2020-2021 Academic Year Sabbatical Leave Project Report

Title: Applying Paleontological Research in Sedimentary Rocks of Southern California to Creation of Classroom-based Research Experiences

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Submitted September, 2021

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Lackey 2020-21 Sabbatical Report

Foreword (includes Statement of Purpose):

In 2019, I proposed to undertake an independent study surveying museum collections and paleontological field sites of Southern California. The products of this sabbatical would include three laboratory modules involving course-based undergraduate research and an instructional display for the Science Exploration Center in Building 61. The rationale for my proposal was that I needed expand my knowledge of the natural history of southern California with the goal of providing students in our oceanography and geology labs the opportunity for course-based research. In addition to designing lab activities that include paleontological methods applied to the discipline, the expertise and up-to-date knowledge I would acquire would help me to identify and contextualize the fossil collections we have in the Exploration center in building 61 and in our lab classrooms. In my application, I emphasized that I am confident in my knowledge of the subject matter and pedagogical methods but after 10 years teaching at Mt. SAC, it was time to infuse my scientific passion and expertise into the classroom. To my excitement, my application for sabbatical leave was approved in early 2020. Soon after that, schools, colleges, universities, and life as we knew it transitioned to the reality of the Covid-19 global pandemic. I finished the Spring 2020 semester with my students online, sure that by the start of my sabbatical project in Fall 2020, most of life would be "back to normal." As we well know, that was not the case.

This report includes descriptions and results of the research I undertook, figures and maps of my field and museum work and copies or descriptions of the "deliverables" relevant to teaching and learning at Mt. SAC. I also wish to include some discussion about what it was like working on this sabbatical project during the uncharted territory of a global pandemic. It was horrifying to see the cases and death toll of Covid-19 rise exponentially around the world. Every day, the news featured heartbreaking stories of the elderly isolated in nursing homes, patients dying alone, and exhausted health care workers. Friends and relatives of mine came down with the virus. Neighbors and teachers at my kids' school, came down with the virus. No one close to me actually died from it, but I have friends with long-haul symptoms. At home, I was thrust into the role of principal, school nurse and PE coach for my kids who were on Zoom school all day. My spouse was teaching college students remotely on zoom, as well, so we had to create ad hoc workspaces in every nook of the house. When the weather was mild, I occupied the back deck, cleaning and sorting fossil shells and spreading out maps and field guides on the picnic table while everyone else was inside Zooming. My sabbatical research was intellectually enriching, but it was against a backdrop of anxiety and uncertainty. Foremost on my mind was keeping my parents, who are in their 70s, from contracting Covid-19 (could be a death sentence) so I grocery shopped for them and helped them get online services and eventually helped them get vaccinated. Many would agree that the ridiculous politicization of public health and safety measures like mask-wearing and vaccination added an extra layer of fatigue and exasperation to everyday life. The pandemic also exposed many of the social and economic inequities in our society. My family is fortunate to have the resources to work and learn from home, stable housing and access to healthcare but I know that many of our Mt. SAC students and other members of our community suffered significant setbacks.

I was extra lucky that the nature of my project fit into the pandemic world. I was able to travel field sites and museums on my own during the pandemic. If I had proposed taking a course or something that required me to travel across borders or in large groups, I would not have been able to do it. Several of my tasks could be completed outdoors (taking field samples, for example) or sitting at my desk at home (library research, making maps and figures, for example). Activities requiring access to the Mt. SAC campus or natural history museums had to be worked out in a way to comply with health regulations and/or put off until the final months of the sabbatical but it all worked out in the end. I collected loads of data, familiarized myself with the stratigraphic terminology and fossil taxa of Southern California and got to know our specimen collection at Mt. SAC. Although it was not quite the way I imagined pre-covid, I got to meet museum experts and fossil enthusiasts and covered a lot of ground (cautiously). This preamble of sorts is included because I believe in acknowledging that the Covid-19 pandemic and associated crises took a toll on my mental health and that of the whole community. It is with joy that I share some good that came out if it: my completed sabbatical project. I got to take a deep dive into paleontology, my passion, that I had not had time to do while teaching a full load. I look forward to reentering the classroom rejuvenated.

Body of Report

Scientific Background (Geology)

Today, the landscape around Mt. SAC is terrestrial, covered in plants adapted to semi-arid conditions. However, if we go back in time to the Miocene, about 17 million to 5 million years ago, the rocks present today were being formed as sedimentary layers under the ocean. In fact, much of the sedimentary and fossil record of Southern California from Santa Barbara, through Los Angeles and Orange Counties and into San Diego contains a rich story of a marine realm extending much farther inland than today. The buff colored hills around our campus and neighboring communities hold fossilized fish, clams, snails and microorganisms in the fine grained sand and silt deposits. In some of the sedimentary layers, organic remains of plankton decomposed and over geologic time, pressure and chemical alteration turned their remains into petroleum deposits. You might have noticed oil pumps along the slopes of Carbon Canyon along the 57. These pump-jacks, as they are known, are retrieving oil and natural gas from the rock formations where structural folds and faults, such as the Whittier and Puente Hills Faults (made famous by the 1987 earthquake) created traps for petroleum. For this project, I explored outcrops of Miocene aged deposits around the Puente Hills and Whittier, and I reviewed maps and field guides and examined museum specimens from the eastern Los Angeles Basin, looking for projects that students could do close to Mt. SAC. The fossil material in the museums is scarce and not always well preserved, and most of the outcrops described from publications of the 1950s and 1960s have since been covered by urban development. One area that still has Miocene fossils accessible (but not close to our campus) is Topanga Canyon . Ultimately, I focused more on the Plio-Pleistocene formations well exposed along the coast and in the canyons of Western Los Angeles County and Ventura County.

The next youngest geologic interval, from about 5 to 2.5 million years ago, is known as the Pliocene, coastal California underwent geologic changes, such as a tectonic shift that emplaced the San Andreas Fault, and numerous small marine basins and river delta systems dotted the landscape. The sea continued to reach further onto the continent than it does today. These Pliocene basins are well known among geoscientists as harboring a rich array of fossil life with species that continued or gave rise to the marine fauna of the Pacific coast today. The intriguing sedimentary layers that eventually filled in these basins make for world-class teaching and research sites. For this project, I examined Pliocene fossils from San Diego, Santa Clarita, Newport Beach, and a few other locales. The mid-Pliocene was an interval of global warming, that many scientists look at as an anaglogue to today's climate crisis.

It is unclear *why* the shift to warmer temperatures occurred in the about 3 million years ago, but climate scientists are interested in examining the mid-Pliocene warming event as an analogue for climate change happening today because the continents were in roughly the same position as they are today, ocean circulation patterns were not much different, and the atmospheric concentration of the greenhouse gas carbon dioxide was similar. Additionally, marine ecosystems much like modern ones were in place, allowing comparisons of life's reaction to warming oceans. As the Pliocene gave way to the Pleistocene, global temperatures dropped again and ice covered the Earth's poles.

Approximately 1.8 million years ago, during the Pleistocene, or Ice Age, global sea level dropped due to Earth's water being locked in ice. Locally, the marine waters retreated from the area around Walnut. The sedimentary record shows river environments and the strata become thinner and less fossiliferous. However, Pleistocene deposits in Newport Bay and Palos Verdes are rich in ocean dwelling molluscs and other invertebrate fossils and remains of marine mammals (whales, dolphins, etc.). Further inland, of course, the ice age of Los Angeles left fossils of terrestrial mammals such as mammoths, mastodons, sabertooth cats and dire wolves made famous by the La Brea Tar Pits. For this study, I examined changes in paleoecology and predator-prey relationships among molluscs in the transition from the Pliocene to the Pleistocene and between early and late Pleistocene using fossils from San Diego, Palos Verdes and San Pedro, Santa Barbara and Santa Maria.

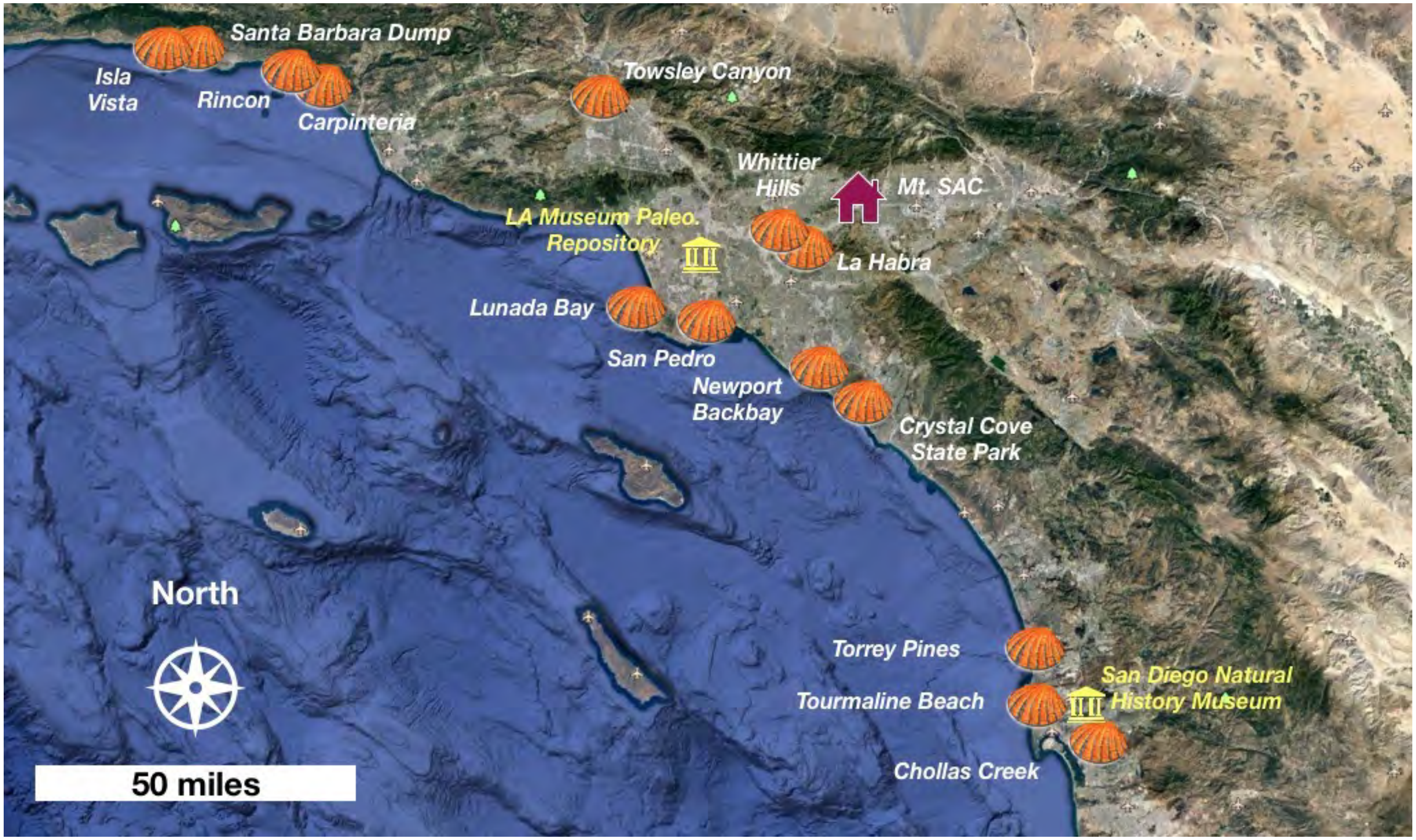
Research Project: Patterns of Drilling Predation in Plio-Pleistocene Molluscs

There are a few groups of snails, both modern and fossil, who make their living by drilling holes into the shells of other snails and clams with a special organ and then ingesting the soft innards of their prey. The perfect, round holes they leave in the shell are well preserved in the fossil record and are direct evidence of predator behavior. Paleontologists can collect information about which species are preferred prey, how the abundance of drilling changes over time, whether the drilling behavior is associated to certain habitats, what size or shape of shell the predatory snails prefer to drill, and much more to learn about marine ecology of the past. Previous studies, most of which focus on the Atlantic and Gulf regions of N.A., have suggested that changes in predator-prey interactions follow faunal turnover and examined latitudinal differences in predation. For this project, I examined species along a latitudinal gradient (north-south along the Southern California Coast) and over a temporal span of about 4 million years that includes some major paleoenvironmental changes. . In my analysis of 12 genera from 19 localities in Southern California Plio-Pleistocene basins, the prevalence of predatory drilling does not appear to be tied to sedimentary unit or latitude. The drilling frequency does, however, appear to be taxon-specific, with presence of drilling more common in some genera than others. Drill site stereotypy – basically, the predator always drills the same spot on its prey - is present in most of the taxa studied. Despite ecological turnover and climate change that marks the Plio-Pleistocene, drilling predator-shelled prey relationships appear stable.

Future work will include more data collection on a large number of taxa and will look at how patterns of prey selectivity when habitat/sedimentary substrate is held constant (good topic for a geology class).

Selected Photographs, Tables and Figures documenting this project
(starts next page)

Localities visited for this project

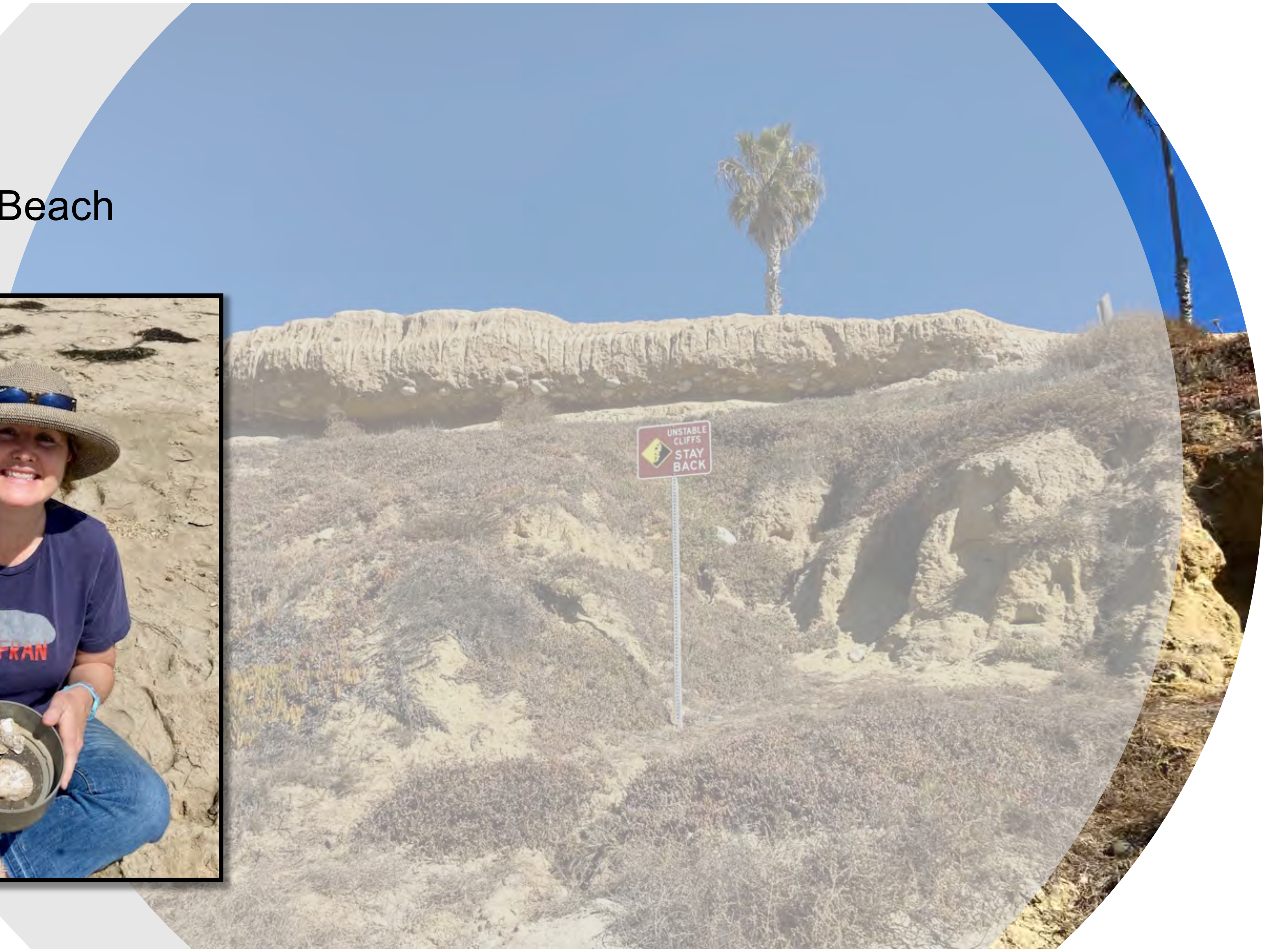


Map of field localities where I collected and took field notes. The museums where I worked are also indicated.

Field Work

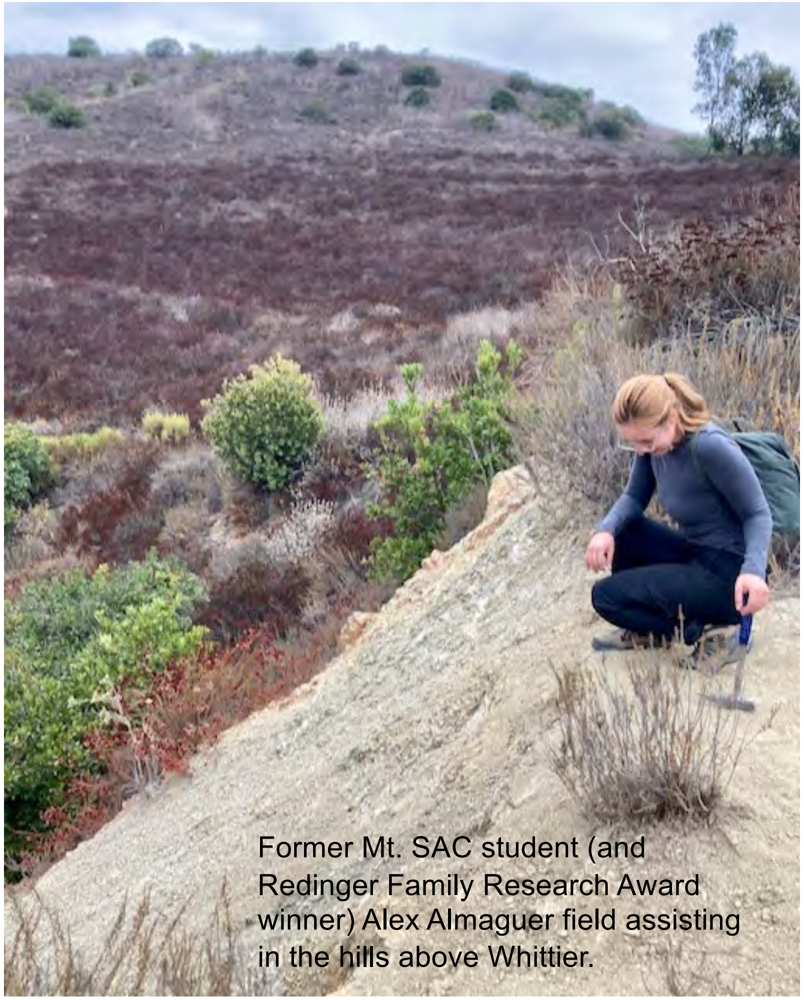
Left: Isla Vista

Center: Pacific Beach

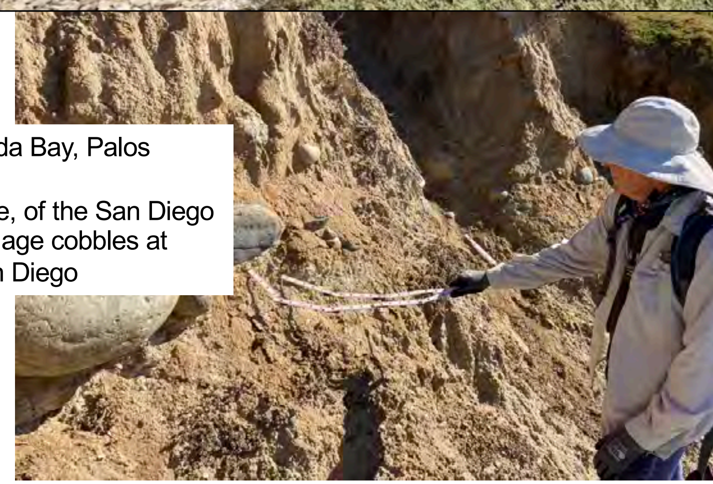


Field Work

Left: Pacific Beach
Right: Crystal Cove



Former Mt. SAC student (and Redinger Family Research Award winner) Alex Almaguer field assisting in the hills above Whittier.



Top: Cliffs at Lunada Bay, Palos Verdes Peninsula
Right: Tom Demere, of the San Diego Nat. points out ice age cobbles at Pacific Beach, San Diego

Field Work
Top: Torrey Pines, San Diego
Right: Towsley Canyon, Santa Clarita

Fossil-Bearing Formations, by region (table researched and created by me)

(Ma = millions of years before present)

	Time interval	**San Diego**	**Los Angeles and Orange County**	**Ventura, Santa Barbara and Santa Maria**
younger *0.13 Ma* *0.56 Ma*	Late Pleistocene	Bay Point Formation Marine Terraces	Palos Verdes Sandstone , Timms Pt. Silt, Lomita Marl, Marine Terraces	Marine Terraces
T I M E *0.78 Ma*	Mid-Pleistocene	"Broadway Fauna"	San Pedro Sandstone	Santa Barbara Formation
1.8 Ma	Early Pleistocene			Careaga Sandstone (2.0-1.5 Ma)
2.6 Ma	Late Pliocene	Upper San Diego Formation	Niguel Formation Unnamed formation at Newport Beach	Pico Formation
4.2 Ma older	Early Pliocene	Lower San Diego Formation		Towsley Formation

south → LOCATION → north

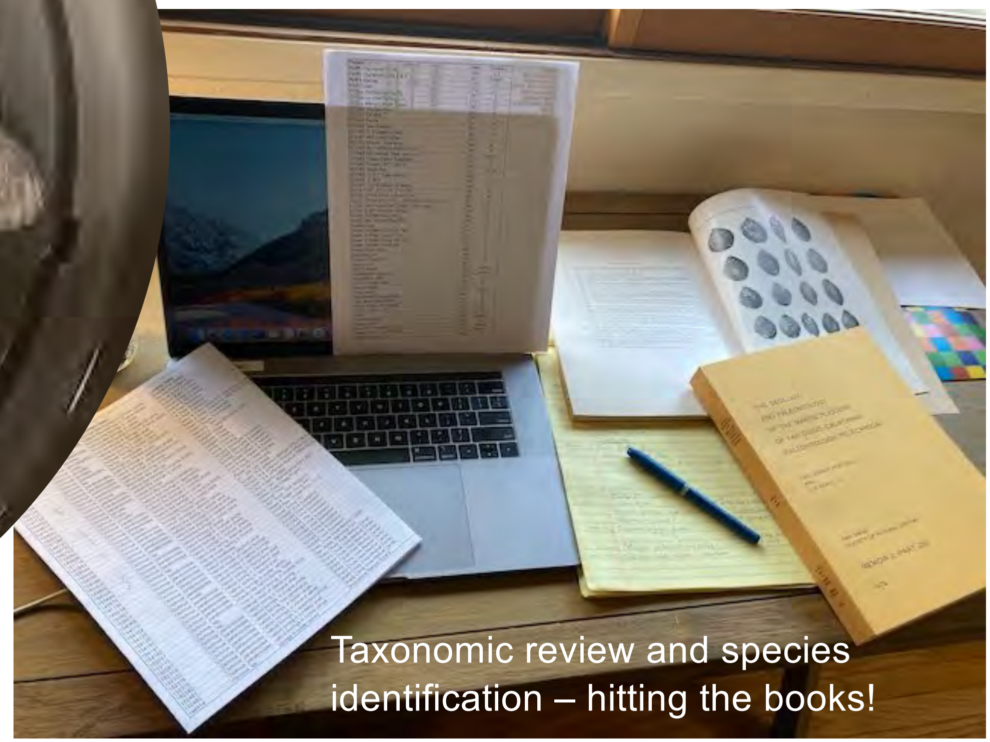
Fossil Preparation: Washing and picking (at home due to the pandemic).

I used the DinoScope to image the wee fossils that I collected.

Digital calipers for measuring fossils

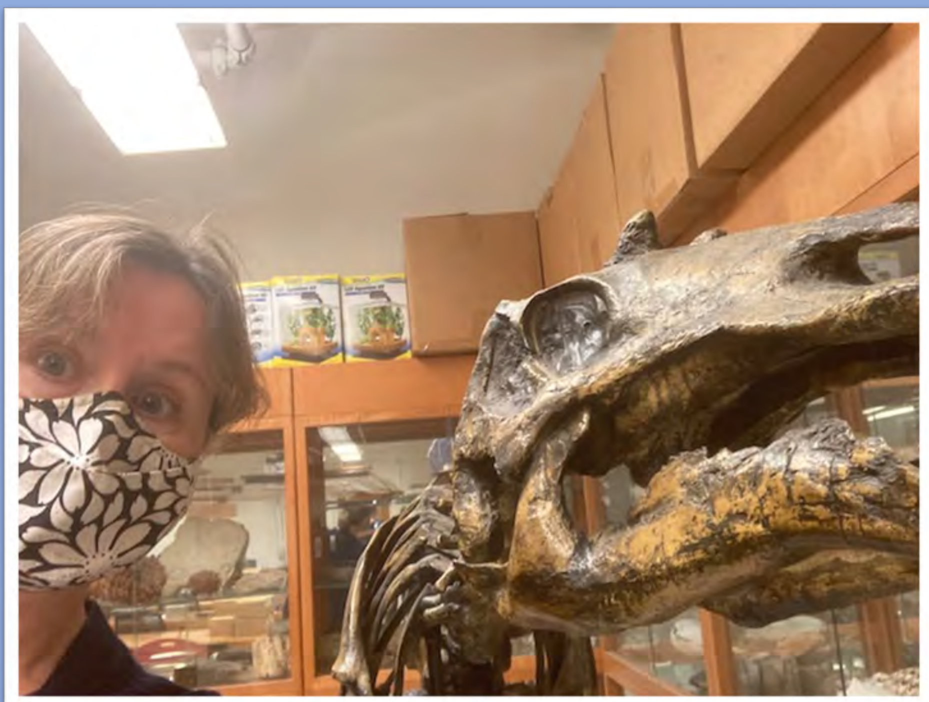
I used a copy stand to photograph fossils in museum collections.

Fossil Preparation: Sieved sample from cliffs near Rincon, Ventura Co.



Taxonomic review and species identification – hitting the books!

Masked up for
museum work!



At the Los Angeles Museum of Natural History

Nasty gastropods! A study of drilling predation in California's geologic past.

Calicantharus humerosus, Pliocene, Laguna Hills

The victims: other snails and clams

Hole drilled by predator

Anadara trilineata, Pliocene, Borderfield State Park, San Diego

Chione undatella, Pleistocene, San Diego

The culprit: Naticid gastropod (moon snail)

More drilled victims…

Turritella cooperi
(Pliocene, Laguna Hills)

Olivella
(Pleistocene, Balboa Park)

Great California Fossil Names!

“Turritella tembloris”

“Californiaconus californicus”

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11-15 - PATTERNS OF DRILLING PREDATION IN MOLLUSCS ACROSS THE PLIOCENE-PLEISTOCENE BOUNDARY IN SOUTHERN CALIFORNIA

Sunday, October 10, 2021
11:45 AM - 12:00 PM
Oregon Convention Center - E141/E142 (Hybrid Room)

Abstract

During the Neogene period, a series of marine basins and embayments covered what is today the continental borderland and coastal plain of Southern California. Sedimentary layers from these basins contain a rich fossil fauna, including thousands of molluscan species, and record ecological transitions through the mid-Pliocene warming event and the shift into the cooler Pleistocene. In this study, I examined evidence of predatory drilling in bivalves and gastropods from shallow marine habitats using specimens from Pliocene and Pleistocene (5.0 to 0.0117 Ma) sedimentary formations ranging geographically from present day Santa Maria to the California-Mexico border. Evidence of predatory shell drilling by muricid and naticid gastropods is widespread amidst these fossil assemblages. Because drill holes are direct evidence of predator behavior, study of the incidence and style of drilling gives clues to past trophic interactions. Previous studies, most of which focus on the Atlantic and Gulf regions of N.A., have suggested that changes in predator-prey interactions follow faunal turnover and examined latitudinal differences in predation. In my analysis of 12 genera from 19 localities in Southern California Plio-Pleistocene basins, the prevalence of predatory drilling does not appear to be tied to sedimentary unit or latitude. The drilling frequency does, however, appear to be taxon-specific, with presence of drilling more common in some genera than others, and the presence of incomplete borings present in only some of the genera studied. Results of this study also suggest no prey size selectivity within ecosystems, the exception being one prey genus in which drilling was absent in the largest shells. Drill site stereotypy is present in most of the taxa studied. Despite ecological turnover and climate change that marks the Plio-Pleistocene, drilling predator-shelled prey relationships appear stable.

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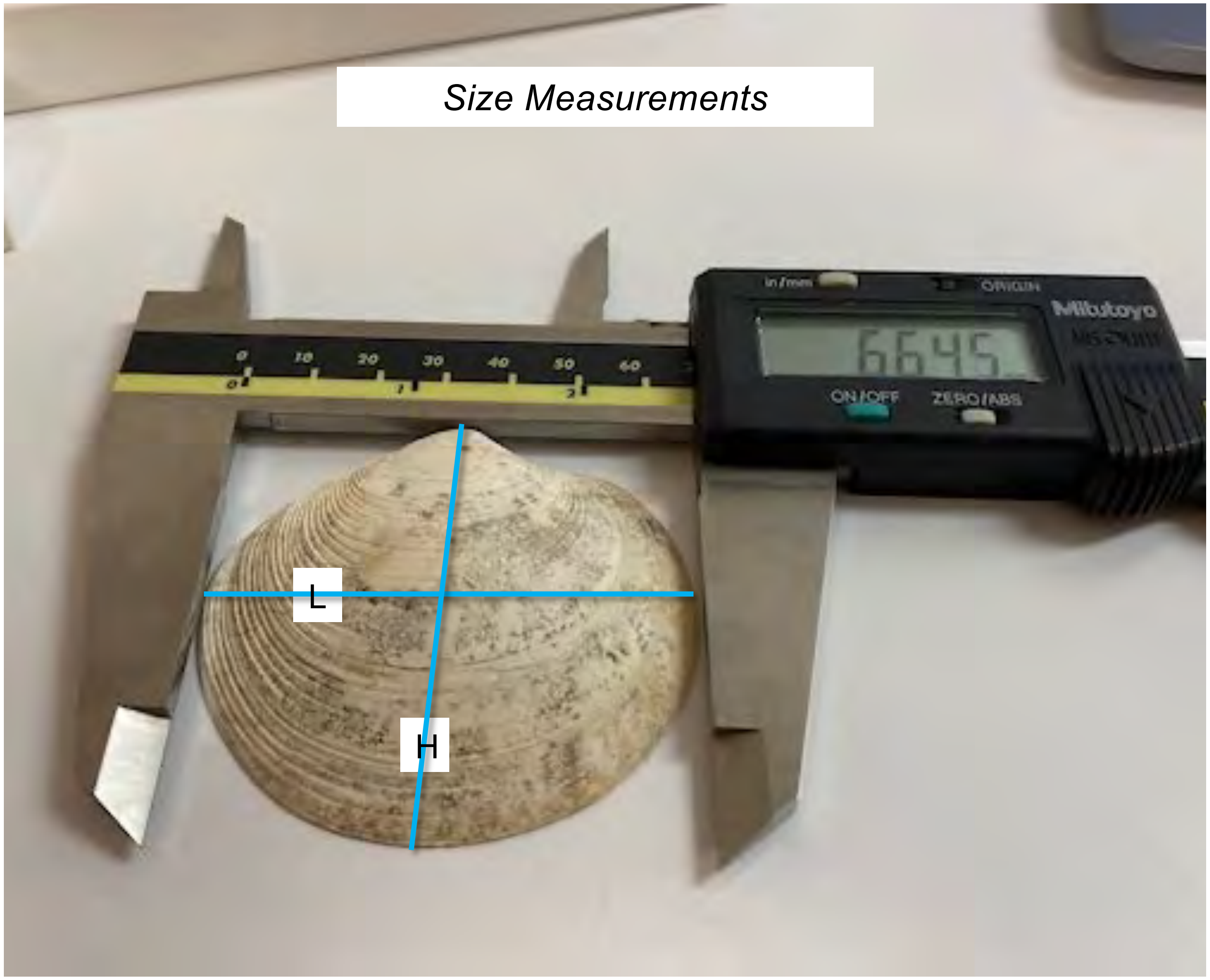
Abstract of research I will present at the Geological Society of America Annual Meeting this October.

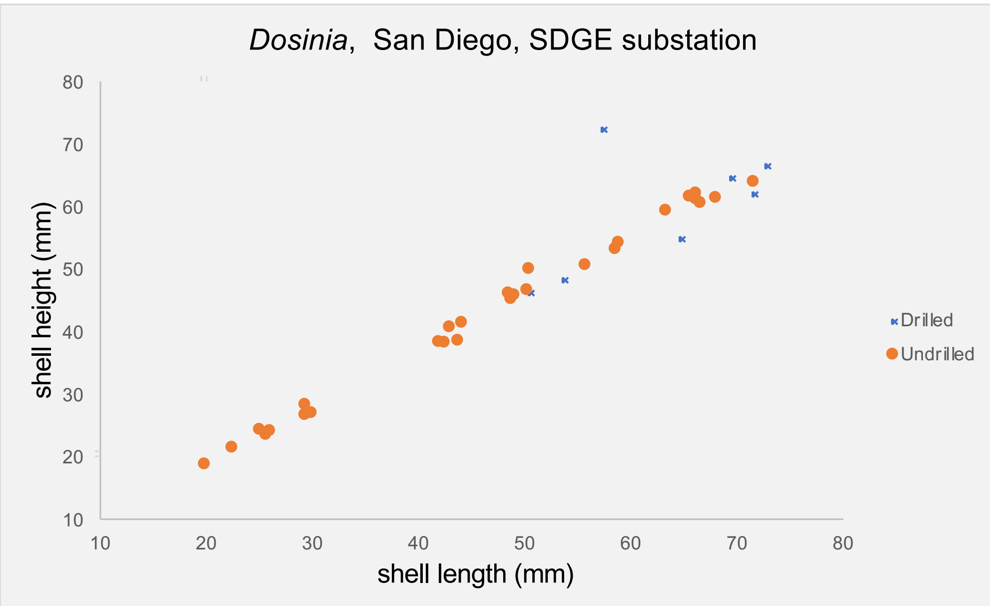

A selection of
Drilling and Size
Data I collected

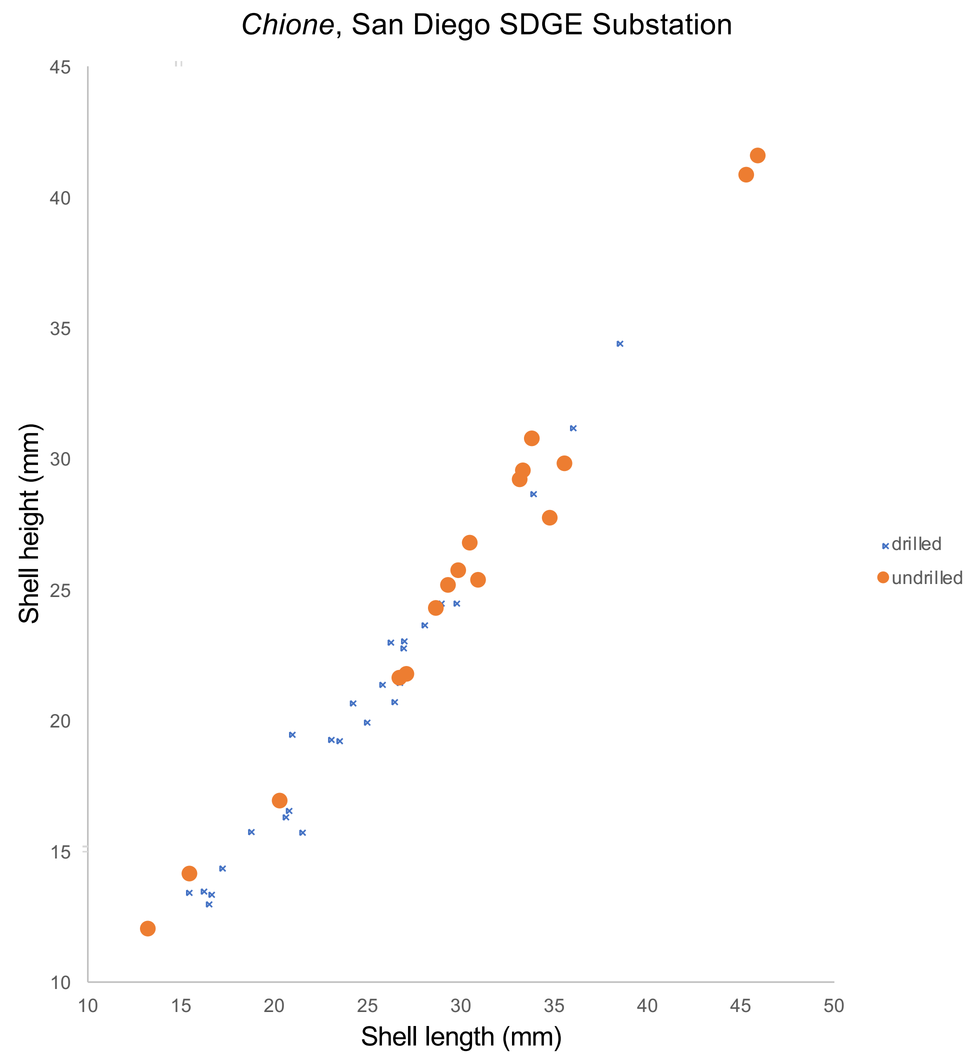
L: length = Maximum distance across anterio-posterior

H: height = Maximum distance from umbo to ventral edge



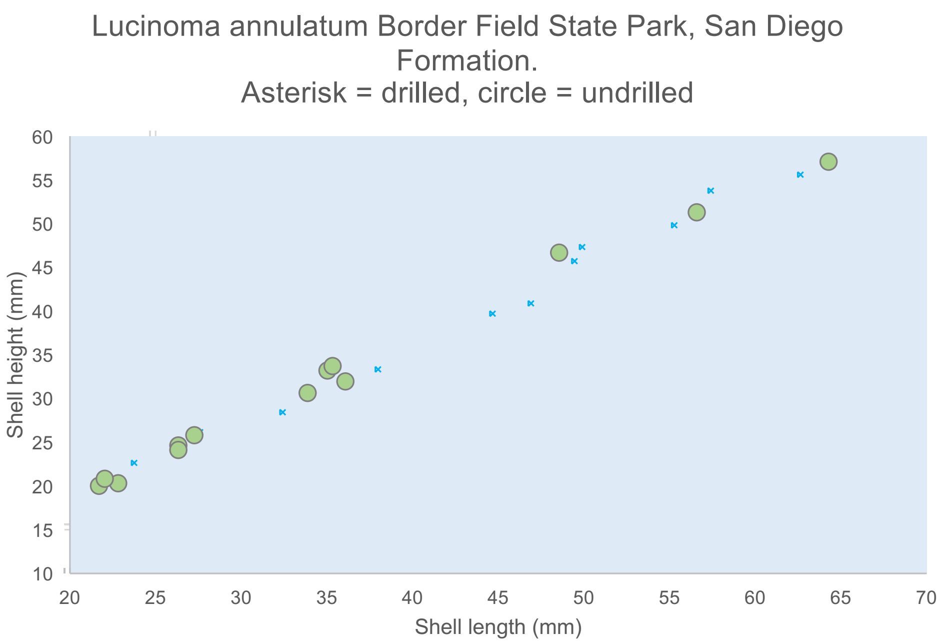
Late Pliocene:
San Diego Formation



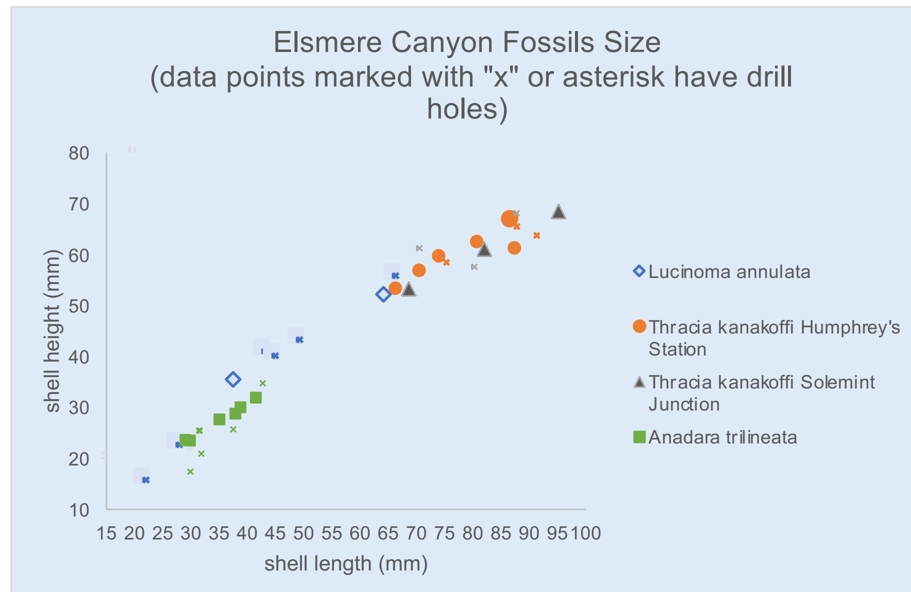


Above: For *Dosinia*, only shells 50 mm wide and larger are drilled.
Right: For *Chione*, there is no correspondence between body size (height and length) and presence of drilling.

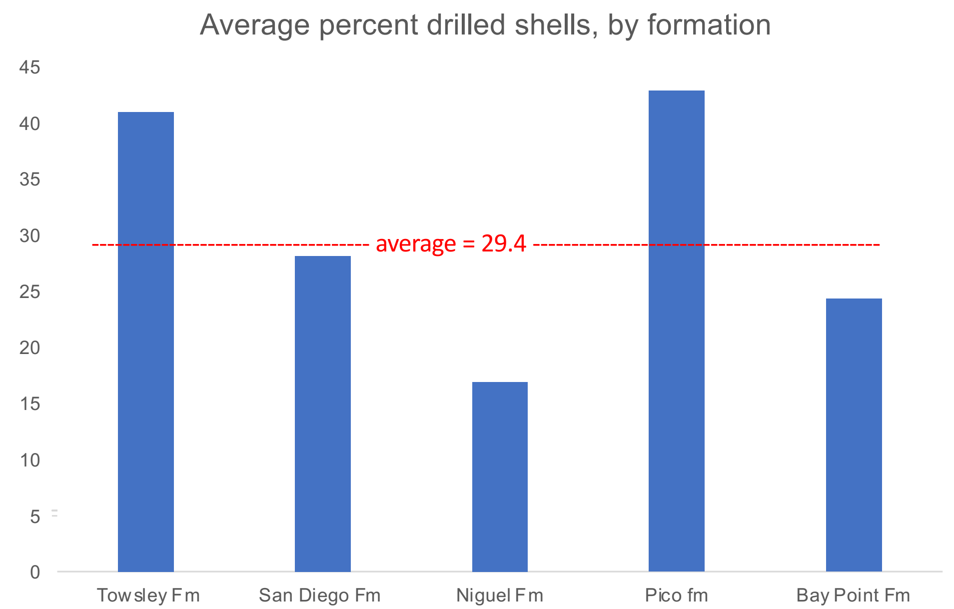
Late Pliocene:
San Diego Formation



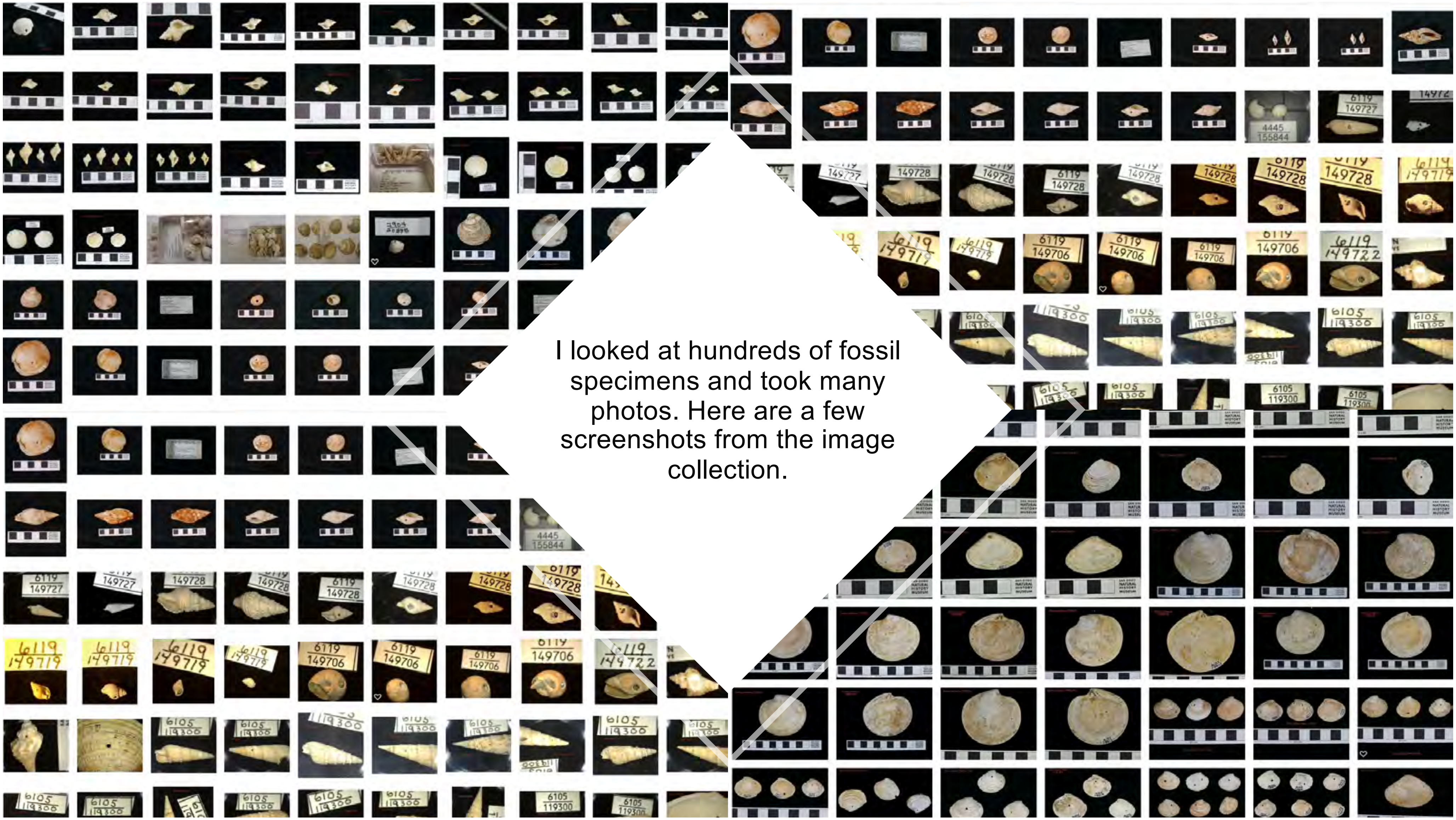
Late Pliocene – Early Pleistocene:
Towsley Formation (Fernando, Pico, Careaga)
Niguel Formation



Percent of specimens drilled, by locality (arranged temporally).
N = total number of individuals counted. Mixed taxa.



Towsley n = 102. San Diego n = 2074. Niguel n = 157. Pico n = 7. Bay Pt. n = 266



I looked at hundreds of fossil specimens and took many photos. Here are a few screenshots from the image collection.

I looked at hundreds of fossil specimens and took many photos. Here are a few screenshots from the image collection.

Example of the collection labels I am made:

MT. SAN ANTONIO COLLEGE EARTH SCIENCES COLLECTION Name 1:Nassarius delosi Name 2:gastropod (snail) Locality:San Pedro, CA Catalog number: Other:18 shells	MT. SAN ANTONIO COLLEGE EARTH SCIENCES COLLECTION Name 1:Turritella cooperi Name 2:gastropod (snail) Locality:San Pedro, CA Catalog number: Other:16 shells
MT. SAN ANTONIO COLLEGE EARTH SCIENCES COLLECTION Name 1:Nassarius cerritensis Name 2: gastropod (snail) Locality: San Pedro, CA Catalog number: Other:4 shells	MT. SAN ANTONIO COLLEGE EARTH SCIENCES COLLECTION Name 1:Nassarius fossatus Name 2: gastropod (snail) Locality: San Pedro, CA Catalog number: Other:4 shells
MT. SAN ANTONIO COLLEGE EARTH SCIENCES COLLECTION Name 1:Nassarius cerritensis Name 2: gastropod (snail) Locality: San Pedro, CA Catalog number: Other:2 shells	MT. SAN ANTONIO COLLEGE EARTH SCIENCES COLLECTION Name 1:Olivella biplacata Name 2:synonym Callinax biplacata Gastropod (snail) Locality:San Pedro, CA Catalog number: Other:10 shells
MT. SAN ANTONIO COLLEGE EARTH SCIENCES COLLECTION Name 1:Trophonopsis lasia Name 2:gastropod (snail) Locality:San Pedro, CA Catalog number: Other:1 shell, broken	MT. SAN ANTONIO COLLEGE EARTH SCIENCES COLLECTION Name 1:Acanthinucella spirata Name 2:Acanthina spirata Gastropod (snail) Locality: Catalog number: Other:

Record of Sabbatical Activities

<u>August-September 2020</u>

- Online research, looking up references on fossil localities, stratigraphic nomenclature for and species common in fossil deposits of Southern California. Used Zotero software to compile a bibliography.
- Used online databases such as GBIF, Morphosource and iDigBio to investigate museum collections
- Created an annotated list of stratigraphic localities to use in creating field trip guides and designing research projects.
- Created a Google Earth file marking localities I visited/would visit.
- Took photos and field notes at San Pedro, Palos Verdes, Newport Bay and Crystal Cove.
- Called museum collection managers at Western Science Center, Alf Museum, Cooper Center, and the Los Angeles and San Diego natural history museums to inquire about research visits and to get ideas for localities to visit. All museums were closed to visitors during the early fall of 2020 due to the Covid-19 pandemic, so I was not able to visit during these months. However, conversations with these experts gave me leads on field sites, suggestions of publications to read, etc.
- Completed the safety training videos and took the return-to-work health survey so that I could go to the Mt. SAC campus. Went into the classrooms to review our fossil specimen collection. Began cataloguing our teaching collections in Excel.
- Used the lab space at Mt. SAC for sieving sediment samples. Later, as Covid cases spiked, I took some equipment home for fossil washing and prep.

<u>October 2020</u>

- Continued online research
- Cross checked Google Earth sites with geologic maps
- Went back into classroom collections to continue with Excel catalogue and read specimen labels to find who collected and when, and to get locality information. Photographed dozens of specimens from the cabinets so that I could catalogue them at home and avoid being on campus too much during the pandemic.
- Visited the Invertebrate Collections Warehouse of the Los Angeles Museum of Natural History, with special permission and Covid-19 safety protocols in place. Had extremely productive discussions with curators Austin Hendy and Lindsay Walker, who gave me lots of ideas for localities to visit and research topics involving their collections. I learned about their amazing collection of silicified insects from the Barstow area and considered the potential for student projects. I decided to focus more on the coastal outcrops and marine fossils this time, but keep the Barstow “glass insects” in mind for the future.
- Multi-day field trip to Santa Barbara County to scope out potential field trip sites and to collect Pleistocene fossils from marine terraces. Wrote the geologic overview for a field guide to that area for use in courses.

- Reconnaissance mission to Whittier Hills to locate strata containing fossils collected by paleontologists at the Los Angeles Natural History Museum in the 1960s; potential for new field work and collaboration with the lead curator of the Invertebrate Paleontology for student-involved projects. A Mt. Sac alumna came with me, which was really fun.
- Scouted locations at Palos Verdes Peninsula using maps given to me by the LA museum team. Collected Pleistocene shells from Lunada Bay.
- Contacted the president of the Southern California Paleontological Society who put me in touch with fossil enthusiasts who know a lot about field sites in the area. I attended the October meeting (Zoom) of the SCPS and got elected Secretary of the club. I continue to be involved with the Society as Secretary and I will give a research presentation at the November meeting. The club's in-person field trips will start up again later in fall 2021, so there will be opportunities to get MT. SAC students involved.
- After meeting with the museum paleontologists and seeing the collections, I decided to focus my project on incidence of drilling predation. [Explanatory note: Some predatory snails drill holes into shells of their molluscan prey in order to ingest the interior soft parts. The drill holes are preserved in fossils and can tell paleontologists about evolution of predator-prey relationships of the past. Many of the shell specimens in the museum collections show drill holes, and well known studies of this type of predation exist for marine fossil beds on the east coast of North America, but there has been little work done on similarly aged fossil beds along the west coast.]. In late October-early November, I undertook library research finding references on drilling predation in the fossil record. I narrowed the time interval of study down to the Pliocene-Pleistocene (about 5 million years ago to present), which is best represented in our region, so my research included references on climate and environmental changes through the time interval.
- Continued to review field guides and maps of Southern California fossil localities in order to plan trips and for writing field guides for my courses.
- Reviewed EPICC virtual field trips (from UC Berkeley) for ideas. Also took notes on making "story map" virtual field guides in Google Earth.

<u>November- December 2020</u>

- Field trip to the Marble Mountains to find Cambrian aged fossil trilobites and other outcrops at a famous locality near Cadiz. Determined that it would be to rugged for vans to navigate. High clearance field vehicle would be required.
- Field trip to Newport Back Bay to collect and document a well exposed Pleistocene shell bed (this is rare because most of Orange County is covered by real estate development). Took GPS coordinates and photos to use in a field trip guide.
- Went to Mt. SAC campus to do some more cataloguing of classroom collections.
- Multi-day visit to the San Diego Natural History Museum invertebrate fossil collection (obtained special permission because the museum was closed to the public during the pandemic). Museum Director Tom Demere took me to famous fossil sites around San Diego. I took photographs and field notes.
- Washed and sorted fossils collected.

- Continued library research and compiling bibliography through Zotero. Read articles on drilling predation and studied field guides with descriptions of the fossils relevant to my project.
- Used microscopes at Pomona College (with permission, following health protocols) to examine the microfossils I collected from field work.
- Photographed microfossils with the "DinoLite" from our oceanography lab.
- In December, Mt. SAC employee who was working in the classroom next door to me tested positive for Covid-19. I did not contract the virus but decided to suspend on-campus work.

January 2021 - Intersession

February 2021

- Field work to collect Pliocene aged fossils at Towsley Canyon, Santa Clarita Valley
- Visited Cal State Northridge Geoscience to examine the collection of Cenozoic fossils collected by Richard Squires. Followed masking and distancing requirements.
- Continued to photograph specimens and add to excel database of Mt. SAC collections and personal collections
- Perused Oceanography and Geology textbook chapters and course SLOs and took notes on how this sabbatical work can align with course content as part of planning spring field and museum visits.

March-April 2021

- Got vaccinated against Covid-19!
- Used guidebooks and online databases to identify species of the fossil molluscs collected in the fall.
- Went to Mt. SAC to continue cataloguing the fossil collections in the classrooms.
- Outlined ideas for lab activities based on stratigraphic and paleontologic knowledge collected so far. Used online resources such as SERCC (Carleton College) and EPIC (UC Berkeley) and materials from a Paleontology teaching workshop I had attended years ago as inspiration for writing the lab exercises.
- March 2021: Spent a week at the Invertebrate Paleontology collection at the San Diego Natural History Museum, which had just opened to the public with limited hours. Worked with Collections Manager Kessler Randall to find specimens needed for my research into drilling predation. Took measurements, notes and photographs for the research.
- Created and edited high resolution images of fossils from the SD museum to use at Mt. SAC and to share with the museum curators.
- Field work at Rincon and Santa Barbara to collect more specimens to use in labs and for my drilling predation research. My 11 year old was on spring break so she came along to field assist.
- SoCal Paleontological Society member Jen Kerr took me to Topanga Canyon to show me the best spot to take a class field trip. Made notes and collected fossils.

May 2021

- Spent a week visiting the Invertebrate Collections Warehouse of the Los Angeles Museum of Natural History. Discussions with Collections Manager Austin Hendy helped me narrow the focus of my drilling predation research (figuring out which taxa and localities would work best since the collections are vast). Took measurements, notes and photographs of specimens for the research.
- Austin Hendy nominated me to be a Research Associate of the Los Angeles Natural History Museum, which will give myself and my students official access to collections and libraries.
- Created and edited high resolution images of fossils from the LA museum to use at Mt. SAC and to share with the museum curators.
- Created powerpoint slideshow showcasing my sabbatical project to share with my Department, other faculty who are applying for sabbatical or other need that arises.
- Obtained geologic maps and special papers from the Pomona College library as a reference for map figures that will be in my drilling predation research presentation and sabbatical products.
- Worked on data collection and plotting for my research project.
- Started making poster display. At my 3rd year review with the Assistant Dean, discussed getting into the exploration center to put up display. He said that more of Mt. SAC would be reopening after spring semester, so I decided to wait on going in.

June-July 2021*

- Made template of label cards for Mt. SAC fossil specimens. Used the photos I took of the drawers to create labels for printing on cardstock at printing services. Decided that the labeling might be a nice student project so I made some notes on how to implement that and will try to recruit someone this fall.
- Continued work on poster and activities for lab and field classes.
- Online research into modern clams and snails similar to the fossil ones I've collected so that students can do comparisons in the field (fossil layers in the sea cliffs compared to modern tidepools).
- Outlined the Sabbatical Report, made map location figure and checked over locality list I had been compiling all year.
- Collected more measurements, using the museum specimens I photographed in May, for the drilling predation project.
- Compiled data and submitted an abstract to the Geological Society of America to present my research results at the national meeting in October.

* Although the sabbatical year ended, the work continued into the summer because I wasn't able to complete museum work until late spring and because my access to Mt. SAC was limited over the academic year.

Conclusions

This sabbatical, "*Applying Paleontological Research in Sedimentary Rocks of Southern California…"* helped me gain current paleontological and geological knowledge relevant to the region around Mt. SAC where I take students on field trips and that provides a setting for student-faculty collaborative research. The justification for this sabbatical was that I've concentrated on pedagogy and classroom management for the past decade and haven't kept current on paleontological research and my graduate field work took place elsewhere so I needed to bone up on the sedimentary and fossil record of Southern California.

For the professional development aspect of this project, I accrued an extensive list of relevant geological and paleontological references and had time to actually read and annotate the references. My research included acquisition of field guidebooks, geologic maps and Google Earth data as well as stratigraphic logs from a variety of paper, internet and personal conversation sources. Such work would not be possible during the semester with a full teaching load. Spending time on the research project and focusing on the connections with personnel at the San Diego and Los Angeles museums, I build up name recognition for myself and MT. SAC in the professional field. I am much better able to serve as a research adviser to Mt. SAC students. I gained *confidence* in my knowledge of the regional stratigraphy, fossil taxonomy and the latest literature so I am ready to forge more connections to experts in the field for the benefit of myself and my students.

My sabbatical year was also the time of the global pandemic, full of fear and uncertainty, and my children being home all the time with no break. While I was undertaking geological and paleontological research, I kept notes and outlines of how I would use a certain set of fossils or a field location in an assignment. I spent a lot of time taking and editing digital images of museum material and my collections to use in teaching. The lab activities included here have scantier detail than anticipated but I am confident that I will be able to improve on them and integrate the information I amassed over the year to produce project ideas for my students and my colleagues for collaboration[1]. I did not get all of the classroom fossil

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[1] When it came time to actually write the lab activities, I struggled. I felt so removed from the classroom and my students because of the isolation necessitated by the pandemic that I nearly forgot how to write

collections re-labelled myself (in part due to lack of access to campus for non-essential work) but I got the specimens catalogued and photographed and I have notes on how a student can help with the labeling and the student can learn how to identify species and recognize common California localities. I am now familiar with the range of specimens we have in our teaching collection and have a sense of what geologic time intervals and locations are well-represented in them, and where we have gaps. This will use this institutional knowledge for class and lab prep and to inform my colleagues about treasures hidden in our department's fossil collection and how they might use it.

The highlight of my sabbatical year, and the work I am most proud of professionally, was the project investigating drilling predation in marine molluscs across the Plio-Pleistocene boundary in Southern California (explained earlier in this report). The study of predator-prey interactions in invertebrates answers key questions about evolution in the fossil record. Studies of drilling predation are well-known from the Atlantic side of North America, but research into the topic from the West Coast is less common. When I discovered that fossils I collected in the field and thousands of specimens at the museums I visited were literally full of holes (drilled by molluscan predators, of course), the research topic came naturally. I spent the last month or so of the sabbatical leave collecting and plotting data on site selectivity and size reference of drilling molluscs, culminating in a submission of a research abstract to a national meeting. The networking with professional paleontologists and the connections I will make when I present my research to a wider audience is exactly what's needed to move forward with student-involved research that will infuse my courses. There enough unanswered research questions about drilling predation and loads of fossil materials needing attention to fuel new student projects and classroom-based research activities into the future. The topic aligns with student learning outcomes in oceanography and geology.

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a lab. I struggled with concentration. When my family members' pandemic-related mental health crises pulled me from my work and it was hard to re-focus. Anxiety about producing an excellent product turned into writer's block. Now that I'm back to face-to-face interactions with students and things are returning to some semblance of normal, it will be easier to write more and organize loose ends.

The curators at Los Angeles Natural History Museum's Invertebrate Paleontology department gave me ideas on how their collections could be used for undergraduate research. They encouraged me to return – once the pandemic eases – with students. In fact, I was nominated to be a Research Associate at the LANHM, which grants me easy access to the collections. One project idea that I discussed with the LA paleontologists is centered on deposits not too far from Mt SAC. Today, much of the area around Whittier and the Puente Hills are covered with real estate developments, but fossil collections from the 1930s-1950s are housed at the museum. I did some brief field reconnaissance around Whittier to look for fossil outcrops still accessible; I didn't find any at the time, but it would be worthwhile to bring students to look again and to field map and then use the LA museum's collections as part of a project. The LA museum also has an array of fossils from an ancient lake near Barstow that still need processing and cataloguing – a good student project. The collections managers at the San Diego Natural History Museum said that my students and I were invited back any time to use their fossils. I also communicated with the director of the Alf Museum at the Webb school in Claremont. They were completely closed to visitors during 2020-21, but I am invited to use their collections when they re-open. The Alf Museum does a lot of work on dinosaurs, but they also have invertebrate fossils that have not received as much attention from paleontologists and they'd be happy to have me work on them.

I produced a poster, entitled *A Paleo Journey Through 5 Million Years of the Southern California Coast* in the Exploration Center in Building 60. It describes the marine basins that existed along the coast between Santa Maria and San Diego during the most recent era in geologic time and presents information on drilling predation in molluscs as well as a warm period about 3 million years ago that is an analogue to the warming climate of today. Besides the research talk I will give at the Geological Society of America, I am also giving a more public-friendly talk to the Southern California Paleontological Society this November. Side note: I got involved with the SCPS in fall 2020, was elected secretary and am helping organize field trips for 2021. I envision using my new expertise to be a speaker for Mt. SAC events or in creating a session for Deborah Boroch Science Day, etc.

In conclusion, this was a worthwhile sabbatical project that will benefit students in oceanography and geoscience classes by adding a paleontological element to complement the expertise of other members of the Earth Science department. It served to renew me because I got to exercise my strengths in paleontological research. I got a break from the 5-5 course load routine I'd been in for a decade. It was exciting to leave pedagogy temporarily, to break away from the same old textbooks, and engage with new topics to put to use in teaching and learning.

Lab Activities and Poster Content STARTS NEXT PAGE.

[Lab activities under construction (I made notes and outlines, compiled maps and field guides and prepared fossils or fossil images but have not finalized the activity):

Exploring Functional Morphology of Marine Invertebrates in the Fossil Record

Field Trip to Isla Vista to collect Pleistocene fossils from the marine terraces, clean and sort in the lab and identify taxa (Students will do this prior to completing the Escalation Hypothesis activity)]

Name: Date:

Oceanography Lab Project
Exploring "Escalation" in Evolution of Marine Life

Evolutionary escalation is the concept of an "arms race" between predators and prey. As life in marine ecosystems evolved, predators got more tricks and prey resisted with adaptations such as thicker shells, tough spines or ridges, novel escape strategies, etc. Here in Southern California, we are lucky to have access to diverse coastal ecosystems and also rock formations containing fossil marine organisms so we can investigate evolutionary escalation. You will be working with Pliocene and Pleistocene aged fossils from around Southern California, perhaps some that you collected on our field trip. You'll also discuss modern predator-prey interactions using field guides to organisms found in marine habitats around here today.

1) Read this article (get on Canvas) about the escalation hypothesis:
***Vermeij, G. "The Mesozoic marine revolution: evidence from snails, predators and grazers"**

[optional: Students answer questions pertaining to the article on Canvas before lab]

List at least three examples of adaptations by predators or prey that illustrate escalation. For example, some molluscs evolved spines on their shells to deter predators.

2) Examine the example specimens (images in separate file):

Moon snail, Neverita, Pleistocene
Olive snail, Olivella, Pleistocene
Mudflat snail, <u>Batillaria</u>, Oligocene
Western Nassa snail, Nassarius, Pleistocene
Turreted snail, <u>Turritella</u>, Miocene
Clam, <u>Thracia kanakoffi</u>, Pliocene
Clam, <u>Anadara trilineata</u>, Pliocene
Clam, <u>Chione undatella</u>, Pleistocene
Oyster, <u>Gryphaea</u>, Cretaceous
Conch snail, <u>Strombus gigas</u>, Modern
Turkey wing clam, <u>Arca zebra</u>, Modern

For each sample shell, write a brief statement about each suggesting what features it has that you could use to tell something about predator-prey interactions.

3) Develop a hypothesis and plan your research:
With your group, brainstorm an evolutionary escalation hypothesis for you to test. Here are some examples:
Drilled specimens will have thinner shells than undrilled specimens.
Shallow burrowing clams will be more frequently drilled than deeper burrowing clams.
Shells with less ornament will be more frequently drilled than those with more ornament.
Size of predator will be correlated with size of prey.
You may use one of those listed here or produce your own. Be creative!

a. Write your testable hypothesis.

b. Which specimens will you use? Bulk samples? Just certain species or groups?

c. What data will you collect? Examples of data to collect might be "number of ribs on a bivalve shell" or "thickness of the snail shell aperture in mm" or "percent of total number of clam shells that have predatory drill holes."

4) a. Conduct your research. You will use the specimens that the class prepared. Be aware that you might have to share with other groups. You will photograph selected specimens for your report. I suggest that you photograph yourself conducting the research, too, to use in your report.
b. Record your results. Your group will meet with the instructor to set up an Excel spreadsheet or other method for recording the data. Carefully record your measurements , counts and observations.

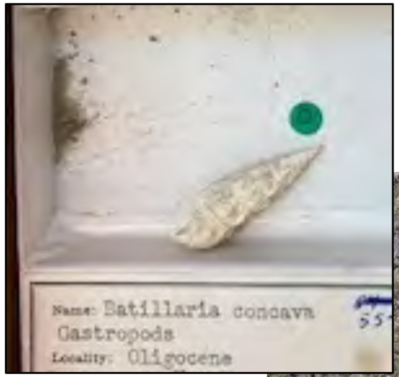
6) Present your results to the class. Each group will make a slideshow that will include the following:
Title and names of group members
Your research question and hypothesis
Summary of methods
Graphs, tables or other depiction of results
Conclusion based on the results
Figures on every slide

* Bonus assignment:
Scientists spotlight on Geerat Vermeij, author of the escalation hypothesis
https://www.nytimes.com/1995/02/07/science/scientist-at-work-geerat-vermeij-getting-the-feel-of-a-long-ago-arms-race.html
[Gary Vermeij is blind. He's an extremely famous paleontologist and has one several awards. He studies the morphology of shells despite being blind. Great example of a successful scientist with a disability.]

SHELL SAMPLES FOR ESCALATION LAB

Moon snail, Neverita, Pleistocene

Snail, Batillaria, Oligocene



Clam, Thracia kanakoffi, Pliocene

Clam, Anadara trilineata, Pliocene

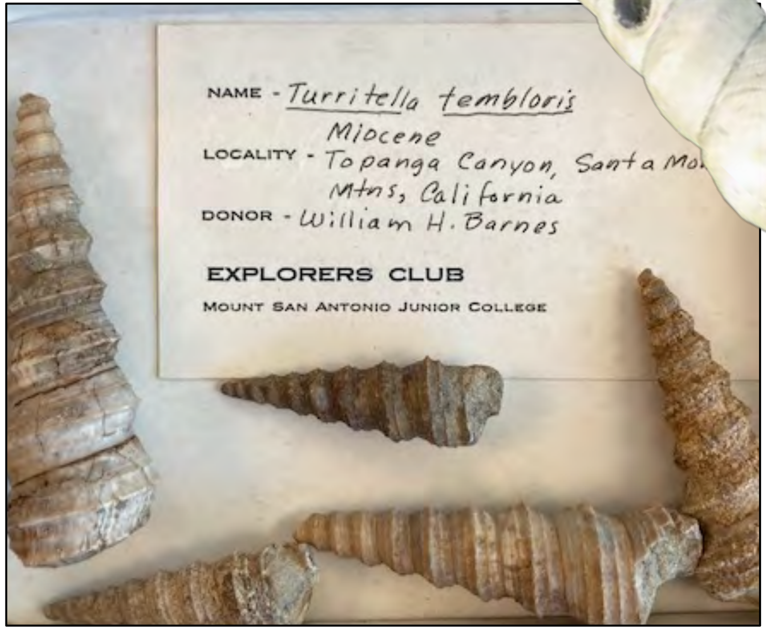
Turkey wing clam, *Arca zebra*, Modern

Western Nassa snail, <u>Nassarius</u>, Pleistocene

Olive snail, <u>Olivella</u>, Pleistocene

Oyster, <u>Gryphaea</u>, Cretaceous

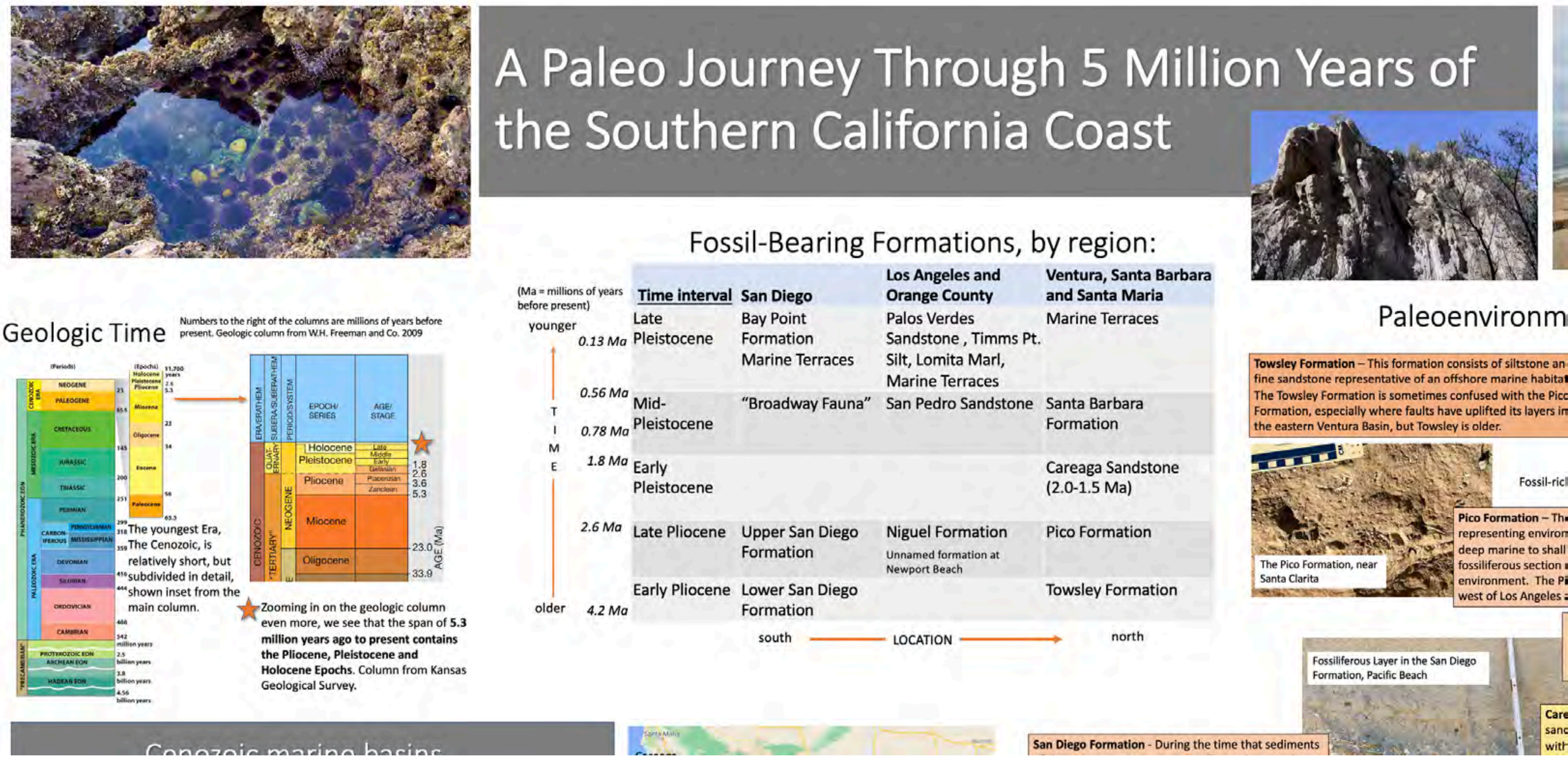
Turreted snail, <u>Turritella</u>, Miocene



Clam, Chione undatella, Pleistocene

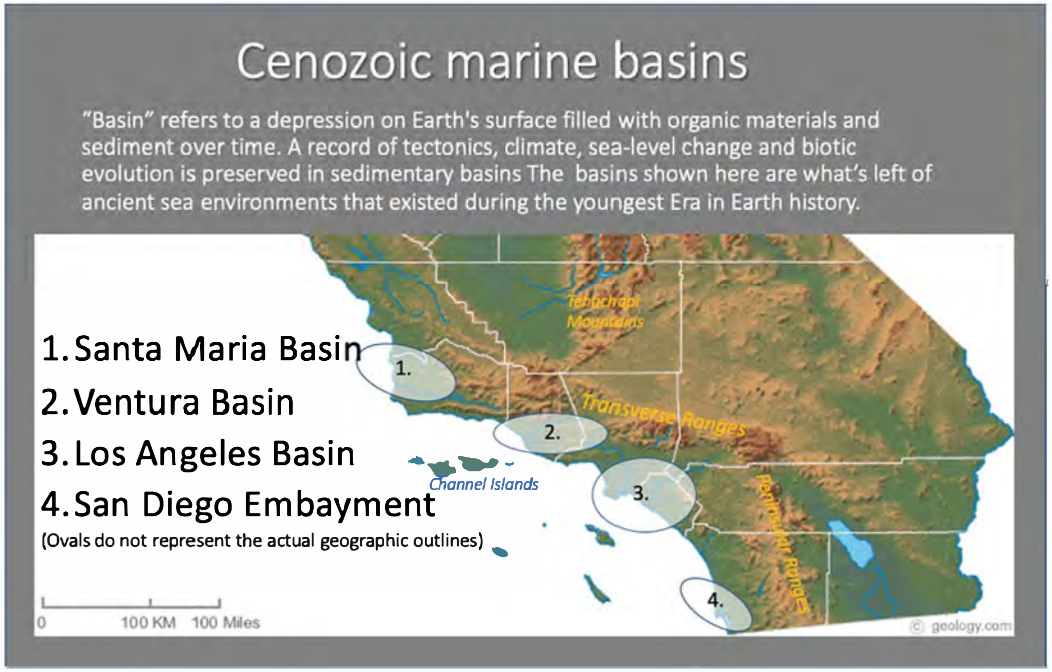
Conch snail, Strombus gigas, Modern

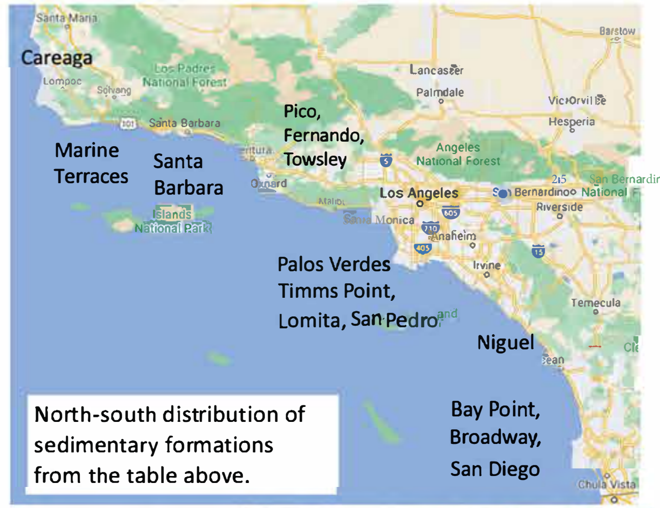
snapshot of poster



snapshot of poster

billion years





San Diego Formation - During the tir
of the San Diego Formation were bei
large, crescent-shaped bay -- roughly
modern-day Monterey Bay -- existed
now includes Tijuana, Mexico, and th
corner of San Diego County from San
Beach. The invertebrate fossils of the
Formation were adapted to sandy ar
shallow marine waters.

San Pedro Sandstone – The San Ped
the Palos Verdes Peninsula was depo
marine environment. Fauna present
event prior to the onset of Pleistocen
sandstone that outcrops near Whitti
closer to a deltaic environment, whe

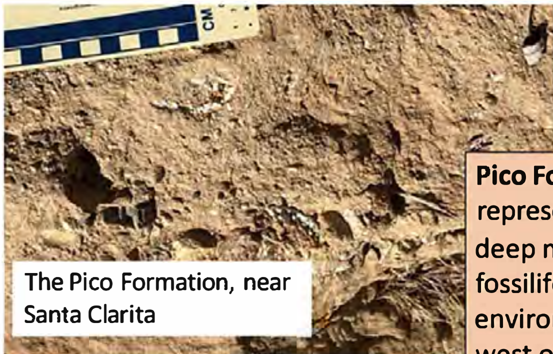
The "Broadway Fauna" – Not really a forma
assemblage in rock layers under downtown
shallow, warm water marine environments
the San Diego Formation layers that outcrop

snapshot of poster

Paleoenvironments

Towsley Formation – This formation consists of siltstone and fine sandstone representative of an offshore marine habitat. The Towsley Formation is sometimes confused with the Pico Formation, especially where faults have uplifted its layers in the eastern Ventura Basin, but Towsley is older.

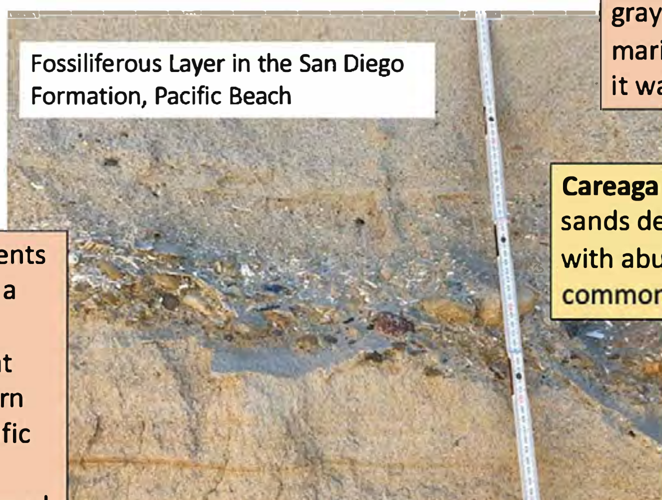
Fossil-rich sandstone of the Towsley Formation



The Pico Formation, near Santa Clarita

Pico Formation – The Pico is a thick sequence of layers representing environments that changed through time from deep marine to shallow marine and river delta. The sandy fossiliferous section near Valencia represents a coastal deltaic environment. The Pico crops out in the mountains north and west of Los Angeles as well as in Ventura county.

Niguel Formation – The Niguel contains gray silty sandstone with abundant marine fossils. At the time of deposition, it was a shallow, marine environment.



Fossiliferous Layer in the San Diego Formation, Pacific Beach

Careaga Sandstone – The Careaga contains sands deposited in a shallow, reef-like setting with abundant scallops and sand dollars. It is common near Santa Maria.

: time that sediments
being deposited, a
;hly the size of
ted in an area that
d the southwestern
San Ysidro to Pacific
the San Diego
/ and rocky bottomed

Santa Barbara Formation - It contains sands with lenses of finer silt and clay that contain shelly fossils representing a nearshore marine environment. It is extremely fossiliferous and crops out along the cliffs and hills around Santa Barbara.

Sifting fossils out of the silty Santa Barbara Formation at Isla Vista.

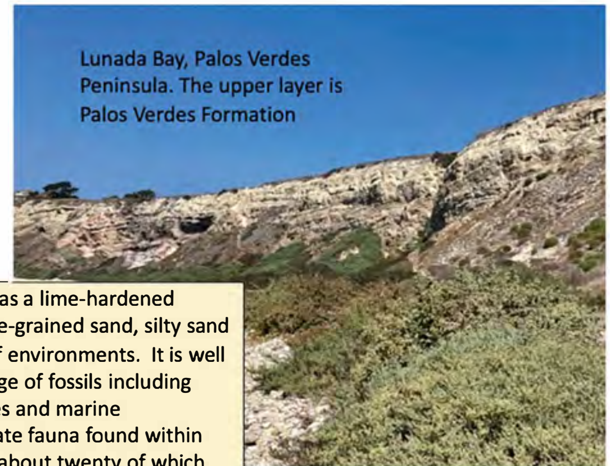
'edro Sandstone is found on
eposited in a shallow, sandy
ent indicate a minor warming
ocene ice ages. San Pedro
ittier and the Coyote Hills is
vhere a river meets the sea.

'mation, but a distinct
wn San Diego represent
its and are slightly older than
crop on San Diego's beaches.

Paleoenvironments, continued

Lomita Marl and Timms Point Silt – These layers within the Palos Verdes Formation contain fine grained sediments, deposited in offshore (50-200 m water depth) environments.The term "marl" refers to a mud containing abundant carbonate – sometimes found in offshore marine habitats. Molluscs found in the marl include both cool water and warm water adapted species, outside the latitudes of present-day Los Angeles.

Vintage 1930 photo of the Timms Point Silt, Palos Verdes Peninsula (USGS).



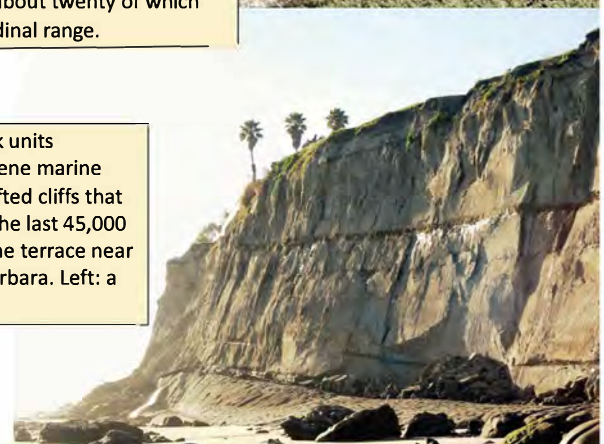
Lunada Bay, Palos Verdes Peninsula. The upper layer is Palos Verdes Formation

Bay Point Formation – The Bay Point formation, common around San Diego, is much younger than the San Diego Formation. It is thought to represent a sandy beach environment. It contains abundant warm water adapted molluscs and other invertebrates.

Palos Verdes Formation – Palos Verdes has a lime-hardened gravel at its base, with a thick layer of fine-grained sand, silty sand and silt from nearshore and shallow shelf environments. It is well known for containing a diverse assemblage of fossils including terrestrial vertebrates, marine vertebrates and marine invertebrates in particular. The invertebrate fauna found within this rock has approximately 250 species, about twenty of which are well north of their present-day latitudinal range.

Snail fossils from the Bay Point Formation (San Diego Nat. Hist. Museum collection)

Marine Terraces – The youngest rock units addressed here are the Late Pleistocene marine terraces. These are tectonically-uplifted cliffs that contain shallow marine fauna from the last 45,000 years or so. Pictured at right: a marine terrace near the University of California, Santa Barbara. Left: a marine terrace at Torrey Pines.



Drilling Predation in the Fossil Record

Who Made that hole? A vicious predatory snail!

A turrid cannibal?

There are a few groups of snails, both modern and fossil, who make their living by drilling holes into the shells of other snails and clams with a special organ and then ingesting the soft innards of their prey. The perfect, round holes they leave in the shell are well preserved in the fossil record and are direct evidence of predator behavior. Paleontologists can collect information about which species are preferred prey, how the nature of drilling predation changes over time, what size or shape of shell the predatory snails prefer to drill, and much more. This helps us learn about marine ecology of the past. Next time you are shell collecting at the beach, look for these holes. If you find them that means your shell was someone's prehistoric snack.

Above and left: Fossil of Carpenter's Turrid (*Megasurcula carpenteria*), from Pleistocene San Diego Formation. Megasurcula drilled holes in the shells of its prey

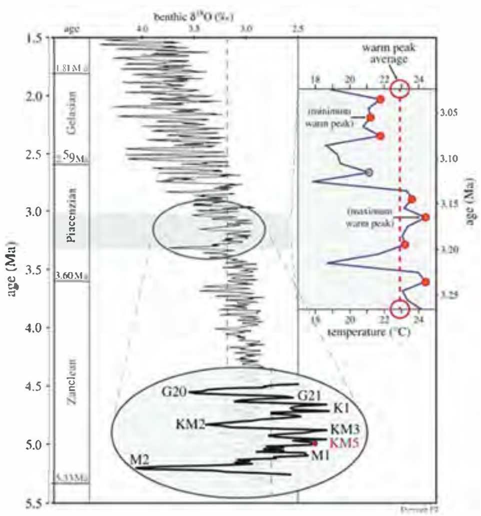
Modern Carpenter's Turrid, a predatory snail from Monterey Bay.

Patinopecten carinus. This warm water species ranges from 5-34 degrees North latitude. Fossils of this species are found in further north.

Global Warming During the Mid-Pliocene, 3.15 - 3.0 Ma

Studies based on microfossils have identified a short period of global warming in the middle Pliocene, 3.3-3.15 Ma. Climate models suggest that atmospheric CO_2 levels were similar to today's and global temperatures were 2-3^0 C warmer than the 20th century average. Certain species of clams and snails found as fossils in rock formations are ranging ranged into more northerly latitudes during the mid-Pliocene than they do today, where they are restricted to warmer, locations south of California. Fossils of these warm-water adapted species appear in the Santa Maria Basin, San Clemente Island, San Diego near the US-Mexico border, Rincon Hill, and the hills of Whittier.

Discotectonica, a tropical snail whose modern range is 23-28 degrees North latitude but ranged into the L.A. area during the Pliocene warm interval.



hart above shows oxygen isotope data, which give clues to past climate, from
ıe sediment cores. Shell material from microfossils is powdered and put into lab
ment that measures the ratio of heavy to light oxygen isotopes. That isotopic
s governed by ocean temperatures and ice sheets on land. When the squiggles
s table (arranged in time order with older layers on bottom) veer to the right,
l temperatures are warmer; to the left means cooler. A temperature proxy is
n in the inset. Notice that at 3.3 Ma, temperatures surpassed average. (Ma =
ns of years ago). Figure modified from *H. Dowsett et al.,* 2013

It is unclear *why* the shift to warmer temperatures occurred in the about 3 million years ago, but climate scientists are interested in examining the mid-Pliocene warming event as an analogue for climate change happening today because the continents were in roughly the same position as they are today, ocean circulation patterns were not much different, and the atmospheric concentration of the greenhouse gas carbon dioxide was similar. Additionally, marine ecosystems much like modern ones were in place, allowing comparisons of life's reaction to warming oceans.

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- J.S. Lackey of Pomona College for access to the Woodford fossil collections
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- Mt. SAC Salary and Leaves Committee
- Mt. SAC Natural Sciences Division

H. Lackey – Sabbatical Project 2020-21

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H. Lackey. Abstract for BOT

2020-21 Sabbatical Project Title: Applying Paleontological Research in Sedimentary Rocks of Southern California to Creation of Classroom-based Research Experiences

This study involved surveying museum collections and paleontological field sites of Southern California with the goal of providing students in our oceanography and geology labs the opportunity for course-based research. The justification for the endeavor was that Dr. Lackey's graduate research was outside of the region so there was a need to gain expertise and make connections with experts in Southern California in order to devise research experiences and lab exercises. Students are naturally interested in fossils, so paleontology is a good "hook" for getting students involved in authentic research. Studies show that access to research and field experiences helps students from underrepresented groups achieve success in the sciences. Dr. Lackey gained a foundation of current paleontological and geological knowledge relevant to Mt. SAC's locale, produced lab activities, a research poster and a photographic and spreadsheet database of fossil species from the classroom collections and local museums. Extensive library research and compilation of field guidebooks and maps for localities in the Santa Maria, Ventura, Los Angeles and San Diego Basins enhanced this foundation and would not have been possible without the sabbatical leave. The research project entitled "Patterns of Drilling Predation in Molluscs across the Pliocene-Pleistocene Boundary in Southern California." was accepted for presentation at a national geological meeting and will be presented to the public at the SCPS meeting in November. Paleontological curators at the Los Angeles and San Diego Natural History Museums invited Dr. Lackey and students to return to use the collections. The potential for student-faculty collaborative projects, through the Redinger Family Research Grant or Geology 99 independent study, and within the oceanography and geology class curriculum abound thanks to this sabbatical project.