THE WESTERN SOCIETY OF MALACOLOGISTS

Annual Report
For 2018

Volume 51
November 2022

Abstracts and papers from the 51st annual meeting of the Western Society of Malacologists meeting jointly with the American Malacological Society 84th annual meeting

University of Hawaii, Honolulu, HI, USA
June 19-23, 2018

CONTENTS

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

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

Western Society of Malacologists

Executive Board 2017-2018

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

STUDENT AWARDS

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

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

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

B: WSM 2017 Student Research Grants in Malacology

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

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

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

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

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

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

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

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

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

Welcome from the Presidents

Aloha mai kākou!

Welcome to the joint meeting of our two esteemed societies! This gathering marks the 84th annual meeting of the American Malacological Society (AMS) and the 51st annual meeting of the Western Society of Malacologists (WSM). This is the second AMS (Dr. E. Alison Kay was president in 1995) and first WSM meeting in Hawaii. We are thrilled to celebrate innovative molluscan research (and researchers) and have an incredible program planned with 160 attendees (42 of which are students ranging from high school to doctoral) and over 130 contributions (talks and posters).

Steeped in the deep cultural traditions of the Hawaiian people, we are gathering on the island of Oahu (The Gathering Place in Hawaiian) to "talk story" about all things malacological.

Presentations and the discussions following are framed within the context of this year's theme, "Building Capacity and Developing Solutions for the Future" and five symposia have been organized around this theme:

Celebrating Women in Malacology (convened by Rebecca F. Johnson, Norine W. Yeung and Ellen E. Strong): dedicating this symposium to the outstanding research and experiences of women in all of the many fields that make up malacology

The Revitalization of Natural History Museums (convened by Rebecca F. Johnson and Paul Callomon): highlighting research, digitization efforts and educational outreach developed to engage society

Amateur Malacologists and Citizen Scientists (convened by Rebecca F. Johnson and Manuel Caballer Gutierrez): recognizing the significant role of amateurs in modern malacology and presenting their citizen science activities

Stemming the Tide of Extinction (convened by Kenneth A. Hayes and Diarmaid Ó Foighil): sharing the latest research on Pacific island land snail research and conservation with a special session at the end for researchers and conservation managers to develop a consortium for determining short- and long-term research goals and conservation management priorities for this fauna

Impacts of invasive species (convened by Kenneth A. Hayes with support from John Slapcinsky and David G. Robinson): providing up-to-date information regarding the systematics, distribution, and negative impacts of invasive molluscs with a 6-hour taxonomic workshop on the first day of the conference providing training in surveys, identification, and current and potential invasive land snail species with specific emphasis on Hawaii and the Pacific Islands.

In addition to these symposia, we have contributed sessions that include: contemporary and historical diversity; ecology; systematics, and evolution; anatomy and morphology; and diversity and delimitation. For the Wednesday lunch session, we have Simon L. Malcomber from the National Science foundation presenting updates and insights, and Thursday, a student-mentor meet-greet-eat lunch session.

The conference is bookended by a welcome reception at the Waikiki Aquarium and a banquet dinner hosted by the Bernice Pauahi Bishop Museum. In between, we hope the participants will enjoy the hospitality of the islands while meeting to explore and discuss the latest discoveries in malacology, socialize with colleagues, and collaborate to develop strategies for conserving molluscan diversity and building research capacity.

As part of our societies' tradition, the conference will also include an auction to support student research, poster sessions, and social networking events. Please come to the auction and, bid onsome great items to support them even more! The final day of the conference is reserved for field trips and exploration of the island, and will include opportunities to visit snorkeling beaches, land snail conservation facilities, and natural area reserves where visitors can see the few remaining endemic snail species.

We would like to give "plenny mahalos" to the organizing committee (especially Ellen E. Strong, Kenneth A. Hayes, John Slapcinsky, Jessica Goodheart), BPBM snailers (Kelli DeLeon, Rachel Sommer, Ryan Kong, Elaine Mahoney, Jaynee Kim, Tricia Goulding, Kim Lactaoen, Connor Kalahiki, Lily Evans, Emily Norman, Rachel Sommer, Jamie Tanino, Kelli DeLeon, James Kwon, Regina Kawamoto) and support team (Janis Matsunaga, Lynette Williams). A super special mahalo to Irene and Ricky Yeung for watching over and helping train our junior snailer David Yeung Ching Hayes while mom and dad worked. We are looking forward to spending time with all of you and hosting you and your families on the island we call home. Enjoy the meeting!

Finally, here are a couple of our personal thoughts regarding being president of AMS and WSM:

Rebecca: I gave my first professional talk at a WSM meeting in San Diego in 1996, as recent college graduate. Over the years, I have found a great community of colleagues and friends at WSM and AMS meetings. I have never forgotten how welcomed and included I felt at that first meeting and every meeting since. Please go out of your way to welcome the many students (and first time attendees) here this week. Thanks to Ángel Valdés, Jann Vendetti, Terry Gosliner, Pat Krug and all the WSM board members past and present for entrusting me with this job and honor. And thanks to Nori for proposing we host a joint meeting in her backyard. Nori and her team have worked tirelessly, made it look easy, and smiled through it all. Thanks, Nori!

Nori: I did not start "snailing" seriously until 2009 and did not even think that I would be hosting an AMS meeting. So here we are and hope we did the Society proud with this conference. Many thanks to Ken Hayes, Ellen Strong, Jeanne Serb, and John Slapcinsky for convincing me that this would be a fantastic idea and that they would help immensely in the organization of it. No, there are no hints of sarcasm at all. Many apologies to Ken and Rebecca for all the last-minute requests and their patience in coming through with it all! Lastly, supah plenny mahalo to my BPBM snailers… da best!

Mahalo piha,

Norine W.Yeung

President, American Society of Malacologists, 2018

Rebecca F. Johnson

President, Western Society of Malacologists, 2018

Meeting Program

84th American Malacological Society
51st Western Society of Malacologists

Honolulu, Hawaii
June 19-23, 2018

2018 Annual Meeting

American Malacological Society

Western Society of Malacologists

Tuesday, June 19, 2018

08:30AM - 05:30PM	**Registration** Gazebo
09:00AM - 03:00PM	**Invasive land snail taxonomic workshop** Kaiulani III
01:00PM - 03:00PM	**WSM Council Meeting** Altitude 37
03:15PM - 05:00PM	**AMS Council Meeting** Altitude 37
05:30PM - 06:30PM	**Honolulu Zoo Twilight Tour of Ectotherm Complex**
06:45PM - 08:45PM	**Reception at Waikiki Aquarium**

Wednesday, June 20, 2018

07:00AM - 08:30AM	*Breakfast (For conference registrants that are Hilton Waikiki Beach guests only; Prince David Room)*	
08:00AM - 05:00PM	Registration 3rd Floor Foyer	
09:00AM - 09:15AM	**Opening Remarks** Kaiulani II & III	
09:15AM - 10:15AM	**Key Note Speaker** Kaiulani II & III	
10:15AM - 10:30AM	*Morning Break* Prince David Room	
10:30AM – 12:00PM	**AMS Symposium: Celebrating Women in Malacology** Kaiulani II & III	
12:00PM - 01:30PM	*Lunch Break* ***NSF Updates: Dr. Simon Malcomber – DEB (12:30 – 1:30)*** Kaiulani II & III	
01:30PM - 03:00PM	**AMS Symposium: Celebrating Women in Malacology** Kaiulani II & III	
03:00PM - 03:30PM	*Afternoon Break* Prince David Room	
03:30PM - 04:45PM	**Contributed Talks: Diversity, Contemporary and Historical** Kaiulani I	**AMS Symposium: Celebrating Women in Malacology** Kaiulani II & III
05:00PM - 07:00PM	**Posters & Exhibits** Light Pupus (Appetizers) 3rd Floor Foyer and Prince David Room	

Thursday, June 21, 2018

07:00AM - 08:30AM	*Breakfast (For conference registrants that are Hilton Waikiki Beach guests)* Prince David Room		
08:00AM - 05:00PM	Registration		
08:45AM - 10:15AM	**Natural History Museums Symposium** Kaiulani I	**Stemming the Tide of Extinction Symposium** Kaiulani II	**Contributed Talks: Ecology** Kaiulani III
10:15AM - 10:45AM	*Morning Break* Prince David Room		
10:45AM - 12:30PM	**Natural History Museums Symposium** Kaiulani I	**Stemming the Tide of Extinction Symposium** Kaiulani II	**Contributed Talks: Ecology** Kaiulani III
12:30PM - 01:45PM	*Lunch Break* ***Student-Mentor Meeting (Light Lunch)***		
01:45PM - 03:30PM	**Natural History Museums Symposium** Kaiulani I	**Stemming the Tide of Extinction Symposium** Kaiulani II	**Contributed Talks: Ecology** Kaiulani III
03:30PM – 03:45PM	*Afternoon Break* Prince David Room		
03:45PM – 04:45PM	**Natural History Museums Symposium** Kaiulani I	**Stemming the Tide of Extinction Symposium** Kaiulani II	**Contributed Talks: Ecology** Kaiulani III
04:45PM – 05:45PM	Discussion Kaiulani I	Discussion Kaiulani II	Discussion Kaiulani III
	AMS-WSM Group Photo (Location TBA)		
05:45PM – 06:00PM	**AMS/WSM Auction for Student Research Awards**		
06:45PM - 09:15PM	Light Pupus (Appetizers and Refreshments) in Prince David Room		

Friday, June 22, 2018

07:00AM - 08:30AM	*Breakfast (For conference registrants that are Hilton Waikiki Beach guests)* Prince David Room	
08:30AM - 09:30AM	Registration	
08:45AM - 10:15AM	**Contributed Talks: Diversity** Kaiulani I	**Invasive Species Symposium** Kaiulani II & III
10:15AM - 10:30AM	*Morning Break* Prince David Room	
10:30AM - 12:00PM	**Contributed Talks: Diversity** Kaiulani I	**Invasive Species Symposium** Kaiulani II & III
12:00PM - 01:00PM	*Lunch Break*	
01:00PM - 02:30PM	**AMS Business Meeting** Kaiulani II & III	
02:30PM - 04:00PM	**WSM Business Meeting** Kaiulani II & III	
05:00PM - 05:30PM	Transportation to Bishop Museum	
05:30PM - 08:00PM	**Banquet at Bishop Museum**	
08:00PM - 08:30PM	Transportation to Hotel	

Wednesday, June 20, 2018

* Eligible for student award; †Moderators

Time	Speaker	Title
9:00		**President's Opening Remarks (Kaiulani II & III)**
9:15	Susan Kidwell	**Key Note Presentation** Dead shells talking: Using molluscan death assemblages to decipher human impacts and shifting baselines
10:15		*Morning Break (Prince David Room)*
		AMS Symposium Celebrating Women in Malacology (Kaiulani II & III)
10:30	Carole Hickman	Anomalies in the Field: Women Chasing their Molluscan Dreams
11:00	Annaliese Hettinger	Loved to death: Leveraging our appetite for oysters on the half shell to resurrect reefs and revitalize coastal communities
11:30	Cathy Marlett	Giving a shell a name: listening to Seri voices
12:30		*Lunch Break* NSF Updates: Dr. Simon Malcomber – DEB (12:30 – 1:30; (Kaiulani II & III))
2:00	Amy Moran	Embryonic metabolism and development of Antarctic nearshore marine gastropods
2:30	Maurine Neiman	Sex in the wild (and especially in New Zealand)
3:00	Jeanne Serb	Being Fearless in 21st Century Malacology or: How I Moved from Studying Correlation to Causation in Scallop Eyes
3:15	Jessica Goodheart*	Comparative morphology and evolution of the cnidosac in Cladobranchia (Gastropoda: Heterobranchia: Nudibranchia)
3:30		*Afternoon Break (Prince David Room)*
		Contributed Talks: Diversity, Contemporary and Historical (Kaiulani I)
4:00	Bruce Jenkins	Taxonomic review of Australian Siphonariidae
4:15	Kevin Cummings†	The Freshwater Mussels of México (Unionidae & Mycetopodidae)
4:30	David Campbell	New light on lampmussels: is *hydiana* hiding in Illinois?
4:45	Gregory Herbert	Early warning indicators of collapse in one of the last "pristine" oyster habitats in North America
5:00	Sean Keogh*	Molecules & morphology reveal 'new' divergent, widespread North American Lampsiline species (Bivalvia: Unionidae)
5:15		**Posters and Exhibits (5:15-7:00)** Light pupus (appetizers) and refreshments
		AMS Symposium: Celebrating Women in Malacology (Kaiulani II & III)
4:00	Gizelle Batomalaque*	Malacofaunal mosaic in Mindanao, Philippines
4:15	Ka'ala Estores Pachecho*	Pseudocryptic speciation of two *Hermissenda* sea slug species
4:30	Daniela Treiber*	Expression and function of a dodecahedral and a pentameric acetylcholine- binding protein from the freshwater snail *Biomphalaria glabrata*
4:45	Gina Contolini*	Climate and population history shape variation in drilling behavior in intertidal dogwhelks
5:00	Tricia Goulding*†	Discordance between mitochondrial and nuclear DNA sequences used for species delimitation in intertidal slugs (Pulmonata: Onchidiidae)
5:15		**Posters and Exhibits (5:15-7:00)** Light pupus (appetizers) and refreshments (3rd Floor Foyer and Prince David Room)

Thursday, June 21, 2018

* Eligible for student award; †Moderators

The Revitalization of Natural History Museums Symposium (Kaiulani I)		
Time	**Speaker**	**Title**
9:00	Rebecca Johnson†	Introduction
9:15	Paul Callomon	The Temple and the Forum revisited: shells in natural history museums
9:45	Carole Hickman	Vital Roles of the Academic Natural History Museum
10:15		*Morning Break (Prince David Room)*
10:45	So Ishida	Citizen science in the Osaka Museum of Natural History, in collaboration with the Friends of the Museum
11:15	Jose Leal	The whizzing snail: Innovation and change at the Bailey-Matthews National Shell Museum, Sanibel Island, Florida
11:30	Rudiger Bieler	Institutional mollusk collections in the U.S.A. and Canada – how far have we come in the past 45 years?
11:45	Bridget Chalifour*	Gut Microbiome Analysis of the Rocky Mountainsail *Oreohelix strigosa* from Museum Collections
12:00	Paul Valentich-Scott	The unsung heroes of natural history museums
12:15	Charlie Sturm	Outreach opportunities at the Section of Mollusks, Carnegie Museum of Natural History
12:30		*Lunch Break* (12:30-1:45) / Student-Mentor Meeting (light lunch)

Amateur Malacologists and Citizen Scientists Symposium (Kaiulani I)		
2:00	Rebecca Johnson	21st Century Natural History: Facilitating discovery, connecting people, and building community to scale science and conservation
2:30	Jann Vendetti	Mentoring in collections: A partnership between Glendale Community College and the Natural History Museum of Los Angeles County
2:45	Angus Davison	Body asymmetry and the making of a 'shellebrity'
3:00	Charlie Sturm†	Without volunteers, collections as we know them could not exist
3:15	BJ Stacey	Adding to the Knowledge of Stylommatophora in San Diego County: Citizen Science Contributions
3:30		*Afternoon Break (Prince David Room)*
4:00	Amy Van Devender	Land Snails of the Blue Ridge Parkway National Park
4:15	David Lum	The Amateurs – Malacology's Additional Eyes and Hands
4:30	Jann Vendetti†	Outcomes from community science focused on the terrestrial malacofauna of Southern California
4:45		**Discussion (4:45-5:45)**
5:45		**AMS-WSM Group Photo (Location TBA)**
6:45		**AMS/WSM Auction (6:45-9:15)** Light pupus (appetizers) and refreshments (Prince David Room)

Thursday, June 21, 2018

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Stemming the Tide of Extinction Symposium (Kaiulani II)		
Time	**Speaker**	**Title**
8:45	Pomaika'I Kaniaupio -Crozier	Hawaiian Protocol
9:00	Kenneth Hayes†	Introduction
9:15	Michael Hadfield	Old shells, new insights: demography and genetics of one-tree populations of *Partulina redfieldi* on Molokai.
9:45	David Sischo	Racing Extinction, Land snail Conservation Techniques Implemented by the Hawaii Snail Extinction Prevention Program (SEPP) and Partners
10:00	Alan Hart	A historical perspective on Oahu tree snail conservation
10:15		*Morning Break (Prince David Room)*
10:45	Paul Pearce-Kelly	*Partula* snail conservation breeding and reintroduction programme: Progress, lessons learned and future challenges
11:15	Rebecca Rundell	Evolution and conservation in the land snails of the Republic of Palau
11:30	Diarmaid Ó Foighil†	Systematic relationships among partulid tree snails of Near Oceania clarify their taxonomic status and the role of regional prehistoric exchange networks in their distributions
11:45	Cindy Bick*	Demographic and ecological factors promote differential survival of partulid tree snails.
12:00	Amanda Haponski	Deconstructing an infamous extinction crisis: survival of three Moorean and Tahitian *Partula* genomic lineages
12:15	G. Curt Fiedler	2018 Conservation Status of Guam's Partulid Snails
12:30		*Lunch Break* (12:30-1:45) / Student-Mentor Meeting (light lunch)
1:45	Norine Yeung	Phylogenetics and biogeography informing conservation of Hawaiian Achatinellidae
2:00	John Slapcinsky†	How has the Hawaiian endemic land snail genus *Auriculella* fared after a century of obscurity during an extinction crisis?
2:15	Tricia Goulding*	Molecular systematics of the Hawaiian Pacificellinae (Stylommatophora: Achatinellidae)
2:30	Melissa Price	Predators, genetics, and climate change: prioritizing conservation actions for endangered Hawaiian tree snails
2:45	Brendan Holland	Behavioral and biochemical evidence for trail pheromones in Hawaiian tree snails
3:00	Ira Richling	Introduced snails on the islands of 'Uvea, Futuna and Alofi (South Pacific) with an outlook on the native fauna
3:15	Alexander Kerr	I Akaleha' siha gi iya Islan Marianas
3:30		*Afternoon Break (Prince David Room)*
3:45	Pomaika'I Kaniaupio -Crozier	Enhancing conservation through cultural knowledge
4:15	Justin Gerlach	Predatory snails and worms in the Pacific
4:30	Floyd Reed	Robust, safe, and reversible gene drive
4:45		**Discussion (4:45-5:45)**
5:45		**AMS-WSM Group Photo (Location TBA)**
6:45		**AMS/WSM Auction (6:45-9:15)** Light pupus (appetizers) and refreshments (Prince David Room)

Thursday, June 21, 2018

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Time	Speaker	Title
		Contributed Talks: Ecology (Kaiulani III)
8:45	Trevor Hewitt*†	Ecological Correlates and Phylogenetic Signal of Host Use in North American Unionid Mussels
9:00	Lindsey Dougherty	Behavioral and Metabolomic Analysis of Aposematic Coloration in Limid Bivalves
9:15	Rachel Wade*	Implications of *Plakobranchus* cf. *ianthobapsus* (Gastropoda, Sacoglossa) kleptoplasty for herbivore ecology, benthic community structure, and invasive species management
9:30	Caitlin Shishido*	Microhabitats as thermal refugia for the gastropod *Nerita picea* (pipipi) in the upper Hawaiian intertidal zone
9:45	Jessica Schaefer*	A rocky relationship? Pair-living in the hermaphroditic gastropod *Siphonaria gigas*
10:00	Alan Kohn	Ecological, evolutionary, and molecular adventures with *Conus*: Then and now; Hawaii and beyond
10:15		*Morning Break (Prince David Room)*
		Contributed Talks: Systematics and Evolution (Kaiulani III)
10:45	Patrick Krug	When Photosynthetic Slugs and Crunchy Algae Coevolve: Host and herbivore Traits Interactively Determine Lineage Diversification in Sea Slugs
11:00	Jorge Alves Audino*	Exploring form and function across phylogenies: convergent evolution of tentacles in pteriomorphian bivalves
11:15	Jacqueline Valera*	A *Crepidula* conundrum: Testing whether slipper limpet resemblance reflects homology or convergence
11:30	Marta deMaintenon	Convergent evolution of herbivory in columbellid gastropods (Gastropoda: Neogastropoda)
11:45	Andrew Wood*	Hybridization among species of predatory marine snails: opportunities for adaptive introgression?
12:00	Thomas Duda†	Niche breadth and phenotypic variation: dietary expansion and diversity of venom components of *Conus miliaris* at Easter Island
12:15	Jorge Alves Audino*	A glance at eye diversity in the seas: how habitat shifts shaped convergent evolution of photoreceptor organs in pteriomorphian bivalves
12:30		*Lunch Break* (12:30-1:45) / Student-Mentor Meeting (light lunch)
2:00	Terrence Gosliner†	Reading between the lines: Revealing cryptic species diversity and colour patterns in *Hypselodoris* nudibranchs (Heterobranchia: Chromodorididae)
2:15	Gabriela Schaefer*	Hemocyanins' sequences and gene architectures as new phylogenetic marker in Heterobranchia?!
2:30	Thomas Linscott	SNPs, Snails, and Lime: Genomic and Geologic Patterns of Ornamentation
2:45	Eric Breslau	Doridina: an RNA-Seq Analysis
3:00	Reham Mohamed	Phylogeny and evolution of *Anguispira* (Gastropoda: Discidae)
3:15	Ellen Strong	Assessing the diversity of western North American *Juga* (Gastropoda, Cerithioidea, Semisulcospiridae)
3:30		*Afternoon Break (Prince David Room)*
4:00	Gary Rosenberg†	Biogeography of Philippine Helicostylinae (Bradybaenidae: Gastropoda)
4:15	Douglas Eernisse	First phylogeny for the radiation of California's diverse endemic shoulderband land snails (Gastropoda: Helminthoglyptidae)
4:30	Kathryn Perez	A preliminary molecular phylogeny of the Eastern US *Oxyloma* (Gastropoda: Succineidae)
5:45		**AMS-WSM Group Photo (Location TBA)**
6:45		**AMS/WSM Auction (6:45-9:15)** Light pupus (appetizers) and refreshments (Prince David Room)

Friday, June 22, 2018

* Eligible for student award; †Moderators

Contributed Talks: Species Diversity and Delimitation (Kaiulani I)		
Time	**Speaker**	**Title**
9:00	Tim Pearce†	Land Snail Populations after Tornado Fells Trees: with and without Salvage Logging
9:15	Manuel Caballer Gutiérrez	Marginellidae & Cystiscidae from South Madagascar
9:30	María Moreno-Alcántara*	The Atlantidae of the southern California Current (Winter-Spring, 2016)
9:45	Douglas Eernisse	Hawaii's only recognized species of *Siphonaria* is instead four separate clades
10:00	Lee Ann Galindo Perez	Phylogenetic species delimitation for the mud whelk of genus *Phrontis* (Nassariidae)
10:15		*Morning Break (Prince David Room)*
	Contributed Talks: Anatomy and Morphology (Kaiulani I)	
10:30	Raquel Hernandez*	Genetic structure and geometric morphometrics of populations of *Ischnochiton erythronotus* in Mexican Caribbean and Gulf of Mexico
10:45	Gizelle Batomalaque*	Don't judge a snail by its shell: using anatomy for the fuzzy helicostyline subfamily
11:00	Angus Davison	Redefining the *Cepaea nemoralis* colour polymorphism
11:15	Melanie Medina*	Selection on genital morphology as a driver of cryptic diversification in sea slugs proposed as biocontrol agents for *Caulerpa*
11:30	Manuel Caballer Gutiérrez†	A new light in integrative taxonomy: the use of UV and deep blue light in species delimitation
11:45	Chris Hobbs*	Shape variation of internal shell features in the Shining Ramshorn Snail, *Segmentina nitida*, integrating CT scanning and 2D geometric morphometrics
12:00		*Lunch Break*
1:00		**AMS Business Meetings (Kaiulani II & III)**
2:30		**WSM Business Meetings (Kaiulani II & III)**
5:00		Transportation to Bishop Museum (5:00 - 5:30)
5:30		**Banquet at Bishop Museum (5:30 - 8:00)**
8:00		Transportation to Hotel (8:00 - 8:30 pm)

Friday, June 22, 2018

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	Impacts of Invasive Species Symposium (Kaiulani II & III)	
Time	**Speaker**	**Title**
8:45	David Robinson	New introductions and the spread of invasive gastropods on the U.S. mainland and Puerto Rico.
9:00	Norine Yeung	Fifty-two species and counting - invasive terrestrial snails in Hawaii
9:15	Wallace Meyer†	Island Hopping: evidence for rapid and widespread movement of non-native snails and slugs across the Hawaiian Archipelago.
9:30	Rachel Sommer*	Life history and microbiome of invasive *Veronicella cubensis* in the Hawaiian Islands
9:45	Jaynee Kim	Rat lungworm intermediate hosts in Hawaii: identification and distribution
10:00	Andrew David	Parasite-host dynamics of the invasive freshwater snail, *Viviparus georgianus* from the Adirondack region of New York
10:15		*Morning Break (Prince David Room)*
10:30	Francisco Borrero	*Bulimulus* cf. *sporadicus* (Gastropoda, Bulimulidae) – a potential emerging agricultural and environmental pest?
10:45	Karina Moreno*	The invasion of the red slugs: *Vayssierea felis* (Collingwood 1881) in the Northeastern Pacific
11:00	Valerie Caron	Biological control of the invasive conical snail *Cochlicella acuta* in Australia
11:15	Carl Christensen	Ancient Aliens: The Globally Invasive Aquatic Snails *Melanoides tuberculata* (Müller, 1774) and *Tarebia granifera* (Lamarck, 1816) in Prehistoric Polynesia
11:30	Andrew David†	Global connectivity patterns of the notoriously invasive mussel, *Mytilus galloprovincialis* Lmk using archived CO1 sequence data.
11:45	Amanda Haponski	Genomic analyses confirm a novel North American invasive clonal *Corbicula* lineage
12:00		*Lunch Break*
1:00		**AMS Business Meetings (Kaiulani II & III)**
2:30		**WSM Business Meetings (Kaiulani II & III)**
5:00		Transportation to Bishop Museum (5:00 - 5:30)
5:30		**Banquet at Bishop Museum (5:30 - 8:00)**
8:00		Transportation to Hotel (8:00 - 8:30 pm)

Oral Presentations

Alphabetical by First Author

Exploring form and function across phylogenies: convergent evolution of tentacles in pteriomorphian bivalves

Audino JA[1], Serb JM[2], Marian JEAR[1]

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Bivalves exhibit a wide range of mantle structures that are considered key attributes in their ecological diversification. Pteriomorphia (e.g., oysters, scallops and mussels) show remarkable mantle diversity, including complex tentacular organs. Nevertheless, it remains unknown: 1) whether tentacles are homologous, 2) how many times they have evolved, and 3) if their evolution is associated with lifestyle transitions. The present study evaluated the evolution of tentacles in Pteriomorphia under a phylogenetic framework of five molecular markers for 185 species across all 19 families. Tentacle morphology was examined for 121 species from 13 families, and their functional anatomy investigated in 8 species by means of integrative microscopy. Tentacles on the middle mantle fold (MFT) are masked by similar external morphology. Ancestral state reconstruction indicates two origins for MFT, i.e., in the epifaunal clades Pectinida and Ostreoidea + Pterioidea. Anatomical evidence based on innervation, tentacle distribution, and cilia types corroborate this hypothesis, and suggest MFT are sensory organs. Interestingly, the shift of the sagittal body plane relative to substrate, from perpendicular to parallel, shows the same historical pattern. Therefore, change in position might have been associated with gains of MFT as evolutionary novelties. In contrast, tentacles on the inner mantle fold (IFT) are shorter, densely ciliated, and sometimes branched. The IFT protects the inhalant aperture, preventing the entrance of large particles. Ancestral state reconstruction indicates IFT are homoplastic in Pectinidae, Spondylidae, Mytilidae and Ostreida. In conclusion, our results provide new evidence to explore morphological evolution and macroecology in bivalves based on integrative approaches.

A glance at eye diversity in the seas: how habitat shifts shaped convergent evolution of photoreceptor organs in pteriomorphian bivalves

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Morphological diversity of eye types is one of the most intriguing topics in evolutionary biology. Varying from simple cups to complex image-forming eyes, bivalves exhibit a wide range of photoreceptor structures and are suitable non-vertebrate models to understand eye form- function relationships across multiple biological levels. The Pteriomorphia (e.g., oysters, scallops, and mussels) display different types of photoreceptor organs and possess a remarkable degree of ecological diversification. The present study evaluates the evolution and morphology of eyes in pteriomorphian bivalves, as well as their history of lifestyle transitions. We use a time-calibrated phylogeny based on five molecular markers (16S rRNA, 18S rRNA, 28S rRNA, COI, and histone H3) for 185 species across all 19 pteriomorphian families.

Morphological data were acquired for 220 species from museum collections, and ecological data were compiled from the literature. Ancestral state reconstruction indicates that the pteriomorphian ancestor was epifaunal, bearing no photoreceptor organs. Subsequently, eyes have arisen at least 6 times independently in all major groups. Five morphological types occur in 11 families, possibly playing roles

in habitat selection and predator detection. Eyes convergently evolved across lineages with different epifaunal habits: byssate, crevice-dweller, free-living, and cemented. In addition, transitions to crevice-dwelling habit were followed by convergent gains of eyespots in some families. Once photoreceptor organs have arisen, secondary losses are correlated with shifts to infaunal habitats. This pattern suggests general maintenance of eyes with likely loss when selection is relaxed. In conclusion, our results provide fundamental evidence to explore hypotheses on eye evolution and macroecology.

Malacofaunal mosaic in Mindanao, Philippines

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Mindanao is the second largest island in the Philippine Archipelago, which was formed from the accretion of land masses of different ages (as old as 39 Ma, and as young as 5 Ma). The island has a range of forest types, which harbor endemic flora and fauna. However, the terrestrial malacofauna have received little attention in terms of biodiversity studies, or even assessments for conservation. We present new findings from our surveys in nine selected sites of Mindanao, and compare them with records in the literature. A total of 72 morphospecies belonging to 16 families were collected, excluding micro snails from leaf litter samples that are yet to be sorted. Of the 72 species, 22 are operculates and 50 are non-operculates. The assemblages in each site were unique, with only a few species in common, which reflect differences in forest type.

Possibly undescribed species were also observed. We expect that with more molluscan surveys in other regions and in different seasons of the year, more species will be included in the list. Furthermore, IUCN assessments are lacking for Philippine land snails, and these gaps are yet to be filled by more studies and surveys.

Don’t judge a snail by its shell: using anatomy for the fuzzy helicostyline subfamily

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Helicostylinae, a subfamily of Camaenidae, are among the most diverse group of land snails in the Philippines. They are known for having a variety of shell forms, and some genera are known to have overlapping conchological characteristics. The recent molecular phylogeny shows the non-monophyly of several genera, which warrants revision of the subfamily. Through anatomical examinations, we determined 15 well-supported genera, and several species that need new genus names. Genera that tend to be co-distributed exhibit shell form convergence among species

belonging to different genera, and a divergence of shell forms among species belonging to the same genus. On the other hand, genera that have a more restricted (i.e. endemic to one island) distributions tend to have uniform shell forms.

Demographic and ecological factors promote differential survival of partulid tree snails.

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Partulid tree snails are endemic to Pacific high oceanic islands and have experienced extraordinary rates of extinction in recent decades involving approximately half of the 128 described species. Our research concerns the island of Tahiti, where two endemic taxa, *Partula clara* and *Partula hyalina*, have differentially survived 40 years of predation by *Euglandina rosea*. Using historical databases, we found that higher clutch sizes rather than relative abundance or distribution was correlated with partulid survival on Tahiti. We further corroborated this association of survival with heightened fecundity using birth rate data from captive populations and with parallel historical and captive demographic analyses of additional island populations: Moorea (Society Islands) and Guam and Saipan (Marianas Islands). We also tested the role of a putative ecological solar refuge in the survival of *Partula hyalina*. This species has a high albedo white shell and regularly occurs in forest edge habitats. We hypothesized that these edge habitats create ecological refuges for surviving *P. hyalina* in which ambient solar irradiation conditions are significantly higher than those tolerated by foraging *E. rosea*. Using custom-designed and manufactured smart, millimeter size solar sensors, we characterized the solar ecologies of predator populations and of surviving *P. hyalina* populations in the field. Our results indicate that their solar ecologies are significantly different, as predicted by the hypothesis, but that any protective effect is intermittent, being attenuated or absent on overcast days. Long-term survival of this species in Tahitian valleys may require proactive conservation of its forest edge solar refuges.

Institutional mollusk collections in the U.S.A. and Canada – how far have we come in the past 45 years?

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In 1975, Field Museum curator Alan Solem published a survey of Recent mollusk collections of the U.S.A. and Canada, and described the sizes, collections strengths, needs, and patterns of growth. We provide a comparison with a new survey that collected data from some 90 institutional collections

in 39 U.S. States and Territories, as well as 4 Canadian Provinces. Total holdings have doubled to about 6 million cataloged specimen lots, of which approximately 5 million are dry shell lots and 3.4 million have digitized records. An additional ca. 1.8 million lots are estimated as quality backlog in need of curatorial attention. Most (ca. 4 million) are gastropods and some 1.6 million are bivalves. About half are marine and about a quarter each comprises freshwater and terrestrial taxa. Particular strength in the combined marine holdings lie in the North Atlantic (with a strong Caribbean component) and the North Pacific; the combined land and freshwater holdings have a strong focus on continental North America and the Caribbean. About 100,000 molluscan type lots were reported, including >35,000 primary types. Some needs identified earlier have been addressed through community efforts and technological development (e.g., on-line literature access via BHL, taxonomic authority files via MolluscaBase), but issues resulting from understaffing and lack of taxonomic expertise remain pervasive. Digitization (including georeferencing) and aggregated online data service (e.g., via GBIF, iDigBio) now allow new levels of large-scale data mining and biodiversity research by integrating specimen data into one virtual collection, independent of physical size or location.

***Bulimulus* cf. *sporadicus* (Gastropoda, Bulimulidae) – a potential emerging agricultural and environmental pest?**

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Land snails of the genus *Bulimulus* Leach, 1814 are common representatives of the native fauna of a number of Neotropical countries. Several of the nearly 100 recognized taxa in the genus, have become introduced into regions outside of their native ranges, and increasingly, through international commerce. Species recognition of several taxa is not easily accomplished on the basis of shells alone, due to similarities in size, shape, coloration, and general lack of conspicuous conchological characters. Generally, species of *Bulimulus* have not been considered as of phytosanitary concern since, their numbers have been relatively low, and thus far it has been thought that they do not directly consume the various agricultural products and native vegetation; instead, they are thought to feed on algal/bacterial films on plants and other surfaces. Despite difficulties with taxonomic issues among various similar species, in the last decade, new information suggests that the South American *Bulimulus* cf. *sporadicus*, may become an agricultural pest, at least at some localities. Records in the U.S.A., by state and federal agencies, and citizen science observations suggest that it can become locally very abundant, potentially causing as yet unknown environmental effects. In addition, the extent of the area where they now occur in the U.S.A. has continued to increase, expanding from several apparent introduction sites in the southern U.S.A. Finally, by their sheer numbers at certain locations, they could become an impediment to agricultural practices and affect crops. Additionally there may be ecological effects that are in need of assessment.

Doridina: an RNA-Seq Analysis

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Nudibranchia is a diverse group of sea slugs characterized by the lack of a protective shell which is lost in in their adult stage. This has promoted the evolution of many different defense mechanisms within Nudibranchia including crypsis, mimicry, and even the ingestion and incorporation of cnidocytes from their cnidarian prey as is seen in the Aeolids (Goodheart & Bely, 2017). Doridina is

the most diverse clade within Nudibranchia having approximately 2000 described species. Members of Doridina are characterized by having a branchial plume at the dorsal end of their mantle and are well documented for having diverse array of secondary metabolite based chemical defenses (Faulkner & Ghiselin, 1983). As fascinating as Doridina is, its phylogeny is not yet fully understood due to a lack of resolution. Sanger sequencing has proven to be an invaluable source for phylogenetic inference; however, it results in relatively short datasets making it sufficient for small-scale analyses. Next generation sequencing provides a more cost efficient method for producing larger datasets and has been successfully applied to the sister clade, Cladobranchia, yet there have been no major phylogenetic reconstructions of Doridina using NGS. Hallas et al. (2017) found that when reconstructing the phylogeny based on four molecular markers (16S, 18S, 28S, and CO1), shallow nodes, at the familial or generic level, were resolved whereas more basal nodes showed a lack of support. In hopes of gaining insight on this fascinating group of sea slugs, this study aims at resolving Doridina using RNA-Sequencing data.

Marginellidae & Cystiscidae from South Madagascar

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In 2010, a biodiversity expedition to South Madagascar was conducted as part of Our Planet Reviewed and Tropical Deep-Sea Benthos programs. The expedition included both a middle-shelf and deep-sea sampling, from the shore to a depth of 991 m (425 stations).

To date, 32 species of the families Marginellidae and Cystiscidae had been recorded from the island of Madagascar. During the ATIMO VATAE expedition, 3196 specimens belonging to 71 species (54 potentially new) and 18 genera were collected from 160 stations (37.4%), at depths between 0 to 624 m. The Family Cystiscidae is best represented, with 37 species (52%) and 1928 specimens (60.3%). Four species, *Persicula shepstonensis* (E. A. Smith, 1906) (462), *Granulina* sp. (346) *Gibberula elisae* Bozzetti & Cossignani, 2009 (305), and *Gibberula lalaina* Bozzetti, 2012 (203) make up 41 % of the catch; 26 species (36.6 %) were represented by 5 or fewer specimens, and 15 (21,1 %) are singletons or doubletons. Fifty-four species are new or possibly new to science. In this presentation, we study the distribution of the species and the proportion of endemic species for both families.

A new light in integrative taxonomy: the use of UV and deep blue light in species delimitation

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To date, marine biodiversity research has been mainly driven by what we can see with our eyes. However, there are lights invisible to the human eye within the electromagnetic spectrum that can be potentially perceived by marine organisms. Thus, to get a wider view on marine life, we must use new kinds of lights.

UV light-induced fluorescence is a rather common phenomenon in the world´s ocean fauna, with an increasing number of fluorescent taxa being discovered every year. Nevertheless, the function of fluorescence is still very little understood. Some cnidarians use it as a protection against UV light, but there are many examples of fluorescent cnidarians in the dark deep sea, for which the biological function (if any) has yet to be determined. Fluorescent pigments might also serve as recognition signals: in the mantis shrimps, for instance, the fluorescent spots on their claws are extremely important for intra-specific communication. This communication function has also been proven for some terrestrial fluorescent spiders and birds.

In this presentation, we present a study case in which UV light is used to induce fluorescence in two cryptic sea slug species from Venezuela, and the usefulness of fluorescence for species delimitation has been tested using morphological and molecular tools in an integrative approach.

The Temple and the Forum revisited: shells in natural history museums

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Displays of shells have long been found in natural history museums everywhere. Their general familiarity as a quotidian class of thing – “snails” and “clams” – makes their larger and more unusual variants all the more impressive by contrast. Their bright and durable colors and intricate sculpture mean that they need little preparation for exhibition beyond cleaning and posing, and their vast morphological variety centered around a relatively small number of common forms is rivaled by few other groups in nature.

The Temple and the Forum are two models of the science museum as a public venue that draw parallels with the institutions of ancient Rome. They were developed by Harrison (2007) and others and expanded with the addition of the Circus by Tresch (2017). Exhibitions of shells may embody both models by stimulating visitors’ fascination with their diversity of form and lifestyle while at the same time being used to present inherently political issues such as habitat destruction and climate change. Shells also act as “boundary objects” linking communities of interest such as archaeology, ethnology and the decorative arts.

Mollusks are viewed with general favor by the public and are distributed worldwide in all habitats, which suits them to be the focus of dedicated shell museums that can link collections and schemes of classification to contemporary environmental concerns and amateur nature study through field studies and outreach programs.

Although the collection of certain natural objects as a hobby is thought to be declining, the trade in specimen shells seems as healthy as ever and many dealers continue to play the same amateur-scientist roles as their Victorian forebears.

This talk introduces two shell museums from the first decades of the 20th century – the Hirase Conchological Museum in Kyoto, Japan and the Maiko Shell Museum in nearby Ashiya.
Particular focus is placed on the roles outreach efforts and publications played in the development of the museums.

New light on lampmussels: is *hydiana* hiding in Illinois?

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The lampmussels and fatmuckets are a group of unionids currently assigned to the genus *Lampsilis*, ranging across eastern North America. Although previous work recognized only *L. siliquoidea* in the upper Mississippi and the Ohio drainages (not counting *L. virescens* in the Tennessee River system), morphological variation among specimens from Illinois led to the suspicion that an additional species might be present. Preliminary genetic data showed significant genetic differentiation between populations from Illinois. *Lampsilis hydiana*, known to range from the type locality in Louisiana north to Arkansas and west to Texas, seemed the most likely identification of the additional specimens. We now add comparative data for several additional species across the range of the group, including *L. hydiana* specimens from Louisiana and Texas, as well as *L. virescens* and *L. straminea* from the Mobile basin and published data for *L. radiata* from Atlantic drainages. One group of mussels from Illinois genetically matches *L. hydiana* from Texas and Louisiana, and the others are *L. siliquoidea*. The two are not sister taxa, with *L. straminea* being the closest relative sampled for *L. hydiana* and *L. radiata* the closest to *L. siliquoidea*. *Lampsilis hydiana* predominates towards the south and west (Kaskaskia River and further south) relative to the range of *L. siliquoidea* in Illinois; the two species overlap in a few Ohio River tributaries.

The type of *Lampsilis*, *L. ovata*, belongs to the group of pocketbook mussels, with taller, more broadly rounded shells, in contrast to the relatively more elongate lampmussels. Like the muckets, which fall into *Ortmanniana,* and the sandshells, in *Simpsonunio*, the lampmussels and fatmuckets do not seem to be sister taxa to true *Lampsilis*. More sampling of the western "*Lampsilis"* species (Ozark region south to Texas) such as *L. bracteata*, *L. brittsi*, *L. powelli*, *L. rafinesqueana*, *L. reeveiana*, and *L. streckeri*, is needed to confirm their identities and affinities.

Biological control of the invasive conical snail *Cochlicella acuta* in Australia

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Four introduced terrestrial snail species have major impacts on crops in southern Australia; the round snails *Cernuella virgata* (vineyard snail) and *Theba pisana* (white Italian snail), and the conical snails

Cochlicella acuta (pointed snail) and *Prietocella barbara* (small pointed snail). All four species can cause severe economic impact by contaminating grains at harvest. Due to the impacts of snails and limited control alternative available, biological control was investigated in 1990s. Few potential biological control agents were identified. Only one was promising and passed host-specificity testing. A fly parasitoid *Sarcophaga villeneuveana* was introduced to control *C. acuta* in the early 2000s. While it established successfully, parasitisation rates have remained low. Recent molecular work on *C. acuta* shows that there is a mismatch between the origin of the Australian snails and the introduced parasitoid, which could explain its low success. The Australian *C. acuta* are more closely associated with Spain, Portugal and Morocco, while *S. villeneuveana* originates from southern France, where a different snail genetic cluster was found. Molecular work on *S. villeneuveana* has not, as yet, demonstrated a clear geographical pattern amongst haplotypes of this species. Further work is currently underway to assess the efficacy of flies from different regions on Australian *C. acuta*.

Gut Microbiome Analysis of the Rocky Mountainsail *Oreohelix strigosa* from Museum Collections

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Oreohelix strigosa (the Rocky Mountainsnail) is a land snail found in the talus slopes of the Rocky Mountains. The University of Colorado's Natural History Museum has densely sampled *Oreohelix* for the past century, many are preserved in ethanol for molecular research. While microbiome compositions are not affected by short-term field season preservation, the effects of decades-long preservation have yet to be studied. In order to accurately assess microbial compositions of museum samples, we first need to ensure gut microbiome degradation is minimal after ethanol preservation. The primary goals of this experiment were, first, to use museum specimens to create a comprehensive assessment on the effects of long-term ethanol preservation on museum specimen microbiome compositions; and second, to quantify any present microbial associations within the gut of the Rocky Mountainsnail. I extracted DNA from museum samples from varying Coloradan counties, ranging in preservation time from 14-16 years. Gut bacterial DNA was sequenced using Next-Generation Sequencing, to determine abundance and diversity of the microbiome. This research will be continued to create a comprehensive timeline of snail microbiome compositions. This may aid in future research regarding the effects of climate change and land use change on Rocky Mountainsnail health in the Front Range.

Ancient Aliens: The Globally Invasive Aquatic Snails *Melanoides tuberculata* (Müller, 1774) and *Tarebia granifera* (Lamarck, 1816) in Prehistoric Polynesia

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From about 2800 to 700 years ago the islands of Polynesia were settled by long-distance voyages of the Pacific islanders. These voyagers intentionally transported an assemblage of economically valuable plants and animals to their new island homes; various commensal species were translocated inadvertently. Previous studies have demonstrated that about ten species of terrestrial snails were among these inadvertently translocated commensals; species of Placostylidae and Partulidae are believed to have been intentionally translocated. *Melanoides tuberculata* and *Tarebia granifera* are globally invasive aquatic snails that are native to (at least) Africa, South Asia, and Indonesia (*M. tuberculata*) and Indonesia (*T. granifera*). Both species are now widely distributed in the islands of Oceania and are actively expanding their ranges elsewhere. The chronology of their arrival in Polynesia has been a matter of uncertainty, and some have suggested that they entered the region prior to the advent of European influence in the 16th century AD; others have assumed that they are instead post-contact introductions. *M. tuberculata* has recently been shown to have occurred in the Cook Islands during the prehistoric period, and we now report archaeological studies demonstrating the prehistoric presence of *M. tuberculata* in the Society Islands of French Polynesia and of *M. tuberculata* and *T. granifera* in the Hawaiian Islands. It is not yet possible to exclude the possibility that one or both of these species may be native to the region, but the most likely conclusion is that they are anthropochores inadvertently translocated into and throughout the region prehistorically.

Climate and population history shape variation in drilling behavior in intertidal dogwhelks

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Trait variation structures ecological dynamics, and while varying abiotic factors like temperature can increase trait variation, population history can constrain it. In marine systems, seawater temperature, pH, and productivity can drive intraspecific trait variation, which can lead to regional trait differences that affect species interactions. In rocky intertidal zones of western North America, *Nucella* dogwhelks are predators of bed-forming mussels. Dogwhelks have low dispersal and are known to exhibit local adaptation to abiotic and biotic conditions. Dogwhelks also show selectivity for prey, but it is not known how environmental factors or genetic relatedness contribute to this selectivity. We conducted an observational study across eight intertidal sites in Oregon and California to determine if environmental conditions and genetic relatedness shape drilling preferences. At each site we measured the length of dogwhelk-drilled mussels and related this to measurements of temperature, pH, and chlorophyll-a. Dogwhelks were sequenced at COI to examine genetic relationships. Results

show the mean length of drilled and available mussels and the standard deviation of sizes drilled varies among sites. A multiple regression model shows that higher and more stable temperature and pH are positively correlated with mussel size drilled, and more so with increasing chlorophyll-a. The standard deviation of drilled mussel size is negatively correlated with chlorophyll-a concentration. Dogwhelk size selectivity was genetically autocorrelated, indicating that some aspects of drilling are conserved among populations. These results show that both climate and evolutionary history shape drilling behavior, creating a mosaic of predator-prey interactions across an environmental gradient.

The Freshwater Mussels of México (Unionidae & Mycetopodidae)

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Mesoamerica is a global hotspot of freshwater mussel (Unionida) diversity. However, the mussel fauna of Central America and México is poorly known and is badly in need of revision. The last comprehensive treatments of the fauna were made by Fischer & Crosse (1870-1902) and von Martens (1890-1901). Frierson (1927) provided a checklist of species from México and placed many of the species in the genera of Crosse & Fischer without comment. The Mussel Project (MUSSELp, 2018) currently lists 75 species from México as valid. We conducted fieldwork in the Río Pánuco in San Luis Potosí, and the Río Conchos (Río Grande del Norte basin in Chihuahua) and examined 1393 total lots (including types) from 16 museum collections collected from México and the Grijalva - Usumacinta basin of México and Guatemala. As a result, we now recognize 58 species of freshwater mussels (51 Unionidae and 7 Mycetopodidae) from México and boundary waters as valid. The basins with the greatest species richness are the Pánuco (14), Grande del Norte (17), and Usumacinta (20). Historically, members of the Unionidae in Central America have been classified with the Nearctic lineages, especially the Ambleminae. Mycetopodids are otherwise endemic to South America (Ortmann, 1921; Frierson, 1927). With the exception of a few species, the Mesoamerican assemblage is distinct from that of North America (only 9 species are shared between them) and consists of a large number of endemic species, making it a transition zone between Nearctic and Neotropic faunas.

Parasite-host dynamics of the invasive freshwater snail, *Viviparus georgianus* from the Adirondack region of New York

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The banded mystery snail, *Viviparus georgianus* (Lea, 1834) is an invasive freshwater mollusc of the northeastern United States, where it has become the dominant gastropod in many lakes and rivers of upstate New York (NY). Despite a series of taxonomic studies carried out in the early 1990s on molluscs in this region, *V. georgianus* was never genetically confirmed in NY and its invasive potential had never approached that of the notorious zebra and quagga mussels. In this study, we report a new population of *V. georgianus* from the Adirondack region of northern NY and genetically confirm its identity for the first time. We also report and quantify a digenetic trematode infection (*Echinostoma* sp.)

for the first time in this species. Approximately 500 snails were collected from May – August 2016, and cercarial shedding was used to quantify parasite load. Overall prevalence was 66.7% and overall mean intensity was 9.4. Interestingly, gravid females appeared to have overall higher parasite load than both non-gravid females and males (overall prevalence = 81.8%, mean intensity = 21.5) while gravid females also showed a strong relationship of decreased fecundity with increased trematode intensity ($R^2 = 0.81$).

Finally, we present an argument for Parasite Induced Trophic Transmission (PITT) in this parasite-host system which involves complex migration patterns of *V. georgianus* from deeper to shallower waters, that coincides with the arrival of Canada geese from southern Ontario into the Adirondack region. These results will then be used to explain the low invasion potential of this mollusc in NY.

Global connectivity patterns of the notoriously invasive mussel, *Mytilus galloprovincialis* Lmk using archived CO1 sequence data.

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The notoriously invasive mussel, *Mytilus galloprovincialis* has established invasive populations across the globe, and in some regions, have completely displaced native mussels through competitive exclusion. The objective of this study was to elucidate global connectivity patterns of *M. galloprovincialis* using a big data approach. Through exhaustive mining of sequence data from public databases (GenBank, EMBL, DNA Databank of Japan, Barcode of Life) and the development of a systematic workflow, we assembled the most comprehensive global CO1 dataset for *M. galloprovincialis* thus far, consisting of 209 sequences representing 14 populations. Haplotype networks were constructed and genetic differentiation was assessed using pairwise Analysis of Molecular Variance (AMOVA). The results showed significant genetic structuring across populations with marked geographic patterning of haplotypes. In particular, South Korea, South China, Turkey and Australasia appear to be the most genetically isolated populations. We were also unable to recover a northern and southern Hemisphere clade of *M. galloprovincialis* as was found in previous studies. These results suggest a complex pattern of dispersal for *M. galloprovincialis*, driven by several factors including both natural and anthropogenic dispersal mechanisms along with potential hybridization events.

Body asymmetry and the making of a 'shellebrity'

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While components of the pathway that establishes left-right asymmetry (chirality) have been identified in diverse animals, it is striking that the genes involved in the first symmetry-breaking step have long remained unknown in the most obviously chiral animals, the gastropod snails. Finally, in early 2016 we reported that we had identified a gene that determines pond snail asymmetry and shell coiling direction, and that the same gene may have a similar function in setting up the left and right side of vertebrate bodies. While this work featured in the scientific press, we were disappointed that the finding did not impact much upon the wider public. I could have left it there, but in late 2016 I acquired a rare sinistral ('lefty') garden snail that came to be known as 'Jeremy'. To study the inheritance of chirality in this snail, I needed to find another lefty mate (lefty snails have their genitals on the opposite side, and so are generally unable to mate with right-coiling snails). By launching a citizen science campaign to find a mate for as Jeremy, the story and the science reached an estimated audience of more than 1.8 billion, via 1000+ media articles over a year-long news story. In

this talk, I will introduce the science of asymmetry, how the citizen science campaign to find a mate for Jeremy inadvertently created a 'shellebrity' snail, and what the study of snail shell coiling can tell us about our own bodies (but not our genitals).

Redefining the *Cepaea nemoralis* colour polymorphism

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In the land snail *Cepaea nemoralis*, one of the most thoroughly investigated colour polymorphic species, biologists have long tried to describe and name the different varieties that make up the various shell forms. Traditionally, the view is that the ground colour of the shell can be one of three major colour classes, either yellow, pink or brown. However, it is frequently difficult to distinguish the different colours, and consistently define different shades of the same colour.

This creates a specific practical problem in terms of collecting and using the shell polymorphism data, and a more general problem in not having a precise definition of the polymorphism. By measuring shell colour using a spectrophotometer, we used psychophysical models of colour vision to define the polymorphism and assess how chromatic differences are perceived by birds, the most important predators of *Cepaea*. The main finding is that colour variation is continuously distributed in colour space; there are no wholly discrete colours, with the major axis of variation among individuals representing variation in saturation, or purity of colour. In this talk, I will put these findings in context, alongside progress in understanding frequency-dependent selection and the evolution of the supergene that determines the major phenotypic differences in shell type.

Convergent evolution of herbivory in columbellid gastropods (Gastropoda: Neogastropoda)

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The neogastropod family Columbellidae is a highly successful group of small epibenthic marine snails distributed in temperate to tropical waters worldwide. While the Neogastropoda is well known as a carnivorous lineage, some columbellid taxa have reverted to a diet that includes substantial amounts of algae. The classification of the family Columbellidae has been based for many years to a large degree on the morphology of the shell and radula. Indeed, membership in the family is traditionally confirmed using the unique morphology of the radula. Inasmuch that these herbivorous taxa have similar radulae, they have been considered to be closely related in one major subfamily. To reconstruct columbellid phylogeny, we assembled a data set including five mitochondrial and nuclear gene markers, for over 80 species in 25 genera and representative outgroups from most buccinoidean families and rooted with Muricidae. Contrary to the prevailing view, the resulting trees indicate that herbivory may have evolved two or more times in columbellids, in both major clades of the family. Coincidentally, it is apparent that the larger size and strap-like morphology of the lateral radular teeth in herbivores arose convergently, and other features of radular morphology are likely to be similarly homoplastic. In addition, the generic and subfamilial classification of the family is in need of extensive revision.

Behavioral and Metabolomic Analysis of Aposematic Coloration in Limid Bivalves

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Members of the marine bivalve family Limidae (d'Orbigny, 1846) are popular in aquaria and known for their bright appearance. In this study, their carotenoid-based coloration was examined to determine if it is noxious to predators. The 'disco' clam *Ctenoides ales* opened to expose its brightly colored tissue during more than half of attacks by the peacock mantis shrimp predator, *Odontodactylus scyllarus*. The mantis shrimp predator entered a catatonic state and exhibited mouthpart cleaning after coming in contact with the disco clam's external, brightly colored tissues. When given a choice of two disco clam tissues to consume, the mantis shrimp predator chose the internal, non-colorful tissues significantly more often than the external, colorful tissues. When given a choice of external tissues from the disco clam and the non-limid Manila clam *Venerupis philippinarum*, the mantis shrimp predator chose the Manila clam external tissue significantly more often. Metabolomic analysis confirmed that disco clam tissues (and those of the congener *C. scaber*) that were pre-identified as noxious had significantly different chemical compositions than the tissues pre-identified as non-noxious. The internal, non-colorful tissue (preferred by the mantis shrimp predator) had metabolite profiles more similar to outgroup bivalve families than to the species' own colorful external tissue (avoided by the mantis shrimp predator). The most significant compounds of interest included peptides, many of which have been found to be bioactive in other marine species. Ongoing research targeting these peptides will determine their potential as defensive compounds underlying aposematism.

Niche breadth and phenotypic variation: dietary expansion and diversity of venom components of *Conus miliaris* at Easter Island

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Populations with expanded niche breadths are expected to exhibit greater phenotypic variation than populations with narrow niche breadths. Members of the marine gastropod family Conidae ('cone snails') tend to show specializations for different prey items and exhibit intraspecific variation in prey

utilization patterns at geographic scales. For example, *Conus miliaris* preys on a much greater diversity of polychaete species at Easter Island than at other locations in the Indo-West Pacific. Because cone snails utilize venom to capture prey and venom components are direct gene products, it is feasible to examine the evolution of genes that are associated with changes in resource utilization. Here we compared venom duct transcriptomes of individuals from Easter Island and two populations that exhibit a narrower niche breadth (Guam and America Samoa) to determine if the expanded niche breadth at Easter Island is associated with an increased diversity of venom components as well as the source(s) of the increased diversity. Although the three populations do not differ in levels of variation of venom gene expression patterns, the population at Easter Island exhibits higher levels of genetic diversity at venom-related genes than do the other populations. These results imply that increased structural and not regulatory diversity of genes is associated with increases in phenotypic variation due to expansions in niche breadth.

First phylogeny for the radiation of California's diverse endemic shoulderband land snails (Gastropoda: Helminthoglyptidae)

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The endemic species radiation of shoulderband snails of the helicoid land snail family, Helminthoglyptidae Pilsbry, 1939, has been especially impressive in California, where approximately 110 species are recognized. Their shells and anatomy were treated in the monumental 1939 monograph for terrestrial North American mollusks north of Mexico by Henry A. Pilsbry, but few of these species or subspecies have been treated since then, and molecular studies have only just begun. They are widely distributed in California's varied coastal, mountain, and desert habitats, usually with a highly restricted geographic range, reflecting isolation within patchy suitable habitat and barriers to dispersal. The few specialists who are trained to identify them using shell and reproductive anatomical characters emphasized by Pilsbry and others, have warned that anthropogenic habitat destruction and species introductions are already posing an escalating threat to California's land snail fauna. Our integration of DNA sequence analysis with dissections has produced enticing results and led to the California Helminthoglyptidae Project (CHP) working group, but we are still at an early stage of collaborative study. Our goals are as follows: 1) document species that are still present, either thriving or imperiled; 2) assess their distribution compared to historical records; 3) provide selected mitochondrial and nuclear gene region sequences of representative material for each species or subspecies; 4) use these sequences to conduct phylogenetic analyses and; 5) record DNA barcodes of expert-identified specimen vouchers. Here we present a preliminary multi- gene (16S, COI, ITS2) phylogeny of mostly southern and some central California Helminthoglyptidae.

Hawaii's only recognized species of *Siphonaria* is instead four separate clades

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In Hawai'i, the bitter tasting 'opihi 'awa or false 'opihi resemble true limpets ('opihi) but are instead eupulmonate gastropods known as siphon limpets (Siphonariidae). Native Hawaiians avoided eating siphon limpets but still used them for medicine or sorcery. Early workers proposed several variety names but more recent authors have treated all Hawiian *Siphonaria* as a single variable species, *Siphonaria normalis* Gould 1846. This same name has been used for similar appearing *Siphonaria* on other islands in the Central Pacific. It was thus a surprise result of our ongoing mitochondrial 16S and COI sequencing and conchological survey of *Siphonaria* from across the main Hawiian islands to find that Hawaiian *Siphonaria* are comprised of at least four independent clades. Our phylogenetic analysis includes all the Siphonariidae sequences now available for much of the more southern and western tropical Pacific, and also new sequences from throughout the Eastern Pacific (DJE, unpublished). Three of the Hawaiian lineages have sequences similar to other parts of the Pacific, implying that they have widespread planktonic dispersal. In contrast, the fourth and most interesting clade is likely an endemic radiation within Hawai'i, with rather dramatic sequence differences between even proximal localities. We have provisionally interpreted the observed sequence variation as reflecting phylogeographic structure across Hawaiian localities, but it might instead be interpreted as a cryptic species complex. The extent of sequence differences suggests that these siphon limpets lack a planktonic larval stage, and represents a Hawaiian endemic species radiation in parallel with better-studied Hawaiian endemic taxa.

Pseudocryptic speciation of two *Hermissenda* sea slug species

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A recent study characterized the common and charismatic species *Hermissenda crassicornis* as a species complex of three distinct species. *Hermissenda crassicornis* and *H. opalescens* are two pseudocryptic sister species that occur in the eastern Pacific with overlapping ranges in Northern California and possibly as north as British Columbia. These species are considered to be pseudocryptic because they could only be distinguished morphologically once sequence data became available. In this study, we conduct comprehensive surveys along the California coast to investigate the extent of the range overlap. Additionally, we examine molecular and ecological differences between *H. crassicornis* and *H. opalescens* to explore the mechanism of speciation between these two sympatric taxa, as well as the processes maintaining reproductive isolation in their range overlap. Specifically, we investigate whether the range overlap is the result of ecological speciation or secondary contact after allopatric speciation. So far, fragments of the mitochondrial gene COI were sequenced to confirm species identification. Mating preference experiments showed that both *H. crassicornis* and *H. opalescens* display assortative mating within species, which suggests the existence of a pre-zygotic barrier between the two species. In order to further investigate the pre-zygotic barrier and its relationship to the mechanism of speciation between *H. crassicornis* and *H. opalescens* we will identify polymorphic sites using restriction site-associated DNA sequencing (RADseq). Specimens from the entire range of the two species will be sequenced to investigate the levels of differentiation in their genomes as well as their population structure. Field surveys will also be conducted to characterize the niche of each species and investigate the possibility of ecological

character displacement. Species of *Hermissenda* are important model organisms in neuroscience and other fields. Therefore, understanding the recent evolution of this group has broader impacts in other areas of science.

2018 Conservation Status of Guam's Partulid Snails

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Guam's three extant, native tree snail species (*Partula gibba*, *P. radiolata* and *Samoana fragilis*) were placed on the US endangered species list in 2015. Prior to listing, there were nearly 20 known populations of *P. radiolata*, two of *S. fragilis*, and one of *P. gibba* on Guam. Today, after extensive survey efforts and tips from colleagues, we've identified more than 60 populations of *P. radiolata*, five of *S. fragilis*, but still only one population of *P. gibba*. The Guam endemic, *P. radiolata*, is more numerous than originally thought; although some populations consist of only a handful of individuals, several number in the hundreds or higher, and it occurs broadly across the island. The other two species are at higher risk of extirpation. *S. fragilis* has always been regarded as uncommon; today its five populations are geographically dispersed and relatively small, from 30 to just over a hundred individuals. The only population of *P. gibba* (~100 individuals) has shifted from a coastal strand forest at Haputo, to an adjacent hillside to the southwest. Historically, *P. gibba* far outnumbered *P. radiolata* across Guam, yet now the tables are reversed. Among the usual suspects, Manokwari flatworms and habitat degradation by ungulates may be overshadowed by plans to clear large swaths of prime coastal habitat for hotel complexes and the specter of super typhoons. Ideas for the direction of future research and conservation efforts will be presented, including changing the public discourse on species that are not inherently regarded as charismatic megafauna.

Phylogenetic species delimitation for the mud whelk of genus *Phrontis* (Nassariidae)

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A collection of nassariids from numerous localities, habitats and depth have been gathered in the Muséum national d'Histoire naturelle in Paris. In this review, the mud whelk species previously named "*Nassarius*" from the Tropical West Atlantic and the Tropical East Pacific (Panamic and Caribbean regions) are treated. Traditional monographs on molluscs recognized as valid between 6 to 12 Caribbean species of "*Nassarius*". We sequenced a fragment of the mitochondrial COI and the 28S rRNA genes of all available species of the clade, now accepted as *Phrontis*. The former *Ilyanassa* (now *Tritia*) from the West USA coast is used as outgroup. Automatic barcode gap discovery and reciprocal monophyly were applied to propose species delimitation hypotheses. Morphological and/or molecular analyses have revealed 21 *Phrontis* lineages, showing extraordinary shell similarity. The tree resulted in recovering several species complexes, such as "*Nassarius corpulentus*", "*Nassarius albus*", "*Nassarius polygonatus"* among others. The results clearly show that the specific diversity of Nassariidae has been underestimated. If all the COI lineages are

confirmed as Secondary Species Hypothesis, their description as new species would mean a remarkable increase in the species richness of Nassariidae from the Caribbean. During this study no case of poecilogony (planktotrophic and non-planktotrophic larval development within a single species) was found. The multispiral or paucispiral protoconch revealed to be conserved character within clades.

Predatory snails and worms in the Pacific

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The roles of the predatory *Euglandina* snails and the flatworm *Platydemus manokwari* as the main drivers of extinction of Pacific Island tree snails are discussed, based on current field-data and ecological studies. Historically, *Euglandina* have been the main predators but have declined in most island groups, on many islands they appear to be extinct but in others small populations remain, with occasional brief population explosions. *Platydemus* has been implicated in the decline in some *Euglandina* populations, but not all. The flatworm species is currently spreading rapidly within and between island groups. As with the early stages of *Euglandina* introductions, the impacts of *Platydemus* are severe and this spread is a cause for concern. The distribution of both species and their range of impacts may be explained by local climatic factors, an aspect which needs more information. The importance of other invasive flatworms and the ribbon worm *Geonemertes pelaensis* are discussed.

Comparative morphology and evolution of the cnidosac in Cladobranchia (Gastropoda: Heterobranchia: Nudibranchia)

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Shell-less gastropods are known to use multiple defensive mechanisms, including internally generated or externally obtained biochemically active compounds and structures. Within Nudipleura, a group of nudibranchs called Cladobranchia possess such a defense: the ability to sequester cnidarian nematocysts. This ability is distributed across ~600 species within Cladobranchia, and many questions still remain in regards to the comparative morphology and evolution of the structure that houses the nematocysts, called the cnidosac. To address this gap, we used histological techniques to describe the cnidosac morphology across many groups in Cladobranchia, and place this variability in a phylogenetic context to better understand the evolution of nematocyst sequestration within this group. Overall, we find that the structure of the cnidosac can vary more than expected based on previous work, but there are few clear evolutionary patterns in relation to this

variation. The sequestration of nematocysts has originated twice within Cladobranchia based on the phylogeny presented here (within Hancockiidae and Aeolidida), but low support for long branches at the base of Aeolidida results in low confidence in the reconstruction of this evolutionary origin. Additionally, the presence of a sac at the distal end of the digestive gland may have originated prior to that of the sequestration of nematocysts, although this result relies on the assumption that the terminal sacs found in related taxa are homologous to the sacs found in Aeolidida. This study provides a more complete picture of the evolution of morphological characters among nematocyst sequestering taxa in Cladobranchia and provides a starting point for comparative studies with other nematocyst sequestering groups.

Reading between the lines: Revealing cryptic species diversity and colour patterns in *Hypselodoris* nudibranchs (Mollusca: Heterobranchia: Chromodorididae)

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A molecular phylogeny is presented for 64 new sequences of the genus *Hypselodoris* (Family: Chromodorididae). *Hypselodoris* is monophyletic and divided into clades that exhibit varying support. Novel diversity was found, with the distinctness of 17 new species of *Hypselodoris* supported by the molecular phylogeny, subsequent species delimitation analysis and morphological data. Colour pattern evolution has been shown to have strongly convergent patterns between representatives of different genera (Rudman, 1991; Gosliner, 2000). The present study also indicates that sympatric species of *Hypselodoris* often have convergent colour patterns between representatives of different clades. This is likely due to Müllerian mimicry complexes in these strongly chemically defended, distasteful, and brightly coloured species. With only a couple of exceptions, most species of *Hypselodoris* studied here display limited polymorphism in colour pattern and each species has divergent colour patterns with closely related species that provide important species identification tools for differentiating species. The three major clades of *Hypselodoris* found here all appear to have a widely distributed ancestor in the Indo-Pacific. In the case of the *H. bullockii* clade, the radiation has been restricted largely to the western Pacific and the eastern margin of the Indian Ocean and appears to be absent from the western Indian Ocean. The remaining clades have a widespread Indo-Pacific ancestor and have members with wide distributions as well as more restricted regional endemics. In many cases, sister species have overlapping ranges and are partially sympatric, indicating likely dispersal following allopatric speciation.

Discordance between mitochondrial and nuclear DNA sequences used for species delimitation in intertidal slugs (Pulmonata: Onchidiidae)

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DNA barcoding efforts have greatly expanded in recent years as the utility of DNA barcodes in accelerating species discovery has been recognized. The application of DNA barcoding to systematics has led to a greater understanding of species diversity in groups with limited morphological differences, and has led to the discovery of numerous cryptic or pseudocryptic species. This has certainly been the case in the Onchidiidae, in which comprehensive sampling and DNA sequencing have been invaluable in delimiting both species and genera, in what was previously a family in which few species could be identified. One of the frequently cited problems in delimiting species using DNA barcodes is that there is not always a "barcode gap" between intraspecific and interspecific genetic divergences. Even when a barcode gap is apparent, species delimitation based on mitochondrial DNA should still be evaluated with other lines of evidence (i.e., anatomy, and when this is inconclusive, other data such as nuclear DNA). DNA sequencing has revealed most onchidiid species are broadly distributed in the Indo- West Pacific, and that a large barcode gap exists between most molecular units. The presence of deeply divergent mitochondrial clades (COI, 16S) which cannot be differentiated with anatomy suggests that there could be cryptic species of onchidiids. However, species delimitation based on nuclear (ITS2, 28S) DNA sequences revealed mito-nuclear discordance in multiple genera. Patterns of mito-nuclear discordance differed between onchidiid genera and are discussed in relation to anatomy and biogeography.

Molecular systematics of the Hawaiian Pacificellinae (Stylommatophora: Achatinellidae)

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Land snails are extraordinarily diverse across the Pacific islands, but this diversity has also been devastated by habitat destruction and introduced non-native species. In the Hawaiian Islands, the majority of land snails are endemic, many to a single island. Like land snails across the Pacific, most are highly threatened, with a large proportion of species considered extinct or critically endangered. However, recent surveys of the Hawaiian land snails have revealed that some species previously believed to be extinct are persisting, and that there is still hope for saving some of the gastropod diversity in Hawaii. Microsnails are important to functioning ecosystems, but current knowledge of microsnail diversity across the Hawaiian Islands is limited, as most species are known only from their shells. The Pacificellinae is an Achatinellidae subfamily with some species having multi-island distributions in Hawaiian, and other species occurring across other Pacific islands. There are ten nomenclaturally valid specific names and three valid subspecific names of Pacificellinae in the Hawaiian Islands, but these have not been evaluated with modern phylogenetic methods. In order to evaluate species diversity in the Pacificellinae and their dispersal across the Hawaiian Islands, we have sampled 7 *Lamellidea* and 1 *Pacificella* species/subspecies across the six largest main Hawaiian Islands and sequenced the COI, 16S, 28S, and H3/H4 regions. A preliminary molecular phylogeny of the family shows that *Pacificella baldwini* is monophyletic with other *Pacificella* species from across the Pacific, and *Lamellidea* and *Tornatellinops* form a monophyletic clade distinct from *Pacificella*. Currently, five Hawaiian *Lamellidea* species are consistently recovered as monophyletic, and additional DNA sequencing is planned to improve species delimitation.

Old shells, new insights: demography and genetics of one-tree populations of *Partulina redfieldi* on Molokai.

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Twenty years of mark-recapture field studies on populations of the Molokai-endemic tree snail *Partulina redfieldi* revealed significant growth in relatively young populations and evidence of genetic isolation from each other. During the study period, single populations increased as much as 6 fold, and regression analyses indicate population ages as low as 20 years. Each population was dominated by one or a few of the many color patterns observed in this polymorphic species, and they differed among trees. Analysis of demographic data revealed that some characters differed among the trees, especially size at birth, maximum shell size, growth rate and fecundity. Because these characteristics suggested that the populations were founded by few genetically different individuals, analyses were undertaken by extracting DNA from ground shells collected from beneath each tree at each visit to the location. We successfully examined four microsatellite markers for four trees, with the assumption that a single pioneer snail would introduce a maximum of two alleles per microsatellite locus. Resulting data across loci revealed a maximum of 7 – 13 alleles per locus in each tree, translating to four to seven founders. Although not singular, these numbers are low and may support the hypothesis that low numbers of founders with few alleles in common can lead, over time, to distinctive populations. If they remain separate over geological time spans, distinctive species will originate, and thus support the hypothesis of J. T. Gulick that the speciose Hawaiian tree snails evolved by vicariant speciation rather than natural selection.

Deconstructing an infamous extinction crisis: survival of three Moorean and Tahitian *Partula* genomic lineages

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An ill-advised biological control program led to the extirpation of 11 of 18 endemic Moorean and Tahitian *Partula* species. However, the conservation status of this critically endangered tree snail radiation is clouded by taxonomic uncertainty. Using museum, captive and remnant wild specimens, we obtained the first high-resolution genomic perspective of their evolutionary relationships and survival. Fourteen nominal species were encompassed within three phylogenomic lineages. Descriptions based on conchological and genital distinctions appear to have over-estimated the number of phylogenetically-discrete *Partula* species on these islands. Notably, our data indicate that all three lineages survive although the details vary in each case. Continued, proactive conservation and management may yet ensure a phylogenetically- representative survival of the fabled *Partula* species of Moorea and Tahiti.

Genomic analyses confirm a novel North American invasive clonal *Corbicula* lineage

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The genus *Corbicula* consists of moderately-sized freshwater clams native to the temperate/tropical regions of Asia, Africa, and Australia and contains some of the most common and successful aquatic invasive species. The genus has both sexual and asexual forms with the former restricted to Asia whereas the latter clones have invaded freshwater ecosystems in North and South America and Europe becoming a major aquatic pest. Three clonal morphotypes have been recognized in the New World– Forms A and B in North and South America, and C (South America). A putative fourth North American invasive *Corbicula* morph, Form D, was recently described in the Illinois River (Great Lakes watershed), where it occurs in sympatry with Forms A and B. Previous results showed Form D to be morphologically distinct possessing rust-colored rays and white nacre with purple teeth. However, its genetic distinctiveness using standard molecular markers was ambiguous. In light of these conflicting signals between morphological and genetic characters, we performed a phylogenomic analysis using 2,245 nuclear genomic loci collected via the next generation double digested restriction associated sequencing (ddRADseq) method. These comprehensive new results reveal Form D to be a distinct clonal lineage from sympatric Forms A and B and from South American Form C. Phylogenomic analyses recovered the four New World invasive *Corbicula* lineages as members of a highly-supported clonal clade, sister to the non-clonal Lake Biwa endemic, *C. sandai*. These results provide new insights into the origin of clonality in this highly complicated system.

A historical perspective on Oahu tree snail conservation

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I'm going to discuss how the entire endemic Oahu tree snail genus *Achatinella* wound up on the endangered species list in the early 1980's. So far, *Achatinella* is the only genus of animals so listed. The spectacular adaptive radiation of Hawaii's native land snail fauna is the result of time, isolation and habitat diversity. The 752-described species of land snails constitute a major portion of the archipelago's native terrestrial fauna. However, Hawaii has been in a long-term state of environmental crisis and many of these unique species have suffered serious decline and extinction. But unlike the high-profile attention paid to endangered Hawaiian birds, the snails have historically disappeared with relatively little fan-fare – until recently. From 1972 to 1978, I conducted an island-wide survey of Oahu with help from other local naturalists to determine the survival status of *Achatinella*. Of the 41-described species by Pilsbry & Cooke in 1912-1914, I located 19 extant species or a possible extinction rate over 50%. That number has since fluctuated. Today, the rate may be a staggering 75% to 80% despite the best efforts of dedicated professionals. After a 40-year hiatus, I've returned to Oahu to see some of the positive – and – negative changes that have occurred in the interim. To some in the 1970's, Hawaii had the dubious distinction of being called "the endangered species capital of the world." Today, that nickname has been replaced by the phrase "the extinction capital of the world."

Early warning indicators of collapse in one of the last "pristine" oyster habitats in North America

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The northeastern Gulf of Mexico is only region left in North America where the spatial extent and biomass of oysters has been stable or increasing since historic times, and it is widely regarded as a last opportunity to achieve sustainable oyster reef habitat. Baselines to assess habitat condition in this priority region, however, are temporally limited and may represent an already shifted reference state. Using an archaeological data archive (A.D. 65 – 1068) in Florida's Big Bend, a mostly undeveloped stretch of Gulf coastline, we find no trends in size during pre-European times despite intensive local use of oysters for food and building material over several centuries. However, oysters from the same sites today are substantially smaller in both mean and maximum shell lengths. Oxygen isotopes from the largest archaeological and modern oyster shells show similar first year growth patterns, but modern oysters decrease growth in subsequent years and suffer early mortality relative to pre-European baseline shells. Our results demonstrate that the last "pristine" oyster reefs in North America are significantly degraded and display a common early warning indicator of population collapse.

Genetic structure and geometric morphometrics of populations of *Ischnochiton erythronotus* in Mexican Caribbean and Gulf of Mexico

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The richness of chitons in coral reef between Mexican Caribbean and Gulf of Mexico is different even though these mollusks are adapted to coral environment. *Ischnochiton erythronotus* is one of the few recordings to both seas, in addition is an abundant species with morphological variability and previously it was proposed as synonym of *Ischnochiton striolatus* according to obtained COI results. We used geometric morphometrics to analyze the shape of mucro, scanning electron microscope and genetic markers: 28S, 16S and COI to analyze the genetic structure of populations in Mexican coral reef and to compare with *I. striolatus* reported data. Our data indicate that the populations in Mexican Caribbean and Yucatan Peninsula are different of the populations of Gulf of Mexico.

Loved to death: Leveraging our appetite for oysters on the half shell to resurrect reefs and revitalize coastal communities

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There is a complex and historical connection between humans and mollusks. Present in nearly every ecosystem in the world, mollusks have been important as a source of food, jewelry, tools, and currency for many thousands of years. My focus here is on the oyster. Once upon a time, most estuaries in North America contained native oyster reefs. Oysters were an abundant and ecologically important part of the fauna, and an important fishery for indigenous people. In the post-colonial United States, oysters were collected in massive quantities with as much as 160 million pounds of oyster meat harvested per year. Today, the majority of native oyster reefs have been lost. We loved our oysters to death. Now, there is great interest in getting them back. The mutual benefits oysters can play in improving degraded ecosystem health while reviving the economic vitality of coastal communities is recognized, and aquaculture may hold the key.
Unfortunately, the industry struggles with a reputation of poor past practices and significant regulatory challenges. We have historically governed marine activities, like aquaculture, through lenses that separate the science, policy, and people. These separate approaches are perpetuated by a fragmented ocean governance system. As we work towards a more integrated future, we continue to be faced by the seemingly unsurmountable challenge of climate change. These challenges will require a renewed attitude toward marine conservation and management, one that includes a values-based approach and holistically incorporates the human, natural, and policy dimensions of the puzzle.

Ecological Correlates and Phylogenetic Signal of Host Use in North American Unionid Mussels

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Mussels in the order Unionoida comprise ~75% of the world's freshwater bivalve species and briefly parasitize fish hosts. We investigated the parasitic relationships among species of North American unionid mussels and their known hosts to test ecological and evolutionary factors correlated with patterns of host use. 69 mussel species were chosen based on the availability of data regarding their fish host repertoires, their phylogenetic relationships, and their ecology.

Phylogenetic least squares regression models identified affinity for low-gradient and riffle habitats and colonization of post-glacial watersheds as the best predictors for number of fish host species per mussel. However, the second-best model identified the number of citations as a predictor of the number of hosts, implying that many mussel–host interactions still remain to be identified. A Multiple Regression Mantel test was performed to identify factors associated with the proportion of hosts shared between all pairs of mussel species. Multiple factors were significantly correlated with proportion of hosts shared, but the total amount of variation explained by the best model was low ($R^2 = 0.14$). There was evidence of topological association between mussels and their host fish ($P = 0.001$) and a significant phylogenetic signal of host specificity ($I = 0.81$, $P = 0.003$), indicating that closely related mussels that overlap in range are likely competing for hosts. Our results provide an initial framework for studying the evolution of host infection strategies but also highlight the large gaps still remaining in our fundamental ecological knowledge of this endangered clade.

Anomalies in the Field: Women Chasing their Molluscan Dreams

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Women have always been anomalies in science. A common streak of boldness and self- confidence, determination, preparedness, resilience, and fierce independence run through many of their stories. The ability to achieve in science is not the monopoly of any gender, race, or nation. Adversity can be an opportunity as well as an impediment. This symposium is a welcome opportunity to share several of my defiant adventures as a woman in malacology, geology and paleontology that have led to recognition and personal satisfaction. It also provides an opening to acknowledge some predecessors and pioneers who were in some way anomalous and especially good at it—notably Carlotta Joaquin Maury, Julia Gardner, Katherine van Winkle Palmer, Ellen Moore, and Myra Keen. And finally, it is chance for historical reflection on how the American Malacological Society and Western Society of Malacologists have been empowering forces for inclusion, not only of women but also other under-represented groups, by practicing malacology without borders. Unlike scientific disciplines that are constrained by factors such as equipment, techniques, questions, priorities, funding opportunities, and societal directives, malacology is relatively unlimited by anything other than its incredible taxonomic diversity and geological longevity. Many of us are happiest and most alive doing field work and observing living organisms, while others thrive on bench work, laboratory experiment, or mastery of a particular technology at a particular grade of organization. Field research and lab research may also go hand in hand. Dream large, and you can do it all.

Vital Roles of the Academic Natural History Museum

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The mission of the natural history museum varies considerably as to how and why collections are built, curated, and used. Most public museums balance behind-the-scenes collections and research with public exhibits and public engagement. Academic museums use collections primarily in research and in undergraduate and graduate instruction. Academic museums typically lack public exhibit space, membership, admission fees, or gift shops and have no public funding or revenue. Faculty, and student field research is important in building collections, and curatorial staff also engage in research and student training. Some prestigious academic institutions have been forced to close museums and send collections to public museums when budgetary support is withdrawn or collection space is needed for more pressing academic functions. Other academic museums have survived either by privatizing and raising their own endowments or because they originated as state collections, archiving state survey material on a university campus. The University of California Museum of Paleontology (UCMP) houses large and important fossil and recent malacology collections as part of the consortium of Berkeley Natural History Museums. Three examples highlight a vital role for academic malacology: (1) Curators of malacology in major public museums received graduate training and curatorial experience in UCMP; (2) Large collections supporting research specialties in the museum have been rescued (orphaned collections) or expeditiously purchased; and (3) the UC field stations, notably the Bodega Marine Laboratory and the Gump Research station in Moorea (French Polynesia) have trained thousands students in field sciences and independent specimen-based research vouchered in the Museum.

Shape variation of internal shell features in the Shining Ramshorn Snail, *Segmentina nitida*, integrating CT scanning and 2D geometric morphometrics

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The Shining Ramshorn Snail, *Segmentina nitida*, is a rare freshwater snail found predominantly in drainage ditches and marshland that is experiencing marked declines in distribution in the United Kingdom (UK) and mainland Europe. The species was included in the IUCN Red Data Book for Invertebrates pre-1994 before a guideline change and is included on the UK Biodiversity Action Plan as a priority species for conservation.

We assessed internal and external morphological variation in *S. nitida* populations from the UK, Germany, Sweden, and Poland using computerised tomography (CT). To analyse external morphology, we used a novel form of landmark-free geometric morphometrics, Generalised Procrustes Surface Analysis (GPSA) (Pomidor, Makedonska & Slice 2016). This form of analysis produces three-dimensional heat maps that highlight differences in shell morphology. We used GPSA to compare shell morphology of European *S. nitida* populations.

Segmentina nitida shells have internal thickenings, which were also recorded in the CT scans. We cropped and aligned these thickenings from 3D models of shells. Snapshots of the aligned thickenings were digitised using 2D landmarks. Relative warp scores were significantly different between UK and Polish snails. Discriminant Analysis and Canonical Variant Analysis (CVA) of the thickenings also revealed distinct groupings of populations within European countries, with some overlap between UK and German snails.

We discuss the possible functions and adaptive importance of the shell thickenings. We also discuss how these methods can be used on museum collections and to compare internal shell structures between and within species.

Behavioral and biochemical evidence for trail pheromones in Hawaiian tree snails

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The importance of pheromones in insect and mammal social systems is well-documented, but few studies have addressed the role of pheromones in land snail behavior. In this study we used a series of behavioral trials and direct analysis in real time mass spectrometry (MS) to test our hypothesis that tree snails use mucous trails in chemical communication. We worked with six endemic Hawaiian land snail species in four genera, three subfamilies and two families. We tested conspecific trail-following in five species, and trail-following occurred at a statistically significant frequency for each species tested (n = 181, P values ranged from <0.0001-0.0494). Percentage of conspecific trials that showed trail-following ranged from 66.7-94.1%.

Interspecific tests did not reveal trail following between species (n = 105, with P values of 0.0577-0.5000). Juvenile achatinelline tree snails did not follow trails of conspecific juveniles (n=30, P=0.5722) or adults (n =30, P=0.4278), nor did adults follow juvenile trails (n = 30, P=0.5722).

Comparative MS analysis of adult and juvenile trails showed distinct chemical signatures in the two groups. Signals corresponding to medium and long-chain fatty acids and other unidentified small molecules were present in adult but not juvenile trails. Considered together, these results support our hypotheses that trail following could serve an important social and possibly reproductive function. This discovery provides evidence for the presence of an ephemeral tree snail pheromone which could have important implications for the conservation of these increasingly rare and threatened species.

Citizen science in the Osaka Museum of Natural History, in collaboration with the Friends of the Museum

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Some natural history museums in Japan have organized 'Friends of the Museum' societies for citizens who want to study and enjoy natural history, fieldwork and collecting specimens. Such societies often play a core role in supporting citizen science at natural history museums. In the Osaka Museum of Natural History, the Friends of the Museum society was established in 1955 and currently has about 1600 members. Several citizen science projects to investigate the biota in Osaka and the surrounding area have been conducted by OMNH in cooperation with the Friends of the Museum. In this presentation some examples with molluscs as target species are introduced.

From 2002 to 2010 we conducted aquatic organism survey projects along two major river systems in the Osaka plains (Yamatogawa and Yodogawa Rivers). We recruited participants from the Friends of the Museum and asked them to report the distribution of designated aquatic organisms. Among the mollusca they plotted the distribution of *Semisulcospira* and *Bellamya* snails along the two river systems, including endangered species ranked in local red lists. We also asked them to collect specimens and established a comprehensive collection encompassing the flora and fauna of those areas. Finally we held special exhibitions describing the nature of the river systems and the citizen science activities.

A current citizen science project to survey alien species in Osaka is focusing on apple snails *Pomacea* spp. And the decollate snail *Rumina decollata*. The outline and progress of this project are reported.

Taxonomic review of Australian Siphonariidae

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The Siphonariidae are a family of marine "siphon" limpets occurring mainly on intertidal rocky shores in tropical, temperate and Antarctic subpolar regions. There are over 200 nominal species appearing in the literature. The taxonomy of this family is confused and fragmented, primarily due to the wide intra-specific variability and inter-specific similarity exhibited in most species in the practical identifiers of shell shape, sculpture and colour. Inadequate descriptions, misidentifications and misinterpretations in the literature have contributed. This presentation outlines the objectives, strategy, techniques being applied, challenges and solutions, progress and early results of a two-year taxonomic project to identify and validate the Australian species in this family. Some 320 locations were sampled around the coast of the Australian mainland and offshore islands over a collecting phase of 9 months. All key type localities within and outside Australia are also being sampled. Some

85 nominal species and forms are in scope for review using a range of molecular and morphological analyses. This project builds upon earlier work resolving a couple of taxonomic issues in Australian and New Zealand *Siphonaria* and similar work on the family by more recent authors.

21st Century Natural History: Facilitating discovery, connecting people, and building community to scale science and conservation

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Collaboration between amateur naturalists and professional scientists in the pursuit of natural history and biodiversity discovery is not new, but in recent years has taken on a different look, mostly due to increased connectivity through technology. We can now communicate and share in ways we could not have imagined only a few years ago. There are many ways to capitalize on this connectivity. We can reach out and build a new team of field associates, we might only know online, which is a traditional model, enhanced by technology. Through my work, I build and support a community of people making and sharing observations of plants, and animals all around them and focus that community on certain problems and questions. I help people discover their local nature and share what they have found, while providing opportunities for people to meet others, make connections, and form new community. Through the iNaturalist platform, we are also connected to each other online and everyone works together to turn our observations of plants and animals into verifiable, biodiversity data. This community of naturalists' collective observations of plants and animals is creating an important global record of what biodiversity is found where, right now. By providing tools to others to do their own local work, designing programs that scale and networking many, disparate local projects together we are generating biodiversity data on the scale we need to make informed conservation decisions, fueling meaningful science, and creating strong local and global communities of naturalists.

Enhancing conservation through cultural knowledge

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Hawaiian cultural knowledge has proven to be effective in the management of natural resources by Hawaiians for centuries keeping ahupua'a (large land divisions) intact from ma uka (upland) to ma kai (sea). Cultural expertise and coexistence has protected species extinction for centuries and provide the clues to current management efforts. Learn of the Hawaiian world view of time, space and practice. Looking through a Hawaiian lens magnifies the understanding of the revolving world we live in, clarifies the approach to take and the role you play.

Pomaika'i Kaniaupio-Crozier, Hawaiian cultural resource expert and current conservation manager for the Pu'u Kukui Watershed Preserve (the largest private nature preserve in Hawai'i), will share his mana'o (thoughts) and lessons learned from kupuna (elders) on enhancing conservation through cultural knowledge.

Key Questions:

What is the importance of incorporating Hawaiian cultural knowledge and practices into our current conservation efforts?

How will Hawaiian cultural knowledge assist in protecting native species from extinction? How much data does Hawaiian cultural knowledge possess?

Molecules & morphology reveal 'new' divergent, widespread North American Lampsiline species (Bivalvia: Unionidae)

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Species are the fundamental unit used in biodiversity research and the recognition of these units or species in imperiled groups of organisms is paramount to their conservation. In the Family Unionidae, the greatest radiation of freshwater mussels, species descriptions have been misled by extreme intraspecific shell variation and conversely interspecific conchological stasis. *Lampsilis teres* (Rafinesque, 1820) a polymorphic, widespread species has historically been split into as many as three subspecies that correlate to phenotypic variants. Recently, one subspecies, *Lampsilis floridensis* (Lea 1852), was elevated to species level based on morphological and molecular differences. However, other subspecies designations are no longer recognized and no study has investigated these phenotypes with molecular characters.

In this study we characterize the genetic and morphological diversity of two phenotypes of *L. teres* from specimens collected across its distribution using geometric and traditional morphometrics and multilocus molecular phylogenetics to test the hypothesis that phenotypes represent separate species. Results from our multilocus molecular phylogenetic analyses unanimously indicate that *L. teres* as it is currently recognized is made up of two divergent, widespread species with sympatric distributions. In this talk we redescribe *Lampsilis anodontoides* (Lea, 1831) and use morphometrics and machine-learning classification algorithms to test if shell morphology alone can be used to identify these two cryptic and sympatric species.

I Akaleha' siha gi iya Islan Marianas

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As with most land-snail faunas of the tropical Pacific islands, the approximately 100 native species of snails known from the Mariana Archipelago of western Micronesia are poorly documented and under pervasive threat of extinction. About 25% still await formal description. Most have only been collected from the two southernmost islands, Guam and Rota. Many described species have not been seen alive in half a century, some not since the publication of their original descriptions. These declines appear primarily due to habitat destruction and unintentional to naïve introductions of generalist predators. Fortunately, several pockets of high diversity are known, all in often small patches of remaining native forest. In this talk, we review native snail diversity in the Marianas and report on their status and prospects for survival.

Dead shells talking: Using molluscan death assemblages to decipher human impacts and shifting baselines

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Human impacts on coastal ecosystems are increasingly well appreciated by both professionals and the public; these stresses include sediment and nutrient runoff, non-indigenous species, harvesting of fin- and shell-fish, and climate change. However, it's difficult to assess mitigation and restoration efforts without knowing what habitats and communities were like under fully natural conditions: in most areas, quantitative benthic sampling started only with the Clean Water Act of 1972, decades or centuries after the onset of stress. Molluscan death assemblages – naturally time-averaged accumulations of dead shells such as collected from a beach or sieved from seafloor grab-samples – can be used to test for recent ecological changes, evaluate human versus natural drivers of those changes, and, in some instances, reveal pre-stress 'baseline' conditions that can inform restoration efforts. Insights come from a combination of 'live-dead' comparison and radiocarbon-based age-dating of shells. Such data permit us to (i) recognize whether a community has changed (does the species composition of the death assemblage contrast with today's living community?), and evaluate both (ii) the nature of that change (which species occur 'dead-only'? which species are more abundant alive than dead?) and (iii) when change occurred (e.g., age of the youngest shell of a now dead-only species). Projects in multiple oceans demonstrate how this approach provides critical, otherwise unattainable information on species and habitats not suspected to be in decline, on the 'footprint' of point stressors such as wastewater, spoil-dumping, and species invasions, and on the progress of recovery.

Rat lungworm intermediate hosts in Hawaii: identification and distribution

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Rat lungworm (RLW) disease, caused by the parasitic nematode, *Angiostrongylus cantonensis*, is an emerging infectious disease that causes eosinophilic meningitis. The first reported case of angiostrongyliasis in Hawaii was in 1961. Between 2001 and 2016, 85 cases of this disease were reported, which is nearly four and a half times as many cases (19) as reported from 1959 to 2000. A state-wide assessment of intermediate hosts (gastropods) was published in 2014 and indicated that 16 of the 37 species tested carried the parasite, including two native species. Recent invasive land snail surveys were conducted in 2016 and 2017 on Maui to provide updated data regarding identification and distribution of invasive snails and the parasite within this island. More than 200 non-native snails representing 21 species were collected from 13 sites across Maui. Of the 205 individuals screened for the presence of *A. cantonensis*, 13% representing nine species were positive for the parasite. Two species were new island records as hosts for the parasite, and one is a new state record, never having been reported as a carrier of RLW in Hawaii. There are now 21 confirmed gastropod hosts for RLW in Hawaii, and the number is likely growing as introductions continue. Knowledge of host identities and distributions for diseases like RLW are critical for developing effective management plans and helping reduce the number of cases of angiostrongyliasis in Hawaii. Continued surveys and screening should be a component of any efforts to control the spread of the disease in Hawaii.

Ecological, evolutionary, and molecular adventures with *Conus*: Then and now; Hawaii and beyond

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To retrospectively summarize 65 years studying the biology of *Conus*, I first examine the confluence of threads from several influential mentors in early years. When asked to suggest feasible research on marine molluscs for a young student to pursue in Hawaii, one of these responded silently but handed me a book: C.H. Edmondson's "Reef and Shore Fauna of Hawaii." Perusal revealed a striking difference in diversity patterns from southern New England's familiar inshore marine environments. The book notes that more than 30 species of *Conus* occur on Hawaiian reefs, rather than the maximum one or two species/genus previously encountered in temperate continental marine habitats, and it stimulated the question that has busied this worker for 65 years: "What are all those species doing there?" The next three years of research led to the question's answer: Where more species co-occur in the same habitat, they do not specialize much more to different components of their habitat, but they do specialize more on different food resource species. All *Conus* species are predatory, and almost all specialize on one prey taxon; for most species these are polychaete annelids, while fewer eat only other gastropods or fishes.

I conclude with the 21st century's burgeoning knowledge of the remarkably rapid rate of evolutionary diversification in *Conus*. This geologically very young genus includes more extant species---systematists now recognize >800---than any other group of marine animals, and some of these advances reflect productive relationships between the Universities of Hawaii and Washington.

When Photosynthetic Slugs and Crunchy Algae Coevolve: Host and Herbivore Traits Interactively Determine Lineage Diversification in Sea Slugs

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Longstanding interest in the eco-evolutionary dynamics of insect-plant and host-parasite systems has yet to clarify how traits of either consumers or their obligate prey affect diversification rates, especially in the sea. 'Musical chairs' models of host shifts versus 'escape and radiate' cycles of niche expansion have proven hard to test, and little work has examined coevolutionary dynamics in marine taxa. Sea slugs in clade Sacoglossa are host-specialized herbivores that repeatedly evolved photosynthetic abilities (kleptoplasty). We built a database of diet records for 420 species, and a molecular phylogeny for 300 species, to reconstruct the history of host use in this clade. Using comparative methods, we then assessed whether traits of slugs or algae (or particular host groups) correlated with increased diversification of slug lineages. Photosynthetic slugs had higher rates of host shifting and diversification, but being physically host associated did not affect slug diversity. Higher rates of consumer diversification were linked with specialization on either uncalcified algae or chemically undefended algae.

Ancestral reconstructions supported recurring, sequential transitions between host groups, from Halimedineae to Bryopsidineae, to Cladophorales, to Dascycladales or non-chlorophytes. Shifts onto Bryopsidineae increased diversification by 70% for photosynthetic lineages, while Cladophorales feeders diversified at up to fourfold higher rates than lineages on ancestral hosts. Shifts to non-chlorophyte hosts occurred frequently but greatly decreased diversification. Transitions to uncalcified algae in temperate zones opened new niches and spurred cladogenesis, but transitions onto non-

chlorophyte hosts yielded frequent evolutionary dead-ends. Slug genus richness was correlated with niche breadth, suggesting ecological caps on diversification.

The whizzing snail: Innovation and change at the Bailey-Matthews National Shell Museum, Sanibel Island, Florida

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The Mission of the Bailey-Matthews National Shell Museum focuses on the advancement and dissemination of knowledge about mollusks. Its scientific collection, exhibits, public programs, and expertise come together to inspire learning, support scientific research, and tell the story of mollusks' standing in nature and importance to human cultures. In recent years, the Museum has been promoting a number of distinctive, novel activities.

These include coaching and engagement of all staff in basic malacology via the daily "Shell of the Day" program and hourly demonstrations of local live marine mollusks to visitors, the "Live Tank Talks". The BMSM collection has expanded and is now fully digitized, thanks to grants from the Institute of Museum and Library Services and the skills of local volunteers and citizen scientists.

Beyond the physical confines of the Museum, "Mollusks on the Move" takes live marine mollusks to area schools, the children's hospital, and organizations, with support from the Golisano Children's Hospital of Southwest Florida and the Sanibel-Captiva Shell Club. Museum educators developed a pioneering curriculum for beach-walking, mollusk-oriented naturalists.
These "Shell Ambassadors" now number about 150 individuals.

State-of-the-art design ideas and architectures, incorporating the popular online guide "Southwest Florida Shells" and the "Shell Blog", ensure strong web and social media presences. In late 2018, with help from volunteering Artificial Intelligence engineers, the Museum will be launching a smart-phone application for identification of local mollusks. Last but not least, plans for the immediate future encompass extensive modification of a currently under-utilized area to accommodate mollusk-themed aquaria.

SNPs, Snails, and Lime: Genomic and Geologic Patterns of Ornamentation

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Few biological forms have held the focus of the human mind for as long as the land snail shell and remain an enigma. Despite widely documented instances of intraspecific variation and convergent evolution of land snail ornamentation between species, there are few ecological factors known to be associated with the evolution of ornamentation. Perhaps as a result of this mostly null-finding, it has been proposed by others that the convergence of land snail ornamentation across multiple species assemblages is the result of sexual selection or from relaxed selection and genetic drift. To understand the possible processes governing shell ornamentation evolution, we conducted a series of land surveys and population genetic analyses on a diverse assemblage of ornamented large land snails (*Oreohelix*). We identify calcareous rock as being associated with ornamented species occurrence and that variably ornamented species form a continuum of ornamentation from 'weak' to 'strong' based on proximity to calcareous geologic units. High levels of admixture between ornamented and unadorned forms were detected, indicating that ornamentation persists even with high levels of gene flow. We propose that ecological sources of selection cannot be ruled out, and

measuring the available calcium at ornamented species sites may be key to understanding the wide convergence of ornamented forms in other land snail groups.

The Amateurs – Malacology's Additional Eyes and Hands

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Amateur naturalists have made numerous significant contributions to the field of malacology. This brief talk will explore how seashell and land shell enthusiasts in the Hawaiian Islands have added to the overall knowledge base of mollusks and how they can continue to serve in this capacity in the future. Through in situ observations of habitats and behavior from beachcombing, snorkeling, and diving activities; detailed analysis and comparison of specimens in their collections; firsthand tracking of population trends; exchange of information and specimens with hobbyists around the world; asking probing questions; providing ample anecdotal evidence to prompt more formal study; and volunteer support to professional researchers, amateur malacologists provide expand our community's capacity to understand the diversity of molluscan fauna.

Giving a shell a name: listening to Seri voices

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The Seri people, a small indigenous group living on the mainland shores of the Gulf of California, have a long and rich history of intimate contact with the natural world. Their unique traditional knowledge—since they are a modern-day cultural and linguistic isolate—illuminates a past world when native groups living along the Gulf's shores flourished there as hunters, gatherers and fishers. Shells from that shore, some beautiful, some uncommon, and some very ordinary, are given life by Seri names. A few names reflect use, some are from folklore and spoken by the shells themselves, while others are descriptive and at times playful. Names such as "old woman's toenail," "coyote's fetish," or "what the sea turtle tattooed" link us to the Seri worldview and their personal connection to this world. Having spent my childhood with the Seris, interacting with children and adults in their language and exploring the area's richly biodiverse and isolated shores provided a unique platform for later research on what the Seris know about mollusks. My research reflects years of spending time as a participant within the community.

Although it began as a mere list of shell names, it soon expanded to include oral history, cultural information, mollusk habitat and ecology, and much more. Investigation often happened through spontaneous and lively conversations, or serendipitous encounters, and at times followed fascinating trails. My consultants, most of them women—some of them childhood playmates— taught me so much and made research a delight.

Selection on genital morphology as a driver of cryptic diversification in sea slugs proposed as biocontrol agents for *Caulerpa*

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Molecular studies often reveal that a nominal species in fact comprises a complex of cryptic species that occur in sympatry and occupy the same ecological niche. This poses a challenge both for classical models of allopatric speciation, in which sister taxa are not expected to overlap, and also for recent models of ecologically mediated divergence with gene flow. The role of selection on fast-evolving genital armature or other reproductive structures and mating behaviors has received little attention in marine systems, but may be an important driver of diversification in highly diverse groups like gastropods with complex reproductive systems.

Here, we resolve cryptic diversity in the *Elysia tomentosa* complex, a lineage of large-bodied sea slugs. Five described species in this complex (two Pacific, three Caribbean) feed on *Caulerpa* spp., including highly invasive species of "killer algae," and some have been studied as potential biocontrol agents; however, different studies returned conflicting conclusions about the degree of host specificity and feeding rates of nominal "*E. tomentosa*" from the Pacific.

Using sequence data for 186 specimens, quantitative species delimitation supported seven species in the tropical Pacific (at least 5 undescribed), and an undescribed Caribbean species. Morphological analysis indicates barb-like penial stylets rapidly diverged between sympatric pairs of sister species, suggesting either sexual selection contributed to speciation, or reinforcement caused reproductive character displacement during secondary contact of incipient species.

Island Hopping: evidence for rapid and widespread movement of non-native snails and slugs across the Hawaiian Archipelago.

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Human-mediated transport has led to the introduction and establishment of many non-native snail and slug species (hereafter land snails) into the Hawaiian Islands. However, we lack a regional framework for understanding how human mediated transport and key ecological factors influence non-native land snail assemblages within and among islands in the archipelago. To investigate the role of human mediated transport in structuring non-native land snail assemblages on the main Hawaiian Islands, we surveyed 79 sites in low elevation areas (sea level to 500 m elevation) on Kauai (23 sites), Oahu (25), Maui (17) and Hawaii (14). Additionally, we explored the role precipitation plays in structuring non-native land snails by examining if land snail assemblages differ between sites that receive low (< 120 cm) and high (>120 cm) mean annual precipitation (MAP). We found that non-native land snail assemblages did not differ among islands, but they did differ between sites with low and high MAP. Combined, our results suggest that once a species is established in the archipelago, few barriers limit its ability to colonize the other islands. As such, within island ecological factors, e.g., MAP, are currently more important in structuring land snail assemblages in the Hawaiian Islands. We propose that more effort is needed to prevent not only initial introduction to the archipelago but also inter- island

transport of non-native snails, and other taxa, if conservation practitioners and land managers are going to mitigate the deleterious impacts non-natives are having on native flora and fauna.

Phylogeny and evolution of *Anguispira* (Gastropoda: Discidae)

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Terrestrial gastropods are one of the most threatened groups of animals on Earth, an issue exacerbated by a poor understanding of the taxonomy, distributions, and conservation status of many groups. *Anguispira* includes 21 species endemic to North America, occurring primarily in Eastern North America, and inhabiting hardwood forest in leaf litter, rotting wood, and limestone outcrops. Unfortunately, these species have been declining and, without a clear phylogenetic framework on which to base taxonomic decisions, it will remain difficult to assess their conservation status and develop conservation action plans. We have begun a comprehensive analysis of anatomical and genetic data to reconstruct the phylogenetic relationships among *Anguispira* species. Shell morphology, reproductive anatomy, radula morphology, and DNA sequences are providing insights into the evolutionary and ecological drivers of speciation in this group. A multigene phylogeny strongly supports many previously recognized clades, but also overturns other assumptions about relationships based on shell morphology. Some shell features (e.g. carination) appear to have evolved more than once. Similarly, radula morphology seems strongly influenced by habitat and life history differences among species. As expected, taxa inhabiting limestone outcrops are morphologically divergent from those living in leaf litter or wood. These patterns are consistent across clades and habitat types. Preliminary analysis of reproductive anatomy appears to be useful in delineating taxa, and helping corroborate species delineations derived from sequence analyses. Further anatomical analyses will be needed to confirm these patterns.

Embryonic metabolism and development of Antarctic nearshore marine gastropods

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Ectothermic marine animals in the Antarctic show unusual patterns of metabolism and development, driven by the constant near-freezing temperature of the Southern Ocean. We performed laboratory and field experiments with the egg masses and embryos of two Antarctic nudibranchs (*Tritonia*

challengeriana and *Tritoniella belli*) and found that in comparison with temperate relatives, embryos of these species had very slow metabolic rates and long development, spending up to a year in the egg mass prior to hatching. Egg masses in the Antarctic also had much longer diffusion distances (i.e. were much thicker), likely attributable to the high ratio of O2 supply to demand compared to temperate regions. The thermal sensitivity of metabolism of the Antarctic embryos was also unusually high, suggesting that both developmental rate and oxygen availability in the egg mass may change rapidly with small changes in temperature. We also described, for the first time, egg masses of the Antarctic buccinoidean gastropod *Antarctodomis thielei*, and tracked the development of one mass of capsules in the field near McMurdo Station. Each of the 11 egg capsules in the mass produced a single juvenile with a shell length of ~7mm; the duration of development from the trochophore stage to hatching was > 8 years. Apart from this study, virtually nothing is known about the biology of *A. thielei.* Greater knowledge of the life history, ecology, physiology, and phylogeny of this species (and of Antarctic taxa in general) are needed to identify the factors that cause its very extended development.

The invasion of the red slugs: *Vayssierea felis* (Collingwood 1881) in the Northeastern Pacific

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Vayssierea felis (Collingwood 1881) is a species of sea slug in the family Okadaiidae, native to the Indo-West Pacific. It is characterized by having a very small body (up to 5 mm long), bright red in color, with no external gill. A few years ago, specimens of this species were found in San Diego and Redondo Beach, California, and are becoming more frequently observed along the northeast Pacific. The increasing number of these nudibranchs in California indicates that it could potentially be an invasive species. In order to determine the origin of the northeast Pacific populations, we obtained specimens collected from Australia, Russia, Japan, Hawaii and California. We hypothesize that the specimens of *Vayssierea felis* found along California will have a similar genetic make-up to that of these other specimens. DNA was extracted from tissue samples of the specimens. The extracted DNA was sequenced for the two mitochondrial genes (CO1, 16S) and a nuclear gene (H3). Phylogenetic and species delimitation analyses were conducted on these genes to determine the relationship among the specimens. We found that the specimens from California are genetically distinct from those found in other regions, suggesting that this group could be a species complex.

The Atlantidae of the Southern California Current (Winter-Spring, 2016)

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Mollusks of the family Atlantidae have a relatively short holoplanktonic life cycle, responding rapidly to environmental changes. It is currently unknown how their distribution and abundance varies with the intra-annual environmental changes. On the California Current System (CCS), the most rapid and

intense changes in the environmental conditions and in the composition of planktonic species in this area occurs between winter and spring, also known as “spring shift”. This study aims to determine the intra-annual variation of the distribution and abundance of the Atlantidae family occurred during the “spring shift” of 2016 off the West Coast of Baja California, Mexico. A total of 15 species were found, where *Atlanta brunnea*, *A. helicinoidea*, *A. oligogyra*, *A. rosea* and *Protatlanta souleyeti* represent distribution range extensions and we recorded for the first time *A. fragilis* in the American Pacific. In both seasons, *A. californiensis* was the most abundant and widely distributed species. In general, the greater abundance of organisms, as well as the greater species richness, diversity and evenness was observed towards the oceanic region and near Vizcaino Bay. However, the highest values of the ecological indices were obtained in winter.

Sex in the wild (and especially in New Zealand)

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Why sexual reproduction (sex) is so common remains a hotly debated topic. Direct study of the costs and benefits of sex requires comparison between otherwise similar sexual and asexual forms. From this perspective, *Potamopyrgus antipodarum*, a New Zealand freshwater snail, is a powerful system to apply to the problem of sex because phenotypically and ecologically similar sexual and obligate asexual individuals and lineages frequently coexist in nature. Many hypotheses for the maintenance of sex focus on whether and how sexual vs. asexual reproduction influences important properties of genome evolution, like the spread of beneficial alleles and the clearance of harmful mutations. Accordingly, my students and I, along with several other collaborators, are leading a genome project for *P. antipodarum.* In this seminar, I will summarize the problem of sex, introduce the *P. antipodarum* system, and discuss how we are using these new genomic resources to address the sex question. I will also provide some context and background for my own journey as a female evolutionary biologist.

Systematic relationships among partulid tree snails of Near Oceania clarify their taxonomic status and the role of regional prehistoric exchange networks in their distributions

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The goals of this study were to produce the first phylogenetic analysis of the partulid tree snails of Near Oceania and establish the extent of anthropogenic introductions in their multi- archipelagic distribution and survival. It involved field sampling throughout the island archipelagoes of Papua New Guinea (PNG) and the Solomon Islands (SI), including the adjacent Remote Oceania Santa Cruz archipelago, from 2012-2016. Specimens were genotyped using two very distinct approaches: Next Generation Sequencing (NGS) double digested Restriction Associated DNA sequencing (ddRADseq) encompassing 4819 loci, as well as a traditional targeted gene approach using a single mitochondrial "barcoding" gene (Cytochrome Oxidase I). Phylogenetic results supported the presence of only 3 species of *Partula* in Near Oceania and 2 more in the Santa Cruz archipelago; in contrast to the respective 5 and 1 species recognized in a recent taxonomic revision. Three of the currently recognized Near Oceania species are instead cryptic populations of a single human-associated (restricted to coastal villages, absent from native forest) partulid, *Partula micans*. It occurs in small scattered synanthropic populations throughout the main Sis archipelago and in multiple PNG archipelagoes, including one record from a coastal village on the PNG mainland as well as a single island record from Vanuatu. It is not possible to identify at present convincing source non-synanthropic populations for *P. micans*, but the phylogenomic data outline three among-island potential regional prehistoric trading exchange networks linking Woodlark with Boiboiawaga and New Britain; New Britain with Buka and Shortlands; and New Georgia with Sanata Isabel and Guadalcanal.

Land Snail Populations after Tornado Fells Trees: with and without Salvage Logging

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Organisms experience dramatic environmental change but little is known about land snail response to habitat disturbance, and natural disturbances like tornadoes might be increasing in frequency and severity with human-caused climate change. In 2012, a tornado felled trees in four places, each 3-6 ha, within 3.3 km of each other in southwestern Pennsylvania. These blowdowns provide natural replicates to examine land snail response to habitat change.

Salvage logging is controversial as leaving trees might promote forest regeneration. To study salvage logging, in each of these four blowdowns, all trees (felled and standing) were taken from half of each blowdown.

Many snails occur in particular habitats; forest species might become less common after forest blowdown, and meadow species might become more common. The propensity of snails to occur near coarse woody debris is legendary; more coarse woody debris in the un-salvaged area might harbor more snails.

Preliminary results found 31 snail species and showed a trend for greater diversity and abundance of land snails in blowdown areas versus adjacent intact forest. However, we found little difference between salvaged and un-salvaged areas, suggesting that coarse woody debris might play little role in the greater diversity and abundance. Vigorous herbaceous plant growth in the blowdown areas, or the ecotone-like juxtaposition of forest and meadow might have contributed to the increases.

Species composition differed among the treatments. Proportion of empty shells versus living individuals differed among treatments, with the greatest proportion of dead shells from salvaged areas and the least in the intact forest.

Partula snail conservation breeding and reintroduction programme: Progress, lessons learned and future challenges

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Widespread extinctions of endemic species of *Partula* tree snails in French Polynesia occurred in the 1970s and 1980s when the carnivorous mollusc *Euglandina rosea* was introduced as part of a disastrous biological control plan to combat the garden pest, the giant African snail. However, the rescue missions to the Society Islands that took place up to the mid-1990s ensured that around 20% of *Partula* species have been maintained in the world's only international invertebrate breeding programme. A long-term collaboration between the French Polynesian environment department and the zoo conservation breeding programme has seen the family Partulidae protected by local law and has resulted in the realisation of an unprecedented and ambitious reintroduction programme. Since 2015 some 7000 individuals of *Partula* snails from 11 taxa (10 species and 1 subspecies), 9 of which are Extinct in the Wild (EW), have been released onto three islands. Following the failure of the secure reserve strategy in the first year, and the reduced threat of *E. rosea*, all snails have since been released directly into trees and shrubs. A new and unexpected threat from the New Guinea flatworm *Platydemus manokwari* has prompted research into its status on all the islands and its efficiency as an arboreal predator and conservation response strategy. Regular monitoring of released *Partula* populations to date has revealed that all the species disperse rapidly from their holding pots into complex habitat and that the mortality rate based on dead shells has been low.

Evidence of successful re-establishment of species is a long-term monitoring project. This presentation will summarise progress to date, lessons learned and some future conservation environment considerations for this and wider species recovery efforts.

A preliminary molecular phylogeny of the Eastern US *Oxyloma* (Gastropoda: Succineidae)

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The succineid genus *Oxyloma* in North America contains approximately 16 described species; however, the identification of these species is difficult to the point where most workers only feel confident in identifying them to family. As a first step towards understanding the evolutionary history and revising the taxonomy of North American *Oxyloma*, we have sampled the four eastern species (*O. salleana, O. subeffusa, O. effusa,* and *O. retusa*) from their respective type localities. We have

compared their mitochondrial COI sequences and nuclear LSU sequences with samples from across their range as well as several members of the genus *Succinea*. A preliminary molecular phylogeny from these data finds three species level clades among these four available names as well as non-monophyly of *Oxyloma* and *Succinea* species, confirming doubts concerning the validity of one of these species and the two genera. Our next steps will be to include anatomical characters and shell morphometrics to revise the taxonomy and form a better understanding of the distributions of these *Oxyloma* species.

Predators, genetics, and climate change: prioritizing conservation actions for endangered Hawaiian tree snails

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Endemic Hawaiian tree snails (Achatinellinae) have been rapidly disappearing due to introduced predators and habitat disturbance, and only remain in fragmented refugia. All populations are at the highest elevations available, over steep precipitation gradients, and will likely be impacted by climate change as native habitats become warmer and drier. Using restriction-site associated DNA sequencing (RADseq) we generated millions of DNA sequences from across the genomes of 67 populations representing 28 species, 6 genera, and 3 subfamilies. We constructed whole and partial mitochondrial genomes, and evaluated nuclear and mitochondrial single nucleotide polymorphisms (SNPs). Alarmingly, we see evidence of limited connectivity among populations for species where multiple populations remain, with a large number of fixed differences among geographic sites. Together with low heterozygosity, this suggests a decreased capacity for adaptation to environmental change. These results may inform decisions to combine populations in predator-free enclosures in ways that will maximize adaptive ability in the face of global climate change.

Robust, safe, and reversible gene drive

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Underdominance is one type of gene-drive that has several useful properties. Foremost among these are reversibility and geographic containment of the genetic modifications. We are developing this system in insects for potential applications here in Hawai'i. This type of system might be ported to gastropods, which is a potential advantage over alternative genetic pest management techniques that are not predicted to be as effective in species without *Wolbachia* and/or hermaphrodites. An open question is what type of effector modifications could be linked to gene drive in order to be useful in controlling invasive gastropods.

Introduced snails on the islands of ‘Uvea, Futuna and Alofi (South Pacific) with an outlook on the native fauna

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During two two-week expeditions the snail fauna of the islands of ‘Uvea, Futuna and Alofi (Territory of the Wallis and Futuna Islands) was investigated in the larger frame of an invasive species survey of the IRD-Nouméa. The malacofauna of these islands was never studied in greater detail before. The first and only publication including not only hazardly species from the islands was compiled by Mousson in 1871 and was based on material assembled by Graeffe. It mentioned 15 species of land and freshwater snails for ‘Uvea and 17 species for Futuna. While ‘Uvea is a rather flat plateau of volcanic origin surrounded by a lagoon bordered by coral islets, Futuna and neighboring Alofi reach altitudes of 500 m or 400 m respectively with karstic ground. The recent mollusc associations represent a mixture of native, cryptogenetic and introduced, partially also invasive species with the highest human impact found on ‘Uvea. The introduced species include among others *Euglandina rosea*, *Lissachatina fulica*, a veronicellid and several subulinids. For ‘Uvea about 19 native species were recorded with five of them probably already extinct. Contrary, Futuna and Alofi harbour at least 26 still extant native species. Even *Partula subgonochila* was surviving at the time of the survey although the Futuna population only consisted of a tiny left-over. The native fauna further encompasses species of the families Helicinidae, Assimineidae, Vertiginidae, Charopidae and Endodontidae.

New introductions and the spread of invasive gastropods on the U.S. mainland and Puerto Rico.

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Invasive snails, slugs and semislugs continue to be introduced into the United States and its territories, while established alien species are expanding their geographic distributions. Ongoing domestic surveys are also discovering populations of long established alien species, and agricultural authorities are hard-pressed to obtain funding to delimit, control and/or eradicate those species that are deemed to be threats to American agriculture, the natural environment, and some that are threats to public and veterinary health. In Florida a large population of the giant African snail (*Lissachatina fulica*), first detected in September 2011, has been targeted as a major eradication program, and a successful and complete eradication is now considered to be a very real possibility. Meanwhile the giant African snail has been detected in 2018 in San Juan, Puerto Rico, and eradication is currently underway. Two species of *Parmarion* that are ariophantid semi-slugs of Southeast Asian origin have been introduced to Puerto Rico and delimitation surveys are currently being conducted. These two species have been shown to have very high parasite loads of *Angiostrongylus cantonensis*, the nematode that is responsible for Rat lungworm disease (eosinophilic meningoencephalitis). In California, *Theba pisana*, previously contained in a small area in San Diego County, is now distributed throughout the county and is now being detected elsewhere in the state. Several invasive species have been successfully eradicated in the Detroit area, although one, *Xerolenta obvia* that had been under an eradication program for nine years, has now been detected in other parts of Michigan.

Biogeography of Philippine Helicostylinae (Bradybaenidae: Gastropoda)

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The helicostyline land snails of the Philippines comprise about 300 endemic species. Phylogenetic analysis shows that the group is not monophyletic, but the core Helicostylinae show strong biogeographic patterning, with some clades restricted to single islands, or groups of adjacent islands. Some distributions appear to reflect Pleistocene aggregate island complexes and other reflect deeper geological history. The continental islands Mindoro and Palawan are basal to some clades, and Sulawesi is a possible area of origin for another. For some clades, biogeography is a better indicator of relatedness than shell morphology or reproductive anatomy, which suggests that adaptive radiations in different biogeographic regions have produced similar arrays of morphology.

Evolution and conservation in the land snails of the Republic of Palau

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Western Pacific islands are well-positioned to receive colonists from one the most biogeographically complex and biodiverse regions on the planet. The Belau archipelago exemplifies patterns of extraordinary endemism among lowland tropical rainforest land snails that result from evolutionary radiations among isolated karst and volcanic habitats over nearly 30 million years. I discuss our lab's research on the geographic distributions, dispersal limitation, evolution, and ecology of Belau land snails, including diplommatinids and endodontoids. I also briefly describe our ongoing work on 100 Ma land snails fossilized in amber (Burma/Myanmar) that provide insights into the early evolution of diplommatinids and the morphology of tropical rainforest snails from the region generally. Lessons from extinct snails also inform modern conservation. We know from elsewhere in the Pacific that many species have been lost, and still more have suffered declines. In Belau, 75% of species that were listed as vulnerable in 1994 (IUCN Red List) are now listed at a higher threat level. More than half of described species are critically endangered. Belau is known in Micronesia for its largely intact lowland rainforest, much of which is protected within the rugged terrain of Koror State's Rock Islands. However certain regions of Belau are also likely to be forest regrowth and/or unprotected from habitat alteration by e.g. limestone mining or development (e.g. urbanization). I discuss our partnerships with Palau's state conservation managers and NGOs, as well as outcomes of our recent undergraduate field course, "Invertebrate Conservation Biology in Palau: From Ridge to Reef."

Hemocyanins' sequences and gene architectures as new phylogenetic marker in Heterobranchia?!

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The clade Heterobranchia comprises more than 30,000 opisthobranch and pulmonate species. In contrast to the hitherto well-accepted monophyly of those two groups, recent molecular data support a non-monophyletic relation of Opisthobranchia and Pulmonata. However, the exact phylogenetic relationship of the different heterobranch lineages is still discussed. Therefore, we need new markers and methods to unravel, corroborate and validate the true relationship within the Heterobranchia.

The marker we use is hemocyanin, the respiratory protein of most of the Mollusca. The typical gastropod hemocyanin consists of up to 20 subunits. Each subunit is composed of eight paralogous functional units representing 3,400 amino acids or 10,000 coding nucleotides, in mean. We are addressing various phylogenetic issues by analysing this molecule as a new phylogenetic marker at different levels. We are analysing (i) the gene sequences, (ii) the gene architectures, (iii) cDNAs and (iv) primary, secondary, tertiary and quaternary structures.
Instantly, we are using these data to study the phylogeny within Heterobranchia.

The hemocyanin genes of Vetigastropoda and Cephalopoda, respectively, encompass 9 – 14 introns per hemocyanin gene. Our analyses of relative distantly related heterobranchs e.g.
Aplysia californica and *Helix pomatia* resulted in detecting 54 conserved introns. Thus, most probably, we unraveled the hemocyanin gene structures as a new synapomorphic character in Tectipleura, corroborating the monophyly of this heterobranch group. Additionally, we can use the sequence data and also the loss and gain of intronic structures for reconstructing the phylogeny within Heterobranchia and we may infer and corroborate multiple independent adaptions for heterobranchs' landing scenarios.

A Rocky Relationship? Pair-living in the Hermaphroditic Gastropod *Siphonaria gigas*

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Animals from crustaceans to primates live in pairs, and previous research has associated pairing with the adaptive benefits of bi-parental care, mate-guarding, and territorial defense. These vertebrate-centric perspectives fail to explain pairing in other taxa. Furthermore, pair- living (i.e., social monogamy) does not entail sexual monogamy. Among gastropods, promiscuity is common and has been associated with fitness benefits via female choice and genetic diversity of offspring. On the rocky Pacific coast of Panama, I observed mating and reproduction in a pair-living, simultaneous hermaphrodite, the pulmonate limpet *Siphonaria gigas*. Paired individuals had greater female reproductive output (i.e., egg mass production) than solitary individuals. Extra-pair mating was observed but was less common than mating within pairs, and genetic paternity is being analyzed using microsatellites to quantify levels of extra-pair paternity. Almost one third of solitary limpets formed partnerships within three months, suggesting a preference for living in pairs. Hermaphrodite mating systems evolve under different constraints than those of gonochoristic

animals, and study of *S. gigas* suggests alternate mechanisms driving the evolution of pairing. In simultaneous hermaphrodites, every individual encountered is a potential mate, yet mating opportunities may be limited. Since *S. gigas* occupy fixed positions on the shore that they leave only during ebbing tides and primarily at night, their movement is restricted spatially and temporally. Thus, pairing may be adaptive due to constraints on mate access.

Being Fearless in 21st Century Malacology or: How I Moved from Studying Correlation to Causation in Scallop Eyes

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Scallops (Pectinidae) are an ideal model to study trait evolution due to their degree of biological diversity in extant species, the link between morphology and ecology, and their preservation in the paleontological record. As such, early research efforts in my lab and others has been to generate the largest, most taxonomically comprehensive multi-gene phylogenetic hypothesis for the family. These data were used to examine the tempo and mode of morphological evolution of specific phenotypes, such as shell morphology and behavior. However, these are correlative studies. My ultimate goal is to understand how changes to the genotype alter the phenotype of an organism. This is not trivial because genes are part of complex pathways and it is very difficult to unambiguously relate phenotypes to specific genotypes while at the same time, relate the phenotypic changes to the organism's ecology and physiology. The phototransduction system offers a rare opportunity to do exactly that. Here, I describe how my lab took an intellectual leap to make this transition. We developed an experimental system to show a causative relationship between genotype (amino acid sequence) and phenotype (light response of a photopigment) in the eyes of scallops. This has allowed us to study adaptation at the molecular level through the integration of bioinformatic tools, quantum mechanic models, and protein manipulation studies. Applying a mechanistic approach to the scallop system will provide strong and deeper inferences about the dynamics and mechanisms of evolution and sets the stage for major advances in understanding molecular adaptation.

Microhabitats as thermal refugia for the gastropod *Nerita picea* (pipipi) in the upper Hawaiian intertidal zone

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The Hawaiian intertidal zone is relatively understudied and little is known about the ecological stressors that affect intertidal organisms there. Typically, intertidal organisms in tropical locations live close to their thermal limits and are highly vulnerable to temperatures above their normal range. Access to thermal refugia may be key to their survival as thermal stress events increase in frequency and intensity. We are investigating the role of microhabitats as thermal refugia in the upper Hawaiian intertidal for the endemic gastropod *Nerita picea* (pipipi). We surveyed the intertidal zone at five sites around the island of O'ahu in summer 2017. We measured temperature distribution at noon-time low tides in 0.25 x 0.25 m quadrats along transects at each site using a thermal IR camera. We also mapped the spatial distribution of snails for comparison with the spatial distribution of temperature. At the hottest location (Ko'olina), temperatures at some points within quadrats reached as high as 51.8° C; however, there was dramatic variation within quadrats, with as much as > 17°C difference between microhabitats within a single site. *N. picea* were primarily found in micropools and pools even when

these were not the coolest microhabitats available. Thus, the rocky Hawaiian intertidal zone is a complex thermal mosaic, which may provide an important buffer for intertidal organisms when the climate warms. Ongoing research focuses on non-invasive methods for assessing physiological tolerance ranges of *N. picea* relative to microhabitat variation.

Racing Extinction, Land snail Conservation Techniques Implemented by the Hawaii Snail Extinction Prevention Program (SEPP) and Partners

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With over 750 described species in 10 families, the Hawaiian Islands were host to spectacular molluscan diversity and is a true scientific spectacle of evolution. Unfortunately, the past century has witnessed continually accelerating range reductions and extinction of much of this incredible fauna, due in large part to introduced predators. Fortunately, all is not lost and efforts to understand and save declining Hawaiian land snail populations have been ongoing for years, thanks to University of Hawaii and Bishop Museum researchers, as well as staff from other state, federal, and private organizations. However, we're racing the clock, and at this point nothing less than a coordinated multi-island partnership approach will begin to stem the tide of extinction. In response to the growing need, in 2012 the Hawaii Department of Land and Natural Resources, in partnership with the U.S. Fish and Wildlife Service, established the Snail Extinction Prevention Program (SEPP). The broad mission of SEPP is to prevent further land snail extinctions in the islands by building on previous work, integrating ex situ and in situ management, and by uniting partner groups across the state with common conservation objectives and sound methods. Here we describe recent extinction interventions along with the novel techniques being implemented across the Hawaiian Islands, which include stopgap predator control, predator exclusion, captive rearing, and reintroduction.

How has the Hawaiian endemic land snail genus *Auriculella* fared after a century of obscurity during an extinction crisis?

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Although isolated in the central Pacific, Hawaii has an extraordinarily diverse land snail fauna with at least 750 endemic species, most of which are restricted to single islands or mountain ranges. Achatinellidae is the second largest Hawaiian land snail family with 209 species divided into five subfamilies, of which two, the Achatinellinae and Auriculellinae, are endemic to Hawaii. While Achatinellinae have garnered significant research, Auriculellinae, comprised of 31 species in the genus *Auriculella* and one species in *Gulickia*, have remained less studied. This is alarming because introductions of non-native species, especially predators, combined with habitat destruction and climate change have resulted in the extinction of 50-90% of Hawaii's land snails. Recent surveys recovered 11 extant species of *Auriculella*, about 35% of the known diversity in the genus. One of these species is undescribed and the first member of Oahu's endemic *A. perpusilla* group to be found in the Waianae Mountains. The *A. perpusilla* group contains small species with inflated whorls and weakly reflected apertures. Descriptions of all *Auriculella* species are based on shell characters and

the reproductive anatomy of only three species including the type species, *A. auricula*, are known. We present preliminary anatomical data for other members of the genus and use this information to compare known species to the new species. Genetic data robustly supports the delineation of the new species from *A. perpusilla*, the only other extant species in the *A. perpusilla* group, but does not support the monophyly of the *A. perpusilla* group within *Auriculella*.

Life history and microbiome of invasive *Veronicella cubensis* in the Hawaiian Islands

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Veronicella cubensis is a widespread invasive slug of the family Veronicellidae. Although it is voracious pests and is a known carrier of *Angiostrongylus cantonensis* (the cause of rat lungworm disease), little is understood of its life history. To gain a more comprehensive understanding of this species a study of various life history aspects was conducted. Slugs were reared in a lab setting to gather data on lifespan reproductive trends including egg production and hatchability. The effect of temperature on juvenile growth was also determined by tracking the weight gain of slugs maintained in either a hot or cool temperature environment over the first six months of life. Observations of its seemingly unusual egg laying behaviors prompted analysis of the microbiome and the possibility of vertical transmission. *Veronicella cubensis* reaches reproductive maturity around 4 months of age, egg masses are variable in size and hatch with a success rate over 80%, and warmer temperatures cause faster weight gain in juveniles. Preliminary microbiome data analysis suggests a substance laid on the egg masses originates from the adult slug hindgut and Enterobacteriaceae are the most abundant bacteria in adult *Veronicella cubensis* hindgut. These results are a valuable addition to the limited knowledge of the reproductive biology of this species and will help us to understand why these veronicellids are such successful invaders and to predict and prevent their further spread.

Adding to the Knowledge of Stylommatophora in San Diego County: Citizen Science Contributions

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Citizen scientists span the spectrum from complete novice to advanced amateur, and southern California offers a wide variety of habitats open to public exploration: coastal, desert, mountains, wetlands, with an abundance of native and non-native species. This talk will focus on the use of iNaturalist by citizen scientists to record their sightings and add to the knowledge of Stylommatophora in San Diego County. Contributions include discovery of new species, expanded range and population sizes.

Assessing the diversity of western North American *Juga* (Gastropoda, Cerithioidea, Semisulcospiridae)

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Juga is a genus of freshwater gastropods distributed in Pacific and Interior drainages of the Pacific Northwest from central California to northern Washington. They are found in a diversity of aquatic habitats, ranging from large rivers to isolated springs, and can comprise as much as 90% of the invertebrate biomass in some communities. As with other freshwater gastropods, the current classification has relied heavily on shell features. However, the extent that similarity in shell morphology is an accurate reflection of phylogenetic affinity is untested. The only previous molecular analysis included limited population sampling, which did not allow robust assessment of intra- versus interspecific levels of genetic diversity. We assembled a multilocus mitochondrial (COI, 16S) and nuclear gene (ITS-1) dataset for ~100 populations, collected across the range of the genus. Each partition was analyzed separately, and in the absence of significant incongruence, a concatenated dataset was analyzed using Bayesian inference. We also explored our data using a variety of single- and multi-locus DNA-based methods of species delimitation (e.g., ABGD, bGMYC, PTP). The results support the interpretation that *Juga* comprises a mixture of widespread, highly variable species and narrow range endemics.

Features of teleoconch sculpture, considered significant in subgeneric classification, were found to be variable in some species. Overall diversity was found to be lower than presently recognized, requiring the synonymy of several species. Of a number of potentially new species identified in non-peer reviewed reports and field guides, all but two were not supported as distinct OTUs in any analysis.

Outreach opportunities at the Section of Mollusks, Carnegie Museum of Natural History

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Outreach to and engagement of the public is essential for the survival of a museum. Carnegie Museum of Natural History has two groupings of activities: Museum wide and Section organized. The Museum holds “Meet the Scientists” and specimen identification days. These are opportunities for staff to meet with the public and show them what is done behind the scenes and where we can help them identify specimens. Another means of outreach is through the Carnegie’s Facebook Live Stream. Museum staff also interact with the public when they participate in a BioBlitz activity.

Within the Section of Mollusks, several different activities are held. We open the Section on one Saturday per month to visitors and offer them half-hour tours. Occasionally, during the weekdays, docents will bring tour groups to the Section for a behind-the-scenes tour. Lastly, we field queries from the public that arrive by way of e-mail, letters, and phone calls. These and other activities will be discussed in this presentation

Without volunteers, collections as we know them could not exist

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Non-professionals are a core working group in the Section of Mollusks at Carnegie Museum of Natural History. In addition to assistance with a variety of research projects, volunteers provide essential efforts in the process of acquiring, sorting specimens from matrix, identifying and updating identifications, rehousing, labeling, cataloging and databasing, distributing (shelving), and organizing. Several examples follow.

Carnegie Museum received a large donation from the research of Hermann Wright in 1932. While most of the lots have locality numbers, the original data cards have been lost. Volunteers have recovered approximately 80% of the locality information by reviewing the published literature, creating a spreadsheet from lots having complete locality data, and other sources of information. These efforts allow us to incorporate this material into the collection.

The extensive Sterki collection of Sphaeriidae (freshwater pill clams) is housed at Carnegie Museum. Sterki rarely identified type material. Volunteers have reviewed the original descriptions for Sterki's Sphaeriidae and separated potential type material. These lots are currently being cataloged so this information can be made available on the internet and be incorporated into the type collection. It will also be used to create the first comprehensive type catalog of the Carnegie holdings.

A third example is the incorporation of the extensive Aldrich collection (pre 1953) into the Carnegie's collections. This collection, worldwide in nature, was housed in non-archival boxes. Volunteers helped to record locality information for each lot, re-housed the specimens in archival vials and trays, updated the nomenclature, and then distributed them into the collection. In total some 17 000 lots were process in less than two years.

Expression and function of a dodecahedral and a pentameric acetylcholine-binding protein from the freshwater snail *Biomphalaria glabrata*

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Acetylcholine-binding proteins (AChBPs) are pentameric hemolymph proteins detected in some molluscs. They were first described in the freshwater snail *Lymnaea stagnalis* (Lymnaeidae) and later also characterized in Haliotidae, Aplysioidae and Planorbidae. AchBPs are structural and functional homologues of the ligand-binding domain (LBD) of nicotinic acetylcholine receptors (nAChR) and primarily studied as water-soluble LBD surrogates. Moreover, the biological roles of these proteins in molluscs are of interest. We found previously that in the planorbid snail *Biomphalaria glabrata* (a schistosomiasis parasite vector), twelve AchBP pentamers are further assembled as a regular

pentagonal dodecahedron, 25 nm in diameter. This size and symmetry allows high-resolution 3D reconstructions from electron microscopical images [1]. Moreover, in *B. glabrata* two different AchBP isoforms are expressed (termed Bg- ACHBP1 and Bg-AchBP2). The recombinant proteins reassemble to functional dodecahedra (Bg-AchBP1) and pentamers (Bg-AchBP2), respectively [1]. Here we show, by immunofluorescence microscopy and in situ hybridization of snail tissues with isoform-specific probes, Bg-AchBP1 presence and biosynthesis in brain cells (suggesting a neural function) and in mantle epithelial cells (suggesting a function in shell growth). We collected experimental evidence that recombinant Bg-AchBP1 dodecahedra bind amorphous CaCO3 and influence CaCO3 crystallization. In contrast, expression of isoform Bg-AchBP2 appears to be restricted to neural cells of the brain (suggesting a neural function, but not a contribution to shell growth). We thank Dr. Rusitzka, Dr. Gebauer, S. Braukmann, Dr. Haugwitz, T. Schubert, E. Sehn and Prof. Schneider for support, and the MPGC for a grant to DT.

[1] Saur et al. PLOS One 2012; 7:e43685

The unsung heroes of natural history museums

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Natural history museums are in a perpetual state of fiscal uncertainty. Governments and other funding agencies tend follow popular funding priorities of the day, rather than develop a dependable plan to finance museums. One consistent positive input to many natural history museums is the thousands of hours donated by dedicated volunteers. At our museum we have dozens of volunteers working in our collections every day. These “unsung heroes” are involved in basic curation and identification of specimens, digitization of specimens and records, georeferencing localities, and organizing drawers and cabinets. Over the past three decades volunteers have curated over 500,000 specimens in our mollusk collection and digitized tens of thousands of records. These generous individuals have provided constant energy and time to assist us in creating a world-class collection.

A *Crepidula* conundrum: Testing whether slipper limpet resemblance reflects homology or convergence

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Crepidula naticarum (Calyptraeidae) lives attached to mostly subtidal naticid moon snail shells occupied by hermit crabs off the coast of southern California and Baja California. Little besides its reproduction has been studied. In 1905, Williamson originally called attention to its similarity to *C. norrissiarum*, describing both as separate subspecies of the same (no longer accepted) parent species. In an unpublished 2013 manuscript, the late James McLean grouped these two species and *C. adunca* Sowerby, 1825 in a separate genus, noting “clear and unmistakable” affinities in their shells. However, a phylogenetic hypothesis based on mitochondrial COI sequences published about 15 years ago depicted *C. naticarum* as only distantly related to the other two species. Still, only one individual *C. naticarum* was sequenced, so this suggested to us that either the sequence result might be flawed or this could be an opportunity to further investigate a surprising example of convergent evolution. We tested the previous result by sequencing COI from more specimens of *C. naticarum* dredged at 25m off the coast of San Pedro, California. Our results matched closely the original sequence result, implying that shell similarities noted by Williamson and McClean more likely arose

convergently, perhaps due to their similar association with snail shells. There is also an important previously documented reproductive difference. In contrast to the planktotrophic (feeding) veligers released from embryos brooded by *C. naticarum*, the offspring of both other species are direct developing, eventually emerging from inside the mother's shell to remain attached to the same host shell.

Land Snails of the Blue Ridge Parkway National Park

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During 2017 the Blue Ridge Parkway National Park and Hands on the Land organized a citizen scientist survey of land snails and millipedes. The Parkway consists of a two-lane road stretching 469 miles through 29 counties in North Carolina and Virginia and about 88,000 acres (35,612 hectares) of adjacent land. As the most visited US national park, the Parkway had 15.2 million visitors in 2017. After two training sessions, we or some of the 47 volunteers visited sites selected by the Parkway to search for snails. These sites ranged in elevation from 347 to 1892 meters. Snails, litter samples, and photographs were forwarded to us for sorting and identification. We identified 4306 specimens in 128 species. Snails at sites ranged from 0 to 311 individuals and 0 to 28 species. The most diverse site was on Grandfather Mountain in Avery County, North Carolina. Of 75 sites, 61 had at least 5 snails and 39 had at least 25.

Twelve species were found in at least 20 sites; while 33 species were found at only 1 site. The most commonly encountered snails were *Zonitoides arboreus* (43 sites), *Striatura meridionalis* (39 sites), *Striatura ferrea* (32 sites), *Haplotrema concavum* (30 sites), and *Punctum minutissimum* (30 sites). Three exotic species were found; and taxonomic problems were encountered with about 15 species. Problems encountered included under-sampling slugs and data reporting in general.

Mentoring in collections: A partnership between Glendale Community College and the Natural History Museum of Los Angeles County

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Since 2015, the Natural History Museum of Los Angeles County (NHMLA) has partnered with Glendale Community College (GCC) in Glendale, California, to host a Museum Studies internship course in collections improvement and specimen-based research. The program aims to educate community college science majors in museum specimen care, collections management, taxonomy and systematics, and specimen-focused research. As of summer 2018, five cohorts of student interns have spent one day per week for 16 weeks (one semester) at NHMLA, typically split between two collections (including Malacology) under the mentorship of taxonomists, curators, and collections managers. Collections work includes identifying, sorting and rehousing specimens, organizing collections space, and updating specimen labels. By their sixth week, students choose a research question and use

microscopy (stacking, stereo/dissecting, SEM), specimen preparation (e.g. fossils), dissection, spectroscopy, X-ray photography, or DNA extraction/analysis to test hypotheses. The students present their research at a seminar that is attended by GCC faculty and NHMLA researchers. In addition, some present posters at scientific meetings and/or are coauthors in manuscripts that are being prepared for publication. Student interns receive course credit at GCC, develop skills in scientific inquiry and analysis, and make connections with NHMLA staff that can benefit their transfer to 4-year colleges and universities. Importantly, this internship increases students' appreciation for natural history museums and collections-based research, while giving them access to career fields (e.g. systematics and malacology) that they might not otherwise encounter as undergraduates.

Outcomes from community science focused on the terrestrial malacofauna of Southern California

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The terrestrial malacofauna of Southern California has been the focus of SLIME (Snails and slugs Living in Metropolitan Environments), a community/citizen science initiative sponsored by the Natural History Museum of Los Angeles County (NHMLA) and hosted online by iNaturalist, since 2015. As of early 2018, SLIME has amassed nearly 8800 terrestrial snail and slug records from approximately 1040 participants. NHMLA efforts to promote SLIME have included malacofauna bioblitzes, tabling at Museum events, school visits, public lectures, and outreach through social media. The project's initial results include the first occurrence species records of the slugs *Ambigolimax nyctelius* (Bourguignat, 1861) and *Arion hortensis* Férussac, 1819, and snails, *Cochlicella barbara* (Linnaeus, 1758), *Lauria cylindracea* (Da Costa, 1778), and *Xerotricha conspurcata* (Draparnaud, 1801) in Los Angeles County, and *Pupoides albilabris* (C.B. Adams, 1841) in Riverside County. All are introduced species in California and one, *L. cylindracea,* is a first occurrence record for the U.S. These outcomes demonstrate the efficacy of mollusk-focused citizen science to document biodiversity in a major metropolitan area, and could serve as a model for similar initiatives at other museums or institutions. Finally, comparable genetic data, especially of COI "barcoding" sequences, are lacking for most of these species in publicly available databases, which makes sequence-based identification and phylogenetic analysis difficult to impossible. Such data would potentially benefit pestiferous species management, necessary systematic revisions, and facilitate studying the influence(s) of urbanization on introduced stylommatophoran species.

Implications of *Plakobranchus* cf. *ianthobapsus* (Gastropoda, Sacoglossa) kleptoplasty for herbivore ecology, benthic community structure, and invasive species management

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Siphonous green algae are important members of the marine environment as nutrient cyclers, ecological engineers, and substrate providers. Siphonous algae are unicellular in construction, yet macroscopic. Because of this unicellularity, morphological characters are often insufficient for species delineation. Additionally, many siphonous algae are diminutive (<2 cm) at maturity, further confounding their collection and identification. To address this challenge, the algivorous sea slug *Plakobranchus* cf. *ianthobapsus* was used as a sampling tool for the detection and identification of siphonous algae. *P.* cf. *ianthobapsus* feeds on algae and sequesters their chloroplasts, a phenomenon known as kleptoplasty. Using a sequestration preference study, *P.* cf. *ianthobapsus*

was found to preferentially sequester chloroplasts from diminutive algal species, most likely due to behavioral and/or physiological constraints.

Molecular assessment using both cloning and Sanger sequencing, and metabarcoding of their stolen chloroplasts, or "kleptoplasts," found *P.* cf. *ianthobapsus* sequesters chloroplasts from up to 23 algal species, several of which are putative new species and records to the Hawaiian Islands. Furthermore, kleptoplast metabarcode data supported little algal community dissimilarity among sites across the Hawaiian Islands, suggesting this diminutive community is cosmopolitan and cryptic within algal-dominated environments. Additionally, these data identified *P.* cf. *ianthobapsus* as an herbivore of the invasive alga *Avrainvillea* in Hawai'i, which provided new range and distribution information for the invasive alga, and therefore may be integral to its management. Exploring this slug-algal relationship allows a more comprehensive understanding of both the herbivore and its hosts, as well as the marine communities of which they are members.

Hybridization among species of predatory marine snails: opportunities for adaptive introgression?

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Hybridization – and subsequent introgression – can assemble novel genetic combinations that fuel evolutionary processes at a number of scales. *Conus* ("cone snails") is a species-rich genus of venomous, predatory marine gastropods that exhibits many hallmarks of adaptive radiation.

The sub-clade *Virroconus* is notable for cryptic morphological variation among its nine constituent species that appears incongruous with recent mitochondrial phylogenies, which split morphologically similar species (previously classified as sister) into separate clades. The extent to which reticulate processes have shaped the evolution of *Conus* has not been closely examined, but rapid diversification, young age, a tendency for close relatives to occur in sympatry, and widespread cryptic morphological variation, suggest ample opportunity for hybridization and subsequent introgression to contribute to patterns of diversification in *Conus* and to complicate our understanding of its evolutionary history. In this study, I use high- throughput RNA sequencing of cone snail venom ducts to clarify the *Virroconu*s phylogeny and to detect patterns of introgression and evidence of past hybridization. I leverage a large dataset of orthologous loci for 9 *Conus* species (7 *Virroconus* and 2 outgroup species) to build a consensus phylogeny, which I then compare with individual gene trees to find instances of discordance indicative of introgression. Analyses suggest widespread mito-nuclear discordance, indicating that mitochondrial introgression may be responsible for incongruence between mitochondrial phylogenies and traditional morphological classifications. Further analyses will contrast patterns of introgression between "housekeeping" genes and venom genes to examine adaptive introgression.

Phylogenetics and biogeography informing conservation of Hawaiian Achatinellidae

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Pacific island land snails are one of the most imperiled animal groups, threatened with extinction from habitat destruction, invasive species, and climate change. The more than 750 species of Hawaiian land snails have come to symbolize the plight of land snail extinctions throughout the Pacific, with less than 250 species of this once hyper-diverse fauna known to be still extant. The most iconic of the Hawaiian land snails, Achatinellidae, once boasted 209 species in five subfamilies, of which two are endemic, Achatinellinae and Auriculellinae. Outside of the Achatinellinae, little is known about relationships, evolution, ecology, or conservation status of the family broadly. To begin filling this knowledge gap, we have assembled a data set of two mitochondrial and two nuclear loci for 743 individuals representing 90 species from 447 sites across the Hawaiian Archipelago. Initial phylogenetic analyses support the monophyly of the family and each of the Hawaiian subfamilies. Speciation in the family does not appear to follow a strict progression rule, resulting from repeated dispersal events among islands followed by diversification and possibly back colonization. An island age calibrated molecular clock is providing insights into the timing of diversification among the subfamilies and the arrival of the family in Hawaii. Although a great deal of Achatinellidae diversity has been lost, there remain glimmers of hope as we have rediscovered species previously thought extinct (e.g. *Auriculella pulchra*, *Newcombia canaliculata*) and discovered several new species that await description. Together, these data are being incorporated into conservation management plans in hopes of conserving the remaining species for future generations.

Fifty-two species and counting - invasive terrestrial snails in Hawaii

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Invasive species are a threat to natural resources, agriculture and human health. Up-to-date surveys of introduced species are crucial for biosecurity plans as they provide data for identification, establishment and spread. Knowing which species are present, and where they occur aids conservation and invasive species managers to determine threat levels and prioritize control measures. In 2008, 38 non-native terrestrial (including freshwater) species were reported as established in Hawaii, and over the last decade, we have recorded an additional 14 species, bringing the number of species of established non-native land and freshwater snails in Hawaii to 52. Several species that were once reported as restricted to only one or two islands have spread more widely, and occur on other islands and continue to spread. Many of these species (e.g. *Arion* spp., *Deroceras* spp., *Veronicella cubensis*, *Laevicaulis alte*, *Limax maximus*, *Pomacea canaliculata*, *Succinea* spp., *Euglandina* spp., *Ovachlamys fulgens*, *Lissachatina fulica*) are known to negatively impact agriculture and natural ecosystems, and some (e.g. *Parmarion martensi*, *Galba* cf *truncatula*, Subulinidae spp., *Cyclotropis* sp.) are also vectors of zoonotic diseases, including Rat Lungworm. Early detection of recent introductions is critical for effective eradication before they spread, which is why continued surveys are needed to strengthen biosecurity and to develop preventive measures aimed at reducing the potential impacts of invasive species.

Poster Presentations

Alphabetical by First Author

Transcriptomic changes in the oviductal gland of *Octopus maya* during the reproductive process in response to heat stress

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The oviductal gland (OG) is a key organ for octopus reproduction since spermatozoa storage and fertilization occur herein. There is the hypothesis proposing that this process is negatively affected by high temperatures, but there are no molecular evidences explaining how temperature reduces the fertilization rate. In this regard, a transcriptomic approach was used to describe the changes in gene expression linked to the different reproductive stages and in response to thermal stress, to understand how temperature affects fertilization. Females were acclimated at 24 °C (preferred temperature) and 30 °C (stress temperature), and OG were sampled before, during and after spawning in both treatments. RNA was extracted and cDNA paired-end libraries for each condition were prepared for sequencing in the Illumina Miseq system. A total of 19,969,819 high-quality paired reads were obtained, which were used for de novo transcriptome assembly. The reconstructed transcriptome consisted in 61,598 transcripts and 50,585 genes. Later, annotation for 24.43 % of the transcripts was achieved by searching homologs in the Uniprot-Swissprot database. In addition, differential gene expression was assessed among the different stages and temperatures, and enrichment analyses were performed using the upregulated genes in each condition. Major differences in gene expression were observed among the different reproductive stages (2,341 transcripts), whereas 93 transcripts showed significant difference between temperatures during spawning. These results show that thermal stress caused alterations at the extracellular matrix level and in the hormone metabolic process, suggesting that these alterations could be involved in the low fertilization rate observed at high temperature.

50 Shades of Red: An analysis of the biodiversity of Goniobranchus Nudibranchs

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In the last several years, the family tree of Chromodorididae has been undergoing refinement due to molecular work, indicating new relationships between taxa. The genus *Goniobranchus* is one clade of the Chromodorididae and used to be included within *Chromodoris*. *Chromodoris* was determined to be non-monophyletic and *Goniobranchus* was separated out. Since separation, molecular work to resolve the internal relationships in *Goniobranchus* has not been undertaken. Over half of the proposed species in this genus are still undescribed. Through genetic sequencing, we have sequenced 79 (75 new) *Goniobranchus* specimens representing 24 previously defined species. We used two mitochondrial (COI and 16S) genes and one nuclear gene (H3) to begin to resolve the genetic relationships between *Goniobranchus* species. Phylogenetics was used with Bayesian inference, maximum likelihood, and maximum parsimony analyses to postulate the evolutionary relationships between *Goniobranchus* species.

RECOLNAT Program: synthesis of 5 years of digitization of the molluscan collections at MNHN

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The Museum National d'Histoire Naturelle (MNHN) in Paris, founded in 1793 by the French Revolution, was the first public institution specifically established to conserve natural history specimens. Current growth of the collections is driven by the Tropical Deep-Sea Benthos and Our Planet Reviewed programs, with a well-established workflow that starts in the fieldwork and ends with the determination of the specimens by the scientific network of specialists associated to MNHN.

The RECOLNAT Program (ANR-11-INBS-0004) is a country-wide project that conglomerates 57 institutions. The main objective of the Program is to digitize the natural collections in France and make them available on the internet. As a result of this effort, 8.8 million specimens of all phyla (about 1 million zoological specimens) have been digitized to date, and 7.6 million images created (https:// explore.recolnat.org/). These specimens come from all continents and Oceans, including samples from South and North America.

The digitization of the molluscan type collection at MNHN has been in progress since 2014, with images of roughly half of the ca 15,000 primary types currently available online (https:// science.mnhn.fr/institution/mnhn/collection/im/item/search) and linked to the World Register of Marine Species (WoRMS). The second area of focused digitization efforts is the molecular collection, which initially benefited from kick-off funding by the Sloan Foundation under the Marine Barcoding of Life (MarBOL) initiative. Online access to images of molluscan types in MNHN has considerably diminished the number of requests for actual loans. The collections are the source of ~100 research publications every year.

What's (dug) up (at Old) Dock

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The Waccamaw Formation contains a rich Early Pleistocene (early Gelasian) fauna with an extreme abundance of mollusks (90+ % of the material) in addition to various echinoderms, arthropods, annelids and vertebrates. This diverse subtropical fauna is found in southeastern North Carolina and eastern South Carolina. Although fossils have been reported since the mid- 1800's, no single monograph exists. Through landowner permission to the North Carolina Fossil club, in three collecting trips to the Old Dock site, I have collected and identified 64 (as of April 30) species out of approximately 500 known from the lower Waccamaw. Notable species include *Caloosarca rustica*

(Tuomey & Holmes 1857), an aberrant *Conus oniscus* W. P. Woodring 1928, *Fusinus caloosensis carolinesis* (Dall 1892), and *Aurinia obtusa* (Emmons 1858). All reasonably complete specimens are being photographed to document the fauna.

Cephalopod paralarvae community structure in Mesoamerican Barrier Reef System

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Paralarvae (PL) are the first growth stage after hatching in all cephalopods. We describe the community structure (species richness, abundance, and distribution) of cephalopod PL at the Mesoamerican Barrier Reef System (MBRS), the second largest coral reef system in the world considered a prime biodiversity hotspot. The oceanic zone from Isla Contoy to Chinchorro Bank in the east coast of Quintana Roo, Mexico, was surveyed by an oceanographic research cruise during March and April 2006. Zooplankton samples were collected using a MOCNESS at four depth strata: a) 100-75 m, b) 75-50 m, c) 50-25 m, d) 25-0 m. The PL abundance registered was grouped by latitudinal transects, day-night collections and distance to the coast to test for significant differences.

A total of 601 PL were collected belonging to 42 taxa. Most abundant families were Enoploteuthidae (51%), Onychoteuthidae (18%) and Ommastrephidae (13%). In general, largest abundances were found south of the study area (Chinchorro Bank). The northernmost transect was the most different regarding PL abundance and specific composition. The species richness in the diurnal and nocturnal seasons was similar, however, the abundance was higher during the diurnal tows. More coastal stations (0-75 km) reported greater abundance and richness of PL. As a sharp contrast with the Mexican Pacific were paralarval communities are influenced by the environmental and oceanographic change at different spatial and temporal scales, the oceanographic homogeneity in the MRBS water column precluded to show differences in the composition of PL. Current velocities better explained the distribution of PL in the MRBS.

DNA barcoding of Gastropod larvae in Panama

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The diversity of tropical marine invertebrates is poorly documented. Large bodied animals with hard parts, like marine gastropods are relatively well sampled, but species from habitats that are difficult to access may still be poorly documented. We sampled planktonic larvae of marine gastropods to assess this hidden diversity in the Neotropics. We collected veliger larvae from the waters of the Pacific coast of Panama, and used DNA barcoding of mtCOI DNA to estimate the diversity of the

region. Barcode gap analysis detected a gap between 3% and 6% divergence. With moderate sampling effort, we documented over 100 operational taxonomic units. When possible larvae were identified by comparison with published sequences in GenBank and by comparison with published morphological descriptions. Samples included numerous coastal caenogastropods belonging to more than 10 families, as well several genera of pteropods. The most unusual larvae belonged to *Gastopteron*.

Management of endangered O‘ahu tree snails using predator-proof enclosures

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The endangered O‘ahu tree snail, *Achatinella mustelina,* is a focal species for the U. S. Army’s Natural Resource Program on O‘ahu in the Wai‘anae Mountains. Ongoing multidisciplinary efforts for the stabilization of this species include intensive long-term habitat management, restoration, removal and control of direct threats posed by invasive plants and predators including rats (*Rattus rattus*), rosy wolfsnails (*Euglandina rosea)*, and Jackson’s chameleons (*Trioceros jacksonii xantholophus*). Automated re-setting traps (A24s) are effective for rat control, however, manual removal is the only method available for eliminating rosy wolfsnails and Jackson’s chameleons. Between 2004 and 2009 a 50% decline occurred in the largest known population of *A. mustelina,* located at Pu‘u Hapapa in the central Wai‘anae mountain range on O‘ahu. In response to this decline, in 2010, 202 *A. mustelina* were moved to the University of Hawai‘i Tree Snail Laboratory for safeguarding and captive rearing. At the same time, construction began on a 0.4 acre predator-proof enclosure at Pu‘u Hapapa. In 2012 and 340 captive snails from the laboratory were returned to the enclosure. Over the next four years, nearly 1400 snails were added to from neighboring areas. Monitoring indicates snail populations inside the enclosure are stable relative to those outside, which continue to diminish in response to predation and habitat degradation. The program manages four enclosures and plans to construct two more. Protecting snails within predator-proof enclosures is a crucial management tool to prevent species extinction in Hawai‘i.

Microsatellite bioinformatic analysis of next generation sequencing data from two *Octopus* (Cephalopoda: Octopodidae) species.

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Next generation sequencing allows to obtain a large number of DNA fragments from non-model organisms, which may contain repetitive motifs or microsatellites. Generally, microsatellites contain from two to six nucleotides as repetitive motifs and they are found in the whole genome of a particular species and are used to characterize and differentiate populations. Octopuses are important fishery species in both coast lines of Mexico and, therefore, it is important to characterize their populations using a molecular marker such as microsatellites. The main objective of this paper was to obtain microsatellite markers from a partial genome sequence of two octopus species from the northeastern Pacific, *Octopus mimus* and *Octopus* sp., and compare their microsatellite distribution. A total of 3868

microsatellites were found in *O. mimus*, while there were 1972 microsatellites in *Octopus* sp. The most common microsatellite type in both *Octopus* species was the dinucleotide followed by trinucleotide and tetranucleotide. The most abundant dinucleotide microsatellite was AC in *O. mimus*, while in *Octopus* sp. It was AG. In trinucleotide microsatellites, the most common motif was ATC with a percentage of 36.28% and 43.31%, respectively. Microsatellite distribution was different between octopuses and also different when compare with microsatellites obtained for *Octopus bimaculoides* complete genome, the most common was AT (48.31%), the number of motifs were different in the latest species, obtaining 29 types of tretranucleotide motifs, whereas for *O. mimus* and *Octopus* sp., we obtained 17 and 14, respectively. The analysis of the produced *Octopus* partial genome sequences allow to suggest differential microsatellite distribution among *Octopus* species.

Characteristics of a recently discovered population of the banded grove snail in Washtenaw County, Michigan (USA)

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Information on the establishment and spread of exotic species is important for understanding the dynamics and potential consequences of biotic introductions. The banded grove snail, *Cepaea nemoralis*, first became established at a few locations in the northeastern United States in the 1800s. It is now known to occur at multiple sites and has a broad though fragmented distribution in North America. We recently observed individuals of this species at a city park in Washtenaw County, Michigan, a county for which *C. nemoralis* was not previously known to occur. To infer the potential age and source of this population, we estimated its size-frequency distribution and compared patterns of genetic diversity at mitochondrial (COI) and nuclear gene (ITS2) regions among this population and populations from elsewhere in North America and Europe. The newly discovered population appears to be comprised of multiple year classes, including juveniles, which implies that it was likely established several years ago. Individuals from this population exhibit no variation at COI and ITS2; individuals from Ingham County, Michigan and most individuals from Ontario, Canada also share this same COI haplotype. This haplotype occurs in a haplotype clade that is represented throughout Europe. These results suggest that North American populations of *C. nemoralis* experienced a bottleneck during or following their introduction and that the newly discovered population in Washtenaw County was established from individuals from one or more North American populations.

Clash of the chitons: How DNA, distribution, and morphology differ in three *Nuttallina* species

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The chiton genus *Nuttallina* (Polyplacophora: Lepidochitonidae) includes extremely common and ecologically important mid-intertidal grazers between San Francisco and south of San Diego, California. Given confusing morphological overlap, the late Antonio Ferreira recognized only *N. californica* (Reeve, 1847) along this coast, and WoRMS (World Registry of Marine Species) has followed his opinion. However, we find substantial genetic and subtle morphological distinctions between three species. *N. californica* and *N. fluxa* (Carpenter, 1864) are dominant north or south of

Point Conception, respectively, but *N. californica* is also locally common on the most exposed headlands of southern California and northern Baja California, Mexico. A third undescribed species, *N*. sp. A, is much less common, known from relatively few localities between Monterey and San Diego counties, but much remains unknown. We have developed a PCR-based DNA assay that unambiguously distinguishes these three species without sequencing, identifying *Nuttallina* samples from multiple central to southern California localities, and at two tidal heights, to address the following questions: 1) Which species are present at selected localities from central to southern California?; 2) Do co-occurring species differ in vertical distribution within a locality, sampled at highest versus lowest shore heights occupied by any *Nuttallina*?; and 3) Are there consistent shape or other morphological differences between the three DNA-identified species? Our morphometric analysis of the disarticulated fifth valve shape revealed at least one diagnostic difference. *Nuttallina* will provide a useful system for investigating range shifts related to climate change and competitive interactions between these closely related and co-occurring species.

The use of scientific illustration in educational outreach, research, and conservation

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Scientific illustrations serve as a vital tool to communicate scientific ideas and meaning to diverse audiences and to document observations. Historically, such illustrations have served as some of the only documentation for scientific discoveries, including the now extinct Dodo bird. Illustrations enhance understanding of written content, while aesthetically pleasing and scientifically accurate illustrations help foster engagement, appreciation and public interest for species, particularly groups that are traditionally underappreciated (e.g. molluscs, insects).

Anatomical illustrations provide accurate depictions of specimens for taxonomic and/or field guides, allowing researchers, conservation managers, and others to identify species more readily. In the age of technology, the classic art of scientific illustration is being replaced by digital imaging in many fields, but some critical aspects of anatomy and characteristics needed to identify and understand organisms are not well conveyed with digital images alone. In an ongoing effort to increase scientific and public understanding, awareness, and appreciation for one of biodiversity's neglected majorities, land snails, we have been developing scientific illustrations aimed at: 1) educating museum visitors about molluscan characteristics and conservation with an animated video and interactive games; 2) increasing interest and appreciation for native Hawaiian land snails through conference logos and t-shirt designs; 3) developing guides depicting the general external anatomy needed to identify native and invasive snails in Hawaii. As such, the knowledge and appreciation of native land snails developed through these products will hopefully aid in conservation efforts.

A biogeographic analysis of loss of planktotrophy in caenogastropod molluscs (Gastropoda, Nassariidae)

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In marine invertebrates the larval development is a key feature for evolution and ecology of species. In planktotrophic development (P), the larvae spend from a few days up to one year in the plankton feeding actively. In non-planktotrophic development (NP), larvae spend very little or no time in the plankton feeding almost exclusively yolk supplies. In the Caenogastropoda, NP is mostly considered as a derived condition that arises in response to conditions that counterselect P, allowing independence from trophic environmental availability. It is suggested that NP represents an advantage in phytoplankton-poor regions as the Mediterranean Sea, in areas where food availability is strictly limited by seasonality as in Antarctica, or in response to major environmental changes occurred in the past.

We have tried to detect and analyze, in a phylogenetic framework, the distribution of events of loss of planktotrophy in a group of marine gastropods, aiming at identifying eco-evolutionary patterns. We used a comprehensive robust phylogeny of the family Nassariidae (Buccinoidea) to identify pairs of sibling species, or group of species, that differ in larval development thus representing independent losses of P in the tree. The fossil-calibrated phylogeny allowed dating events of loss of P by using a relaxed molecular clock model. We found at least 15 P-NP switches in the Nassariidae and most of them were dated to the Miocene (23-10 Mya) and the Pliocene (4-2 Mya). For most of them plausible paleoceanographic scenarios were reconstructed to explain the environmental conditions that may have favored the loss of planktotrophy.

Speciation in *Dondice* species from the Tropical Western Atlantic

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The general assumption that speciation in the ocean is a rare process, associated in most of the cases with the emergence of a geographic barrier, i.e., allopatry, prompted to the interpretation that other forms of speciation are less likely to happen in the marine realm. However, recent evidence suggests that ecological-based and sexual mechanisms could promote population separation facilitating reproductive isolation between species in absence of geographic barriers. Here we assess the mechanism of speciation in two sympatric nudibranchs species from the Western Atlantic: *Dondice occidentalis* Engel, 1925 and *Dondice parguerensis* Brandon & Cutress, 1985. Previous morphological and molecular work on these sister species did not find conclusive evidence for their separation, and their validity is still unclear, suggesting a case of incipient or incomplete speciation in nudibranchs. We hypothesize that the two *Dondice* Caribbean species could represent a case of ecological speciation, in which dietary specialization has played an important role in the isolation of individuals, resulting in

the emergence of a new species. Hence, the reproductive isolation is a side effect of divergent selection in which populations have adapted to different habitats. Our main goal is to investigate the mechanism of speciation in *Dondice* Caribbean species and the main driver behind this process. To test our hypothesis, we propose to study their population structure by implementing Next Generation Sequencing techniques, as well as their mating and feeding behavior. Providing an interpretation of the evolutionary history of these nudibranchs could bring new insights into the study of marine biodiversity.

Optimizing temperature in green abalone culture methods to increase resilience in the California aquaculture industry and restore wild populations

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Wild abalone were once abundant along the California coast, but populations have been impacted by habitat loss, Withering Syndrome (WS) disease, and serial depletion from commercial and recreational fishing. Because the abalone fishery was officially closed in 1997 for all species in California, the abalone market now relies solely on the aquaculture of red abalone (*Haliotis rufescens*). Red abalone require colder water temperatures than other species and it is of major concern that climate change and el Niño patterns will negatively affect growing conditions on California flow through farms. We are investigating the application of existing culture methods of red abalone on green abalone (*Haliotis fulgens*). Green abalone are a southern species suited to warmer waters, making them a potential candidate for the changing aquaculture industry in California. To implement our project, we have developed a 3 by 3 factorial design to investigate the effects of using different temperature regimes on broodstock conditioning, fecundity, fertilization rates and settlement success in captivity. Study results should contribute to our goal of making abalone aquaculture more resilient through diversification of cultured species, while also restoring wild populations so that one day a sustainable fishery can be reestablished in southern California.

Sibling rivalry - defining colour polymorphisms in *Cepaea nemoralis* and *Cepaea hortensis*

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Studies on the origins and maintenance of conspicuous polymorphisms have been formative in developing our understanding of the way that natural selection shapes populations. The shell of the land snail *Cepaea nemoralis* presents a well-studied, yet potentially problematic colour polymorphic system, because traditionally individuals are placed into one of three major colour classes, yet actually colour is continuously distributed. As a similar though perhaps more limited polymorphism is apparent in the sister taxon *Cepaea hortensis*, we set out to use spectrophotometry and psychophysical models of avian colour vision to accurately define the colour phenotypes present in both *Cepaea* species, and to present them in an ecologically relevant context. Overall, by establishing a method for quantitatively

measuring colour, this work will allow further insight into the maintenance and evolution of the polymorphisms present in the *Cepaea* genus, and ultimately aid in understanding the supergene which underpins the genetic basis of the polymorphism.

Transcriptomic response to chronic and acute thermal exposure, in the gills of juvenile geoduck clams *Panopea globosa.*

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The Cortes geoduck *Panopea globosa* is a large bivalve with high commercial value that distributes in the southern coasts of Baja California Peninsula and inside the Gulf of California, inhabiting a wide range of temperatures. According to recent studies, temperature has a strong influence in the population structure and in the reproductive cycle of this species. Moreover, it seems that the temperature decrease in winter triggers its sexual maturation. On the other hand, a new record of this species in shallower waters suggests that it is able to adapt to a warmer environment. With the aim of better understanding the molecular mechanisms that allow this clam to cope with different thermal shifts, we compared the transcriptomic response in gills of juvenile individuals exposed to chronic and acute thermal conditions. In addition, the metabolic rates were compared among the experimental individuals. Results show that under acute and moderate (29 ºC) thermal exposure, there was a significant increment in the individuals' metabolic rate and protective mechanisms against oxidative stress were activated. Nevertheless, when acute experimental temperature was high (31 ºC), we observed a shift to reparative mechanisms through the activation of protein re-folding processes. Additionally, the response to DNA damage was upregulated when the thermal stress was chronic, but also the response to oxidative damage, and to endoplasmic reticulum stress. In conclusion, *P. globosa* presents alternative molecular pathways in response to different thermal stress levels, making this species an interesting model to describe the transcriptomic plasticity under a climate change scenario.

Historical geographic distributions of *Auriculella* (Achatinellidae), *Catinella* (Succineidae), *Succinea* (Succineidae) species on Maui

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The Hawaiian Islands are home to a diverse group of land snails, with estimates of the number of species ranging from 752 to 1,461 species. As a result of the extreme isolation of the islands, land snail colonists have diversified extensively into the highly endemic fauna known today. However, a combination of human mediated impacts, including invasive species, habitat destruction, and climate

alteration have resulted in dramatic reductions in population sizes for many native species, with some researchers estimating that only 25-35% of native land snail species are still extant. Little is known regarding habitat suitability of most native snails. This is in part due to their rapid decline, and poor understanding of their historical distributions. To better understand the factors linked to population decline and provide new hypotheses for identifying locations where populations may still occur, we have begun assessing historical distributions of species from three genera in two families Achatinellidae (*Auriculella*) and Succineidae (*Catinella* and *Succinea*) on Maui. These two families are not closely related, and although species belonging to them may be similar in size, they have different shell shapes, and are anticipated to have very different habitat specificity and distributions. Historical and current geographic data from the Bishop Museum malacology collection were used to create distribution maps via QGIS. Preliminary results indicate that many populations have become extirpated and existing populations are restricted to high elevational areas. Future work includes developing distributional maps of all native land snail species and assess relationships among various environmental parameters (e.g. precipitation, elevation) to determine species survivorship.

Historical distributions of *Auriculella* spp. and *Elasmias* spp. (Achatinellidae) on the Island of Oahu, Hawaii

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The remoteness of the Hawaiian Islands has helped make the archipelago an endemism capital of the world, resulting in a very high diversity of land snails, of which 99 percent are endemic. However, native Hawaiian land snails, like many land snails across the Pacific, have declined dramatically, as many have been driven to extinction by habitat destruction and invasive species such as rats (*Rattus* spp.), the Rosy Wolfsnail (*Euglandina* spp.), the Garlic snail (*Oxychilus alliarius*), and numerous others. An understanding of historical distributions is critical for assessing the extent of diversity loss and determining contemporary conservation status.

Museum collections serve as a vital resource for such research. We have used the Bishop Museum malacology collections to assess the historical distributions of two Hawaiian land snail genera, *Auriculella* and *Elasmias* (Achatinellidae). Lots of 20 *Auriculella* spp. and 2 *Elasmias* spp. collected 1903-1953 were georeferenced for this study using QGIS, an open source platform that can analyze geospatial data. So far, preliminary assessments of the geographic and distributional data indicate that the number of *Auriculella perpusilla* and *Elasmias luakahaense* populations have declined dramatically, and most of the existing populations or no longer found in low elevational areas. The historical distributions for these species will inform conservation by providing baseline data to target future survey work and to potentially assess the impacts of invasive species, climate change, or other threats on Hawaiian land snails. An understanding of the historical geographic distributions of threatened land snails in combination with updates from current distributions will help to predict potential locations of remaining snail populations, which may help prevent the extinction of these remaining species.

Comparative benefits of kleptoplasty within clade Sacoglossa under ecologically relevant conditions

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Understanding the ecological role of kleptoplasty (retention of functional chloroplasts in sacoglossan sea slugs) could provide insight into how photosynthetic mutualisms evolve. Basal lineages digest algal plastids within hours, but in two lineages (genus *Costasiella*, superfamily Plakobranchoidea) plastids are taken up by digestive gland cells and photosynthesize for short (1-2 weeks) or long (up to 9 months) periods. Some recent studies argue kleptoplasty provides no nutritional benefit to the slug, however; others argue photosynthesis only yield fitness benefits under starvation conditions, whereas other studies claim kleptoplasty actually kills short-term retaining species during starvation. We used a 2x2 design to distinguish among competing hypotheses, testing for interactions between light (high versus low) and feeding (fed versus starved) for species varying in retention ability and plastid source. Feeding in the light was consistently beneficial, indicating kleptoplasty is ecologically relevant, but effects varied with slug retention ability and algal source of plastids. Short-term retainer *E. velutinus* (host: *Halimeda*) grew only in high-light/fed conditions. Long-term retainer *E. crispata* lost weight in all treatments when pre-fed *Halimeda* (faring best in high-light/fed), yet maintained weight in high light when fed *Penicillus*, consistent with measurements showing higher photosynthetic efficiency of *Penicillus* plastids in *E. crispata*. Short-term retainer *E. subornata* (host: *Caulerpa*) lost weight at equal rates in all treatments but consumed significantly less algae in high-light versus low-light conditions, indicating benefits of photosynthesis if ingesting toxic algae incurs costs. Photophysiological measurements indicated low light prolonged plastid function, showing evidence for photoacclimation within all species.

Sex-specific effect of the hydrocarbons exposure on the transcriptomics response in *Crassostrea virginica*

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The negative impact of an oil spill on marine invertebrates varies with location, the magnitude of the spill, the stage of life and the capacity of organisms to prevent or process contaminants. One way to assess this impact is through the study of the effects of exposure to hydrocarbons on organisms that live throughout the water column and sessile organisms as indicators of the ecosystem health. To have a better understanding of the hydrocarbons effect on the reproductive physiology of marine invertebrates, we exposed to the eastern oyster *C. virginica* to different concentrations of Water-accommodated fractions (WAF) from light oil and evaluated the transcriptomic response using RNA-

Seq. The oysters were sampled in Morales Laguna (Tamaulipas, Mexico) and exposed to WAF during three weeks. Assembly of reads from gonad, using Trintiy software, generated 61,694 'Genes'. Database Swissprot/Uniprot and PFAM-A were used for the annotation of proteins. At the end of this process were kept 145,454 transcripts. Gene ontology analysis showed that more abundant categories were related with metal ion binding, energy production and transcriptional process. Also, the differential expression gene analysis suggested that WAF exposure had a higher impact on females and juvenile individuals, down-regulating genes related to the maturation and reproductive processes. Another set of transcripts was composed of enzymes involved in the oxidative stress response such as superoxide dismutase (Cu-Zn), glutathione S-transferase and catalase. Finally, genes and metabolic pathways, found in this oil exposure experiment, suggest their potential application in environmental conservation, although more studies are needed.

Transcriptomic analysis of the optic lobes of *Octopus maya* males under chronic thermal stress during the reproductive process

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The optic lobes (OL), visual centers of the cephalopod brain, are important sensory, learning and memory centers. However, little is known about the regulatory mechanisms involved in the OL of *Octopus maya*. To characterize the biological processes regulated by the OL and assess if thermal stress and reproductive stage can affect their gene expression, octopus males were acclimated at 24°C (preferred temperature) and 30°C (stress temperature) for 30 days. After, males were mated with females acclimated at 24°C. The OL of males were sampled before and after mating in both treatments. Total RNA was extracted and four paired-end cDNA libraries were prepared for sequencing in MiSeq platform. We obtained a total of 24,597,974 paired high- quality reads. The transcriptome was de novo assembled with Trinity software, obtaining 88,616 contigs and 81,987 unigenes (N50= 850). From these, 19.64% of contigs were annotated using Uniprot-Swissprot database. Additionally, differential gene expression analysis was carried out among temperature treatments and mating conditions, showing 463 transcripts with differential expression; from which, 284 transcripts were differentially expressed between the thermic conditions. We identified putative encoded proteins involved in biological processes like chemotaxis, oxidation-reduction, nervous system development, cell fate specification, apoptosis, response to external stimulus and histone modification. Remarkably, genes such as *Hsd3b, odc1, Isl1, sod2, Elavl4, prss12, nrxn3a, pcdha8, phf10* and *smarcd1* are linked to neural system development in other species. These results provide new evidence showing that OL are linked to nervous system development and play a role regulating the response to thermal-stress in *Octopus maya* males.

Determining Sexual Selection Using Morphological Trails and Sperm Precedence in A Simultaneous Hermaphrodite, *Alderia willowi*

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Hermaphrodites can display both male- and female-advantage traits, with male traits (including penial stylets and pheromonal manipulation) allowing sperm donors to assert their agenda over the female function of sperm recipients, and/or out-compete rivals when multiple mating occurs. However, cryptic female choice may allow sperm recipients to preferentially use sperm of select males, although little is known about this mechanism. To distinguish whether female choice is operating or getting bypassed by hypodermic insemination, fertilization patterns were linked to morphological traits of sperm donors or sperm precedence. Individuals were mated with large then small slugs, or small then large slugs, to test the effects of (a) body size of sperm donors, versus (b) sperm precedence, both known to influence paternity success in other hermaphrodites. Microsatellites were used to determine percent paternity of each sperm donor in clutches laid by the sperm recipient. If body size is under sexual selection, I predict higher paternity rates in larger sperm donors who mate first and equal or higher paternity rates in larger sperm donors who mate second, whereas if there is no effect of body size, I predict paternity rates will be based on sperm precedence. I will summarize results showing that pheromones from egg cues stimulate short-term egg laying; I predict such cues may alter patterns of sperm utilization. My research investigates the theory of sexual selection on hermaphrodites and will provide further insight into how chemical signaling mediates population ecology.

Objective prioritization of exotic terrestrial gastropod pests: development of a new model

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A primary goal of the USDA-APHIS's Plant Protection and Quarantine (PPQ) division is to protect agriculture and natural resources in the U.S. from the entry, establishment, and spread of exotic plant pests. To aid this mission, we are developing a statistically robust risk assessment tool, which categorizes exotic terrestrial gastropods based on their likelihood of causing serious impacts to agricultural and natural resources. As part of the model development process, we have identified 27 genera of mollusks that include species that were previously introduced to the U.S. and we have prepared an initial list of predictor variables, or risk criteria, that may contribute to the impact potential of these organisms. The exotic pests in this training dataset are being analyzed as though they were not yet introduced. We therefore rely only on information (behavior, impacts, and controls) from outside the U.S. to obtain data for our risk criteria. We estimate the actual impacts the organisms have had using the information we obtain from the U.S. We will then develop an ordinal logistic regression model using mutual information from entropy based techniques to identify the most informative subset of predictor variables. Our model categorizes exotic pests as high, moderate, or low impact species, allowing PPQ decision-makers to more judiciously allocate agency resources towards regulatory activities such as early detection surveys.

Distribution of non-native slugs in the Hawaiian Islands

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Non-native snails, which includes slugs, have been introduced to Hawaii through agricultural and horticultural trade and introductions continue to increase in concert with rising numbers of visitors and trade. There are no native slugs in Hawaii, and the introduced ones threaten Hawaiian forest ecosystems and native snails through herbivory, disease and parasites, competition, and by serving as food source for invasive predators such as rats (*Rattus* spp.) and carnivorous (e.g. *Euglandina* spp., *Gonaxis* spp.) and omnivorous (*Oxychilus alliarius*) snails. To clarify the numbers of established slug species in Hawaii and allow resource managers to develop better control strategies we have assessed the identification and distribution of 14 established slug species populations on the six main Hawaiian Islands. We also provide detailed data for the six most invasive species that should be a priority for management. Two temperate (*Deroceras laeve, Milax gagates*), two tropical (*Veronicella cubensis, Laevicaulis alte*) and two species that span both temperate and tropical areas (*Limax maximus, Meghimatium bilineatum*) in their native ranges were chosen to assess their elevational range in Hawaii. We hypothesized that the tropical species would be restricted to low elevation habitats, with temperate species in high elevation areas. However, both *D. laeve* and *V. cubensis* ranged from sea level to more than 1000 m. *Meghimatium bilineatum* had a wider elevational range than (sea level to 1775 m) compared to *L. maximus* (only found above 500 m). It cannot be assumed that introduced species will invade elevational areas based on their native range and other environmental (e.g. precipitation, temperature) and biological (competitiveness, dispersal strategy, feeding behavior) factors are needed to predict where non-native species will become established.

First records for California and discovery of the brittlestar host for the parasitic eulimid snail, *Stilapex cookeana* (Bartsch, 1917).

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We have identified a parasitic gastropod (Eulimidae), found in Los Angeles and Orange counties of southern California, as *Stilapex cookeana* (Bartsch, 1917). This species was previously only known from shells at the type locality on the Pacific coast of Baja California Sur, Mexico and from more southern scattered lots as far south as Ecuador. Our recent collections of this striking but tiny orange-colored snail are the first from anywhere north of the type locality. If the identification is correct, these are the first live-collected *S. cookeana*, which we always found firmly attached to the banded brittle star, *Ophionereis annulata* (Le Conte, 1851). The host is a common species in southern California and occurs as far south as Ecuador, which is consistent with the reported range of *S. cookeana*. Others have concluded that the *S. cookeana* type material, with shells reportedly found on an abalone, were an accidental association because eulimids are well known to specialize in parasitism

on particular species of diverse echinoderm taxa. Many eulimid species are known to have high host specificity, and the hosts of the other nine recognized species of *Stilapex* Iredale, 1925, when known, are likewise all found on specific ophiuroid species. Members of *Stilapex* are unusual for eulimids in having quite stout shells, superficially resembling *Lacuna* (Littorinidae) but with a well-developed protoconch. More specimens and further morphological, reproductive, and genetic research on the collected individuals, and comparison to the *S. cookeana* holotype, are necessary for confirming its specific identification and assignment to *Stilapex*.

Effect of the stress for acidification on the development of umbonated larvae in *Panopea globosa*

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Due the increase of the atmospheric concentration of CO2 and the absorption of this by the ocean has resulted in a decrease in the pH of seawater causing the lower availability of carbonate for the biomineralization process in organisms such as echinoderms and mollusks. This effect has been evaluated through physiological parameters, and gene expression analysis. The species *Panopea globosa* has a distribution in the high Gulf of California and this fishery is of economic importance in the Northwest of Mexico, extracting up to more than 1000 tons per year, causing the interest in its incipient aquaculture. During the larval development it goes through important processes vulnerable to changes in pH, for example, the calcification. In this work, veliger umbonated larvae of *P. globosa* were exposed at an acid pH (7.3-7.5) and a control pH (8.0), finding a negative effect on the growth, reducing the size in the larvae exposed to acidic pH compared to those developed at seawater pH and electron microscopy confirms this, showing damage to the shell. There is an increase in oxygen consumption observed in the larvae exposed in low pH. Gene expression analysis was performed by real-time quantitative PCR technique, in the case of the gen ATP synthase, a pattern was not found. In the case of the gen carbonic anhydrase, an inverse relationship pattern was observed, and the NADH dehydrogenase and perlin genes showed a higher expression in the experimental treatment.

Rehousing and inventory of the fluid-preserved Mollusca at the Academy of Natural Sciences of Philadelphia

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Over the past three years, with grant funding from the U.S. National Science Foundation, we have rehoused and inventoried the ethanol-preserved collection of mollusks at the Academy of Natural Sciences of Philadelphia. The project was motivated by the realization that old Bakelite and metal lids were failing at an increasing rate. More than 42,000 existing lots and 8,000 lots received from other institutions have been rehoused and inventoried, with maintenance records linked to the primary database record for each lot. Jars and vials have been grouped in modular trays, which can be slid off shelves for inspection, eliminating the need to leave headroom to lift out jars, which has compressed the collection by more than 40% and will increase speed of future maintenance checks. Composition by habitat is marine 41%, terrestrial 34% and freshwater 25%. Taxonomic composition is Gastropoda 81%, Bivalvia 16%, Polyplacophora 2% and Cephalopoda 1%. Geographic composition is North America 41%, Asia 21%, Caribbean 14%, Oceania 8%, Africa 7%, Australia and South America 2-3% each. Formalin was rarely used in the collection, so many samples are appropriate for DNA extraction.

Transcriptomic changes in *Crassostrea virginica* gonad, exposed to hydrocarbons mixture and potential implications in reproduction

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The *Crassostrea virginica* oyster has a biological and economic importance in the Gulf of Mexico, which is known as an area of high extraction and production of hydrocarbons. Exposure to hydrocarbons can affect important physiological processes in bivalves, one of these processes is gonadal maturation. However, the effect of hydrocarbons on the gonad of *C. virginica* has not been assessed to determine possible damage during the maturation process in undifferentiated organisms. Based on the above, the aim of this study was to evaluate the effect of a combination of aliphatic hydrocarbons and aromatic polycyclic hydrocarbons (PAH) on the expression of genes in the gonad

of undifferentiated juveniles of *C. virginica* and to compare the response to different exposure times. An accumulation of PAH was observed in the soft tissue of *C. virginica*. The transcriptome of the *C. virginica* gonad exposed to hydrocarbons was generated under laboratory conditions, where the negative effect of exposure of these on the gonadal maturation was evidenced with the sub-expression of 22 genes involved in different stages of this process. Also, genes in the immune system were down-regulated, which may indicate that exposure to hydrocarbons causes immunosuppression in bivalve mollusks. In addition, a group of oxidative stress genes was down-regulated too. This will contribute to a better understanding of the effect of hydrocarbons on the reproductive process in bivalve and, at the same time, it will allow us to identify potential biomarkers associated with hydrocarbon contamination in the gonad of *C. virginica*.

Females in the Field: an Archival Study

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Following the Civil War, naturalists were exploring the Southern Appalachians for plants and animals. Their new discoveries preceded the changes wrought by logging in the 1880's and 90's and the chestnut blight of the early 1900's. Later, their discoveries helped justify the creation of the Great Smoky Mountains National Park in 1934. Much of the first field work and collecting was done by local amateurs. Two of the most renowned local conchologists of that era also happened to be women. Annie E. Law (1842-1889) and Mary Lathrop Andrews (1837-1908) lived and explored in eastern Tennessee and western North Carolina. Both worked on the diverse clam fauna of the Holston River, but their most lasting contributions were their explorations of the Blue Ridge Mountains, from Roan Mountain to the Great Smoky Mountains looking for land snails. During her life, Miss Law is credited with finding eleven new species of mollusks and Mrs. Andrews with at least four. Many of the species came from high elevation areas that were difficult to access. While neither woman described her own finds in the malacological literature, they were each in close communication with various experts like James Lewis, W. G Binney and later H.A. Pilsbry and Bryant Walker. While it is unclear if their two lives intertwined, their respective contributions to mollusk research in the region brought them together during a great era for "citizen scientists". Knowledge of their contributions might be lost without the feminine endings (-ae) of the species patronyms.

Effect of shell contraction behavior on gamete dispersal and fertilization success of the red abalone, *Haliotis rufescens*

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Broadcast-spawning marine invertebrates such as red abalone require dense aggregate populations for successful reproduction. Today most local abalone populations exist in low aggregate densities, potentially impacting fertilization success. Synchronized spawning and sperm chemotaxis are known mechanisms for increasing fertilization success. Another mechanism may be an observed but unquantified contraction behavior. I will examine the effects of contractions on gamete dispersal and fertilization success in the red abalone, *Haliotis rufescens*. I hypothesize that gamete plume height increases with increasing contractile force. I am measuring the force of abalone contractions using a

force transducer, capturing high-speed images of resultant gamete plumes, and measuring the peak of the plumes on ImageJ. I expect that gamete plume height will be positively correlated with increasing contractile force. I further hypothesize that gamete dispersal distance and fertilization success will increase when gametes originate from larger contractions, relative to smaller contractions or slow discharge.

Using passive plankton traps *in situ*, I will quantify dispersal distances of eggs released with small versus large contractions over the course of this summer and fall. Eggs released from larger contractions are expected to disperse farther. I will calculate percent fertilization of eggs deployed in mesh bags *in situ* at progressive distances along a transect from an epicenter where sperm is released via contraction and slow discharge. Fertilization will be detected at greater distances when sperm is released by contractions versus slow discharge. My research will increase our knowledge of abalone and help guide out-planting strategies for on-going and future reintroduction efforts.

Meeting Minutes

Minutes, Executive Meeting, Western Society of Malacologists
Fifty-first Annual Meeting, 22 June 2018, Honolulu, HI

Board members present: President Rebecca Johnson, Immediate Past President Jann Vendetti;1st Vice President Patrick Krug; 2nd Vice President Miguel del Rio Portilla; Treasurer Kelvin Barwick; Member-at-large Alvin Alejandrino;

The meeting was called to order and four topics were discussed:

Annual Reports

We need to report on our thoughts on Annual reports. Our plan here is to take Wendy up on her generous offer to prepare 2014-2019. We will ask Hans Bertsch if he would like to be the editor and we will ask past editors to serve as an advisory board. We also decided we would digitize any volumes not on BHL and add a link to the BHL series of reports on our website. We also decided that after 2018 we will no longer have the free option of a printed copy. If members would like a printed copy they will have to pay for it at cost. Do we need everyone to vote on this?

Student Awards

Announce the student and collections awards. We should have the meeting awards with AMS decided by the meeting, but we will see. We will be funding 3 poster awards at $150 each (1 for high school, 1 undergrad, and 1 grad student). We will also fund 1-2 oral awards @ $200 each. We will pool our funds with AMS.

Nominations

President- Pat Krug

1st VP- Miguel del Rio Portilla

2nd VP- TBD

Treasurer- Kelvin Barwick

Secretary- Wendy Enright

MAL- Alvin Alejandrino

MAL- Rebecca Johnson

2019 Meeting

Questions to address:

1. Do we share the Treasurer's Report with them?

2. If AMS writes checks to the student winners, can we send them a check for the balance after the auction proceedings are split?

3. Am I missing anything?

Jann Vendetti

WSM Past President

General Business Meeting Minutes—unavailable

Treasurer's Report

June 19, 2018

WSM cash flow for June 16, 2017 thru June 15, 2018:

In-flows	
Membership	$970.92
Interest earned	$3.61
Student grant donations (available balance $4785.85)	$6,815.33
Reimbursement for cash advance on mugs/totes	$82.00
Total in-flow	$7,871.86
Out-flows	
Student grants awarded	-$8,401.00
Student paper/poster awards	-$650.00
2017 conference	-$2,240.95
Bank charges	-$11.14
IT security services	-$360.00
State of California nonprofit registry	-$20.00
Office supplies	-$63.87
Total out-flow	-$11,746.96
Net	**-$3,875.10**

Cash on hand as of June 15, 2018:

Checking		$16,974.12
Savings		$13,148.56
Credit card		$0.00
	Total	**$30,122.68**

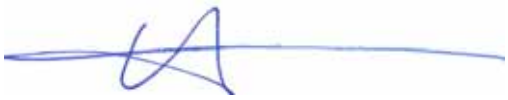
PayPal cost not realized above (2.9% plus $0.30 per transaction)

Donations & membership		$302.00
Fees		-$15.16
	Net	**$286.39**

Membership report:

51 Regular members (same as 2017)

7 Institutional members (increase of 1 from 2017)



Kelvin Barwick
Treasurer

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