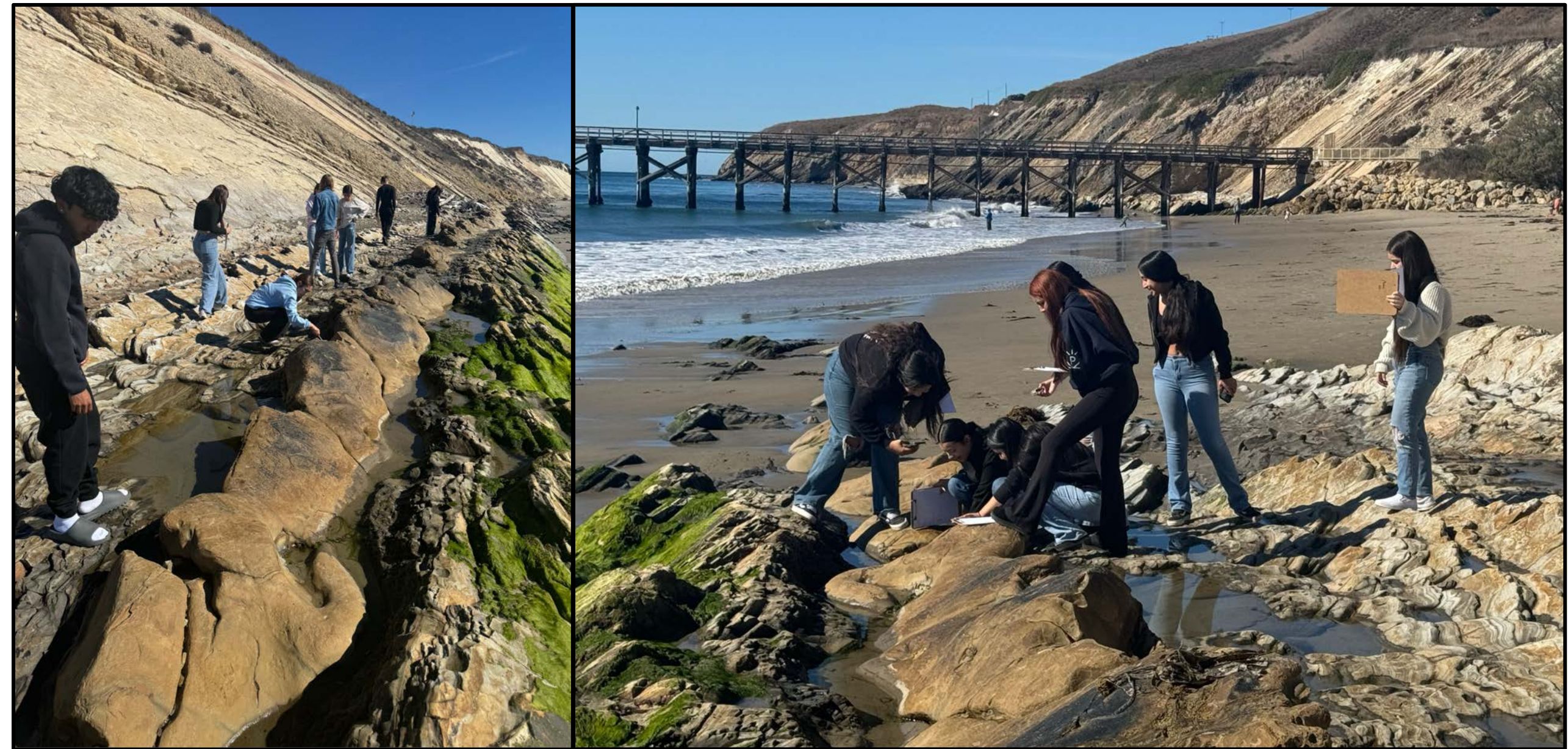


# Background - Marine Science at Lompoc High School and Marine Heat Wave Research

Since the fall of 2021, I have been developing a locally relevant marine science curriculum for juniors and seniors at Lompoc High School. My goal is to provide my marine science students with experiences that encourage them to appreciate our local marine ecosystems from the sandy beach to the kelp forest. Being a participant in the Authentic Research Experience for Teachers program (ARETS@LTER) at Santa Barbara Coastal Long-Term Ecological Research Program (SBC-LTER) has given me experience with current marine heat wave (MHW) research in Dr. Gretchen Hofmann’s Lab. Experimenting with purple urchins, a locally relevant fisheries species, my cohort of RETs tested how MHW conditions affect sea urchin feeding preferences. Additionally, we investigated giant kelp zoospore germination at normal and MHW temperatures. It is exciting to be able to bring this research to my classroom so that my students can make connections with the current research at our local university.

## Why Bring Primary Sources and Scientific Research into the High School Classroom?

- **Connect** students with locally based ecological research to find purpose in protecting local resources.
- **Locally relevant** research is memorable and meaningful
- **Practice communicating:** writing procedures, explaining analysis, and presenting at science fairs,.
- Authentic research **requires repetition and problem solving**.
- Experiments give a **variety of different outcomes** to learn from.



## How to Bring Scientific Primary Sources into the High School Classroom

1. Find locally relevant journal articles connected to topics of study in curriculum.
  - a. Contact local scientists if necessary to obtain full article.
  - b. Select articles that have an abstract students can comprehend.
2. Introduce students to reading abstracts by first identifying key vocabulary.
  - a. Students select and highlight one key vocabulary term in the abstract.
  - b. Discuss selections the class.
  - c. Students underline what is being studied and indicate the study’s findings.

Repeating this process with several abstracts related to a theme allows students to understand the formatting of abstracts and quickly identify the **key terms**

Chan, K. Y. K., Kuo, J., McDonald, A. M., Ringer, A. L., & Hofmann, G. E. (2024). Coastal marine heatwaves in the Santa Barbara Channel: decadal trends and ecological implications. *Frontiers in Marine Science*, 11, 1476542.

Marine heatwaves (MHWs) are of increasing concern due to the emerging ecological and socioeconomic impacts on coastal ecosystems. Leveraging the data of the Santa Barbara Coastal Long-Term Ecological Research project, we analyzed the MHW event metrics observed in the kelp forest ecosystem and across Santa Barbara Channel, CA, USA. Not only was there a significant positive trend in the number of MHWs recorded, their duration and intensity were also increasing over time. MHWs were detected year-round, suggesting that marine organisms have exposure risks regardless of their phenology. Exposure at one life history stage could have a legacy effect on the subsequent stages, implying little temporal refuge. In contrast, the coastal mooring data revealed that near-surface and bottom events were not necessarily coupled even at less than 15 m. Such spatial variation in MHWs might provide a temporary refuge for mobile species. These observations also highlight the importance of depth-stratified, long-term coastal monitoring to understand spatio-temporal variation in MHW stress on coastal communities.

1. After reading, select 1 key term in this abstract and highlight it every time it is used.
2. Underline one sentence that includes what the scientists are studying and bold one sentence that includes the main findings of the scientists.
3. Summarize the main findings in simpler language.

Scientists are seeing that marine heatwaves are happening more often, getting hotter and lasting longer which means coastal ecosystems are getting more heat stress

Sample abstract from marine heatwave article with example annotations



## How to Read, Write, and Modify Procedures Using Primary Scientific Literature

1. Provide hands-on, lab-based introduction to a research topic.
  - Students may not fully understand experimental design on the first trial. There will be errors.
  - Analyze the results together so students can understand the importance of accurate measurements moving forward.
2. Introduce students to methods from related journal articles.
  - Ask students to highlight differences from classroom procedure and underline similarities to identify how classroom lab procedure could be modified in subsequent trials.
  - Define technical vocabulary including names of species.

Emery, K. A., Dugan, J. E., Bailey, R. A., & Miller, R. J. (2021). Species identity drives ecosystem function in a subsidy-dependent coastal ecosystem. *Oecologia*, 196(4), 1195–1206.

Read through “Study site and organisms”

- **Define**
  - Subsidy-a resource that flows from one ecosystem to another
  - Detritivore -an organism that consumes dead organic material
  - Arthropod- An invertebrate with an exoskeleton and jointed legs
- What is the name of the genus of beach hopper?
- Megalorchestia
- What type of kelp is the focus of this study?

**Macrocystis**  
**Study site and organisms**  
Sandy beaches of Santa Barbara, California, USA, are characterized by large but variable inputs of stranded giant kelp (*Macrocystis pyrifera*), or wrack (> 500 kg m<sup>-1</sup> year<sup>-1</sup>; Dugan et al. 2011) from highly productive nearshore kelp forests. This major subsidy to beaches is consumed by a diverse assemblage of highly mobile intertidal detritivores (Lastro et al. 2008; Michaud et al. 2019). We focused on six intertidal arthropod species that make up > 90% of abundance of invertebrate detritivores on these beaches: four congeneric species of talitrid amphipods (two large-bodied species, *Megalorchestia* *comiculata* and *M. californiana*, and two smaller species *M. minor* and *M. benedicti*), a tenebrionid beetle (*Phaleria rotundata*) and an oniscid isopod (*Alloniscus perconvexus*). These taxa are representative of families of important intertidal detritivores on sandy beaches worldwide (Brown and McLachlan 2006). *Oecologia* (2021) 196:1195–1206

Our treatment mesocosms were plastic tubs (19 cm × 17 cm × 9 cm) filled to ~6 cm depth with sieved (1.5 mm) dry sand from Campus Point beach (34.41 N, 119.84 W), mixed with filtered seawater to achieve a moisture level of 10–15% by weight, approximately equivalent to that of the 24-h high tide line where the densest aggregations of these intertidal wrack consumers are typically found.

- What is a mesocosm?  
A mesocosm is a plastic tub containing sand kelp and consumers where they studied the beachhoppers in.
- Looking at the highlighted sections, what is the difference between this procedure and what we did in class?  
They got their sand at the beach and added water to their sand because it was dry, they also sieved their sand.

Using this procedure, explain 2 changes we could make when we repeat this procedure.

- Change 1 - One thing we can change is the type of sand we use. Using dry and sieved sand next time we do this procedure as well as adding moisture to the sand ourselves.
- Change 2 - Another thing we can do is cut the kelp blade into pieces of uniform shape so that water loss between mesocosms would be more consistent.

Student work identifies differences between methods from journal article and initial classroom experimental procedures and highlights changes to procedure for second classroom experimental trial

Sample excerpt from methods section of a journal article with vocabulary support for students

## Implementing Student Modified Procedures in the Classroom

1. After an introductory, first experimental trial and reading of primary scientific literature, guide students in writing a modified procedure.
  - Emphasize using appropriate scientific vocabulary.
  - Encourage students to use methods from related journals to improve procedure.
  - Remind students to be specific with numbers and measurements in their procedures.
2. Complete a second experimental trial using the modified procedure
  - Emphasize to students that authentic research often requires scientists to test and repeat procedures.



## Our Project: Investigating the Possible Effects of Marine Heatwaves on the Kelp Forest and Sandy Beach Ecosystem

- MHW in the North Pacific Ocean have been increasing. UCSB scientists are studying how warmer ocean temperatures can affect kelp growth and the ecosystems that depend on it.
- The Dugan Lab studies how kelp deposited on S. California beaches is used by arthropods in the sandy beach ecosystem. During a MHW, certain species of kelp might have lower nutritional quality. These arthropods are an essential source of food for many shorebirds.
- Using published protocols from the Dugan lab, students investigated the types of kelp beach hoppers prefer by providing beach hoppers with both giant kelp and feather boa kelp blades.



**DATA Nuggets**

Activities that bring real scientific data into the classroom, giving students a chance to explore the science process and scientific methods.

HOME WHAT ARE DATA NUGGETS? CURRENT DATA NUGGETS MAKING A DATA NUGGET

**8.27.25** Can kelp help the plovers?

The activities are as follows:

- Teacher Guide
- Student activity: Graph Type A, Level 2
- Student activity: Graph Type B, Level 2
- Student activity: Graph Type C, Level 2
- Reading Passage

It's a beach day! You're walking through the sand on a beautiful California beach, looking for a place to get your things. You notice there are clumps of dead-up seaweed everywhere. As you walk under some of these clumps to try and find your towel, a strange like bug jumps out at you and scurries off your hand into nearby dead seaweed. Small birds are flying across the sand, and hopping bugs, you wonder, is this beach healthy? Yes! These are all parts of a thriving food web.

Readback are there to many important species that each play a role in the ecosystem. On the Pacific Coast of California, the dead-up seaweed is typically made up of several species of kelp. Kelp captures the sun's energy through photosynthesis. Beach hoppers, the little jumping "bugs" are actually small crustaceans that feed on the kelp. In turn, these beach hoppers are the main food source for birds.

Shrewy plovers are a type of bird that loves to eat beach hoppers. The abundant species is threatened in California due to habitat loss. The sandy beaches where the plovers live and feed are also places where people like to walk and play. Scientists want to better understand what makes up the base of the food web that supports plovers to keep their populations secure.

Beach hopper on a seaweed

## Beach Hopper Experiment Authentic Scientific Research in the Classroom

Students worked in groups of 4-5, each responsible for preparing their own mesocosm with sand, beach hoppers, giant kelp, and feather boa kelp. Four groups prepared a mesocosm with smaller beach hoppers from a beach east of UCSB and the other four groups prepared a mesocosm with larger beach hoppers from a beach west of UCSB. Kelp was carefully rinsed, dried with paper towel, and weighed prior to place in the mesocosm. After three days, the mesocosms were opened; the remaining live beach hoppers were counted, and the kelp was weighed again to determine how much kelp had been consumed by beach hoppers. A laboratory assistant was responsible for maintaining a control mesocosm to determine water loss by the kelp over the three day period.

Students analyzed the data in Google Sheets as a class data set. First students determined how much kelp was consumed in each mesocosm taking into account the water loss observed in the control. Then students calculated the amount of kelp consumed per beach hopper. We are currently working on a procedure to calculate the amount of kelp consumed per gram beach hopper to account for discrepancies in beach hopper size.