent population on the La Paz coast, in spite of the anthropogenic impact of the city. In March 2010, 2012, 2014 and 2015 digital photos and direct counting of individuals were taken using $1m^2$ frames with 100 divisions of $10cm^2$, in 8 random selected frames from an intertidal 50m transect. During 2015, 600 oysters were measured *in situ* for shell height, and 50 for height and total weight. A 0.5mm size-class histogram was obtained and then submitted to Battacharya´s Modal identification analysis. Seven modal values were identified in correspondence to one month age and were plotted in comparison to the Von Bertalanffy model (L_∞=68.2, t_0=-0.1577) for the construction of a *Static Life Table* to obtain the mortality equation (N_t=-1.3376N_0+9.988, r^2=0.9231). The result of the spatial pattern of the oyster population was *clumped* in all the years studied. The Pielou Index (PI: S^2/Mean) was always >1. The oyster population showed a clumped distribution in the intertidal area studied (PI=19.88, *t*=249.41>>1.96) with a cluster distribution with an increase of oysters per cluster from 2010 to 2015 (3.81: 2010, 4.77:2012, 7.97:2014, 8.52:2015, Student's t-test at *p*=0.05). The average number of oysters per sampled unit showed significant differences per year after ANOVA comparison; the number increased from 24 to 40 oysters/$10cm^2$. The Shannon-Wiener Index was H´=0.290±0.101 and the Simpson Index was D=0.632±0.158, supporting low diversity and high dominance of *Chthamalus anisopoma* in the oyster community. The results suggest a stable community of *Saccostrea palmula*.

INVESTIGATION OF THE PHYLOGENETIC RELATIONSHIP BETWEEN *NAVANAX INERMIS* AND *POLYALPHOS* USING DNA AND PHOTOGRAPHIC ANALYSIS

Sarah M. ChristianScher* τ, Ángel Valdés

Department of Biological Sciences, California State Polytechnic University, Pomona, Pomona, CA 91768 USA; smcary@cpp.edu; aavaldes@cpp.edu

Taxonomic classification of sea slugs has long relied on morphological characteristics such as color or patter when identifying species. The cephalaspideans *Navanax inermis* and *Navanax polyalphos* are considered to be closely related but separate species; a distinction based on the differences in size and coloration. Preliminary data comparing the mitochondrial DNA (mDNA) of the two species has revealed that they may not be separate species, but two variations of a single species. By collecting tissue samples and photographs from individuals along the Pacific coastline of California and Mexico, as well as the Gulf of California, I hope to discover a pattern in either the genetic variation or morphological differences between *N. inermis* and *N. polyalphos*. Here we investigate the color morphs of *N. inermis* and *N. polyalphos* from specimens collected at different locations along the Pacific Coast. Tissue samples will be collected and catalogued, then analyzed using PCR amplification of the nuclear H3 and mitochondrial CO1 genes. Quantitative digital analysis will be done on the photographs. Intra- and inter-group analysis will be done to determine if there are any significant links between color, pattern, and geographic locations.

COMPLETE MITOCHONDRION GENOMES OF MOLLUSK SPECIES BY NEXT GENERATION SEQUENCING: CHALLENGES AND PITFALLS

Miguel A. del Río-Portilla*, Carmen E. Vargas Peralta, Claudia Farfan, Fabiola Lafarga De La Cruz

Departamento de Acuicultura, CICESE. Centro de Investigación Científica y de Educación Superior de Ensenada, B.C., Carretera Ensenada-Tijuana #3918. Zona Playitas. Ensenada, B. C. México

In the past decade, next generation sequencing techniques have exponentially increased the capabilities to genetically analyze different species, and the mollusks are not the exception. In this paper, we indicate the procedures used for obtaining the mitochondrion genome of different mollusk species by using next generation sequencing. Also we will explain how gene annotation is carried out, by using available software and mitogenomes in public databases. We also indicate the problems we have found and challenges these techniques have in order to obtain the mitogenomes of mollusks. So far we have been able to obtain mitogenomes from some geoduck, octopus and clams.

PREDICTING EFFECTS OF INCREASING ENVIRONMENTAL VARIABILITY ON THERMAL RISK TO BLACK ABALONE: COMBINING ECOMECHANICS WITH BEHAVIOR

Elizabeth A. Duncan - *1 τ, Luke P. Miller - 2, Mark W. Denny - 2, Bengt J. Allen - 1

1 - California State University, Long Beach, CA 90804 USA; liz.duncan90@gmail.com; bengt.allen@csulb.edu, 2 - Hopkins Marine Station of Stanford University, Pacific Grove, CA 93950 USA; millerlp@gmail.com; mwdenny@stanford.edu

Black abalone (*Haliotis cracherodii*) were once a common intertidal inhabitant on rocky shores in California, but have experienced dramatic population declines and local extinctions due to overharvesting and the emergence of withering syndrome (WS). Susceptibility of black abalone to infection by WS is related to higher body temperature variability during aerial exposure at low tide, suggesting that temperature stress is a key risk factor determining their long-term viability. Our research is designed to quantify how body temperatures and associated risk of disease to black abalone might be altered in response to anthropogenic climate change. We created a heat-budget model for black abalone and coupled it with long-term meteorological records at Hopkins Marine Station (HMS) to generate information about environmental and topographic controls of body temperature at this site. We simultaneously collected real-time data across microhabitats at HMS on the distributions of body temperatures (Tb) of live abalone with a calibrated infrared camera and operative environmental temperatures (Te) with species-specific thermal mimics. These data will be combined to derive quantitative measures of the thermal quality of the habitat at HMS and the precision, accuracy, and effectiveness of thermoregulation by black abalone in the field.

IT'S NOT EASY BEING SEEN: BLACK ABALONE (*HALIOTIS CRACHERODII*) ABUNDANCE AND HABITAT AVAILABILITY IN SOUTHERN CALIFORNIA

Kari A. Eckdahl*, and Danielle C. Zacherl

Department of Biological Science, California State University Fullerton, Fullerton, CA 92834 USA; keckdahl@fullerton.edu; dzacherl@fullerton.edu

The black abalone (*Haliotis cracherodii*) is an endangered species that was once abundant in the rocky intertidal zone of southern California until overfishing and Withering Syndrome drastically reduced

populations. In recent years, surveys on the Channel Islands began documenting an increase in juvenile abundance. The current status of black abalones on the southern California mainland has remained unknown with individuals rarely seen south of Point Conception since 1993. I conducted rocky intertidal surveys for black abalones at mainland localities from Point Conception to San Diego to estimate current abundances and document population demographics of any black abalones present. I also conducted habitat assessments to estimate the quality and availability of potential black abalone habitat. Surveys were also conducted at Channel Island localities on Santa Rosa, Santa Cruz, and Anacapa Islands to compare black abalone demographics and habitat quality to the southern California mainland. Surveys at 19 mainland sites found 75 black abalones dispersed among 5 sites; a proportion were smaller individuals (< 40 mm) indicating some recruitment has occurred within the last few years. Densities are much lower at island (0.06-0.64/m2) and mainland (0-0.01/m2) sites than the estimated minimum density (0.75-1.1/m2) required for successful recruitment to occur. Good and moderate habitat for black abalones is present on the mainland (0-35% and 0-60%, respectively) and islands (0-20% and10-62%). This study provides current data on the status of *Haliotis cracherodii* in southern California and will help policy makers determine the best course of action for the recovery of this species.

CASES OF CRYPTIC CHITON AND LIMPET SPECIES PAIRS IN THE NORTH PACIFIC: WHAT DO THEY IMPLY ABOUT SPECIATION PROCESSES?

Douglas J. Eernisse

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Species are often accorded special status. DNA sequencing has proven effective for better resolving and even dating past genetic separation events associated with speciation, but can also reveal a complicated history of introgression and other complexities of incomplete reproductive isolation between closely related species, even those we can readily distinguish with morphology. Likewise, sequencing can reveal genetically distinct species that have quite uniform morphology, known as cryptic species. Phenotypic plasticity can further obscure minor diagnostic differences so that morphological identification is impractical. Instead of viewing this as a problem it can be viewed as an opportunity to better understand speciation processes, for example, the Neogene diversification leading to the fantastic species-rich chiton and limpet fauna endemic to the North Pacific. With my students and others as collaborators I have densely sampled mitochondrial 16S and COI and added some nuclear markers for most North Pacific chiton and limpet species. Most of these are readily distinguished by 16S or COI, even cryptic species that are relatively recently diverged. Cryptic species include multiple north/south pairs that can partly overlap in their range, and this zone of parapatry can dynamically shift with changing climate. There are potential advantages of studying these species pairs, even when DNA-based identification is required. Study of cryptic species pairs can help reveal how biodiversity arises, how similar species interact, and the role of thermal and other adaptations in their short- and long-term reproductive success. These pairs also provide potential model systems for tracking faunal shifts associated with climate change.

SOUTHERN CALIFORNIA HAS THE REAL *BRACHIDONTES ADAMSIANUS* (MYTILIDAE)

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The warm temperate intertidal fauna of southern California has an interesting mixture of species whose individual ranges might extend north into the cooler Oregonian province, or occasionally south into the Gulf of California, but only rarely much further south. Species reported to extend between the SCB and much lower latitudes are often revealed by DNA studies to instead be cryptic species complexes. We investigated whether this could be the case for the reportedly wide-ranging small ribbed mussel, *Brachidontes adamsianus* (Dunker, 1857). It had been sequenced from the Pacific coast of Panama and Mexico in recent studies that emphasized Caribbean congeners. We newly sequenced mitochondrial 16S and COI for southern California to northern Gulf of California *B. adamsianus* but these, collectively, were not even closely related to *B. adamsianus* GenBank sequences from mainland Panama and Mexico. The latter "southern" sequences did closely match other new samples we sequenced from Loreto in the southern Gulf of California. We obtained images of the syntypes of *B. adamsianus* (from "Panama") and these surprisingly matched our "northern" specimens closer than they did our Loreto specimens. By sequencing nuclear 28S, we successfully matched our southern California sequences to what previous authors have called *B. adamsianus "II*" from islands off the Pacific coast of Panama, currently only represented by 28S sequences in GenBank. These appear to correspond to the real *B. adamsianus* and the species is indeed widespread. The distinct *B. adamsianus "I"* from mainland Panama to Loreto is not easily assigned to any named species.

THE IMPORTANCE OF STUDENT INVOLVEMENT IN PHYLOGENETIC SYSTEMATICS: FROM CSU TO UC AND BACK AGAIN

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Molecular phylogenetic tools play a crucial role modern taxonomy. These tools have the potential to provide objective means of species delimitation where morphological characters are insufficient. The evolutionary context provided by phylogenetics can also enrich traditional taxonomic studies, yielding insight into questions about the speciation process itself. Rapid advancement of techniques for both collecting and analyzing phylogenetic data, however, has necessitated a progressively more collaborative nature in the work of taxonomists and evolutionary biologists. Comprehensive species descriptions require morphological, phylogenetic, and even behavioral data, but specialization typically precludes one researcher alone from handling all these tasks. Thus, student involvement becomes an integral part of research at nearly every level. The majority of future scientists now seek research experience in one or more labs, beginning as early as first-year undergraduates or even high school students, and graduate students often take on the role of mentor in the earliest stages of their graduate work. Benefits of the mentor-mentee relationship are reciprocal. Mentees learn specific research techniques, and more broadly about life in academia. Mentors—whether graduate students, postdocs, or faculty—learn by instruction and stay critically connected to the fundamental work that drives their research programs. While earning a master's degree at CSLA, a PhD at UCLA, and now as a postdoc at CSLA, I have mentored 20+ students in lab and analytical techniques. I will talk briefly about my research

in phylogenetic systematics and phylogeography, followed by what I have learned thus far as a mentor during my young academic career.

GREEN EGGS AND HULLS – LINKING SPAWNED EMBRYOS WITH ADULTS IN SOUTHERN AUSTRALIAN CHITONS

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We used molecular sequences of COI genes (barcoding) from chiton eggs or embryos collected as plankton and from adults collected in the field to identify the eggs and reproductive traits of southern Australian chitons. We obtained molecular sequences for 24 species of adults and 21 species of eggs/embryos. We matched eggs and adults for 10 species from a wide array of chiton taxa and identified 11 additional genetically distinct chiton eggs/embryos for which we lack adult material for identification. These samples are the first broad molecular survey of the southern Australian chiton fauna and permit construction of hypotheses on phylogenetic relationships of species and radiations of taxa within this fauna. The linking of eggs and their hulls with species also expands our knowledge of how hull morphology is indicative of taxonomic grouping of chiton species.

FLUCTUATIONS IN THE PACIFIC CALICO SCALLOP (*ARGOPECTEN VENTRICOSUS*) FISHERY OF MAGDALENA BAY, BAJA CALIFORNIA SUR, MÉXICO

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Scallops are an important fishery and have been under intensive exploitation in México. Commercial fishing activity began in the Gulf of California in 1970, and at the end of the 1980's annual landings averaged about 32,000 t (1989). The scallop fishery is notoriously variable, so by 1991 to 1995 landings had declined to about 270 t (1993). Reports of landings from the Mexican Annual Fishery Statistics Reports (SAGARPA-CONAPESCA) provide data on arrival records of landed catch, locations and value for *Argopecten ventricosus* (Sowerby, 1832). In 1988 the presence of the resource was detected in Magdalena Bay and continued until 2013. In 1990 and 1991, the catch was 25,290 t, with another high value in 2008 (14,984 t). The principal fishing area of *Argopecten ventricosus* was Magdalena Bay, with the species representing 99% of the total scallop catch in Mexico during the first decade of the 21st century. In 2010 a maximum value of 11,926 t was recorded, but landings declined steadily until the fishery was closed in 2014. Although the causes have not yet been established, large oscillations in scallop catch have occurred several times in the past decades due to a combination of several factors, such as overfishing, diseases or climatic variations (El Niño). But all signs suggest the continuing coastal water warming trend and substantial changes to water quality will certainly contribute to the scallop's future decline.

TALES, IMAGES AND SHELL MIDDENS IN THE ENVIRONMENTAL HISTORY OF BAJA CALIFORNIA

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For centuries, the peninsula of California was known as the *Island of California*, a mythical place where stories of amazons and treasures were intertwined. Ethnohistoric and subsequent records tell us of various species of mollusks that were abundant in the seas of Baja California and also indicate their excessive exploitation that for centuries doomed many species to their decline or even extinction. Thanks to these records, along with scientific literature, the intergenerational memory of fishermen and the shell middens left by prehistoric Indians, it is possible to evaluate changes in the population of mollusk species in the North Pacific and the Mar de Cortes as presented here. In analyzing collective memory, archaeological record, data files, diaries, photographs, and traveler logs we can understand the changes in human-environment relationships and prevent the "shifting baseline syndrome" as Daniel Pauly declared 20 years ago. But, environmental history also shows how impacts of natural origin affected human communities in the way they used coastal resources. Changes to the coastline are indicated by differences of the modern coastal environment and the midden's mollusk composition. The taxonomic composition on mollusks' exploitation of both hard bottom and soft bottom suggests the existence of ancient coastal landscapes that were transformed into new environmental scenarios by several factors related to climate change.

RECRUITMENT OF NATIVE AND NON-NATIVE OYSTERS ONTO A CONSTRUCTED BED IN ALAMITOS BAY, CA

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Oyster restoration projects seek to increase oyster density via augmentation of mudflat with hard substrata to increase recruitment. We examined the effects of a constructed oyster bed on the settlement and recruitment rates, and adult densities of native *Ostrea lurida* and non-native *Crassostrea gigas* at Jack Dunster Marine Reserve in Alamitos Bay, CA. Effects on community composition were also examined. Dead *C. gigas* shell was used to construct a 2X30m bed. Throughout the next two years we periodically monitored shell loss via point-contact sampling, settlement via deployment of replicate (n=4) ceramic tiles, and recruitment and adult oyster density via excavation of replicate (n=7) 25cm X 25cm plots randomly placed within the bed and at an un-augmented control bed. After heavy shell loss of ~72% after one year, the bed was augmented on the seaward side with more shell. There were higher densities of *O. lurida* recruits and adults on the constructed bed relative to the control, with densities on the initial bed 5X, and on the new section of bed 62X, those of reference populations throughout Alamitos Bay. *C. gigas* also recruited in densities 3X greater than reference populations. Adding more shell at the seaward side achieved a higher shell % cover and increased *O. lurida* densities. The constructed bed was more successful recruiting native *O. lurida* than non-native *C. gigas*.

OPISTHOBRANCHS OF PNG, SEEING IS BELIEVING!

John Greenamyer, Michael Miller*

A short video presentation featuring seldom seen Opisthobranch species of the Milne Bay region of Papua New Guinea, perhaps the last frontier of sea slug exploration. John Greenamyer and Mike Miller are both sea slug aficionados and have collaborated thru the years in various projects depicting their behavior. In this presentation, we travel to PNG, considered to be one of the last frontiers of Sea Slug study.

MOLLUSCAN MONOGRAPHY IN THE DIGITAL AGE

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Molluscan taxonomic and faunal monographs are poised for a revolutionary resurgence as a consequence of new imperatives and new opportunities. Although the imperative to document biodiversity produced resources for expeditionary research and collecting, it aborted short of demanding and producing the hoped-for revolution in published results. Impediments have included (1) decline of malacologists with taxonomic expertise; (2) tangle of available names in purgatory; (3) lack of respect for systematic monography in academia; (4) pressure to publish short papers in high-impact journals; (5) lack of funding opportunities, and (6) demise of series devoted to monographic publication. The list is longer, but it would be flogging a dead horse to mention taxonomic deadbeats and the “cool trip syndrome” that failed to motivate taxonomists beyond the free plane ticket to Fiji. New opportunities have opened up in the digital age, including publication that is (1) rapid with rigorous peer review; (2) electronic-only, free to authors, and featuring unlimited high-resolution color and black-and-white illustration; (3) open access to increase dissemination, use, and citation; (4) linked to literature, museum data bases, supplemental information, and resources previously requiring considerable scholarly effort; (5) conducive to incorporating new monographic elements. An ongoing monograph of the Paleogene marine bivalves of the deep-water Keasey Formation in Oregon, appearing in four parts, is presented as a model for breaking away from traditional format and content to include faunal responses to global change, taphonomic and diagenetic aspects of preservation, and integrating living lineages with their fossil record and historical biogeography.

GENETIC DIVERSITY OF *FELIMARE CALIFORNIENSIS* IN SOUTHERN CALIFORNIA FOLLOWING REGIONAL EXTINCTION AND RECOVERY

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Felimare californiensis is a sea slug that ranges along the coast of Baja California, including both the Gulf of California and the Mexican Pacific. The northern extent of its range during the twentieth century was southern California, where its bright colors were frequently observed. This nudibranch experienced a regional extinction in southern California during the 1970’s that lasted twenty years. This slug has

returned to southern California, and has been consistently found at Catalina Island during the past decade. Within the past three years, *F. californiensis* has also been sighted along California's coast. The population was tested for genetic structure using samples from throughout its range. Polymerase chain reaction (PCR) amplified the 16S and CO1 mitochondrial genes, which were then sequenced with Sanger method. Analysis included a haplotype network, fixation index analysis (FST), and analysis of molecular variance (AMOVA). Preliminary results indicate a need for taxonomic revision, and also suggest minimal genetic structure in the population. Microsatellites will be developed late in 2015 to improve the resolution of spatial-genetic relationships within the population. The expected outcome of this research is determination of the genetic diversity within the southern California subpopulation, and a comparison between this and other groups within the population. Recolonization of this animal in southern California presents a unique opportunity to examine dispersal within a recent temporal context. This study of population genetics is of relevance to the conservation and potential recovery of other mollusks in southern California.

NORTHWARD MOVEMENT OF *PHIDIANA HILTONI*

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Phidiana hiltoni, a species of nudibranch, is known for its pugnacious behavior, note its synonymized name, *Phidiana pugnax*, as it often attacks and eats other aeolids along with its more common diet of hydroids. Its historical range was from the Gulf of California to central California, but as of the early 1990's, the species has been found as north as the San Francisco Bay area. This has already proven a problem for the native species of sea slugs in the Bay area as *Phidiana hiltoni* is not only showing signs of competing with them for hydroids, but has also been observed fighting and eating native species. Specimens of *Phidiana hiltoni* will be collected from all along its habitat range, historical and new, their DNA sequenced and we will develop a genetic map of this species. This map will help us get an idea of where the new population is deriving from.

MOLLUSKS AMONG OTHER SURPRISING INVERTEBRATES LIVING AT THE BOTTOM OF SHIP CHANNELS OF CALIFORNIA DELTA

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Diverse, novel, initial fall and winter, 2014-15 sampling of ~13-m (40-feet) -deep dredged ship channels NW of Stockton, CA, already has yielded several taxa of live freshwater mollusks, among surprising, previously unreported diversities of other macroinvertebrates there. Infauna and epifauna were common on these firm, muddy bottoms, swept by quite swift, murky water. Initial comparisons are being made with adjacent, shallower (3-m-deep) bottoms just outside the ship channel, where invertebrates appear even more abundant and diverse.

THERMAL DEFENSE STRATEGY DETERMINES LIMPET RESPONSE TO ACUTE TEMPERATURE STRESS ON ROCKY SHORES

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Climate change models predict increases in the frequency and intensity of extreme weather events. Most organisms living in the rocky intertidal zone are ectotherms living at or near their thermal tolerance limits; the fitness consequences to these organisms will be determined by their capacity to adjust their thermal sensitivities and the associated energetic costs. Found together in the high intertidal zone, *Lottia scabra* exhibits high constitutive levels of the stress protein Hsp70 but no additional induced synthesis at high temperatures, whereas *L. austrodigitalis* exhibits low levels of constitutive Hsp70 and high inducibility. Respiration rates (as a proxy for metabolic rates) of field collected and laboratory acclimated limpets was measured before and immediately following exposure to one of five peak temperatures (14, 24, 28, 32, and 36ºC) acting as an acute temperature stress event during a 4.5hr simulated midday low tide. Both species exhibited elevated respiration following exposure to 24ºC and decreased respiration at 36ºC, whereas only *L. austrodigitalis* increased respiration after exposure to 32ºC. As 24ºC is below the temperature stress threshold of these two species, it is presumably not a result of activation of the heat-shock response. Increased metabolic rates of *L. austrodigitalis* at 32ºC correspond to activation of Hsp response to elevated temperature. *L. scabra* does not have increased metabolic rates at 32ºC due to maintenance of constant high levels of Hsp. Decreased rates following exposure to 36ºC is likely the result of near-lethal temperatures impeding natural processes and shutting down the body's response to overwhelming stress.

A BITING COMMENTARY ON SPECIES DELIMITATION: INTEGRATING MULTI-LOCUS DATA AND RADULAR CHARACTERS TO UNRAVEL CRYPTIC DIVERSITY IN SEA SLUGS

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Biodiversity is underestimated by conventional taxonomy in soft-bodied taxa like sea slugs that have few discrete characters. Recent methodological advances provided tools for objective delimitation of species from molecular data, but there is little consensus on how best to integrate DNA and morphological characters in species discovery. Here, we discuss recent work on diverse clades within Sacoglossa, herbivorous and often photosynthetic sea slugs, showing that diversity is much higher than presently recognized. In 14 cases, hypotheses of cryptic species based on complimentary analyses of mitochondrial and nuclear genes were supported by subsequent tests using radular tooth characters, and/or differences in penial anatomy, larval development or host use. In each case, one nominal 'species' actually comprised two to three (n=8 cases), four to five (n=2), or seven to ten (n=3) species

distinguishable by multiple criteria. We will discuss ongoing work using Bayesian methods to delimit species by integrating external morphology and radular measurements with coalescent analyses of molecular data. The presence of cryptic species compromises the literature on diverse topics including biocontrol of invasive algae, drug discovery, and endosymbiosis research. Notably, four sacoglossan lineages are the only specialist consumers of "killer algae", fast-growing and toxic green algae in genus *Caulerpa*, and thus represent potential biocontrol agents. However, all four contain unrecognized cryptic diversity, including "*Oxynoe viridis*" (seven distinct species), "*O. azuropunctata*" (3 spp.), "*Lobiger viridis*" (3 spp.), "*Elysia tomentosa*" (9 spp.), "*Polybranchia orientalis*" (>4 spp.), and "*Stiliger smaragdinus*" (2 spp.); thus, the true degree of host specificity in *Caulerpa*-consumers remains unknown.

HOW MANY POPULATIONS ARE THERE? GENETIC POPULATION STRUCTURE OF THE OLYMPIA OYSTER, *OSTREA LURIDA*, IN SOUTHERN CALIFORNIA

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Restoration of the historically impacted Olympia oyster (*Ostrea lurida*) is ongoing along the West Coast but in southern California, where restoration is underway, there is almost no information regarding its genetic structure. Project managers cannot yet effectively allocate time, money, and resources to best harness existing genetic variation. We aim to provide baseline genetic structure estimates for remnant Olympia oyster populations in nine southern California estuaries extending from Ventura County to San Diego County at the U.S.-Mexico border. Previous mitochondrial DNA sequence comparisons have not yet revealed enough variation to evaluate whether or not oyster populations are structured, so we have used more variable microsatellite markers. Our null hypothesis was that southern California populations have some genetic structure and that genetic similarity will reflect geographic proximity, as expected for isolation-by-distance (IBD) models. STRUCTURE analysis of six microsatellite loci supports one population, while Geneland suggests 3 populations. Mission Bay and one of the San Diego sites each form their own populations with the other seven sites forming a third population. Pairwise FST values between one of the San Diego sites and all other sites were significant after Benjamini and Hochberg correction. Whether the genetic structure of the Olympia oyster in southern California is one or three populations, the data do not support an IBD model. Population genetic characterization will enhance the opportunities for restoration managers to successfully restore this and possibly other native estuarine species.

I'VE GOT MY DEGREE, NOW WHAT DO I DO? APPLICATION OF TAXONOMIC SKILLS IN THE REAL WORLD. YOU TOO CAN BE A PAID TAXONOMIST!

Lawrence L. Lovell – 1, 2, 3

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That degree will not necessarily prepare you for a job in the real world after college. The lectures attended, the books read, the exams passed are all part of what's required to get that degree. But many

times it is other things, the skills that one learns along the way that prove to be the most valuable, in the real world, to a prospective employer. Taxonomy - the identification of things - is one such skill and potential professional career path. Taxonomy is necessary to census communities of plants and animals (extant and extinct) in order to compare and understand how ecosystems function. Government and private industry taxonomic jobs exist. Applied taxonomy is required to evaluate plant and animal communities that are being impacted or potentially will be impacted by human activity. Federal, state, and/or local regulations require monitoring of human environmental impacts – waste water outfalls, harbor dredging, gas and oil platforms & pipelines, power corridors, highway construction, etc. City/county/state agencies and consulting companies maintain taxonomic staff to perform such work. Accurate taxonomy is essential to accurate results and well supported scientific conclusions. You may also decide that taxonomy will be an avocation, outside of your chosen career path. It is a way to relate to and be more connected with the natural world. Whether you make it your profession or your avocation, taxonomy can be very enjoyable and rewarding.

THE SLUG WITHIN THE BIVALVE: RECONCILIATION OF SHELL-BASED TAXONOMY AND MOLECULAR DATA IN JULIIDAE (HETEROBRANCHIA: SACOGLOSSA)

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Juliidae is a member of the Sacoglossa, a herbivorous clade of heterobranch gastropods. Juliidae has a complex taxonomic history derived from the fact that these gastropods have bivalve shells. The current taxonomy of Juliidae is largely based on shell morphological traits and to a certain extent on internal and anatomical traits, such as the radula and the reproductive anatomy. Based on these data, Juliidae is considered to have two extant genera, *Berthelinia* and *Julia*, both with pan-tropical distributions. A species-level molecular phylogeny of Juliidae has been made using a combination of three genes, 2 mitochondrial (CO1, 16S), and 1 nuclear (H3). Geometric morphometrics were used to quantify shell morphology of recent taxa, based on extant shells as well as fossil shells from the literature. The morphometric data has been integrated with the molecular phylogeny using comparative methodologies.

UNDERSTANDING THE BIOGEOGRAPHY AND TAXONOMY OF TWO CALIPHYLLIDAE GENERA: *POLYBRANCHIA* AND *CYERCE* (GASTROPODA: HETEROBRANCHIA: SACOGLOSSA)

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Limapontioidea is a paraphyletic superfamily that requires biogeographic studies and an extensive taxonomic reevaluation (Order Sacoglossa). The family Caliphyllidae has two monophyletic genera: *Polybranchia* and *Cyerce*, both with pantropical distributions. The biogeography and systematics of these two genera were conducted using nuclear (H3) and mitochondrial (CO1 and 16S) DNA. Additionally, the validity of the Eastern Pacific and Caribbean *Polybranchia viridis* species was evaluated using scanning electron microscopy to examine the morphology of the radulae and the male reproductive organs. Preliminary data suggests the existence of previously overlooked diversity within Caliphyllidae.

ECOLOGICAL ASSESSMENT OF NARMADA RIVER WITH SPECIAL REFERENCE TO DIVERSITY OF MOLLUSCANS

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Mollusks are helpful in purification of water via their capacity to act as scavengers. The Narmada River is one of the most important rivers of India, which covers 98,796 sq. km of total watershed area. Narmada is considered to be a life line and west flowing river of the state of Madhya Pradesh. A limnological study was carried out for a period of eight months for selected stations of the Narmada River. In the present study various species of mollusks belonging to class Gastropoda and Pelecypoda were recorded. Among the gastropods, *Vivipara benglansis* was dominant followed by *Bellamya benglansis* at both stations. Among the pelecypods *Perreysia caerulea* was dominant throughout the study period. The highest Shannon-Wiener index (H') was observed in station II and the lowest in station I. The minimum H' value was observed in December and maximum in March. The result of the present study emphasizes the importance of conserving the world's freshwater molluscan populations, which are declining at an alarming rate through habitat destruction and pollution.

WESTERN UNITED STATES NEOGENE MOLLUSCAN PALENTOLOGY: PROSPECTIVE PROJECTS

Charles L. Powell

U.S. Geological Survey

This is going to be an unusual talk. I was recently diagnosed with a genetic disease that is shortening my career as a molluscan paleontologist, but not my life. I have a large number of incomplete projects that I would like to find co-authors for or pass on to others. These projects vary from more than half-written to just ideas or observations that need to be documented. They can be divided into three major categories: 1) documenting faunas, 2) biostratigraphy, and 3) taxonomy. Fauna's partially documented include: the Pleistocene Lomita Marl Formation, the San Diego Formation, and the Imperial Formation in the Indio Hills north of Palm Springs. Partially completed biostratigraphic projects include the Miocene to Pliocene Purisima Formation along Monterey Bay, and Pliocene and Pleistocene rocks from the Aleutian Islands north to the Canadian border in Alaska. Taxonomic projects include the description of numerous new species, including 1) > 40 new species of bivalves and gastropods from the late Miocene "Imperial" Formation in Riverside County, 2) a new fossil Naticid (Gastropoda) from Alaska that is recognized by having spiral riblets; 3) a new *Argopecten* (Bivalvia) from the middle Miocene of central California; and 4) one of my earliest projects started over 35 years ago synonymizing two California fossil Cancellarids (Gastropoda) from the Pliocene of California. I would also like to complete two annotated bibliographies: one of Pleistocene mollusks from California (1866-2000), a second on Tertiary fossils (invertebrate, vertebrates and plants) from the San Francisco Bay area, central California, and an obituary for Warren O. Addicott. Anyone interested?

BIOGEOGRAPHY OF *BOREOBERTHELLA AUGUSTA* MARTYNOV AND SCHRODL 2009 IN PRIBILOF CANYON AND ZHEMCHUG CANYON, BERING SEA

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A new genus and species of pleuobranchoidean opisthobranch*, Boreoberthella augusta* Martynov and Schrodl 2009, was described from specimens collected in the 1930's, 1971 and 1991 in the Sea of Japan and near the Komandorskyie Island in the northwestern Pacific. The species was described based on preserved animals, thus the morphology and coloration of live animals remained unknown. In 2007 live specimens and video images of an unidentified pleurobranch were collected during exploration of the Pribilof and Zhemchug canyons in the Bering Sea. Expert examination of the specimen, especially the radular and jaw morphology confirmed its identity as *Boreoberthella augusta*. The occurrences of the species in the canyons, depth and distributional range as well as a description of the living animal are presented.

NESTING BEHAVIOR OF THE CHESTNUT COWRY, *NEOBERNAYA SPADICEA*

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Females of the chestnut cowry *Neobernaya spadicea* (Swainson, 1823) are active nest builders. Smooth surfaces are preferred for nests, and the empty shells of the large rock scallop (*Crassadoma giganteus* Gray, 1825) is commonly used for this purpose. Surface debris is removed from smooth surfaces where the nest will be formed after mating. Once prepared, 2-5 males are attracted to the female. After mating the female deposits an average of 239 egg capsules attached via a short pedicle to the base matrix. Each capsule may contain over 1,000 embryos. Females remain on/or adjacent to the capsules, while males remain around the margins of the cluster. After a few days males began to disperse; two weeks later only one male is occasionally found still present with the female. Additional information on the role of the male, and distribution records for southern Baja California are presented.

OBSERVATIONS ON THE BIOLOGY OF THE MUREX *PTEROPURPURA TRIALATA*

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Of the seven species of *Pteropurpura* found in the Californias, the Three-Winged Murex, *Pteropurpura trialata* (Sowerby 1841) is only the second species to have major aspects of its biology published. The adults specialize on finding and feeding upon the vermetid snail, *Serpulorbis squamigerus*. Two years of underwater data collection indicate that growth, reproduction and occurrence is closely linked to seasonal fluctuations in ocean water temperature. Growth tends to occur with low water temperatures and reproduction occurs with increasing water temperatures. Females deposit an average of 60 egg

capsules containing an average of 485 eggs/capsule on near vertical surfaces. The shape and size of adult snails is markedly different between San Diego and Los Angeles, with LA shells being larger and wider than those from SD. The juvenile of this species and their habitat remains unknown. Information on longevity, seasonal abundance, sub-adults, and new records for occurrence in Baja California Sur are included.

DIVERSITY AND DISTRIBUTION OF CEPHALOPOD CLASS IN THE MEXICAN PACIFIC WATERS

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Cephalopods in Mexican waters are disproportionately studied; while the Gulf of México has been analyzed three times, Pacific waters were only partly analyzed. We use the information of the main Mexican Cephalopods collections as well the electronic information of the collections of the Harvard University Museum of Comparative Zoology, Chicago Field Museum, Smithsonian Natural History Museum and finally the information that we could consult at Scripps Oceanographic Institute, Natural History Museum of Los Angeles County, Santa Barbara Natural History Museum and California Academy of Sciences. We could find 118 reported species with only 86 species records in biological collections. We found a geographical skew to the northern part of México, mainly the west coast of Baja California Norte and central portion of Gulf of California. The oceanic portion and the southern part of the country is poorly sampled, indeed we didn´t find specimens for Chiapas State. Analysis of cephalopod distributions has been challenging and imprecise work. With publications of the databases of the collections, this enterprise could be turned into an easier and more accurate activity.

SEEING DOUBLE WITHOUT BOOZE: INTEGRATIVE TAXONOMY REVEALS UNEXPECTED NUDIBRANCH CRYPTIC SPECIATION IN THE NORTH PACIFIC

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Molecular investigation of the population structure of several species of North Pacific nudibranchs revealed the existence of multiple cryptic and pseudocryptic species pairs. An integrative approach, including molecular, morphological, developmental, and ecological data was used to provide evidence for species delimitation. Several of these cryptic species pairs have overlapping ranges suggesting sympatric speciation may be responsible for producing this pattern. On the contrary, other cryptic species pairs are largely allopatric, but the boundaries between their ranges are not consistent with traditional views of Northeastern Pacific biogeography.

A DEPAUPERATE MARINE BIVALVE FAUNA IN WESTERN SOUTH AMERICA?

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Bivalve Seashells of Western South America is the next in a series of monographs on the eastern Pacific Ocean marine bivalve fauna. The study region originates at Punta Aguja, Piura, Perú (5.8°S), and continues south to the southern tip of Isla Chiloé, Los Lagos, Chile (43.4°S), inclusive from the intertidal zone to the deep sea. Through a literature review for the Perú-Chile Province, and direct examination of specimens in museum collections, a marked decrease in bivalve diversity has been observed when compared with similar northern latitudes. In the Alaskan, Oregonian and Californian Provinces, we have documented over 470 bivalve species, and 892 species in the Panamic Province, whereas we currently only have records for 240 verified species from the Perú-Chile Province. One factor in the observed decrease in the number of species present in the southeastern Pacific is certainly a function of under-sampling, especially in deeper waters. In addition, the narrow continental shelf throughout much of the province affords fewer shelf habitats, and may also be leading to a much lower bivalve diversity.

STUDENT RECRUITMENT & MENTORING: COUPLING COLLEGIATE TEACHING WITH MALACOLOGICAL MUSEUM COLLECTIONS

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Actively recruiting students from college classes to work with museum collections is one way to increase student participation in malacological research with a taxonomic focus. My appointment with the Natural History Museum of Los Angeles County and its vast malacological collection has, in a short time, allowed tenable projects for graduate students and student volunteers, as well as promising mentoring relationships. Without advocacy, these world-class collections and their potential may be unfamiliar to potential student researchers. Similarly, opportunities to work with the collection may be missed by students because collections lack an engaging web presence and/or searchable database. As teaching and mentoring are two aspects of academia that I value, I will discuss my efforts in recruiting students from classes at CSULA and Glendale Community College to work in the Malacology collection at the NHM.

LAND SNAIL COLLECTION AT THE NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY: GROWTH & POTENTIAL

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A diverse and rich collection of terrestrial gastropods (or land snails) comprises approximately one tenth of the Malacology collections at the Natural History Museum (NHM) of Los Angeles County. Recent inventories based on lot and drawer counts estimate between 80,000 and 100,000 wet and dry specimens. This collection's strengths lie in its regional and endemic California fauna, the critically

endangered genus *Polymita* from Cuba, and varied North American taxa. Together this collection encompasses eighteen families and approximately 1,075 species and subspecies in 33 specimen cabinets, 594 trays, 20,000 lots, and close to 40,000 specimens, all of which have locality and specimen numbers. This collection is one of the largest of Californian taxa in the western United States and ranks among the top three malacology collections in North America for total number of non-marine mollusc specimens. This collection is uniquely poised to become a focal point for regional and national molluscan research, which has profound value to science. One research project, begun as a pilot initiative at the NHM in 2015, asks citizen scientists to participate in an inventory of southern Californian land snails, the first of its kind in the region.

A PALEOECOLOGICAL RECONSTRUCTION OF OYSTERS FROM ORANGE COUNTY, CALIFORNIA: UNDERSTANDING THE PAST TO HELP RESTORE THE FUTURE

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Present restoration projects aim to repopulate the native oyster *Ostrea lurida* into southern California estuaries. To aid restoration, it is imperative to know the baseline community structure of oyster reefs before human disturbance. The modern history of oysters has been well documented by biologists, however the paleontological history is less well known. This study aims to provide information on how oysters and their communities have changed through time within southern California by examining museum specimens through time. We tracked oyster size, diversity, and abundance over 6 time intervals within the last 90 million years. Results indicate that oysters peak in size during the Miocene and decrease in size beginning in the Pleistocene and continuing into the Holocene. Multiple oyster species existed since the Late Cretaceous. Four species existed in the Late Cretaceous, three species within the Eocene, four species within the Miocene, one species in Pliocene, two species in the Pleistocene, and one species in the Holocene. *Ostrea lurida* did not appear in the fossil record until the Pleistocene and continues to occur in the Holocene through the present. Thus, oyster diversity declines through time. Comparison of Pleistocene and Holocene abundance data reveals that the Pleistocene exhibits higher diversity, higher oyster abundance, and higher ecological abundance than the Holocene. Overall, oysters become smaller, less diverse, and less abundant through time.

A BRIEF REVIEW OF SEVERAL CONOIDEAN TURRI-FORM GENERA (GASTROPODA) FROM THE INDO-PACIFIC BY MORPHOLOGICAL ANALYSIS

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The historical use of the catch all name “Turridae” had long been used as a systematical approach whereas works by McLean (1971), Taylor, Kantor & Sysoev (1993), Bouchet & Rocroi (2005), and Bouchet, Kantor, Sysoev & Puillandre (2011) defined various arrangements by subfamily and/or family levels. These works have evolved to satisfy a temporary placement within a systematic arrangement which is continuing to change based on morphological, phylogenetic, and anatomical studies. Due to the enormously vast and complex differences in Conoidean families, genera and species, much

confusion has occurred in terms of specific assignments. As a result, many unnamed species occur within this grouping of the Gastropoda. Some genera within this group have historically been lumped together due to general morphological differences, whereas recent studies of protoconch details and phylogenetic analyses have clearly demonstrated that these distinctions warrant division into separate families.

POSTER ABSTRACTS

In alphabetical order by first author

DETERMINING POPULATION STRUCTURE AND REPRODUCTIVE POTENTIAL OF PINTO ABALONE (*HALIOTIS KAMTSCHATKANA*) IN SOUTHERN CALIFORNIA

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Seven species of abalone (genus *Haliotis)* are native to the west coast of California, five of which once supported viable fisheries. The pinto abalone (*Haliotis kamtschatkana*) once supported a modest fishery in California. However, stock collapse of this and other abalone species led to the closure of fisheries in central and southern California in 1997. In 2013 NMFS was petitioned to list the pinto abalone as threatened or endangered under the US ESA. Although a 2014 status review by NMFS concluded that listing was not warranted at this time, they noted that a significant lack of baseline data increased the uncertainty of their assessment and pointed to a need for improved monitoring of the species throughout its range. Pinto abalone are included in the 2005 CDFW Abalone Recovery and Management Plan, in which two criteria are used to define abalone recovery: evidence of a broad size distribution and minimum spawning density (MSD) of 0.2 animals/m^2. However, basic demographic data from targeted surveys are lacking. Recently, preliminary SCUBA surveys in San Diego, CA, where one of the only currently known populations of pinto abalone are present, show that while densities are far below the MSD threshold, there is evidence of recent pinto abalone recruitment and individuals within the population represent a broad size range (13 – 151mm maximum shell length). Ongoing surveys will continue to examine population structure and reproductive potential for pinto abalone in San Diego. These data and procedures will inform recovery efforts for pinto abalone and other abalone.

EVOLUTION IN ACID: LOCAL ADAPTATION IN A SHELL-DRILLING PREDATOR

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On the west coast, the intertidal whelks *Nucella ostrina* and *N. emarginata* prey on mussels by drilling a hole through the mussel shell. These direct-developing whelks do not disperse at sea and therefore can evolve to match their local intertidal habitats. The purpose of our research is to understand how ecological and evolutionary factors influence the interaction between the whelk predators and their local mussel prey (*Mytilus* spp.), and how this may affect intertidal communities. First, we are exploring how ecological factors, such as predation, competition, planktonic food availability, temperature, and

pH influence how whelks prey on mussels. We are especially interested in how pH affects whelk predation, since acidic water can affect calcification in whelks and mussels, and may reduce mussel shell thickness. We will explore how evolutionary factors, i.e. the ability of whelks to evolve in response to their local environment, influence whelk predation. We will also examine how whelk predation may change the mussel population structure and if that translates to differences in the greater intertidal community. Finally, we will test if pH and whelk evolution interact by executing a multi-generational experiment rearing whelks in different acidities and observing their predation.

REGIONAL MONITORING OF THE SAN DIEGO SOFT BOTTOM BENTHOS (2009-2014): THE MOLLUSCAN EXPERIENCE

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The City of San Diego performs regular monitoring of the soft bottom benthos in the near coastal area of Point Loma south to Punta Bandera in northern Mexico. These fixed monitoring stations are supplemented annually by a regional sampling effort of randomly distributed stations that expand the sampling area and provide additional depth strata although they do not extend past the Mexican border. In 2013, this regional sampling was part of a larger project known as Bight '13 which involved multiple agencies including all four major publicly owned treatment works in the Southern California Bight. During the last five years of regional sampling, many species have been identified as new to the San Diego area, including the deep water bivalve *Periploma rosewateri*. Data are presented on molluscan community structure across different depth strata and grain size habitats as well as a more detailed presentation on some of these new taxa.

THE COMPLETE MITOCHONDRIAL GENOME OF *OCTOPUS BIMACULOIDES*

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The complete nucleotide sequence of the mitochondrial genome of *O*. *bimaculoides*, the California two-spot octopus, is 15,733 nts in length. It contains 13 protein coding sequences, two rRNAs and 22 tRNAs. Seven protein genes, both ribosomal and 14 transfer RNA genes are in the L chain. The mitochondrial gene arrangement of *O*. *bimaculoides* is similar to that of *O. vulgaris*.

EFFECT OF HOMEOPATHIC DRUGS ON GONADAL MATURATION AND OOCYTE QUALITY OF CATARINA SCALLOP *ARGOPECTEN VENTRICOSUS* (SOWERBY II, 1835)

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Homeopathy has been applied with positive results in aquaculture. The Catarina scallop*, Argopecten ventricosus,* is a marine species with economic importance in the Northwest Mexican Pacific, with a high commercial and nutritional value, which has motivated the performance of several studies focused on

aquaculture. The gonadic conditioning of brood stock helps enhance the sexual maturity and improves oocytes quality for obtaining healthy larvae and juveniles with high performance for grow-out in the field. We evaluated the effect of three homeopathic formulas (Pav-Mix/Pha 30C, Pav-Mix/Sit 30C, Vid-Mix 30C) in the experimental conditioning of adult scallops (4.14±0.06 cm) in laboratory conditions. A fourth group of non-treated scallops was maintained as a reference for analysis purposes in aquaculture facilities. The scallops were conditioned in 40 L experimental units provided with aerated, filtered, and UV-sterilized seawater, which was completely exchanged every third day. All treatments were added daily to culture water. The food included a blend of the microalgae *Isochrysis galbana* and *Chaetoceros calcitrans* (150,000 cel.ml-1 twice a day). Histological and histochemical, quantitative and qualitative techniques were applied in both treated and non-treated scallops. The oocyte quality was determined by digital image analysis using parameters such as area, theoretical diameter, maximum diameter, nucleus/cytoplasm relation and roundness index. Lipids, carbohydrates and lipofuscin index were evaluated in gonadic tissue. Scallops treated with Pav-Mix/Pha and Pav-Mix/Sit had improved oocyte quality in relation to Vid-Mix and the control ($P<0.05$). The homeopathy could be a potential alternative to optimize the conditioning procedures of brood stock in mollusk hatcheries.

SEASONAL DYNAMICS ON STRATEGY, REPRODUCTIVE EFFORT AND OOCYTE QUALITY OF THE MUSSEL *MODIOLUS CAPAX* (CONRAD, 1837) IN THE GULF OF CALIFORNIA

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Mitiliculture is a productive activity in several countries of the world. The mussel *Modiolus capax* is distributed naturally in the Gulf of California, Mexico, and as other mussels, has potential to be cultivated. However, studies focused on the knowledge of its reproductive biology are scarce, which limits the development of applicable aquaculture technologies. This study was analyzed by histological and histochemical, quantitative and qualitative techniques for the strategy and reproductive effort annual dynamics of this species during the period February/2013 January/2014. Morpho-physiological indexes such as condition index, gonad and somatic coverage area tissues were estimated. The gonadic cycle of *M. capax* was categorized into five stages of development for male and female, identifying five categories of oocyte development. The sex ratio was determined to be 1:0.88 M:F. The results show that *M. capax* reproduces throughout the year with a maximum gametogenic activity in spring-summer and partial and total spawning observed mainly in summer and autumn. The oocyte morphometric quality was determined by digital image analysis using reference parameters such as Area (AO) Theoretical Diameter (TD), Maximum Diameter (MD), Nucleus/Cytoplasm relation (N/C) and Roundness Index (IR) of oocytes. Histochemical indicators such as Lipid Index (LI) and carbohydrates (CHI) were evaluated in oocytes and mussel ovarian tissue. *Modiolus capax* applies a "conservative" reproductive strategy because gametogenesis is made from the energy stored in their somatic tissues. The greater reproductive effort of the species takes place between April and August with the largest transfer of reserves to gonadal somatic tissue compartments.

THE CALIFORNIA HELMINTHOGLYPTIDAE PROJECT: GENERA *HELMINTHOGLYPTA, CAHUILLUS, EREMARIONTA, MICRARIONTA, AND PLESARIONTA*

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Our project goal is to advance the still limited understanding of the diversity, anatomy, distribution, and phylogeny of California's native helminthoglyptid land snails, including exploring species diversity and estimating phylogenetic affinities for *Cahuillus* and *Eremarionta*, genera that are common in the Mojave Desert and surrounding arid lands. Are these desert snails most closely related to the coastal and/or offshore island genera, including *Helminthoglypta*, *Plesarionta* and *Micrarioranta*, or do they have closer affinities to the east, for example with members of a better studied genus common in the Sonoran Desert, *Sonorella*? Our studies could be extended to better characterize the tempo and mode of land snail diversification in California. We are: (1) observing and photographing live specimens, (2) analyzing shell structure, especially embryonic whorl ornamentation with SEM, (3) dissecting and preparing permanent, stained, slide-mounted reproductive systems for enhanced viewing of internal structures including dart morphology, and (4) sequencing and performing molecular phylogenetic analyses for combined data sets from two mitochondrial gene regions, COI and 16S. We are completing such studies on multiple species illustrated here that represent five of the six above-mentioned helminthoglyptid genera. Our preliminary molecular results have indicated that species diversity has likely been underestimated, even though there are many species currently recognized as valid. Our results have so far not resolved the affinities of the Mojave Desert snails, which we expect might eventually be resolved with more thorough sampling of taxa, the addition of nuclear gene markers, and the integration of morphological characters in a combined data set analysis.

THE GENUS *CHITON* IN SOUTHEASTERN PACIFIC OCEAN

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In the New World, the genus *Chiton* is represented by about 16 species that are restricted to tropical latitudes or the cooler portions of the Southeastern Pacific Ocean (SEP). Altogether, six species are currently recognized from the SEP but, for some species, the taxonomic status and geographic distribution have remained controversial. In this study, we undertook morphological and molecular analyses to compare and describe the *Chiton* species from SEP. We used two mitochondrial markers (COI and 16S) to infer the phylogeny of the *Chiton* species from the SEP using likelihood and Bayesian approaches. For morphological description and morphometrics we used 20-30 specimens of each species from different locations along SEP. For outgroups, we selected members of the approximately 85 species of Chitonidae: Chitoninae worldwide. Relative to other Chitoninae in our analysis, the SEP members of *Chiton* represent a monophyletic group only when particular other southern hemisphere

members are included. This combined clade is closest to a reciprocally monophyletic grouping of mostly other New World *Chiton* spp. In our results, we found that *C. cumingsii* is a sister species of *C. magnificus* and *C. boweni*, while *C. granosus* is a sister lineage of *C. barnesi* + selected species from New Zealand or South Africa. Although our taxonomic sampling is not complete, our molecular analysis implies that recent proposals to assign *C. barnesii* to a separate genus, *Radsia*, are not supported. We have also reconsidered whether *C. boweni* is separate from or a junior synonym of *C. magnificus*. Funding: FONDECYT 1130266 to CMI and NSF DEB-1355230 to DJE

ECOLOGY OF DISPLACEMENT: CONSEQUENCES OF CATASTROPHIC DISLODGEMENT ON OWL LIMPET ECOLOGY

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Although the study of territorial behavior has given us a rich understanding of the costs and benefits of defending a resource from competitors, one of the most difficult costs to measure is that of a catastrophic loss of territory. The territorial owl limpet, *Lottia gigantea*, is at risk of a catastrophic loss of territory, because it can be completely dislodged from the substratum by other aggressive conspecifics. However, its fate after such dislodgement is unknown. In the present study, we forcefully dislodged limpets engaged in a territorial response from the substratum and examined the consequences of this dislodgement on their mortality and growth. We hypothesized that the vast majority of dislodged limpets would perish, and those that survived would have slower growth than their undisturbed counterparts. We found that survival of dislodged limpets was surprisingly high (25-56 %). During the 2-3.75 month period following dislodgement, limpet growth ranged from -2.9 to 3.8 mm and most individuals grew between -2 and 2 mm. Furthermore, the growth of dislodged limpets was not significantly different than that of their undisturbed counterparts. These observations lead us to conclude that, far from being a terminal event, dislodgement is on average a relatively small perturbation in the life history of this territorial species.

DO INTERIOR SHELL COLOR AND PROFILE DIFFERENCES COINCIDE WITH DNA EVIDENCE FOR A PAIR OF OVERLAPPING CRYPTIC LIMPET SPECIES?

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In 1866, Carpenter proposed the name "*cribraria*" for a variety of what today is considered *Lottia fenestrata* (Reeve, 1855). More recent authors have used the variety name to correspond to the observation that more northern *L. fenestrata* have a darker coloration near the marginal edge on the shell interior, with the dark morphotype reported from as far south as Cayucos, California. This happens to approximately coincide with our discovery, based on combined maximum likelihood analysis of both mitochondrial and nuclear gene regions, that *L. fenestrata* is actually a north/south pair of distinct sister species with a transition zone we have narrowed down to the vicinity of Cayucos. To test whether the color or other differences could be reliably used to identify each species, we performed image color analysis, basic morphometric comparisons, and further sampling of limpets in the portion of California's central coast corresponding to the apparent transition zone between the species. Quantified color measurements were much more variable in the southern restricted *L. fenestrata* than in the more

northern species, and we found that shell shape and profile consistently differed. Both of these traits have enough variation so that they are unlikely to allow confident discrimination by themselves.

MOLECULAR AND MORPHOLOGICAL GEOGRAPHIC VARIATION OF *SIPHONARIA LESSONI* ALONG THE SOUTHEASTERN PACIFIC OCEAN

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The pulmonate marine gastropod *Siphonaria lessoni* has a wide distribution in South America, and in this research we studied the molecular and morphological variation along the Southeastern Pacific Ocean (SPO). We performed phylogeographic analyses using the mitochondrial gene COI from 244 individuals and morphometric analyses for 700 individuals using Principal Component Analysis (PCA). *Siphonaria lessoni* showed a high genetic diversity including 141 haplotypes, 122 polymorphic sites and averaged six nucleotide differences between pair sequences. Two genetic units were found along the southwest coast of South America. Further, we found asymmetric gene flow with a high number of migrants per generation moving south and a low number of migrants moving north. The first PCA axis explained 87.4% of the variance in body size. The second axis explained 9.7% of morphological variation. The PCA showed a high correlation between the total length and width, and an inverse correlation between the height and the distance apex, meaning that higher individuals would have a shorter apex. Both PCA axes (I and II) are correlated with latitude, suggesting that southern individuals would be bigger and would show a higher morphological variation. The body size variation was mainly associated with sea surface temperature, salinity and chlorophyll-a through latitudinal gradient. Meanwhile the shape was related to the salinity and oxygen. Finally, these results independently suggest that the southern population, in which individuals are bigger and morphologically more variable, also would be significantly different genetically in relation to the northern population on the Southeastern Pacific Ocean. Funding: FONDECYT 3140610.

RECRUITMENT, SURVIVAL, AND GROWTH OF THE OLYMPIA OYSTER (*OSTREA LURIDA*) AND THE JAPANESE OYSTER (*CRASSOSTREA GIGAS*) AS A FUNCTION OF TIDAL HEIGHT

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Surveys of seawalls in southern California bays have uncovered zonation of native (*Ostrea lurida*) and non-native (*Crassostrea gigas*) oysters, where non-natives reach their maximum density higher in the intertidal zone than natives. This zonation may be explained through differences in settlement, recruitment, and/or growth and survival across species. We explored the effects of varying tidal heights on recruitment, survival, and growth of native and non-native oysters in San Diego Bay, California during summer and fall 2014. To assess recruitment levels, twenty ceramic tiles were placed onto a fence at varying tidal heights and replaced every two weeks for 5 months. To measure growth and survival, ten ceramic tiles, each with ten recently settled native oysters and two to four non-native oysters, were

transplanted to varying tidal heights from -0.25m MLLW to +1m MLLW and checked periodically for 14 weeks. Increased tidal height significantly reduced recruitment of both species, with a more significant decline for native oysters. After 14 weeks, native oysters experienced 100% mortality at all tidal heights; non-native oysters survived throughout the tidal range. Growth of both native and non-native oysters was not significantly affected by tidal height, but non-natives showed a trend toward faster growth at lower tidal heights. Recruitment patterns alone may explain adult zonation patterns for *O. lurida,* but further studies are required to understand why *C. gigas* is not achieving higher densities at lower tidal heights. Results will help facilitate installation of restoration beds at tidal heights that maximize native performance and minimize non-native performance.

ENVIRONMENTAL VARIABILITY AND INVESTMENT IN THERMAL DEFENSES: THE IMPORTANCE OF RECENT HISTORY

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Climate change models predict an increase in the frequency and intensity of extreme thermal events, suggesting that exposure to stressful high temperatures will likely become more common for many organisms. Because investment in thermal defenses is energetically expensive, a trade-off is expected to occur between thermal tolerance and growth or reproduction. In this study, we investigated how frequency of exposure to chronic heat stress influenced allocation of resources to competing demographic parameters in the California mussel, *Mytilus californianus*. We exposed mussels daily to 32 °C during a 6-h simulated low tide 0, 1, 4, or 7 days per week, for 8 weeks. We then challenged them with an acute exposure to more extreme temperatures (36, 39, or 42 °C). Our data provide support for the idea that acclimatory responses to temperature stress can drive trade-offs among traits, as predicted by theory. Chronic sublethal heat stress invoked a cost to individuals, expressed as a reduction in shell growth or size-specific tissue mass. However, increased frequency of prior thermal conditioning resulted in higher survival following acute exposure to potentially lethal temperatures. We are currently quantifying treatment-specific Hsp70 expression levels in our experimental mussels and expect to see a similar pattern.

PCR-BASED TESTS FOR DETECTING THE PRESENCE OF AN INVERTED MITOCHONDRIAL TRNA GENE CLUSTER IN SELECTED *CHITON* GENERA (POLYPLACOPHORA: LEPIDOCHITONIDAE)

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The chiton family, Lepidochitonidae, has been highly problematic in chiton systematics. Its monophyly has not been established and there is has been much confusion about which genera should be included within it. The complete mitochondrial genome was recently determined for representatives of two Eastern Pacific genera that are normally included in Lepidochitonidae, *Nuttallina* and *Cyanoplax*, and both were found to share a derived inversion of a seven-gene cluster of tRNA genes relative to other chitons and even other mollusks. Using the available chiton mitochondrial genomes, we designed PCR primers to test whether members of selected other chiton genera share this derived inversion found in *Nuttallina* and *Cyanoplax*. For example, there is already sequence evidence supporting a closer

relationship between these genera than either has with the type genus for the family, *Lepidochitona*, whose members are found mostly in the North Atlantic. Our mixtures of three or four primers in an otherwise normal PCR reaction are being explored to test whether species of *Lepidochitona* (and other selected other genera) also share this derived inversion for the seven-gene portion of their mitochondrial gene order, and if so this evidence could help support the monophyly of Lepidochitonidae. Alternatively, we could find that only a more restricted Eastern Pacific clade possesses the inversion, and this would lead to new opportunities to study the history of speciation within Eastern Pacific chitons.

THE COMPLETE MITOCHONDRIAL GENOME OF THE BUTTER CLAM, *SAXIDOMUS NUTTALLI*, BY USING NEXT GENERATION SEQUENCING

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The butter clam, *Saxidomus nuttalli*, inhabits the coasts of Baja California, and is usually fished for self-consumption, but it is a poorly studied species. Nowadays, next generation sequencing techniques help 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 butter clam. A gill sample was fixed in 95% ethanol and DNA was extracted with a commercial kit and sent for mate pair Illumina sequencing. Fastaq files were processed and analyzed with CLC Genomics Workbench and the largest contig was found to be the mitochondrion genome of the butter clam. Annotation was carried out with DOGMA and Mitos software and by comparison with other Veneridae species. The mitogenome comprises a total of 18,466 nucleotides, with a rich A+T feature (65.7%). Twenty-two tRNAs, two ribosomal RNAs, and 13 genes were found and their order was similar to other Veneridae species. In this paper we discuss the potential use of this information for phylogeny and fishery studies of this and other Veneridae species.

RAFTING ACROSS AN OCEAN: JAPANESE TSUNAMI DEBRIS AND TRANSPORT OF *MYTILUS* SPP. TO THE PACIFIC COAST OF NORTH AMERICA

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In March 2011, the Tohoku Earthquake (magnitude 9.0 Mw) and consequent tsunami generated tons of marine debris (including docks, vessels, buoys, and other material) which were moved offshore of Japan. This floating debris, some of which supported existing fouling communities, has slowly been transported across the Pacific Ocean, and landfalls have been reported and sampled in Hawaii, Washington, and Oregon. Mussels in the genus *Mytilus* were some of the most common organisms found on the debris in all landing sites. Tissues were taken from mussels on landed debris by collaborators and sent to Moss Landing Marine Laboratories for genetic identification and analysis using the mitochondrial gene region for cytochrome oxidase subunit III (COIII). The majority of mussels were found to be the widely-introduced species *Mytilus galloprovincialis*, though the North Pacific-native *M. trossulus* and Korean

mussel *M. coruscus* were also present in low abundances. This study aims to investigate the following: (1) What is the potential for the introduction of Japanese *M. galloprovincialis* to populations of *Mytilus* spp. in the northeast Pacific, and (2) What is the current distribution of the introduced *M. galloprovincialis* and native *M. trossulus* in this region? The debris generated by the Tohoku Earthquake and tsunami presents a novel opportunity to study both the potential for successful "natural" introductions of marine species, as well as the mechanisms of genetic transfer between populations of the same species that occur on opposite sides of an ocean basin.