

Next Generation Science Standards (NGSS)
Performance Expectations (PEs)
Relating to the Santa Barbara Channel,
Channel Islands National Marine Sanctuary, and
Channel Islands National Park
Grades 7-12

Grade 7

- MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.**

Relationship to local area includes, but is not limited to:

The effect of warm water periods or El Nino conditions on food availability for Brown Pelicans and Sea Lions and consequently, their populations.

Teachers could also learn how to look at chlorophyll satellite maps from various seasons or years. These maps are used to measure productivity at the foundation of the ecosystem.

On board the NOAA Shearwater vessel, teachers could conduct a plankton tow and learn other ways that the health of the ecosystem is measured locally.

- MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.**

Teachers could look at longer term sets of data that exist for the NOAA Marine Sanctuary. There is a strong desire by teachers to have access to real data related to local phenomena to give to their students for purposes of data analysis, argumentation, and engineering design solutions. One area to investigate is how temperature relates to kelp coverage, specifically the link between urchin barrens and lush kelp forests.

- MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.**

Teachers would greatly benefit from learning how actual practicing scientists engage in evaluating design solutions. One method would be to use SeaSketch to look at how various spatial plans protect different known habitats or specific populations.

Additionally, teachers can also learn how to use predictive models about the tradeoffs for the future.

MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales.

MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

Both of these Earth Science PEs relate to observable phenomena at the Channel Islands. The geologic history of the Channel Islands is well documented and many features relating to this history would be observable when on board the NOAA Shearwater Vessel. Teachers need to learn about our local geologic history and current geologic processes to better understand the whole watershed region that includes the CINMS. The CINMS includes the unique features shaped by geological processes including: the Santa Barbara Channel, the Santa Cruz Channel, and the deep water Santa Cruz Basin. Teachers will follow-up learning about the local area with relevant, contextual lesson planning and instruction.

MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth’s mineral, energy, and groundwater resources are the result of past and current geoscience processes.

MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Both of the above performance expectations are under the heading, “Earth and Human Activity”. Relationships to the Channel Islands can include the effect of grazing on the Channel Islands, the limited availability of groundwater on the Channel Islands, and the presence and impacts of oil reserves beneath the seafloor in the Santa Barbara Channel. In relation to natural hazards, possible future events would include earthquakes, tsunamis, and major El Nino events.

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

This Engineering PE could apply to many issues and phenomena surrounding the Marine Sanctuary. The Marine Reserves, especially the “no take” zones are an excellent example of a designed solution to an existing problem. Questions that teachers may have include: How were the areas picked? How are they working? What is the cost of creating a reserve? What is the impact on local fisherman? What is the

impact on biodiversity? Teachers could then translate this learning into designing accessible, yet relevant problems for students to solve. Another local topic would include the issue of ship striking whales and the work that is being done to reduce this occurrence.

Grade 8

MS-LS4 Biological Evolution: Unity and Diversity

MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.

Knowledge of local fossils helps us understand our local geologic history. Questions that teachers need to be able to answer in order to plan effectively include: How are the fossils on the Channel Islands similar or different from ones found in the Santa Ynez Mountains? How was the Transverse Range created? What do our local rock strata and fossils tell us about the geologic and climate history of Santa Barbara and the Channel Islands? How can understanding past extinctions help us understand climate change?

MS-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

Teachers can learn about the wealth of local evidence of evolution relating to both extinct species (Pygmy Mammoth fossils compared with continental Mammoth fossils) and living species (Island Fox compared with other Fox species, Island Scrub Jay compared with other Jays)

MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

Rather than teaching this PE with textbook examples, students would benefit from learning about local examples such as black abalone and sea stars that have survived wasting events. Teachers need to learn about our local species that relate to this PE. Additional questions to learn about may include: How does this PE relate to the differences in terrestrial species sizes from the Channel Islands to the Mainland? (Scrub Jay...) How does this PE relate to local marine life? What variations are observable in our local populations?

MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.

The Channel Islands are part of the Transverse Range. There is significant fossil evidence and local rock strata to place the formation of our local geographic features within the context of the geologic time scale for Earth. Teachers would benefit from increasing their understanding of local geologic formations and processes. Teachers would greatly benefit from professional learning experiences that connect them with local Geological Sciences professors (Dr. Tanya Atwater, for example) and grad students.

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Overfishing of the Santa Barbara Channel relates to the global issues with overfishing and over consumption of fish. Additionally, consumption of fossil fuels leads to new exploration by oil companies. Teachers would benefit from having experiences to help them understand how our local marine and oil resources fit into the global picture of human population growth and resource consumption. Additionally, teachers need to learn about the impacts of climate change on our fisheries.

MS-PS4-1. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

Ocean waves: How do these interact with our local geography? How do the Channel Islands impact ocean wave travel? Why is the Santa Barbara Channel dangerous for a novice boater? How does the creation of rock arches relate to the destructive absorption of wave energy? How does the reflection of waves with the interaction of current cause the "Potato Patch" off the West End of Santa Cruz Island.

High School Biology

HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Many intertidal species in the Sanctuary exhibit observable feedback mechanisms to maintain homeostasis. Intertidal organisms are able to retain water to avoid desiccation during low tides. Teachers would benefit from learning about how these feedback mechanisms work.

- HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.**
- HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.**
- HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.**

Teachers would benefit from learning about which environmental factors in the Channel Islands National Marine Sanctuary are most influential in affecting carrying capacity and biodiversity for marine species. Additionally, knowledge of how changing conditions impact ecosystem health and stability would be valuable.

- HS-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.**
- HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.**
- HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.**

The above 3 PEs all relate to the cycling and flow of carbon. Relevance to our local marine life includes the topic of ocean acidification and the role of species loss on the food chain.

- HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.***

There has been much work done to eradicate invasive species on the Channel Islands: sheep, cows, boars, ice plant, rats, and more. Teachers may not be aware of all the work that has been done on the Channel Islands to try to revive species on the island that exist nowhere else in the world, for example the Island Fox. Additionally, there has been successful reintegration of the Bald Eagle, and removal of the Golden Eagle.

HS-LS2-8. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

Examples of group behavior that are observable in the Channel Islands National Marine Sanctuary include: schooling fish, pods of dolphins, feeding aggregations of whales, and large pinniped colonies (especially on San Miguel Island).

HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

Teachers would benefit to know what local examples exist of genetic variations due to environmental factors exist in our local area and marine sanctuary. How is Ocean Acidification affecting inherited traits and mutations?

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Both of the above PEs on biological evolution could be directly related to species in our local marine and terrestrial ecosystems. An emphasis on genetic similarities and differences with species in the Channel Islands compared to the mainland.

HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*

Substantial work has been done in the Marine Sanctuary and on the Channel Islands to mitigate human impacts. Teachers would greatly benefit for learning about these local efforts to protect and restore threatened species in order to preserve biodiversity. Two examples include: restoration of wetland at Santa Cruz Island after ranching, and the establishment of marine reserves. This knowledge will help teachers make relevant connections in Biology.

High School Earth Science

HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

Teachers need to understand the role of the water cycle in the stability of our climate and our ocean currents.

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*

HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

The above Earth and Space Science PEs focus on the Earth and human activity. Teachers would benefit from learning about programs that exist in the Marine Sanctuary and in other locations designed to monitor species that are affected by human impacts (for example research on coral reef resiliency). There are several options of programs that exist for teachers to learn about via the CINMS: the LiMPETs rocky shore or sandy beach monitoring program, the safe passage program to incentivize ships to slow down to avoid collisions with whales, the Marine Protected Area monitoring for kelp forest ecosystems. Additionally, Teachers could learn about and plan to use the NOAA Deep Sea Coral Community lesson plans, which include rich multimedia resources to help students understand the deep water species variety and the implications of ocean acidification.

Finally, one option for designing original methods for monitoring or minimizing human impact includes using the program SeaSketch. SeaSketch is an accessible mapping platform that supports collaborative science-based geodesign - design over space. The geodesign process is increasingly recognized as a valuable teaching tool to improve the integration of disparate information to make inferences about complex systems.

Teachers can integrate this program into lessons that would allow students to design elements of their own monitoring programs or spatial plans that measure and reduce human impacts respectively.

High School Physics

- HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.**
- HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.**
- HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.***
- HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).**

The above 4 PEs can relate to both climate change and ocean circulation. Ocean circulation distributes energy and drives global weather patterns. Understanding how energy cycles at the macroscopic scale helps to connect the climate to both carbon and water cycles. Teachers need to understand climate change as a change in the balance of the carbon and water cycles. Teachers would benefit from learning about ocean circulation and currents at a global scale and at a local scale. Connections can also be made locally to El Nino conditions. Furthermore, the PE that mentions building a device to convert energy from one form to another can be coupled with one of the Engineering PEs below to look for design solutions to our energy issues related to climate change.

- HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.**

NOAA data and websites could be used to give the above PE on waves some real world context for students.

High School Engineering Design - Part of all NGSS High School Science Courses

Students who demonstrate understanding can:

- HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.**

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

The above PEs for Engineering Design relate to essential work being done for the CINMS to mitigate human impacts. Teachers would benefit to learn about how scientists work to design solutions to complex real world problems. High school teachers need real world data and phenomena to bring these concepts into their classrooms.