MPA Toolkit
Unit 2

Grades 3-5

Produced by the Humboldt, Del Norte, and Mendocino Collaboratives in partnership with the California Department of Fish and Wildlife

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Written by: Melinda Bailey

Acknowledgements

Lead Author:
Melinda Bailey, Science Educator and Curriculum Developer

Editors:
Marnin Robbins, California Department of Fish and Wildlife, Eureka, CA
Joe Tyburczy, California Sea Grant Extension
Angela Edmunds, California Department of Fish and Wildlife, Eureka, CA
Leslie Kashiwada, California Department of Fish and Wildlife, Ft. Bragg, CA

Contributors:
Ruthie Maloney, RAM Consulting, Regional Tribal Liaison
Vanessa Munoz, Education and Stewardship Coordinator, Friends of the Dunes
Dena Childs, Trinidad Rancheria
Shirley Louse, Trinidad Rancheria
Erik Fraser, Humboldt County Office of Education Graphics Department
Calla Allison, Director, California MPA Collaborative Network
Leandra Lopez, Technology Manager, California MPA Collaborative Network Cecille Allison, volunteer
Jen Ortega, Environmental Science & Management, Humboldt State University
Kelsey Benson, Environmental Science & Management, Humboldt State University
Robert Clarke, Environmental Science & Management, Humboldt State University
Mark Bailey, volunteer, retired science teacher
Rikki Eriksen, California Marine Sanctuary Foundation
Rosa Laucci, Marine Program Manager/Marine Biologist, Tolowa Dee-Ni' Nation
Humboldt State University Telonicher Marine Lab, Trinidad, CA

Fiscal Sponsor:
Friends of the Dunes (Suzie Fortner, Program Director & Interim Executive Director)

MPA Community Collaborative Co-Chairs:
Joe Tyburczy, Humboldt County MPA Collaborative
Dr. Beth Chaton, Humboldt County MPA Collaborative
John Corbett, Del Norte County MPA Collaborative
Rosa Laucci, Del Norte County MPA Collaborative

Dear Educator,

Welcome to the MPA Toolkit - a collaborative project designed for practical use by both formal and informal educators. This Toolkit has many different components including two units of study, equipment necessary to conduct activities, examples of marine specimens, and other objects meant to enrich the learning experience while teaching about Marine Protected Areas (MPAs). The two units of study (Units 1 & 2) are aligned with the Next Generation Science Standards (NGSS) and have a wide range of activities easily modified to various age groups. Materials can be easily adapted to a range of audiences including those out in the field, in the classroom, or at a workshop. Each activity is designed for students to learn about a particular concept or goal in order to more fully understand how California's MPAs work. In addition, every lesson applies the 5E Instructional Model and has links to additional online information. I hope you find the Toolkit interesting, informative, and fun. We'd love to hear from you.

Sincerely,

Melinda Bailey
Lead Author

Submit all comments and suggestions to: calla@mpacollaborative.org
Calla Allison, Director MPA Network

Unit 2: Table of Contents

Preface

Why this Toolkit was created

The MPA Toolkit is to inform youth about the California Network of Marine Protected Areas and to provide informed stewardship and enjoyment of these marine "parks". It is intended for use either in the classroom or on-site (e.g., beach, estuary, etc.). The Core MPA Messages found below steered the direction and content of each lesson as education and engagement are key components to the overall success of the MPA Network.

How to use the Toolkit

When you use this MPA Toolkit you will find a wide spectrum of tools. Each Unit of study can be found in a hard-copy format within the accompanying MPA Toolkit "chest" or on a flash drive found on a lanyard in the upper section of the Toolkit. Each lesson is connected to NGSS core ideas, MPA goals, and includes a plethora of extension activities and additional information. Within each lesson you will find important background information to get you started and a recommended procedure to make it easy to use. Integration of the 5E instructional model is applied at the end of every lesson. Most of the materials necessary to conduct activities are present and others are easily available in local stores or classrooms. Many lesson make a connection to Traditional Ecological Knowledge (TEK) also referred to as Indigenous Knowledge and refers to the accumulating body of knowledge passed down through generations. Examples include a Yurok doll adorned with shells and other regalia and the Yurok language as it relates to the ocean. Additional items related to TEK can be found in a separate pocket folder located in the Toolkit. A poster tube is another part of this Toolkit and within it are bamboo poles for activities, a large Northern California MPA map, and several posters to make learning relevant and fun. A good place to start is the gray binder, which is easy to thumb through to give you a first glance at some of the important messaging and visual aids to get you started.

Core MPA Messages

1. MPAs can protect natural diversity and ecosystem functions.
2. MPAs can sustain and restore marine life populations
3. MPAs can improve recreational, educational, and study opportunities
4. MPAs can protect representative and unique habitats
5. The MPA Network has clear objectives, effective management, adequate enforcement, and uses sound science.
6. California's MPAs are designed and managed as a network.

What is an MPA

Marine Protected Areas or MPAs are special places set aside in the ocean, similar to a national or state park on land, where people are encouraged to visit and explore, but where harvest of wildlife (and other resources such as rocks, sand, oil, archeological artifacts, etc.) is limited or prohibited. MPAs are not only found along the California Coast, they exist all around the globe including the Indian Ocean, across the Pacific from Hawaii to Australia, and elsewhere.

Why We Need MPAs

The world's oceans and coasts are increasingly threatened by development, pollution, overfishing, and natural events, which strain the health of our marine ecosystems. MPAs are a tool to help reduce those stresses and restore marine ecosystems. They can also act as an "insurance policy" by conserving biological diversity, protecting spawning and nursery areas, and protecting habitats such as wetlands that can shield communities from coastal storms and flooding. These benefits, along with other economic benefits from recreation, tourism, and fishing, help sustain coastal communities.

Protecting Biodiversity

Marine biodiversity is the variety or abundance (the number of different microbes, algae, plants, and animals) of life found in the ocean. Because California's MPAs are protected areas, they may foster robust populations that are better equipped to withstand current and future threats such as climate change, seasonal cycles, and ecosystem changes. Maintaining biodiversity is important because it is often used as a measure of the health of a particular habitat or biological system, however, this concept has its limitations. For instance, invasive species can add to the overall diversity of a system but have detrimental effects on an ecosystem. When the environment changes, some plants and animals survive and reproduce, while others die or move to new locations. When you have many species instead of only a few, there is a much better chance that the important roles or niches, critical for survival and keeping the balance of life, will be maintained. Therefore, encouraging marine biodiversity is important for keeping natural ecosystem balances, protecting coastal resources, maintaining beauty or aesthetic pleasure, and economics. If you are lucky enough to visit a MPA, you will often see a diverse web of life thriving there.

California's MPAs

Stretching for a picturesque 1,110 miles along the Pacific Ocean, California has the third longest coastline in the United States. The California coast is a fascinating place both biologically and geologically and is full of abundant natural resources. Upon visiting one will find pristine beaches, rugged sea stacks, rocky shorelines, and a wealth of sea life, from sea lions to bull kelp. Economically, California's coast resources support a $43 billion coastal economy. Commercial and recreational fisheries and tourism continued to be important economic drivers for those living along the coast and proper management of these resources is essential.

In 1999, California passed the Marine Life Protection Act (MLPA), requiring the establishment of a statewide network of Marine Protected Areas (MPAs). Under the MLPA, the state brought together scientists and groups of ocean community members to work together to identify MPA locations. Recommended placement of MPAs were weighed by the California Fish and Wildlife Commission, who finalized the MPA Network in stages between 2007 and 2012, using the best science to direct them.

In California, MPAs were set aside to act as a **network** protecting the animals and plants (i.e., algae) that live in them as well as various habitats found along the coast. Similar to state or national parks, MPAs have clear boundaries that are regulated in the hopes of promoting greater diversity and larger animals compared to unprotected areas. When marine life and the habitats in which they live are left alone, they are allowed to recover from human impacts (such as over fishing) or natural ones (such as La Nina events which are warming trends).

California has 124 MPAs, which results in protection for 16% of California's coastal waters. Some of the habitats you can find in these MPAs include kelp forests, estuaries, sandy bottoms, rocky intertidal zones, rocky reefs, and subterranean canyons. In addition, many coastal areas have been important to native peoples who have relied upon them for their livelihoods and spiritual values for generations. In addition, MPAs can help protect this cultural heritage by limiting extraction while managing for future generations to enjoy.

MPA Toolkit Unit 2 (grades 3-5)		
Lessons	**Objective(s)**	**Connections to NGSS**
In this unit, students will learn about some of the main purposes of Marine Protected Areas (MPAs) as well as how they work using visual observations, modeling, and discussion. Students will identify marine organisms, and learn the importance of biodiversity, protecting cultural heritage, and how the spillover effect works in no-take zones. In addition, they will model how MPAs can act as a network through larval dispersal between two adjacent sites. Lastly, they will utilize an online PORTS program to help understand how the use of Remotely Operated Vehicles (ROVS) can increase our knowledge of ocean habitats as they participate in a mock citizen science project where they count fish.		
Lesson 1 – Planktonic Playground <u>Phenomenon:</u> Zooplankton or animal larvae are dispersed through ocean currents.	**Lesson 1:** In this lesson, students learn that Marine Protected Areas act as a huge network. They learn about plankton especially zooplankton or larvae and model how they can be dispersed between adjacent areas. MPAs have been designed large enough for adult populations to thrive and close enough together so that larvae can travel from one to the other. **Learning Objectives:** A) Students will understand that larva and other forms of zooplankton are dispersed through ocean currents. B) They will model the dispersal of larva between two adjacent Marine Protected Areas (MPAs) to approximate a functioning network.	Lesson 1: 3LS1.B, 3 LS2.C, 3 LS4.D, 4 LS1.A, 5 LS2.A, 5 ESS3.C
Lesson 2 – Food Web Diversity <u>Phenomenon:</u> An ecosystem becomes unstable when top predators are removed.	**Lesson 2:** Students model a marine food web using species cards and string. Once they have formed a foodweb and model the exchange of energy (i.e. food) between organisms and the sun, the food web is altered by adding one or more stressors to the system. Additionally, students learn what biodiversity is, and how MPAs can protect and enhance biodiversity which often allows complex ecosystems to be more stable.	

	Learning Objectives: Students will be able to model the relationship of energy transfer in a marine ecosystem by modeling a food web and will understand how MPAs can help maintain or enhance marine biodiversity.	Lesson 2: 3LS2.C, 3 LS4.D, 4LS1.A, 5 PS3.D, 5LS1.C, 5 LS2.A, 5ESS3.C
Lesson 3 - Who Am I? <u>Phenomenon:</u> California MPAs help protect the diversity and abundance of marine life that lives along the North Coast.	**Lesson 3:** In this lesson, students will become familiar with some marine organisms California MPAs are likely to protect. They will learn that MPAs target those species with small home ranges compared to those with large home ranges. In addition, this lesson uses student language art skills, as they need to be able to read and comprehend biological characteristics, listen, and answer questions correctly. They use critical thinking skills to find out who they are using questioning.	
	Learning Objectives: A) Students will be able to identify some marine organisms likely to be benefit from California Marine Protected Areas (MPAs). B) They will attempt to identify what these species are by asking yes or no questions using critical thinking skills to find the answer.	Lesson 3: 3LS1.1, 3 LS1.B, 3 LS3.A, 3 LS4.D, 4 LS1.A, 5 LS1.C, 5 LS1.C, 5 ESS3.C
Lesson 4 - Shells that Sing and Dance <u>Phenomenon:</u> Abalone is a type of shellfish harvested by humans for food and worn in Native American regalia and used in ceremonies.	**Lesson 4:** In this lesson, students learn about several mollusks including red abalone. They learn an added benefit to California Marine Protected Areas is the protection of cultural heritage. Here students learn the meaning of heritage and identify some of the seashells and other objects used in Native American ceremonies by observing what is on a Yurok tribal doll. The doll is adorned with abalone shell, clam shells, dentalium, and other beads including pine nuts. At the end of the lesson they identify the uses of some of these objects.	
	Learning Objectives: A) Students will understand that MPAs can help protect cultural heritage. B) They will be able to identify several shelled animals (mollusks) including the red abalone, a species with	Lesson 4: 3LS3.B, 3 LS4.B, 4 LS1.A, 4 ESS2.B, 5 LS2.A, 5 ESS3.C

	cultural significance to local Native American tribes.	
Lesson 5– Network Spillover Phenomenon: Marine Protected Areas (MPAs) can increase biodiversity and replenish fish stocks outside their boundaries through the spillover effect.	**Lesson 5:** Students "fish" for popcorn from bowls to model the importance of sustainability and a phenomenon called the "spillover effect". One group represents a No Take Zone and by the end of the exercise their bowl is overflowing. This lesson brings home the message that Marine Protected Areas (MPAs) can act as a savings account. Some areas that are protected can have high populations of targeted fish species that can spillover thereby repopulating or enhancing existing MPAs or nearby areas outside of MPAs.	
	Learning Objectives: A) Students will learn that California Marine Protected Areas (MPAs) are part of a network where the spillover effect can benefit multiple species and nearby ecosystems.	Lesson 5: 3 LS2.C, 3 LS4.D, 5 LS1.C, 5 LS2.A, 5 ESS3.C
Lesson 6 – "Dive In": Exploring MPAs through ROVs Phenomenon: Remotely operated vehicles (ROVs) provide a tool for marine scientific research.	**Lesson 6:** This lesson uses an already existing PORTS interactive program where students learn about MPAs. This lesson will emphasis the fact that MPAs can offer and improve recreational, educational, and study opportunities. Footage from ROVs is incorporated.	
	Learning Objectives: A) Students will answer questions about California Marine Protected Areas (MPAs) through an online PORTS slideshow. They will identify at least two purposes for MPAs including the fact they provide recreational and research opportunities.	Lesson 6: 3LS2.C, 3LS3.B, 3LS4.D, 4LS1.A

MPA Toolkit

For Humboldt and Mendocino Counties

UNIT 2

Grades 3-5

Lesson 1: A Planktonic Playground.

NGSS -- DCI (Disciplinary Core Ideas):
3LS1 From Molecules to Organisms: Structures and Processes
3LS1 Growth and Development of Organisms
3LS2.C Ecosystem Dynamics, Functioning, and Resilience
3LS4.D: Biodiversity and Humans
4LS1.A Structure and Function
5LS2.A Interdependent Relationships in Ecosystems
5ESS3.C Human Impacts on Earth Systems

Time:
30 – 90 mins.

Toolkit Materials for the Teacher
Note: You will need to purchase or make bubble solution for this activity.

- ✓ MPA Poster: *The California Network of Marine Protected Areas: Safeguarding an Underwater Wilderness.*
- ✓ Pictures of various forms of larvae including forms of zooplankton.
- ✓ Information on California MPAs (refer to online resources)

Learning Objectives: A) Students will understand that larva and other forms of zooplankton are dispersed through ocean currents. B) They will model the dispersal of larva between two adjacent Marine Protected Areas (MPAs) to approximate a functioning network.

Phenomena: Zooplankton or animal larvae are dispersed through ocean currents.

Background information:
Marine Protected Areas (MPAs) throughout the country have been developed and designed for a variety of purposes including conservation of cultural heritage (refer to Lesson 4), conservation of marine habitats, enhancement of certain populations of fish and invertebrates, and increasing biodiversity. In this lesson, students will learn that California Marine Protected Areas (MPAs) span the coastline of the entire state and have been designed and positioned to act as a network.

MPAs need to be designed to be large enough so that adult populations can live there, yet be positioned close enough that larval exchange can occur between them (refer to image 1 below). The distance zooplankton or larvae (larvae is plural for larva) travel depends on many factors including the size of the larvae, wind force, ocean currents, and how close to the surface they are. Many individual MPAs are large enough to span the home range of many species: a minimum of 5-10 km (3 – 6 miles) alongshore; many extend from the mean high tide line out to the 3 nautical mile limit of state waters (~5.5 km). The network generally has spacing of 50-100 km (18 – 62 miles) between individual MPAs to ensure that there is connectivity between them – that the MPAs are close enough together that eggs, larvae, or other propagules of many species can move from one MPA to the next. This positioning may also enhance populations, and thus fishing, in the areas between the MPAs. (There are several maps in your toolkit to see the locations of relevant MPAs).

You may think of this functioning network model as a *dispersal network or a model of spatial connectivity*. In order for the

- ✓ A way to make large circles either using chalk or hula hoops (hula hoops are not included in the Toolkit)
- ✓ Fans (optional)*

*Items not included in toolkit

Toolkit Materials for the Students

- ✓ Bubble solution *^ *recipe below*.
- ✓ Wire bubble makers for making bubbles
- ✓ Hula hoops *
- ✓ Paper and colored pencils or pens (optional) *

*Items not included in toolkit

^ *Bubble Solution Recipe*:
To make your own bubbles:
3 cups water
¼ c. Dawn dish detergent
2-3 tsp. glycerine (available in Drug stores)
Stir all ingredients well. Divide up into containers for students to use.

Connections:
Physical geography, physics, engineering, zoology, language arts, mathematics.

network to work, the distance between them needs to be strategically placed. This lesson focuses on how eggs, larvae, and other forms of zooplankton may be exchanged between two adjacent MPA sites in order for students to model a network design. The majority of young fish, invertebrates, and kelp begin as plankton.

Plankton is a term used for microscopic life in both freshwater and salt water. It comes from the Greek word for "wandering". Although many of these organisms have some form of locomotion, they cannot move against the stronger oceanic currents – hence, they are seafaring "drifters". These buoyant materials can be carried vast distances by constantly moving ocean currents with little or effort.

Plankton can be separated into two main groups: plant-like drifters or **phytoplankton** and animal-like drifters or **zooplankton.** Phytoplankton is the backbone of almost all aquatic food webs and is explored further in the next lesson (Lesson 2: Food Web Diversity). Similar to land plants, phytoplankton obtains energy using sunlight though the process of photosynthesis. These microscopic organisms produce approximately 50% of the Earth's oxygen and similarly absorb nearly 50% of the carbon dioxide in our atmosphere.

Organisms that spend their whole lives as zooplankton are called **holoplankton** (permanent plankton) and include, shrimp, jellyfish, and foraminifera or forams (refer to image 2 below). Others spend only part of their lives as zooplankton or larva and are called **meroplankton** (temporary plankton) (refer to images 2 & 3 below). This is the form of zooplankton emphasized in this lesson. Most fish and marine invertebrates begin their lives as meroplankton (or larvae). Not all zooplankton are tiny. Some types of plankton such as jellyfish can get quite large and are referred to as *macroplankton*. As you discuss animal life cycles in the beginning of this lesson, it may be useful to show some images of meroplankton (refer images 2, 3, and 4 below).

As aforementioned, the movement of larvae depends on water currents, wind direction, and other sources of energy such as upwelling (refer image 5). Air and water behave similarly and the same laws of physics can be applied. The greater the force applied to a "drifter" the further it will move. In this exercise air will act like ocean currents.

Suggested procedure:
Some setup is required before beginning this activity. You will need to draw circles using chalk or use hula hoops to delineated the boundaries for several sets of Marine Protected Areas

Key MPA Ideas:
California MPAs can sustain and restore marine life populations.

California MPAs are designed and managed as a network.

Vocabulary:
Ocean current
organism
juvenile
larva
zooplankton
disperse
network

Suggested extensions:

- Have students make a birth announcement regarding a marine species that begins its life as a form of meroplankton (see links below).
- Find out the life cycle of a local commercially harvested fish.
- Have students design a model of plankton that hovers near the top of a water column and slowly sinks (see NASA link below).
- Watch a film on the ocean and feeding relationships such as the BBC series *The Blue Planet*.

(MPAs). Where you decide to set up this activity will influence the result of this modeling activity. In this activity, students will be using bubbles (or other lightweight materials) to model the movement of larvae (or bubbles) on ocean currents from one MPA site to another. Performing this activity outside might be the best arrangement because you will want to have some airflow (ocean currents) to move the bubbles (fish and invertebrate larvae) around. Using one or more fans inside a large room is another option. Where you place the circles (MPA boundaries) might take some practice before students begin. Keep in mind that the movement students make will also influence how the bubbles will travel. They might want to blow on them or wave their hands to manipulate where they land. Set up the rules as you see fit. In a functioning network there should be some exchange between two adjacent MPAs to model success of the MPA network design acting as a network.

Begin this lesson by introducing what a Marine Protected Area is using various materials found in the Toolkit. Marine Protected Areas are like underwater parks. There are several different kinds. Some are no-take zones and others allow for removal of certain specified resources, including fishing. All MPAs are monitored and enforced to some degree. Next, hold up the large poster found in the toolkit titled: *The California Network of Marine Protected Areas: Safeguarding an Underwater Wilderness*. Point out the word "network" found at the top. Explain that MPAs along the California Coast are designed to act as a huge network. This means that they can influence each other in some way. One way is for the transfer of larvae between two or more sites.

Ask the students to give one or more examples of an animal life cycle that includes a larval stage. Examples include: a termite grub, fly maggot, or caterpillar – the larval stage of a moth or butterfly. Ask them whether something like a crab has a larval stage. Explain that most of us may not be as familiar with the life cycles of marine species, but many include a larval stage. Image 4 shows the life stages of a barnacle and crab. Show them this picture, examples of sea life, other visual aids. Explain that marine larvae are zooplankton and they can't swim on their own. Instead, plankton are "drifters" and are moved by currents and other forces such as wind. Let them know that they will be modeling ocean currents using air. Air and water act the same and the same laws of physics apply.

If your group is relatively large, have some students practice transporting "larvae" into MPA sites by blowing bubbles while others watch. The ones that practice may work in pairs. Be sure to set up several areas to avoid interference. They will need to watch

• Connect plankton to math by researching the various size classifications plankton are broken into and then learn about and/or match the equivalent sizes.	where their "larvae" land. Hopefully, "larvae" will be exchanged from one MPA site to another. Depending on time you want to spend on this modeling activity, adjust the distances. Perhaps they can be the engineers! Begin by placing the MPA sites (circles) farther apart. After a few practice attempts move the sites closer together. The placement should be such that several bubbles reach their intended target. There are many ways to adjust this lesson. While practicing with the dispersal of bubbles (or fish larvae) it is optional for them to record how many "larvae" make it to their desired destination. If a "larvae" lands outside of an MPA it can still have value. Enhancing populations outside of MPA sites has benefits to our oceans too. You can have bubbles that pop before they hit represent non-human consumption. Many different animals eat zooplankton. How far you want to go with this exercise is up to you. Have the students share their experiences at the end and explain what it was they were trying to model and what sorts of variables interfered with their success. When they are finished, ask them how their model can be related to real life. For instance, strong winds can affect where and how far larvae are moved (or dispersed). By dispersing larvae between two adjacent sites, populations of fish and other organisms can be enhanced. Conclude by asking the students what they were trying to model in this lesson. Having the students draw this network model is good engineering practice. They can begin by drawing two circles with all larvae located in the first circle followed by two circles with many of the larvae gone from the first circle, several inside the adjacent circle, and others positioned outside the circle. Remember to conclude the lesson by explaining California MPAs are designed to act as a huge network. Show them Image 1 below to reinforce this idea.

MPA Goal Connections:
#2 To help sustain, conserve, and protect marine life populations, including those with economic value, and rebuild those that are depleted.
#6 To ensure that the MPAs are designed and managed, to the extent possible, as a component of a statewide network

Online resources:
National Geographic Video: Plankton Revealed (approx. 7 mins). Good overview of phytoplankton and zooplankton and their critical role in the marine food web.
https://www.nationalgeographic.org/media/plankton-revealed/
Encyclopedia Britannica and Scripps Institute video, *Beginning of the Food Chain*. An old but good video on plankton and their importance in a food web.
https://www.britannica.com/science/food-chain/images-videos/media/212636/128172
Project Oceanography, Unit Six/SSWIMS/Plankton Unit
www.marine.usf.edu/pjocean/packets/f01/f01u6.pdf
Invisible Watery World: Student reading option:

https://askabiologist.asu.edu/explore/plankton
Bigelow Laboratories and NASA Sink or Swim Phytoplankton activities:
https://archive.bigelow.org/foodweb/microbe2.html
Fish and Wildlife, Crab Life History from from 1 mm zoea to adult
https://www.dfw.state.or.us/mrp/shellfish/crab/lifehistory.asp
Meroplankton Match-up activity from OMBI University of Oregon
https://oimb.uoregon.edu/Documents/GK12/GK12-First-Plankton.pdf

Engage: Begin by asking students to give an example of larvae to find out what they already know about animal life cycles. Examples could include a larva from an insect or a worm.
Explore: Show examples of marine organisms that have a larval stage (refer to Teacher References).
Explain: Explain that California MPAs are designed to act as a huge network. The spacing between them needs to be close enough together that larvae can be transported from one to another.
Elaborate: Discuss the fact that certain fish and invertebrate larva (or meroplankton) can potentially help enhance or repopulate areas within a specific MPA or in nearby areas. The placement of MPAs along the California Coast were partially selected for the distance certain larvae can be dispersed.
Evaluate: Ask students what they were trying to model in this activity. A correct response would be that they were trying to model a network. In this case larvae was able to move from one site to another. The exchange of larvae could help enhance existing populations of fish and other marine organisms.

Teacher References:

Image 1: MPAs act as a network

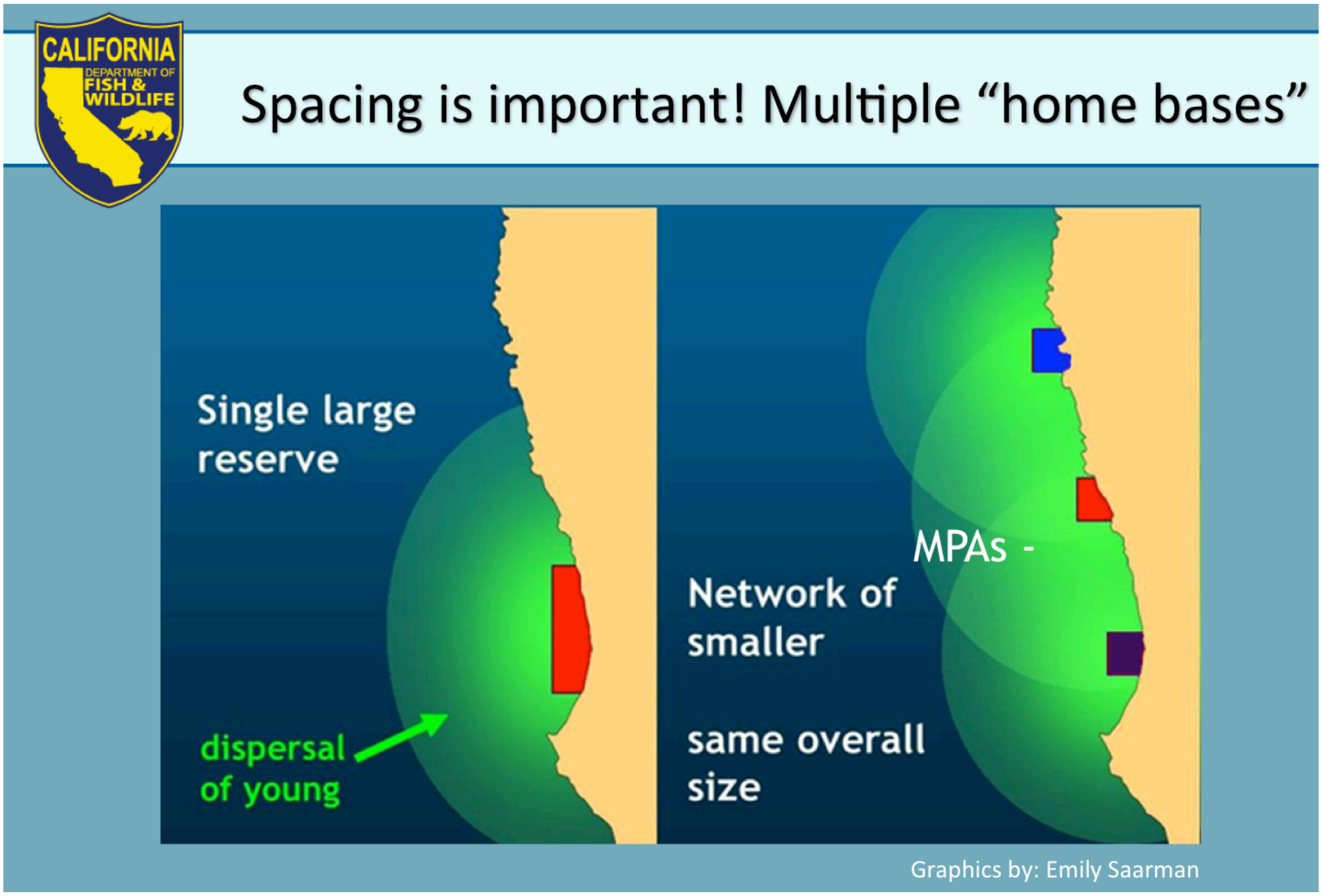
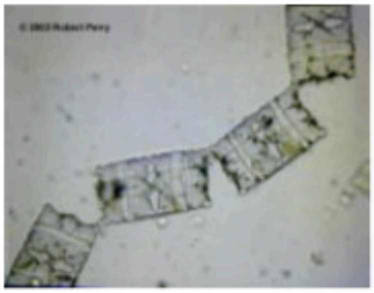
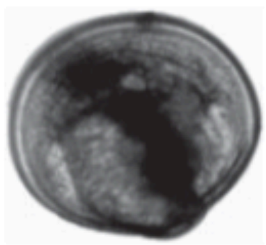


Image 2: Examples of Plankton (source: Ocean Globe)

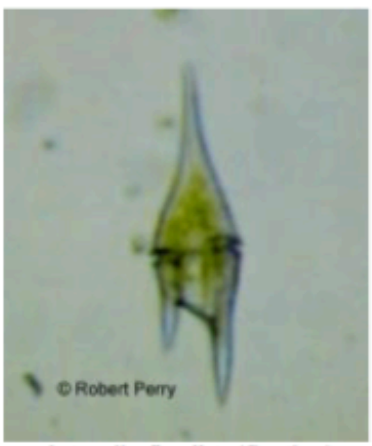
Activity #1 - Teacher Guide Sheet



phyto - diatom chain (Biddulphia)



zoo - bivalve veliger larva (clam)



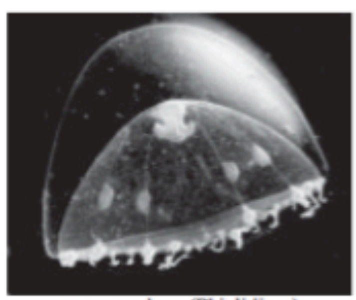
phyto - dinoflagellate (Ceratium)

phyto - diatom (Coscinodiscus)

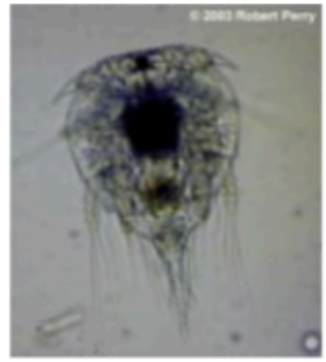
phyto - dinoflagellate (Ceratium)

zoo - copepod (Calanus)

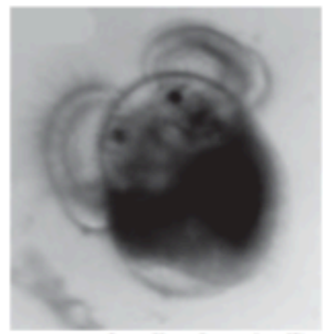
zoo - echinopluteus larva (sand dollar)



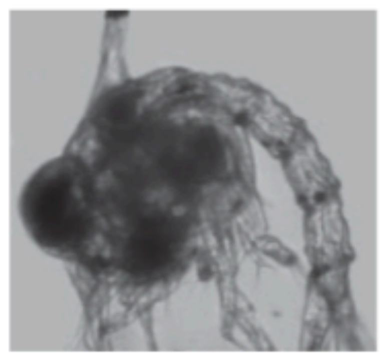
zoo - medusa (Phialidium)



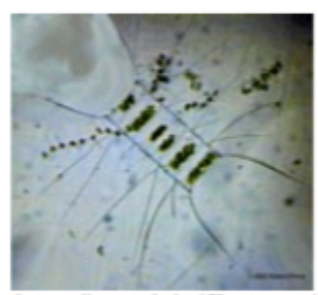
zoo - nauplius larva (barnacle)



zoo - early veliger larva (snail)



zoo - zoea larva (crab)



phyto - diatom chain (Chaetoceros)

Plankton page 13

Image 3: Examples of Meroplankton

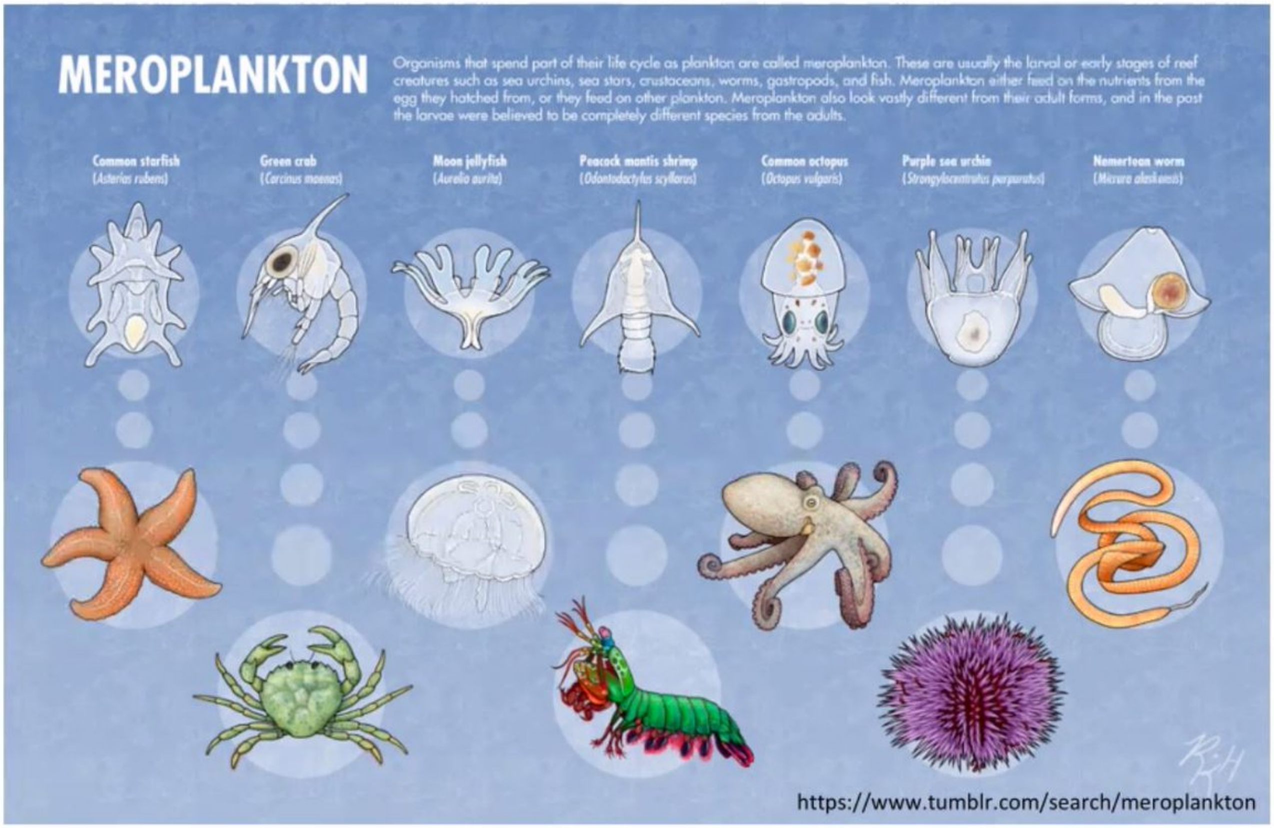


Image 4: Life cycle stages for a barnacle and crab

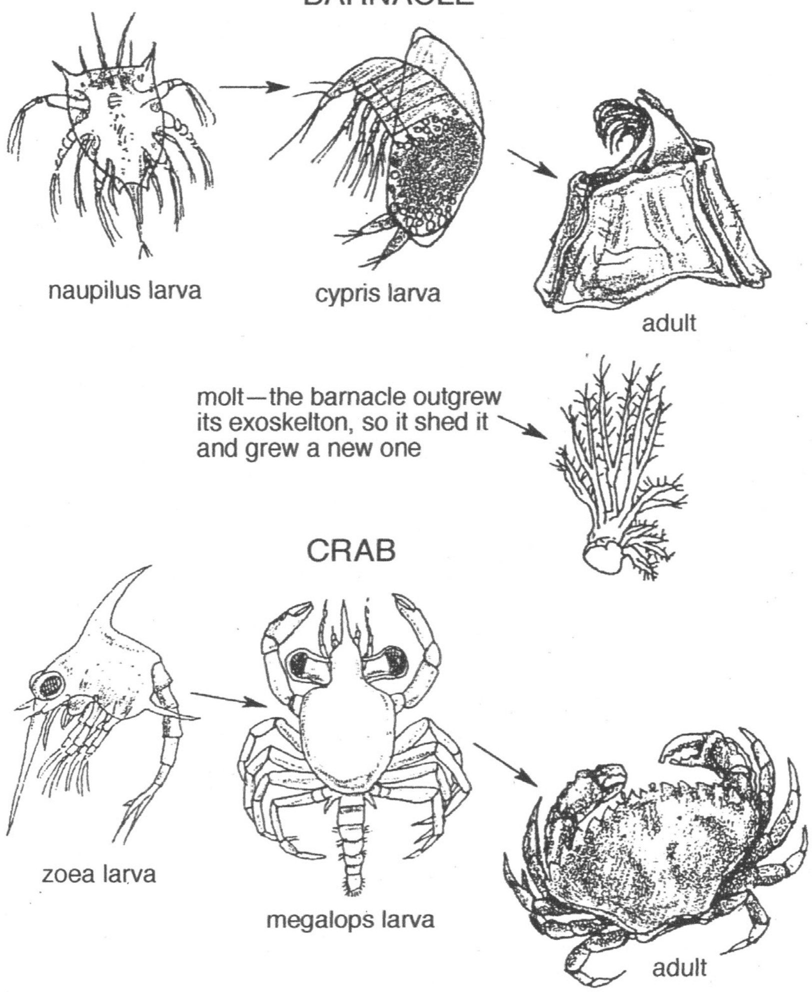
PROJECT Oceanography

Unit Six
SSWIMS/Plankton

Zooplankton Identification Sheet

Animal Plankton

BARNACLE



From
Getting to Know Plankton
ã 2000 James A. Kolb
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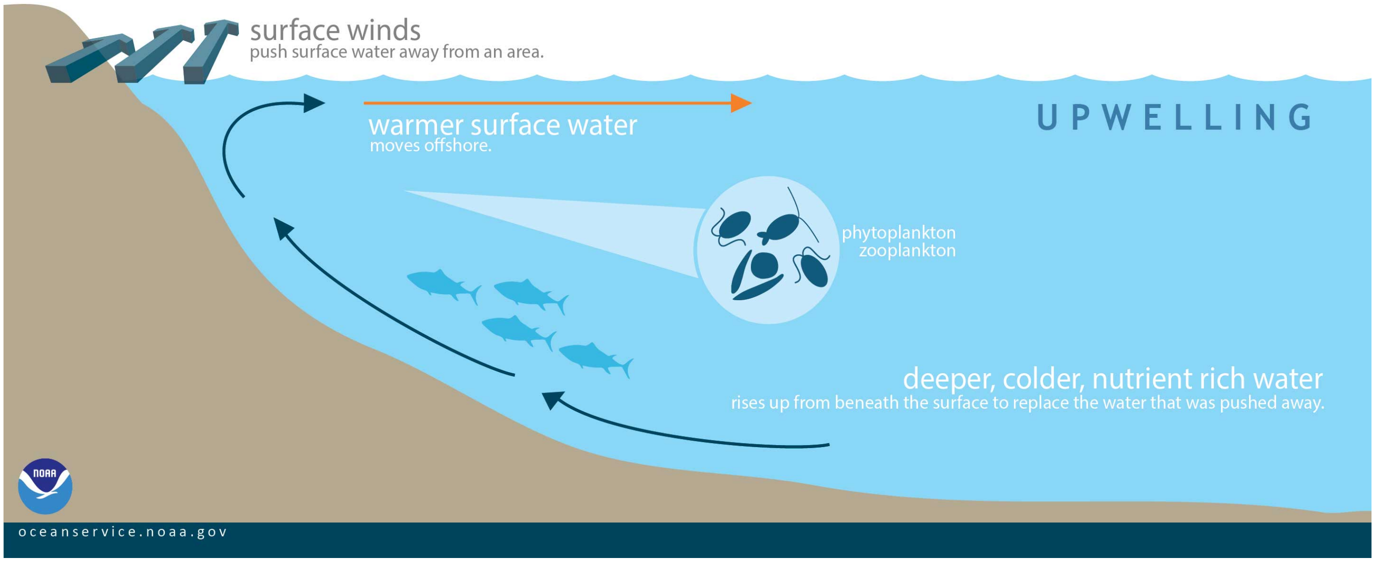
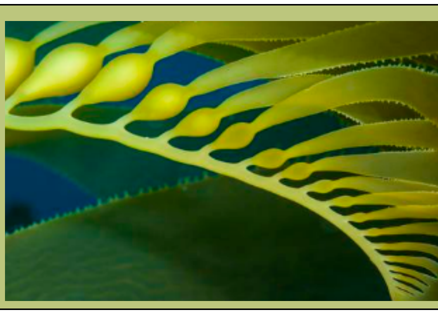
Image 5: Upwelling and movement of coastal waters





MPA Toolkit

For Humboldt and Mendocino Counties

UNIT 2

Grades 3-5

Lesson 2: Food Web Diversity

NGSS -- DCI (Disciplinary Core Ideas):
3LS2.C Ecosystem Dynamics, Functioning, and Resilience
3LS4.D Biodiversity and Humans
4LS1.A Structure and Function
4ESS2.E Biogeology
5PS3.D Energy in Chemical Processes and Everyday Life
5LS2.A Interdependent Relationships in Ecosystems
5ESS3.C Human Impacts on Earth Systems

Time:
30 – 60 mins.

Toolkit Materials for the Teacher

- ✓ Pictures of food webs
- ✓ Dried animal specimens and/or rockfish puppet (optional)
- ✓ Yarn for a food web
- ✓ Ball of yard to be passed to form a food web.
- ✓ Book: Ultimate Ocean-pedia for pictures (optional)
- ✓ Book "This is the Sea that Feeds Us" by Robert F Baldwin (optional).

Learning Objectives: Students will be able to model the relationship of energy transfer in a marine ecosystem by modeling a food web and will understand how MPAs can help maintain or enhance marine biodiversity.

Phenomenon: An ecosystem becomes unstable when top predators are removed.

Background information:
Except for a few exceptions, all food webs begin with the energy from the sun. The sun's energy is captured by a plant's leaves, which have specialized pigments that can convert sunlight into sugars. All organisms that can make their own energy using sunlight (i.e., the process of photosynthesis) are called **producers**. Examples of producers include trees, shrubs, grass, kelp, and phytoplankton. In an ocean or marine environment, "plants" or producers are usually algae including tiny microscopic ones called phytoplankton. Both phytoplankton and other forms of algae belong to a mixed group of organisms called protists and are the foundation to marine food webs.

Animals must eat to survive and are called **consumers**. By eating plants, energy is transferred from the plant to the animal or animal-like organism (i.e., zooplankton). Therefore, a consumer is an organism that eats for a living. All animals are consumers, including humans. **Primary consumers** feed directly on plants or in this case on algae. Animals that don't consume algae directly eat other animals and are referred to as **secondary** or **tertiary consumers**. Eventually energy or food travels through a food web up to an apex predator, such as a large fish, whale, or shark. There will almost always be more producers than consumers in an ecosystem (refer to images below).

The most stable ecosystems have greater complexity. The number of different organisms that live in a particular ecosystem is referred to as **biodiversity**. The greater number of species in an ecosystem, the higher the biodiversity there is (Refer to Image 6). Biodiversity is an important concept. Every organism has a

Toolkit Materials for the Students

- ✓ A species card with a yarn necklace.

Connections:
Biology, ecology, zoology, mathematics, language arts.

Key MPA Ideas:
MPAs can protect natural diversity and ecosystem function.

California MPAs can sustain and restore marine life populations.

Vocabulary:
biodiversity
consumer
keystone species
marine
organism
phytoplankton
producer

Suggested extensions:

- Connect this lesson to ocean bottoms by including decomposers or detritus in a food chain.

particular niche or role that they play within a system. Some species play a more important role than others and are considered **keystone species**. Keystone species are critical in maintaining the balance within an ecosystem. For instance, kelp forests need predators such as sea stars that can keep sea urchin populations in check. If sea urchin populations become too high they end up eating so much kelp that the system can collapse. Sea star wasting disease recently killed off almost all sea stars in California affecting kelp beds. Kelp forests are suffering because of the removal of important predators which kept sea urchins in check, such as the spiny lobster or sea otter. An overpopulation of sea urchins causes them to go hungry and they end up eating everything in their path creating what are called *urchin barrens* (refer to Image 7 below). Kelp is another keystone species because a wide variety of organisms depend on it for food, shelter, and a place to raise their young.

California Marine Protected Areas (MPAs) use an ecological approach to preserve biodiversity. Instead of trying to preserve only a few targeted species (for instance certain species humans like to eat, such as abalone or rockfish), they aim to protect whole ecosystems in a wide variety of habitats. Not only will the abalone or rockfish benefit from take limitations, but a whole slew of other organisms benefit as well. Maintaining biodiversity can lead to greater resiliency within an ecosystem. **Resiliency** is the ability to rebound after a particular stressor emerges, such as unusually warm water, overfishing, disease, or intense storms. For instance, say a particular species becomes extinct or highly reduced because of disease. If an ecosystem is diverse enough, there will usually be another species that can fill the missing role the missing species had within that particular system. Often the particular niche a species has is connected to the position it has in a food web. Therefore, you can think of biodiversity as a kind of safety net!

Suggested procedure:
This lesson has students model a food web to demonstrate feeding relationships and the interconnectedness of living things. It is designed for a group of 21 or fewer students. Adjust the lesson according to the number of students in the group. Remove some cards if you have a small group. If you have a large group, you can form two groups or modify the lesson by adding more cards.

If necessary, begin by showing them one or more examples of a land based or terrestrial food web (see image 3). For younger students, you may want to introduce the idea of "energy transfer" using a food chain, which is a simpler model compared to a food

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- Watch the Bill Nye episode on Biodiversity.
- Watch a film on the ocean and feeding relationships such as the BBC series *The Blue Planet*.
- Use the *Wild Ocean Activity Book* for a relevant activity (see pg. 22 & 23). Options include coloring and identifying marine organisms.

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web. (Refer to images 1 and 2 below for examples of both). A **food web** is many different **food chains** grouped together.

It is important that the students understand that this lesson introduces how Marine Protected Areas (MPAs) can help enhance or maintain biodiversity within a marine ecosystem. Write the word **biodiversity** on the board (or say it) and take a minute to explain its meaning (see definition above). Explain that biodiversity relates to the fact that the environment can support many different organisms living together in a huge web of life. In order for this to happen, the environment needs to have plenty of food or energy. MPAs maintain biodiversity by restricting what organisms can be harvested or collected. They are like parks that are located in the ocean. Just like parks, they have boundaries (although somewhat invisible) map stretching all the way down to the ocean floor that are enforced by rules and officials.

Before handing out species necklaces, take a little time to explain what a marine food web is. Several images can be found below to assist with this. A **food web** models the interconnected feeding relationships within an ecosystem. Ask: what does the word *marine* mean? Answer: **Marine** refers to things related to the ocean. For example whales, sea stars, urchins, clams, and kelp are all examples of marine life because they live in the ocean. Hold up a plastic toy of a fish or a picture of a marine predator, such as a sea star and ask: "Does anyone know what a sea star eats (or whatever organism you have choosen)?" (Answer: sea stars eat other invertebrates such as crabs, urchins, snails, and chitons). An option at this point is to show them preserved examples of these specimens (or show more pictures). Go down to the next trophic level and ask: "What might a snail or crab eat (use the examples they give)?" Possible answers include seaweed, kelp, and algae. Next ask: "What does kelp or seaweed *eat*?" (Answer: seaweed or kelp get their energy from the sun). Next, ask: "Are sea stars at the top of a food chain"? (Answer: No). Ask: "What might eat a sea star?" Correct answers include octopus, fish, sea otter, etc. Ask them why the transfer of food or energy from organism to organism is called a "web". Answers will vary. An ecosystem is complex and interconnected, hence a "web" is a good design.

For this activity, use the set of food web cards provided in the toolkit. If necessary, quickly review each card so the students know what they are. Each card has yarn hanging from it so it can be hung as a necklace around each student's neck. Once you are ready, pass out one species card to each student. Everyone should now stand in a circle passing the ball of yarn around to form a web as follows.

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	Ask the students to think about which card represents the resource that all life depends on (answer: the sun). Hand the one end of the big ball of yarn to the student with the "sun" card. This student should wrap some of this yarn around his/her hand. Now ask, “What would be next in the chain?” or, “What organism uses the sun’s energy to grow?” The students should decide that the answer is a producer or in this case algae or kelp. The person holding the sun card, while still holding onto one end of the yarn, should then toss the ball to the student with a kelp nametag. You may then ask a question such as, “Who eats kelp?” in order to have the students think of where the yarn will go next. Continue through the list in the same manner until all of the labeled cards have been used and each student is holding a piece of string. The sun will have multiple strings held or this is where other students can step in. With a large group it might be easier to have multiple “suns”. (A species list identifying who eats what is given below). Next, ask the group to step back until the string is taught. This is important so that they can feel a tug on the yarn. The student with the original end of string (sun nametag) should now gently begin tugging. If someone feels a tug during this time, he/she should tug in response. This should progress until everyone is tugging, which will also cause the web to shake. You may now note that all things in the ecosystem are connected! Now remind them that Marine Protected Areas are places that have restrictions on what can be taken so the number of organisms can be higher in MPAs compared to areas that are unprotected. Explain that now you are going to introduce a “stressor”. It can be human-made (i.e. excess run off, oil spill, etc.) or natural (i.e. hurricane, disease, severe climate change, etc.). Ask the students how the stressor impacts the entire ecosystem, when one of the links is damaged by stress. Have one or more links drop out of the circle due to the introduction of the stressor. Make sure you take out a top level predator such as a ling cod or wolf eel. By removing a top level or a apex predator, the group is modeling a trophic cascade. (A trophic cascade is a biological phenomenon triggered when a top predator is removed changing the relationships of predator and prey). If time allows, reduce the number of organism in a new food web and repeat the last exercise. They should see that the web unravels much quicker with less biodiversity. To review, ask the students some questions: Q: What does a food chain or food web try to show? (Answer: a group of plants and animals arranged by what they eat). Q: How does a paper model of a food chain or food web show the direction energy travels? Answer: arrows are used to show the

	direction energy flows. Q: What happened when we removed a link (an organism)? Possible Answer: Organisms that depend on it are affected. Q: How can a Marine Protected Area make a stronger "web?" Answer: MPAs can protect some or all of the organisms in an area. In general, the more complex or biologically diverse a place is the more stable it is. By protecting places, people can maintain healthy ecosystems and thereby help ecosystems recover if they have been impacted. In the toolkit you will find a book titled, "This is the Sea that Feeds Us" by Robert F Baldwin. It fits nicely into this lesson and can be a great way to summarize how we depend on a marine food chain to feed us. *(Note: Lesson has been modified using Web of Life Activity from Fish Smart).*

MPA Goal Connections:
#1 To protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.
#2 To help sustain, conserve, and protect marine life populations, including those with economic value, and rebuild those that are depleted.

Online resources:
Encyclopedia Britannica and Scripps Institute video, *Beginning of the Food Chain*. An old but good video on plankton and their importance in a food web.
https://www.britannica.com/science/food-chain/images-videos/media/212636/128172
BBC Video *Army of Sea Urchins*. Shows animals of rocky reefs, especially those found in the kelp forest. Can be used as an introduction into some of the organisms they will learn about in this lesson.
https://www.youtube.com/watch?v=D3W4OCnHyCs
Watch a short video on sea otters – as keystone species.
https://www.seaottersavvy.org/ecosystem-superheroes
Complete a paper food web using "It's A Plankton Eating Plankton World" activity.
https://askabiologist.asu.edu/sites/default/files/resources/activities/plankton/plankton_eat_plankton_packet5.pdf.

Engage: Begin by holding up a preserved sea star specimen and asking students what it might eat and what might eat it.
Explore: Have students model a marine food web using species cards and yarn. Once situated, students will tug on each other if they are connected in some way to observe interrelationships with a marine ecosystem.
Explain: Explain that MPAs can help make marine ecosystems stronger or more resilient by maintaining or enhancing biodiversity. Generally, the more complex a system is, the more stable it is.
Elaborate: Expand their knowledge by altering the food web and adding one more stressors. Have one of the stressors remove a keystone species or apex predator and explain what a trophic cascade is. They should observe how the changes affect the web they have created.
Evaluate: Ask the students several questions at the end of the lesson including, "what happens if a species or a link in a food web disappears?" and "How can an MPA help enhance or maintain biodiversity?"

Unit 2, Lesson 2: Teacher Reference:

Card Necklaces:

Sun card (3 total)

Producers:
Bull Kelp – sun
Sea lettuce – sun
Feather Boa – sun
Phytoplankton – sun

Primary Consumers:
copepod – eats phytoplankton
Sea urchin – eats sea lettuce/kelp, acorn barnacle
Turban snail – eats kelp/green algae
Kelp crab – eats kelp
Rock crab – eats copepod, acorn barnacle, hornmouth snail, kelp crab
Gumboot chiton – eats kelp
Abalone – eats kelp/phytoplankton
Acorn barnacle – eats kelp/phytoplankton
Rock greenling – eats copepod
Hornmouth snail – eats copepod

Secondary and Tertiary Consumers
Wolf eel – rock crab, kelp crab, snail, sea urchin, acorn barnacle
Sunflower star – eats snail, chiton, sea urchin, crab, hornmouth snail, acorn barnacle
Cabezon – eats crabs, snails
Red octopus – eats crab, cabezon, lingcod, rockfish, crab, snail, barnacle, greenling
Ling cod – eats rockfish, cabezon, kelp crab, rock crab, red octopus,
Rockfish – eats plankton, fish, rock crab,
fisherman – eats ling cod, abalone, red octopus, rockfish, sea lettuce, sea urchin, rock crab, cabezon

Apex predators include: fisherman, wolf eel, sunflower star, lingcod

Note: Cards are laminated and in the Toolkit

Sun	Sun
Sun	Bull Kelp
Feather Boa	Sea Lettuce
Phytoplankton	Bull Kelp
Turban Snail	Sea Urchin
Kelp Crab	Gumboot chiton
Rock Crab	Abalone
Hornmouth Snail	Copepod
Sunflower star	Cabezon

Red octopus	Lingcod
Rockfish	Fisherman
Wolf eel	

Image 1: Comparison food chain and food web

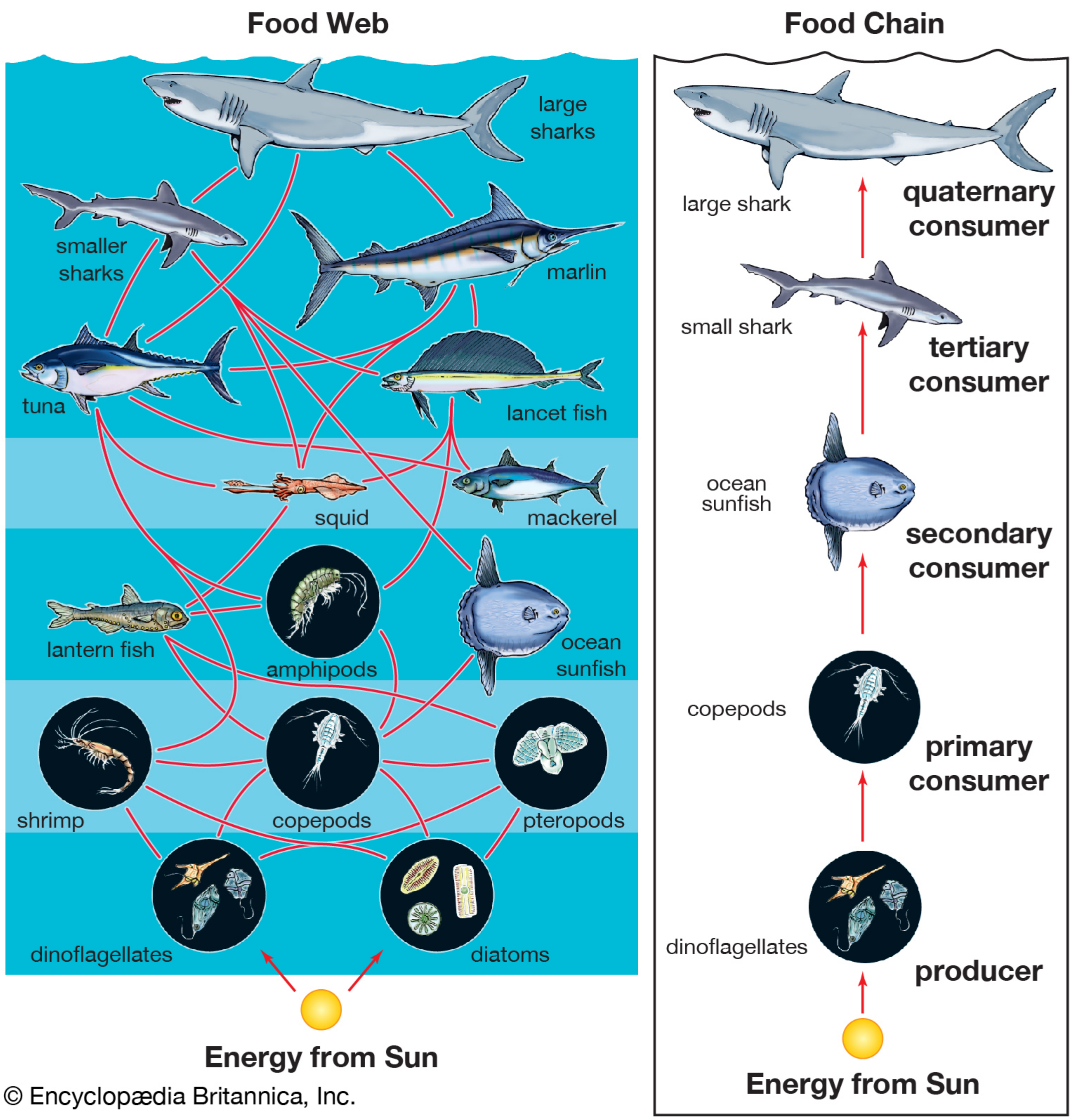


Image 2:
Example of a marine food chain beginning with phytoplankton.

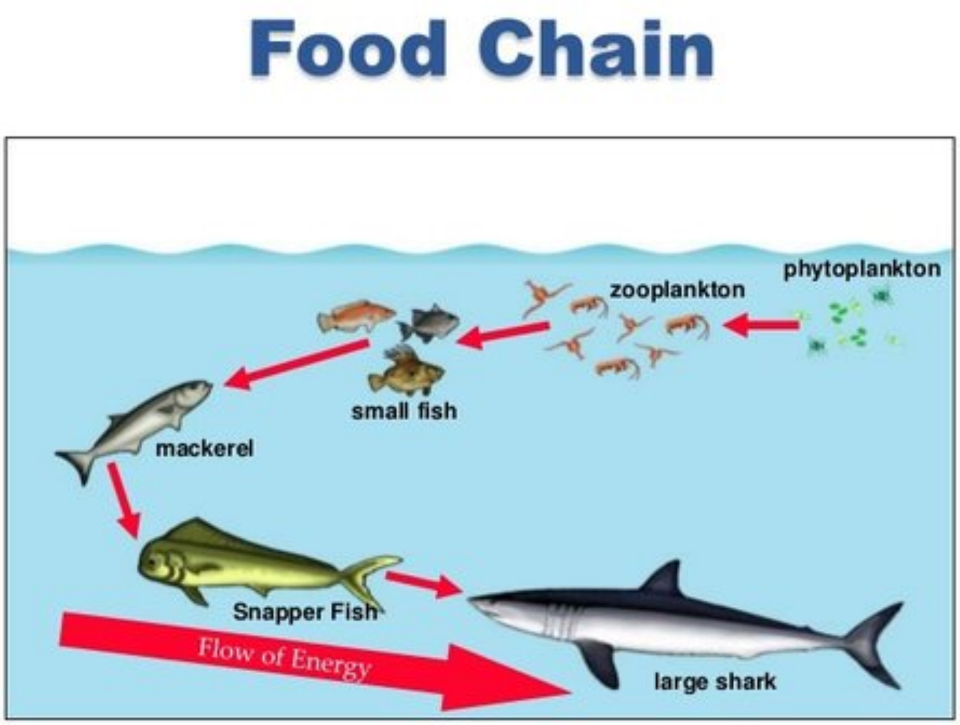
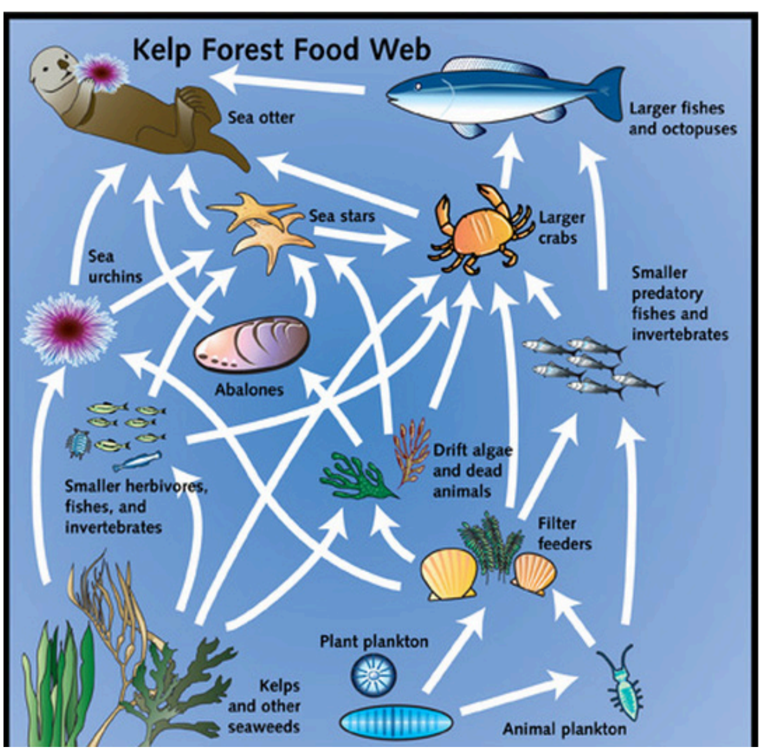


Image 3: Example of a marine food web. The sea otter is a keystone species and an apex predator.



Source: from Weebly
Image 4: General marine food web (note: arrows are backwards; the flow of energy goes upwards)

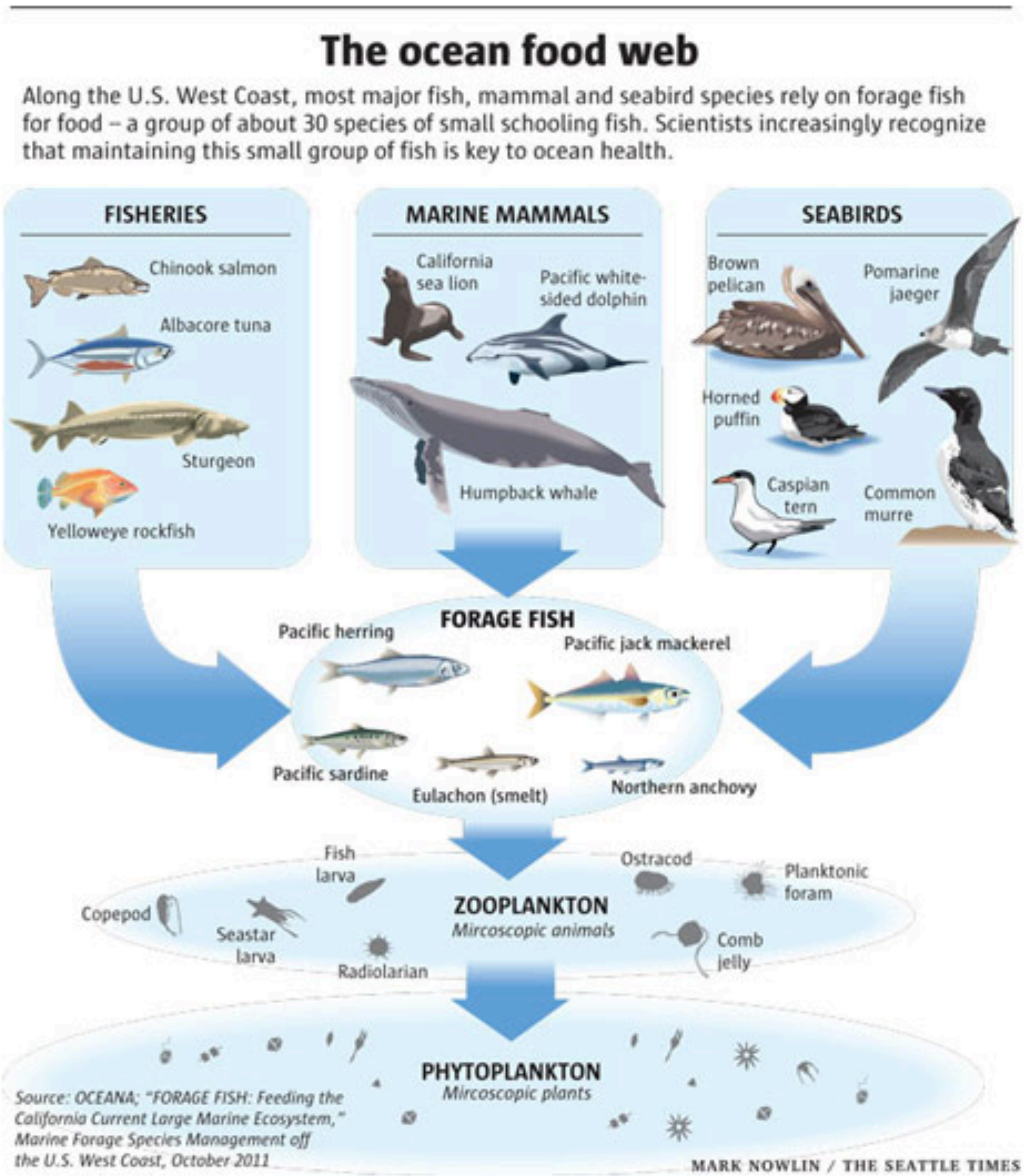


Image 5: Example of a simplified land-based (terrestrial) food web.

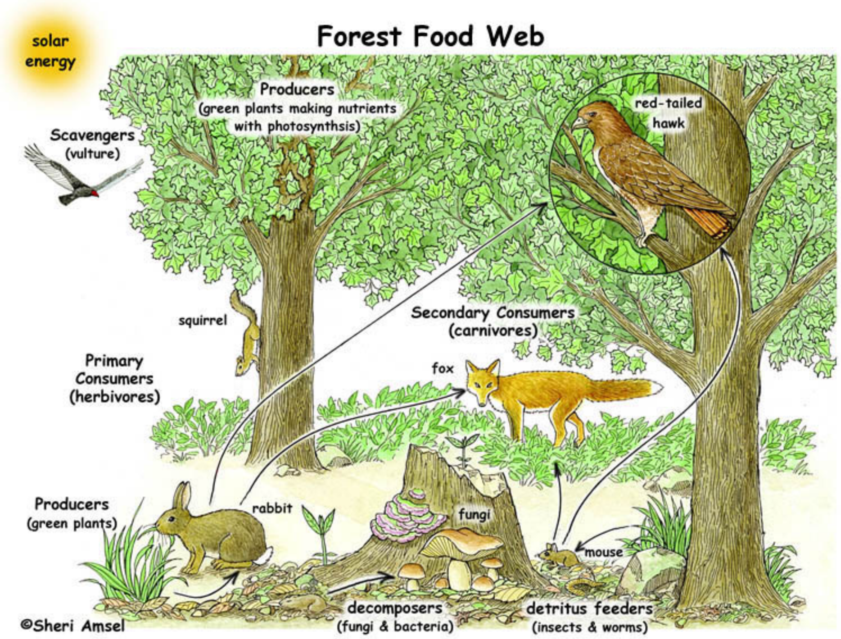
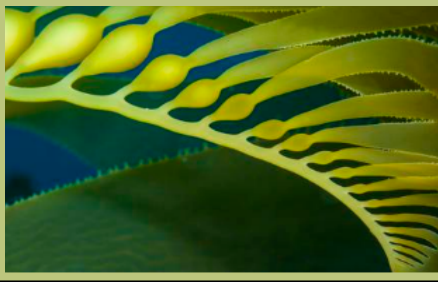


Image 6: MPAs have higher biodiversity

Diagram of potential benefits to marine life and habitat inside and outside a marine protected area.

Image 7: Urchin barrens (Sea Grant and CDFW websites)



MPA Toolkit

For Humboldt and Mendocino Counties

UNIT 2

Grades 3-5

Lesson 3: Who Am I?

NGSS -- DCI (Disciplinary Core Ideas):
3LS1. From Molecules to Organisms: Structures and Processes
3LS1.B Growth and Development of Organisms
3LS 3.A Inheritance of Traits
3LS3.B Variation of Traits
3LS4.C Adaptation
4LS1.A Structure and Function
5LS2.A Interdependent Relationships in Ecosystems
5ESS3.C Human Impacts on Earth Systems

Time: 30 – 90 mins.

Toolkit Materials for the Teacher

- ✓ MPA posters and pamphlets showing various species protected in MPAs (optional).
- ✓ Pre-made "Who Am I" cards (30 total)
- ✓ Picture of highlighted species (optional)
- ✓ Power Point of *Who Am I* (on pen drive – optional)
- ✓ Clue Cards (optional)
- ✓ CMPA Coloring Book (optional)
- ✓ Online resources (see links below)

Learning Objectives: Students will be able to identify some marine organisms that are likely to benefit from California Marine Protected Areas (MPAs). B) They will attempt to identify these species by asking yes and no questions using critical thinking skills to find the answer.

Phenomenon: California MPAs help protect the diversity and abundance of marine life along the North Coast.

Background information:
The California coast and ocean are among our most treasured resources. The productivity, wilderness, and beauty found here is central to California's identity, heritage, and economy. The need to safeguard the long-term health of our marine environment was recognized by the California Legislature in 1999 with the passage of the Marine Life Protection Act (MLPA). The act aims to protect California's marine natural heritage through establishing a statewide network of marine protected areas (MPAs) designed, created, and managed using sound science and stakeholder input.

The Northern California MPA region encompasses Humboldt, Del Norte, and Mendocino Counties. This region encompasses approximately 1,000 square miles, representing about 13% of the total of state waters. It includes 26 marine managed areas (including 19 MPAs, one state marine recreation management area, and six special enclosures). For information about specific MPAs found along the North Coast, refer to the variety of pamphlets, maps, and posters found in the Toolkit as well as the online resources below.

In this lesson, students will about many of our local marine species. The selection of species (30 total) includes organisms from different trophic levels (refer to Lesson 2) and was designed to include a variety of kelp (producers), invertebrates, and vertebrates to give a good overview of many marine organisms likely to benefit from Northern California MPAs. Depending on how much time you want to spend on this lesson, you may want to point out some simple differences between vertebrates and invertebrates with the students before beginning the activity.

Toolkit Materials for the Students

- ✓ Pre-made identification cards on a string to wear as a necklace.
- ✓ Yes or No question cards (optional)

Connections:
Zoology, biology, physical geography, language arts, art

Key MPA Ideas:

MPA can sustain and restore marine life populations.

MPAs can protect representative and unique habitats.

Vocabulary
biological
characteristic
vertebrate
invertebrate
organism
habitat

Suggested extensions:

- Visit a rocky intertidal zone or an aquarium to look at marine organisms up close.
- Visit REEF Check's website to see what organisms are being monitored across the temperate reefs of California (see link below).

Vertebrates all have a backbone and would include fish such as the cabezon and wolf eel, as well as birds such as brant and snowy plovers. **Invertebrates** lack a backbone and include the red octopus, California sea cucumber, giant green sea anemone, and rock scallop. You will find that the invertebrates belong to different groups based on characteristics. For instance, mollusks have a "foot" and usually have a hard shell. One exception is the octopus, a mollusk that has lost its shell. A few important commercial fish species are named such as lingcod and rockfish. Including some of these fish can help foster a discussion about our need to harvest certain species for food. They should understand that fishing is allowed in some types of MPAs as long as it is done according to regulations. Regulations are put in place to sustain and/or restore populations. Some of the animals and kelp used in this exercise are shown on the MPA poster: *Safeguarding an Underwater Wilderness*, but not all of them. It is a good starting point for introducing a variety of organisms that can be protected in MPAs. At the end of the lesson, you may want the students to color the smaller image of this poster. It is also available in the coloring book found in the Toolkit or online.

Depending on the degree of prior knowledge students may have, you may want to begin this lesson by watching a video, flipping through identification guides, or showing pictures of the highlighted species using a Power Point show or other means (refer to online resources below and those on the pen drive). Another option is to take some time for the students to research one or more of the highlighted species on their own or with a group. Researching a particular species can also be a great follow-up activity. The list of species used in this lesson can be found below in the Teacher References.

Suggested procedure:
Begin by explaining that in this lesson they will be playing a game where they solve a mystery called "Who Am I?". Using partners, they need to identify different species that live in or near the ocean, all of which are likely to benefit from a Marine Protected Areas (MPAs). Explain that the highlighted species belong to one of five different groups. 1) seaweed or kelp (i.e, producers), 2) invertebrates (animals that lack a backbone), 3) fish or vertebrates, and 4) birds (vertebrates) and 5) marine mammals (vertebrates). Some of the species don't actually live in the ocean such as birds, but they are still likely to benefit from Marine Protected Areas (MPAs) due to the safeguarding of their food sources. Other species are absent, such as dolphins and sharks, because these species are have huge ranges extending well beyond the boundaries of most MPAs.

• Connect the life cycle of an abalone using the abalone puppets in the Teaching Toolkit. • Have the students come up with a list of human activities that may impact marine habitats. Compare these to the types of recreational activities humans can do within an MPA. • Using the Monterey Seafood Guide, have the students research one of the seafoods people like to eat.	If you feel students need to review the species beforehand, there are several options available. One is to display all 30 species on the screen to give a visual aid. Another is to use the *Key Habitats in California* pamphlet and go over those species shown there. A potential problem with this is not all species highlighted in this activity are in the pamphlet. If you want to use this option, pass the pamphlet out to each student or in pairs before they begin the guessing game using clues first. Give them a few minutes to look it over. After they have a chance to look at the organisms on the pamphlet, read one of the "clue cards". Using the clues given, see if students can guess which organism you are describing. Have them raise their hand if they think they know the answer. Before you respond "yes" or "no", pick another student and ask if he or she agrees with the previous response. Do this a few times and then say the correct answer. This will likely engage them a bit more as they have to pay attention to what others are saying. Once the species has been identified, have them all find it on the pamphlet or poster. Repeat this a few times until you feel they can complete the exercise with success. Gather up the pamphlets and continue to the next step. Clue cards can be used without using the pamphlets. Next, write down or show the entire list of highlighted species (or make you own list). There is also a slide of all 30 species (refer to image x below). By having a list or a slide showing pictures of each highlighted species in this activity will allow students to have an easier time figuring out "who they are". Feel free to leave out this option if you want to challenge them. Have the students line up and call out alternating numbers 1, 2, 1, 2, etc. as you go down the row. All 1s will go first (they begin as "guessers") and will work with a partner who is a #2 (2s are called "helpers"). Helpers will put the organism around the neck of #1s with the description side facing out on their back. Those who are "guessers" should not know what they are ahead of time. Before beginning the main activity review the steps: 1) All students work with a partner. One (the guesser) needs to ask only yes or no questions to find out "who they are". Cards are available to assist with this task. The partner or "helper" tells their partner if they are right or wrong by answering YES or NO. 2) When they are the "guesser", the card should be worn on their backs with description side out. Once he or she has correctly guessed who there are they should wear the card around their necks on their chest (not their back) to identify who they are. Once they have figured out "who they are" they can reverse roles.

3) Switch tasks. Now the person who was the "guesser" becomes the "helper" and needs to ask YES or NO questions to guess who they are.

If a student becomes frustrated because they cannot guess *who* they are easily, give them praise for being a good sport and for making a valiant attempt. Remind them of some of the aids available (pictures, list, etc.). Once everyone is done guessing, they should be wearing their species card on their chest with the picture facing out. Give them a few minutes to move around and find out who others are. There are several more options from this point including: physically arranging themselves by group (i.e., producers, invertebrate, fish, etc.), making a food web (see lesson 2), or reading the characteristics about themselves on the reverse side of their card. This is also a good opportunity to talk about species that are readily consumed by people. Examples include spot prawns, red abalone, California mussel, cabezon, lingcod, and Dungeness crab. There is a good poster showing commercially harvested seafood in the Toolkit. Remind the class that all of them are likely to benefit from Marine Protected Areas.

Lastly, wrap up this lesson by asking questions to find out what they have learned.
Q1: What species were likely to benefit from MPAs? (Answer: All of them)
Q2: What characteristics made certain animals and/or kelp easy to guess and others more difficult? (Answers will vary)
Q3: Why are these species likely to benefit from MPAs? (Answers will vary. Correct answers include: populations are monitored, regulations are put in place, and MPAs protect entire ecosystems)
Q4: Why is it important to protect an entire habitat as opposed to just one species? (Answer: By protecting habitats a variety of interconnected organisms are protected making the web of life more stable)
Q5: Why might humans want to harvest some of the species highlighted in the game? (Answer: to eat or to use in regalia such as jewelry)
Q6: Why aren't tuna, dolphins, sharks and other large marine animals likely to benefit from MPAs? (MPAs are fairly small and are located close to shore. Large animals such as tuna, dolphins, and sharks have high migratory (or mobile) ranges and spend a lot of time in areas outside MPAs).
Q7: What might be the value in prohibiting certain consumptive behaviors? (Answer: to protect, enhance, or restore marine species by using an ecological approach which safeguards biodiversity).
A coloring sheet of the MPA poster can be found below.

	EXTENSION: An optional extension after the completion of the activity above is to take time to have students research certain marine organisms using *biological characteristics* to describe them. Biological characteristics include things like multiple legs, stinging cells, tube feet, or having a hard shell. For additional information, you may want to show them a short film depicting marine animal behaviors and characteristics. A recommended BBC film is found in the links below. Ask them if any of the animals featured in the film had similar biological characteristics. For instance, the giant sea star, brittle stars, and leather stars are all echinoderms and have spiny skin and tiny tube feet. Sand dollars, sea urchins, and sea cucumbers are also echinoderms because they have radial symmetry and are spiny.

MPA Goal Connections:
#2 To help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.
#4 To protect marine natural heritage, including protection of representative and unique marine habitats in California waters for their intrinsic value.

Online resources:
BBC Video *Army of Sea Urchins*. Shows animals of rocky reefs, especially those found in the kelp forest. Can be used as an introduction into some of the organisms they will learn about in this lesson.
https://www.youtube.com/watch?v=D3W4OCnHyCs
REEF check website for Humboldt and Mendocino Counties
http://www.reefcheck.org/reef-news/humboldt-state-university-students-become-reef-check-divers
Monterey Bay Critter Cards includes those for rocky reefs
http://www.montereybayaquarium.org/-/m/pdf/education/activities/aquarium-ss-crittercards.pdf?la=en
Field Guide to Oregon's Rocky Intertidal
http://lubmengelab.oregonstate.edu/sites/default/files/general/speciesid.pdf
LiMPETS, Long Term Monitoring Program and Experiential Training for Students Invertebrate database. Some of the vocabulary used on this website is advanced.
http://limpets.org/rocky-intertidal-monitoring/ri-species/invertebrates/
Pacific Coast, seafood supplier in Eureka, CA. This link takes you to a list of species that can be found in local supermarkets. (There is a poster in the Toolkit as well)
https://www.pacificseafood.com/species/

Engage: Introduce the highlighted species by using pictures and reading off clues to have students guess the "mystery species". Show them some pictures of the highlighted species using visual aids.
Explore: Using the highlighted species, conduct an activity where the students guess "who they are" using yes and no questions answered by a "helper" or partner.
Explain: Explain they will need to use critical thinking skills and use the answers to the yes or no questions to help form another question to help solve the mystery species (like 20 questions).
Elaborate: Once students have finished the activity have them explore who others are. Ask why humans may want to harvest certain species. Discussed locally fished species for the commercial market.
Evaluate: Test for understanding through questioning. Ask the students why certain species benefit from MPAs and others don't. Ask what characteristics made certain animals and/or plants (kelp) easy to guess and others more difficult. What might be the value in prohibiting certain consumptive behaviors?

Teacher Reference Sheet Lesson 3 (30 species)

Producers (4)	Invertebrates (14)	Fish (7)	Birds (3)	Mammals (2)
Bull Kelp (#27) Laminaria Giant Kelp (#34) Sea Palm Kelp	Red Abalone (#13) Ochre Sea Star (#27) Purple Urchin (#17) Rock Scallop (#18) CA Sea Cucumber (#15) Turban Snail (#14) Red Octopus (#12) Dungeness Crab (#48) Hermit Crab (blue) California Mussel (#25) Giant Green Anemone Sunflower star Gooseneck Barnacle (#11) Spot prawn (#53)	Cabezon (#16) Lingcod (#55) Wolf Eel (#33) Shiner Surfperch (#26) Bat Ray (#49) Rockfish (generic) (use #29,31,41, 44, 54) Leopard Shark	Black Oystercatcher (#23) Snowy Plover (#6) Brant (#5)	CA Sea lion (#40) Harbor Seal (#43)

NOTE: Number next to a species refers to the corresponding number on the MPA poster (the MPA Network pamphlet mentioned in this lesson uses the same illustrations)

Image of all 30 species (source: Marnin Robbins)

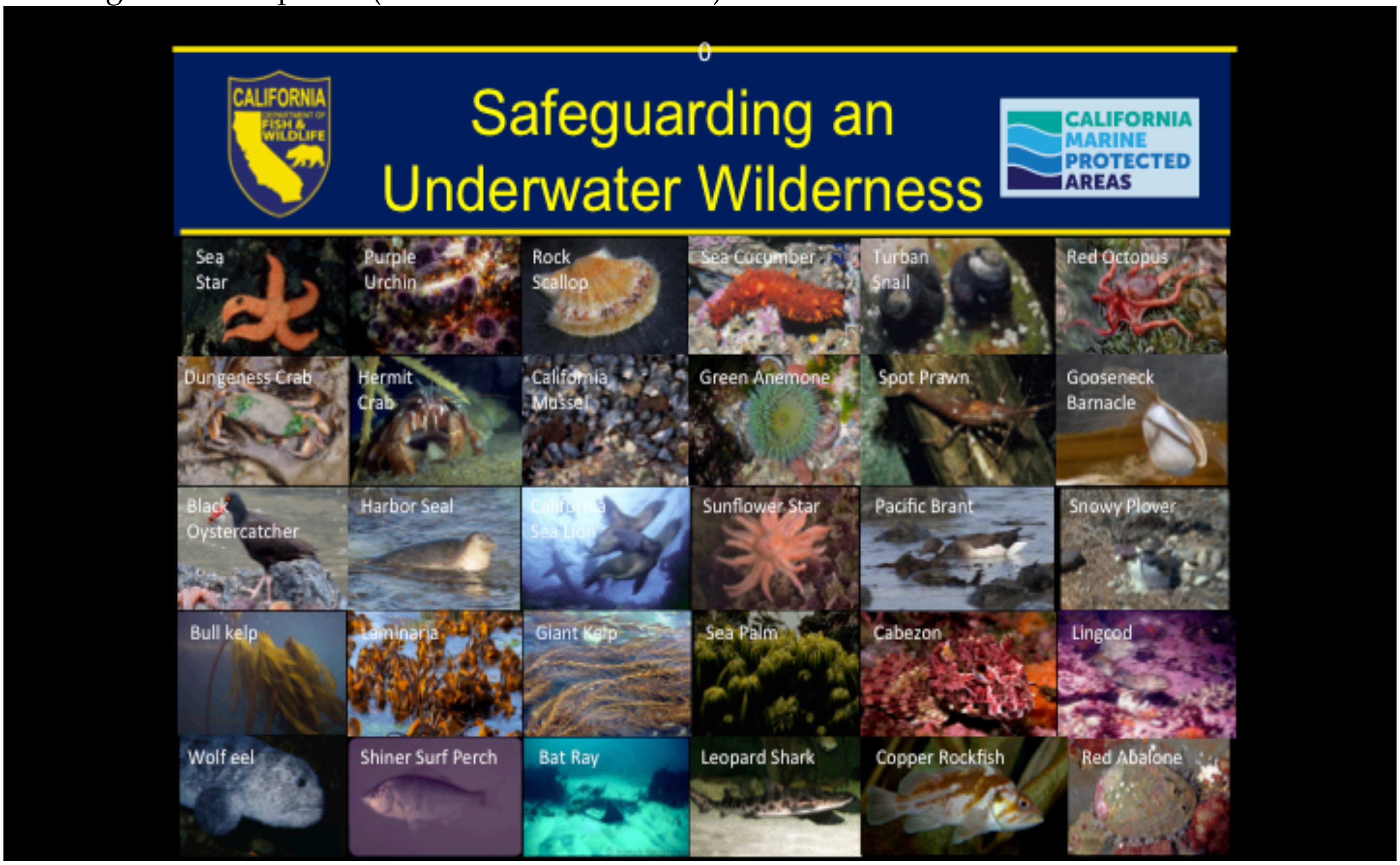
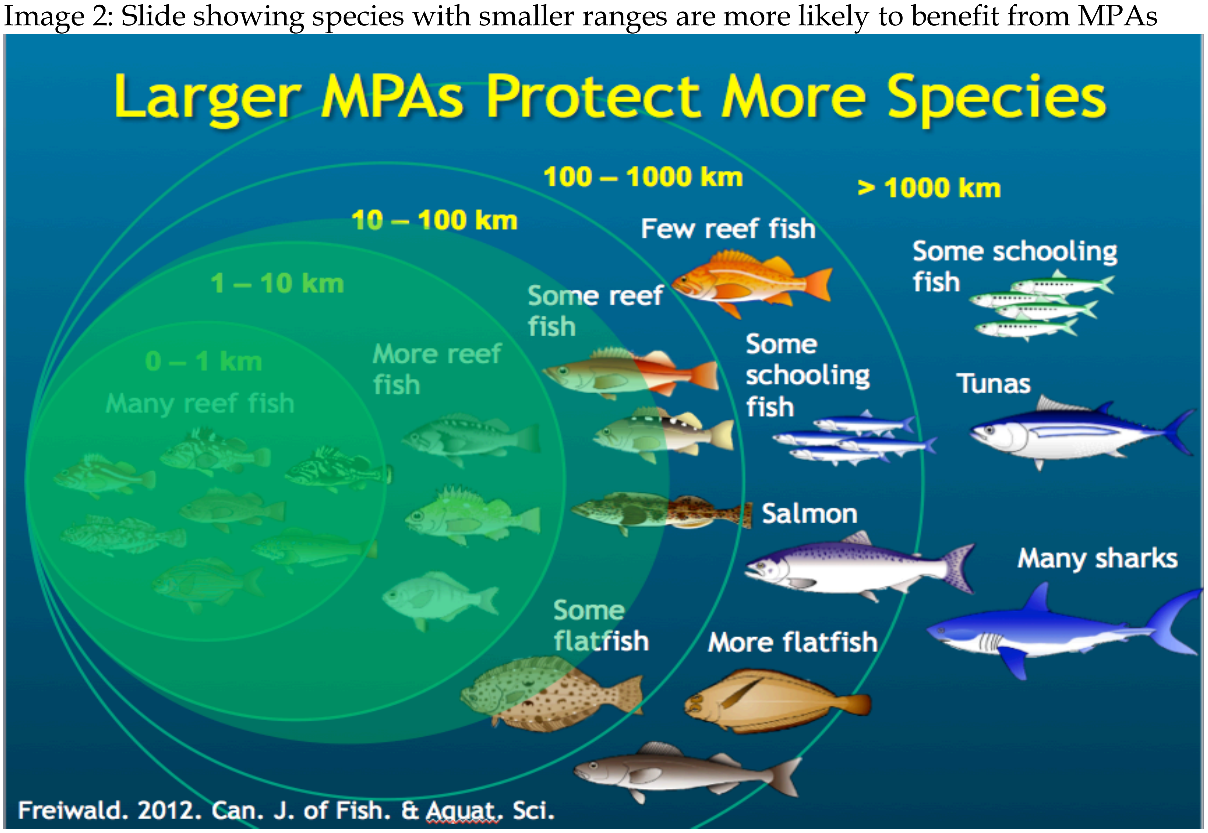


Image 2: Slide showing species with smaller ranges are more likely to benefit from MPAs



Clue Cards (optional). Read to the students as practice. *Note: Clue cards do not use yes or no questions.*

#27 Bull Kelp (*Nereocystis luetkeana)* I am tall and green and my holdfast keeps me in place. I help to make a safe home for other critters like sea urchins, sea stars, crabs, snails, and young octopuses. I can wash up on shore and look like a whip. In perfect conditions, I can grow quickly - up to 10 inches in one day!	**#34 Giant Kelp** (*Macrocystis pyrifera)* I boast of a height of up to 175 feet tall and I grow at incredible rates of up to 12 inches per day. You usually find me south of San Francisco Bay. Gas filled bladders keep my tall body upright in rough ocean waters and my holdfast keeps me stable on the ocean floor. Sea otters wrap themselves up in me during stormy weather.
Lingcod (*Ophiodon elongates)* A tasty treat for humans and sea lions, you can find me on the ocean floor surfing the reefs. With my razor sharp teeth and my rock-like camouflage, I'm well equipped to prey on fish, crabs, and octopuses. I find my place near the top of the food chain.	**#26 Shiner Surfperch** (*Cymatogaster aggregate)* At only 7 inches long, I live in large schools to stay safe. Fine me silver and gray in both salt and fresh-water. If I am a male, I can change colors to suit mates.

#49 Bat Ray (*Myliobatis californica*) A distant cousin of sharks, I am a winged water glider of the ocean floor. I flap my nearly 6 foot long "wings" to navigate the bottoms of kelp forests, coral reefs, and bays to discover my prey. Although I am generally a gentle giant, be careful. My tail holds a barbed spine that can really pack a punch!	**#13 Red Abalone** (*Haliotis rufescens)* My shell is beautiful and some make jewelry out it. Using my foot, I stick strongly on rocks; waiting for kelp to drift by for me to eat. Under the right conditions I make beautiful pearls, but leave me put, please! Many of my relatives have been commercially fished to the brink of extinction.
#5 Brant (*Branta bernicla nigricans*) I love to eelgrass and can also eat algae. A long distance flyer, I winter in the south along coastal areas and breed in the north. You can often find me in Humboldt Bay. I am a black colored goose.	**Purple Urchin** (*Strongylocentrotus purpuratus)* Careful! My body may look like a pincushion, but I am alive. I walk across surfaces underwater using "tube feet". I love to eat kelp, but I have to keep a careful lookout for sea otters, sunflower stars, and CA sheep- head because they love to eat me.

Teachers:

Note: Clue Cards are optional. Gives a chance to practice ahead of time.

Set of Who Am I Cards (worn around necks) are in the Toolkit.

Next page:
Yes or No questions cards (optional). These will need to be copied and cut beforehand.

1. Am I likely to benefit from a Marine Protected Area? 2. Do I get my energy from the sun? 3. Am I an invertebrate? 4. (if no #3) Do I have feathers? 5. (if yes #3) Do I have a shell? 6. Do I live in a (estuary/kelp forest/rocky area)? (pick one) 7. Am I larger than a baseball? 8. Make up your own Am I a_______________ ?	1. Am I likely to benefit from a Marine Protected Area? 2. Do I get my energy from the sun? 3. Am I an invertebrate? 4. (if no #3) Do I have feathers? 5. (if yes #3) Do I have a shell? 6. Do I live in a (estuary/kelp forest/rocky area)? (pick one) 7. Am I larger than a baseball? 8. Make up your own Am I a_______________ ?
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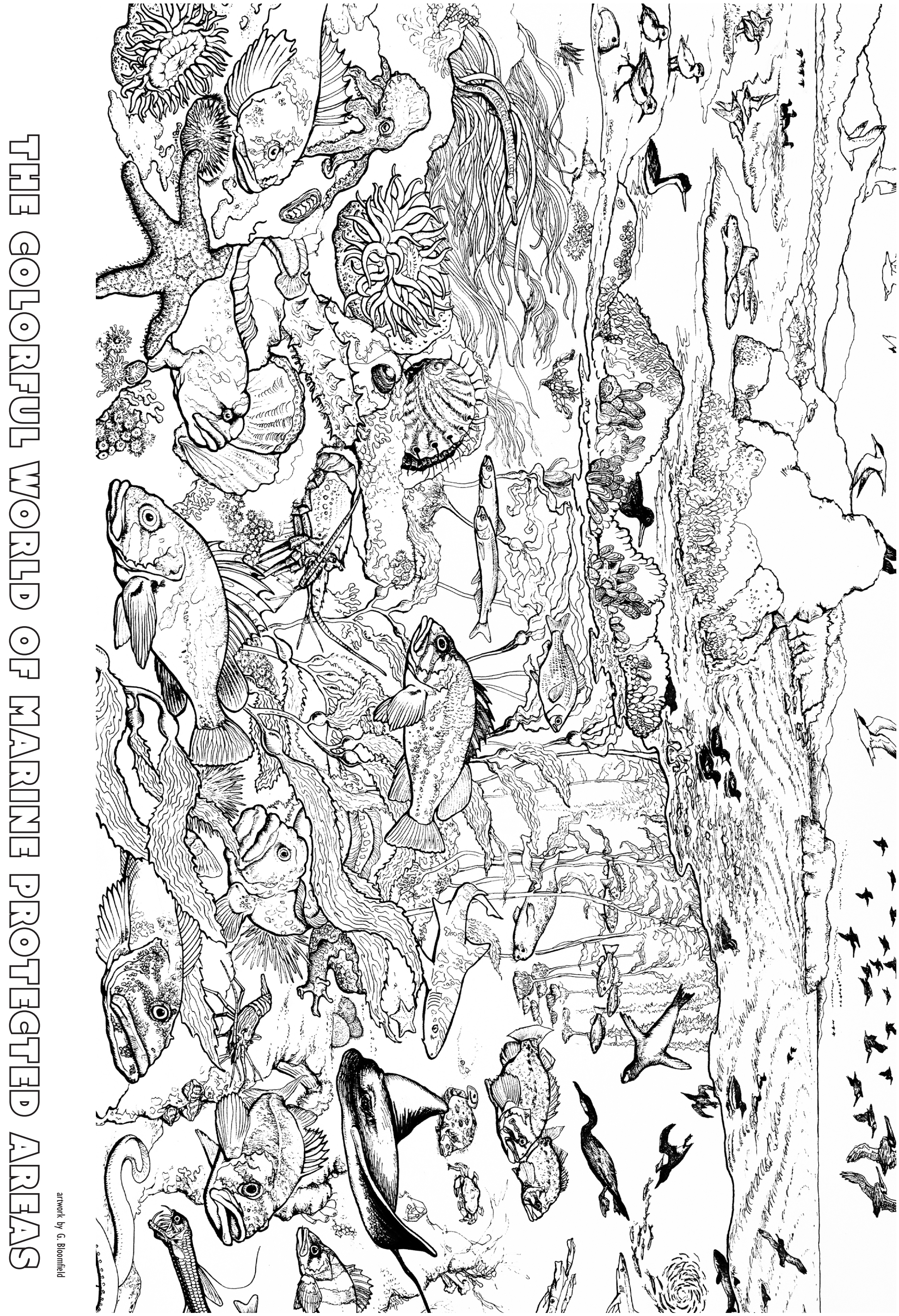
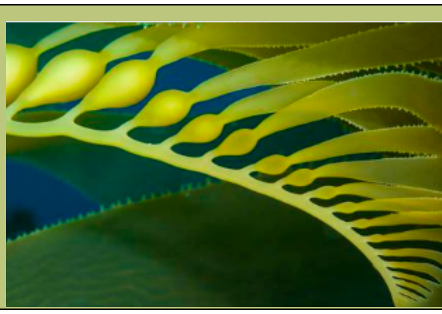
Optional Coloring Sheet





MPA Toolkit

For Humboldt and Mendocino Counties

UNIT 2

Grades 3-5

Lesson 4: Shells that Sing and Dance

NGSS -- DCI (Disciplinary Core Ideas):
3LS2.C Ecosystem Dynamics, Functioning, and Resilience
3LS4.B. Natural Selection
3LS4.C Adaptation
3LS4.D Biodiversity and Humans
4ESS2.E Biogeology
4LS1.A Structure and Function
5LS2.A Interdependent Relationships in Ecosystems
5ESS3.C Human Impacts on Earth Systems

Time:
30 – 90 mins.

Toolkit Materials for Teacher

- ✓ Samples of clams, mussels, olive shells, and abalone.
- ✓ Native American doll
- ✓ Pictures of Native American regalia (optional)
- ✓ Abalone puppets (optional)
- ✓ Traditional Ways Coloring Book (optional)
- ✓ Dentalium DVD (optional)

Learning Objectives: A) Students will understand that MPAs can help protect cultural heritage. B) They will be able to identify several shelled animals (mollusks) including red abalone, a species with cultural significance to local Native American tribes.

Phenomena: Abalone is a type of shellfish harvested by humans for food and worn in Native American regalia and used in ceremonies.

Background information:
(Modified using *Lessons of our Land*, Lesson 3, K-2)

California Marine Protected areas (MPAs) have several functions. Previous lessons in this unit have introduced the idea of MPAs acting as a network and that they use an ecosystem approach to enhance biodiversity and strengthen populations. By protecting biodiversity, MPAs can enhance ecosystem function and protect unique marine life habitats. Another benefit to MPAs is that they protect cultural heritage – the main emphasis in this lesson.

Along the North Coast, many Native American tribes continue to depend on the rich diversity of marine and coastal plant life as a critical source of sustenance and ritual. Both rocky shorelines and sandy bottom habitats have been a rich source of fish and shellfish for hundreds if not thousands of years for coastal native peoples. This lesson focuses on the cultural significance of shellfish for ceremonial dress or regalia -especially the red abalone - a food favored by many animals and people.

Several species of abalone live along the North Coast of California including the rare pinto abalone and flat abalone, but the one most people are familiar with is the red abalone (*Haliotis rufescens*). Another species found mostly south of Mendocino is the black abalone (*Haliotis cracherodii*). **Abalone** are a type of marine snail, which depends on kelp to survive. Different species live at different depths and can live among the rocks including intertidal zones, rocky reefs, and kelp forests. Species can be identified by differences in their shell size and shape, coloration,

Toolkit Materials for the Students

- ✓ Student worksheet
- ✓ Abalone coloring sheet (optional)
- ✓ Yurok word search (optional)

Connections:
Social science, physical geography, biology, zoology, language arts, art

MPA Core Ideas:

MPAs protect representative and unique habitats.

The MPA network has clear objectives, effective management, adequate enforcement, and uses sound science.

Vocabulary:
abalone: food source and regalia; used for necklaces, ceremonial dresses, quivers
adorn: to decorate
clam: food source; small clam shells were used for regalia
culturally: refers to culture
dentalium: a tooth-like mollusk used for money, necklaces, and other regalia
heritage: something that is handed down from the past as a tradition.
mussel: food source; the shell is used as a woman's eating spoon
regalia: means to adorn oneself

and respiratory pores among other things. Their rich delicate meat is highly prized as food by people. In the old days, Native American tribes would pry them from rocks using a piece of strong bone to pop them from rocks. Today all abalone species are in decline.

Red abalone is the largest species and is the most abundant. It is the only species recreationally fished in Northern California and abalone diving still remains a popular sport, but is prohibited for the foreseeable future. They can typically be found clinging to rocks from the mid intertidal zone down to 80 feet depending on environmental factors. Since the 1970's, red abalone populations have plummeted, especially in Southern California. Thousands have been taken with little regard for the future of the species even though fishing regulations are in place. Since 1997, it has become illegal to hunt red abalone south of San Francisco Bay. Unfortunately, in the last several years (e.g., 2015-2018), red abalone populations along the North Coast have been devastated and several factors are thought to be responsible - dubbed "the perfect storm". Simply put, large scale oceanographic events have led to unusual warm waters. Unusual warm waters have caused sea star wasting disease, which has severely reduced sea stars therefore increasing sea urchin populations (sea stars predate on sea urchins). The increase in sea urchins has severely decimated kelp beds. Because abalones depend on kelp (mostly free floating kelp) they are basically starving. As of 2017, there is a ban on the harvesting of red abalone and monitoring will determine whether harvesting is reinstituted or not. *Note: Please refer to additional information below if you want a more thorough explanation.*

It is important to note, that MPAs can help abalone populations to recover through a variety of means including monitoring, establishing no-takes zones, and enhancing biodiversity.

In Unit 1, Lesson 5 students learn the value of preserving Big Old Fecund, Female, Fish, otherwise known as B.O.F.F.F. Although the life histories of the two species (rockfish vs. abalone) vary widely you can find two abalone puppets inside the Toolkit tucked inside the cardboard box. When discussing the purpose of MPAs, it is recommended that you take a little time to show them the difference in the amount of eggs a large abalone can produce compared to a young abalone. Older abalone produces a lot more eggs. You may also want to compare the sizes of the two abalone shells. A seven-inch wide abalone is most likely at least 10 years old. Red abalone can live over 40 years! The record is just over 12 inches across.

Suggested extensions:

- Invite a Native American guest speaker who is knowledgeable about the ocean and its resources.
- Have students color and fill in the abalone page from the Monterey Coloring Book.
- Have students explore various invertebrates in more detail including crustaceans, mollusks, and cnidarians (see Tide Pool Taxonomy link below).
- Take a field trip to a marine science center such as the HSU Telonicher Marine Lab in Trindad or the Bodega Marine laboratory where students can observe life critters under microscopes and touch them in touch tanks.
- Have students engage in an art project where they bead a wristband or other object that they wear.

TEK (Traditional Ecological Knowledge)

English	Yurok
Abalone	yer'
Mussel	pee-'eeh
Horseneck clam	kep-oh
Dentalium	terk-term

As previously mentioned, abalone and other shellfish play a central role in Native American cultural practices. Abalone shells have been used in a variety of ways including being sewn into women's dresses and worn as regalia (refer to online resources below). Other types of shellfish are also important and include: mussels, barnacles, olive shells, limpets, and dentalia. Several examples of these shells can be found in the plastic bag within the Native American doll case.

Clams along with dentalia can be found by digging in sandy bottom habitats. The species of dentalium *(Dentalium pretiosum)* used historically may be locally extinct. *Dentalium pretiosum* was named by the Spaniards and means precious dentalia. Refer to the section on dentalium in the left hand column for more information as it relates to Native American culture. There is also an informative DVD on dentalium in the Toolkit in the TEK section.

Suggested procedure:
In this lesson, students will look more closely at the regulations put in place for the red abalone and will view a Native American doll (and pictures) to see how important collecting from the land and sea are to Native American tribes. Pull out the Native American doll in the Toolkit for the students to observe (Note: the doll is in a separate case, not in the main Toolkit). Admire and point out the amount of work and different items used in the dress. This costume is modeled after one still used today where only young maidens who have undergone cleansing and who are deemed worthy can wear.

Next, explain to the students that an additional benefit to MPAs, besides protecting sea life and their surroundings, is to protect cultural heritage. **Heritage** usually includes something that has significance within a culture or family and is passed down to the next generation. Shellfish and other sea life have been and still are important as food and for use in ceremonies to coastal Native American tribes such as the Tolowa Dee-ni, Yurok, Wiyot, Sinkyone, Wailake, and Coast Yuki tribes. Explain that Native Americans have an oral history tradition. Keeping traditions alive depends on the memories and experiences of older people (or elders) who can share their stories, pass down skills, and teach others how to live. At this point it is optional to show the students a video regarding Native Americans (see online resources below) and/or pick pages to use from the Traditional Ways Coloring Book found in the TEK folder.

Next, go over the meaning of ceremony and regalia. **Regalia** means to adorn oneself. It can have a much deeper meaning as

The Story of Dentalium: Dentalium shells were money to many Native America tribes. They were called *Pelin-cheeck* meaning Great Money, or *Tseihkeni-cheek* meaning small money. Although only sparsely distributed along the North Coast of California, dentalia are shells that look like small elephant tusks and are sometimes called tusk or tooth shells (refer to online resources or images in the Toolkit binder). They were used ornamentally as beads, money, and symbols of wealth for thousands of years and many varieties can be found around the world. Today they are still used in ceremonies. The Native Americans of the Pacific Northwest initiated the used of dentalia as a standard of monetary exchange and as a sign of wealth. They were used to purchase items such as boat, weapons, food, or even a wife. For instance, a small boat cost one strand of dentalium shells (a strand was about the length of a man's arm). Today most beadwork is done with the more plentiful Asian variety of dentalium shells or one found in Canada. Dentalia shells or *terk-term* in Yurok are used in necklaces and most often used in traditional ceremonies including the Deerskin Dance, the Jump Dance, and the Brush Dance. Tattoos on men's arms measured the length of the dentalium used for purchasing small or large items.	much regalia integrates symbolism and is connected to the spiritual world. Explain that certain ceremonies and "dress" are things that are passed down from generation to generation. This is what is meant by **cultural heritage**. Ask the students how people use regalia today. Answers may include make-up, jewelry, fashion, tattoos, hats, etc. Ask if they think regalia is important to people today. Answers will vary. Together discuss the "source materials" for the various things they see on the doll. Examples include the leather made from cow or deer skin, the string made of cotton (originally it would have been made from sinew), the tough fibrous tissue that holds muscle to bone. Shells, as already discussed, come from various mollusks that live in the ocean. The beads are varied. Some come from the ocean and others from land. If you look closely, you will see that some beads are seeds. These seeds are pine nuts. Additionally, the doll has strips of braided beargrass – a type of grass that lives inland from the ocean and is used in many ceremonies and in basketry; and the braids are covered by animal fur, mostly likely a member of the weasel family. Together, see how many different species of shellfish they can observe on the doll. Highlight the abalone beads and ask if anyone has ever seen or eaten abalone. If you want to focus on abalone, explain to them the current fate of the red abalone along the California Coast. Explain to them that because people like to eat abalone, there are fishing regulations regarding how many one person can hunt and a legal minimize size. As a side note: current regulations for the fishing of abalone on the North Coast are: no more than 3 abalone per person as a daily bag limit; a minimum size of 7 inches across; and only 12 can be taken in one year. Keep in mind regulations change from year to year and county to county. This is a good time to pass around the abalone puppets (as discussed in the introduction above). Feel free to pass around examples of abalone shell and other shells found in the Toolkit. You may also want to show them pictures of Native American traditional dress (refer to links below or the images in the MPA binder). At this point it is optional to show them the DVD on dentalium or use the Traditional Ways Coloring Book. Once you have reviewed the significance of dentalium, have the students complete the student worksheet where they identify the marine animal and match the type of marine organism to one or more tribal uses. End the lesson, by asking students what might make a particular *area* culturally significant. Answers may include that an area might be rich in food where people hunt or fish. Other ways a

	place can hold culturally value is that it is has been used traditionally (and may still be used) for ceremonies and celebrations. Remember that MPAs are like underwater parks. They serve a variety of purposes for a variety of people. Once they are done with the student worksheet, an optional extension is to attempt to connect various shells (i.e., clam, abalone, dentalium, olive shell) to different habitat types protected by Marine Protected Areas. There are posters of the six habitat types in the Toolkit. Ask where they think the various species of shellfish might live. For instance abalone and olive shells live in rocky regions. Clams and dentalium shells typically live in sandy bottoms. Several online resources listed below can be used to discuss characteristics of marine species. Summarize this lesson by showing the short video about the Tolowa Dee-ni' Nation and Northern California MPAs (refer to link below). A further option is for them to color the abalone page from the CMPA coloring book (included in the Toolkit) and have them fill it out the requested information. Lastly, to emphasize the Yurok language you can find a Yurok Word Search regarding Sea Life below.

MPA Goal Connections: #4 To protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic value.

Online resources:
Humboldt MPA Collaborative video about the Tolowa Dee-ni' Nation. Reveals the importance of ocean resources, especially surf fishing to native food sustainability and tribal identity.
http://www.mpacollaborative.org/humboldt/
https://www.youtube.com/watch?v=-hs3zZde5jg
North Coast Panels and MPA Signs. Useful for a quick overview of each MPA set aside in the North Coast Region. Each has a reference to Native American uses.
http://californiampas.org/outreach-toolkit/printed-materials/signs/north-coast-panels-signs
Lessons of the Land, *Shellfish, Shells, and Traditional Regalia*.
https://www.lessonsofourland.org/lessons/shells-dentalium-and-the-ocean/
Lessons of the Land, information on traditional ceremonial dances and regalia
https://www.lessonsofourland.org/lessons/ceremonies/
Charlie Throm's Mount Shasta Earth Day Message about sustainability and taking care of the Earth.
https://www.youtube.com/watch?v=7bW0P-XYd8w&list=PLyWEXaNYLXKmRHEjNcmBaVj_B9BERleS_
LiMPETS, Rocky Intertidal Species Database.
http://limpets.org/rocky-intertidal-monitoring/ri-species/algae/
California Tide Pools: *Where to Find Tide Pool Animals*. This site has several good links.
http://californiatidepools.com/where-to-find-tide-pool-animals/

Engage: Ask the meaning of regalia and have the students give examples of how people adorn themselves.
Explore: Hold up the Native American doll in the Toolkit and ask what is the first thing they notice. Highlight the fact the doll is covered by abundant seashells, including clam, dentalia, and abalone shells.
Explain: Explain a benefit of MPAs is they help protect places of cultural significance, which is part of human heritage.
Elaborate: Ask students what might make a particular Marine Protected Area culturally significant. Answers may include: A place used for ceremonies and celebrations, a place where people hunt or fish, a place where people collect things such as shells, to be used as food, medicine, or in ceremony.
Evaluate: Using questioning or the student worksheet to review what students have learned in this lesson by identifying sea life with cultural significance to Native American tribes and the importance of heritage.

Teacher Resources:

For visuals refer to the pages in the gray binder and the images on the pen drive under the title TEK.

Name

____

Saa-'a-goh —We Speak Our Language

Yurok Words of the Month: Sea Life

Hidden in the grid are 38 Yurok Words/Phrases—frontwards, backwards, up, down, and diagonal.

n	w	l	e	t	m	r	e	p	k	e	w	w	w	k	k	e	u
h	e	k	e	g	e	s	h	a	s	p	e	e	h	e	k	a	o
t	n	h	o	n	e	h	c	a	s	h	a	e	w	m	e	w	t
n	e	r	r	g	r	g	e	m	c	o	k	e	r	o	p	t	s
k	n	r	e	g	e	n	p	e	h	n	n	h	w	e	a	u	h
l	e	e	k	o	p	r	w	w	e	c	w	e	l	k	a	u	w
y	e	p	p	w	w	w	c	u	g	e	e	n	g	t	m	e	h
o	p	e	t	u	t	h	g	e	e	w	p	s	e	s	o	k	e
w	u	g	c	o	e	e	h	p	l	l	n	e	u	t	h	o	l
e	e	n	c	c	h	y	r	s	r	h	k	s	e	e	g	h	u
h	c	e	h	c	w	k	o	m	c	e	e	e	k	s	o	c	h
e	h	e	h	l	k	u	e	s	l	e	g	w	o	w	h	a	o
o	k	w	o	r	o	r	e	o	r	k	o	r	k	p	k	o	s
w	a	e	e	e	n	n	w	e	l	l	c	h	e	h	h	e	n
k	a	k	m	e	r	e	r	x	s	h	c	r	a	p	a	r	r
e	m	s	r	o	n	r	x	o	p	r	g	k	g	r	l	w	h
w	e	s	w	k	e	s	n	t	k	e	r	h	k	e	r	h	h
e	s	e	k	y	l	m	o	h	r	w	k	a	a	y	o	k	e

Abalone:	yer'	Night fish:	mokw-chech
Backbone (fish):	le-kee-ta'	Octopus:	paa-mew
Barnacles:	'yerr-ner'	Oyster:	he-kwol' son'
Candlefish:	kwo'-ror'	Perch:	wah-kwehl
Crab:	ko'-ses	Quahog:	sekw-sew
Dentalium shell:	terkw-term	Razor clam:	chper-ger'
Dried surf fish:	ke-ges	Red cod:	che-noh
Eel:	ke'-ween	Salmon:	ne-puey
Fin, bone (fish):	che-chekw	Scales (fish):	peesh-'on
Fish skin:	mer-ner's	Seaweed:	che-gel'
Fish tail:	tuuek	Sea serpent:	kne-wo-lek
Flounder:	hlper-gerp'	Shark:	kaa-mes
Gills:	mer-'erx	Small turtle:	kerh-kerh
Horseneck clam:	kep-oh	Smelt, surf fish:	hehl-kues-leg
Kelp:	paa-moh	Starfish:	ko-yaakw'
Kelp:	werhl-keehl	Steelhead:	chkwohl
King salmon:	che-guen	Sturgeon:	kah-kah
Ling cod, snapper:	loh-tuen	Sucker fish:	ne-nee-puech'
Mussel:	pee-'eeh	Surf fish:	he-woy

Student Worksheet

Name ______________________________

Shells that Sing and Dance

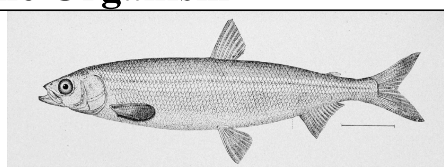
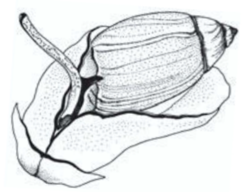
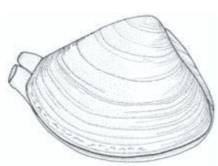
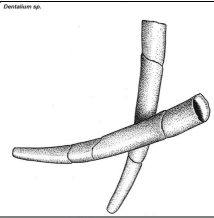
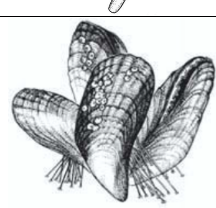
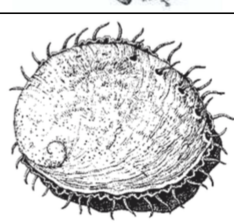
A. Worn in ceremonies (regalia)

B. Used as a food source

C. Used as money

D. Used in jewelry

1. Match the common name to each picture.
   (mussel, abalone, olive shell, clam, surf smelt, dentalium)
2. Highlight how the organism below can be culturally important using the letters.

Marine Organism	Name
	
	
	
	
	
	

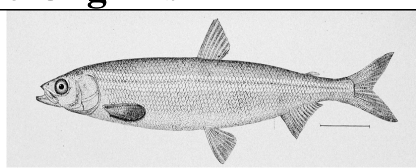
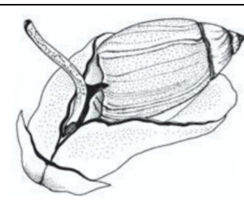
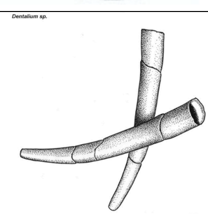
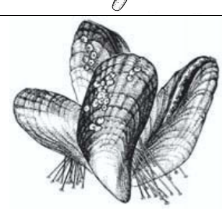
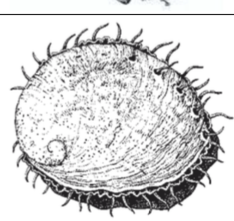
Student Worksheet (KEY)

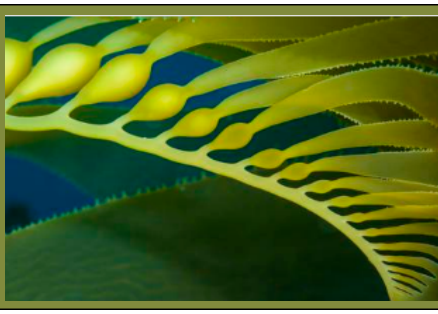
Name _____KEY________

Shells that Sing and Dance

A. Worn in ceremonies (regalia)
B. Used as a food source
C. Used as money
D. Used in jewelry

1. Match the common name to each picture.
   (mussel, abalone, olive shell, clam, smelt, dentalium)
2. Highlight how the organism below can be culturally important using the letters.

Marine Organism	Name
	Surf smelt B
	Olive Shell A, B, D
	Clam A, B, D
	Dentalium or Tusk shell A, C, D,
	Mussel A, B,
	Red Abalone A, B, D



MPA Toolkit

For Humboldt and Mendocino Counties

UNIT 2

Grades 3-5

Lesson 5: Network Spillover

NGSS -- DCI (Disciplinary Core Ideas):
3LS2.C Ecosystem Dynamics, Functioning and Resilience
3LS4.D: Biodiversity and Humans
5LS1.C Organization for Matter and Energy Flow in Organisms
5LS2.A Interdependent Relationships in Ecosystems
5ESS3.C Human Impacts on Earth Systems

Time: 45 – 75 mins.

Toolkit Materials for the Teacher

- ✓ Information on MPAs including the poster "*The California Network of Marine Protected Areas*"
- ✓ Plastic bowls (for a cove)
- ✓ Popped popcorn*
- ✓ Whistle or timer*
- ✓ Poster paper (optional)

Toolkit Materials for the Students

- ✓ Cups* (for a boat)
- ✓ Spoons (fishing implement)
- ✓ Plastic bowls

*Not supplied in the Toolkit

Learning Objectives: Students will learn that California Marine Protected Areas (MPAs) are part of a network where the spillover effect can benefit multiple species and nearby ecosystems.

Phenomenon: Marine Protected Areas (MPAs) can increase biodiversity and replenish fish stocks outside their boundaries through the spillover effect.

Background information:
Modified from *Fishing for Solutions*, Undersea Legacy Unit.

Marine Protected Areas (MPAs) operate across a wide spectrum of scales, geographical locations, and fisheries. The ***spillover effect*** refers to when larva or adult fish exit a Marine Protected Area (MPA) potentially offering an increase in fish populations adjacent to it. As you may have already learned throughout this unit (see Safeguarding an Underwater Wilderness poster or MPA maps included in the Toolkit), there are several different types of MPAs along the California coast including **State Marine Reserves** (SMR) denoted in red, **State Marine Conservation Areas** (SMCA) denoted in blue, and **State Marine Recreational Management Areas** (SMRMA) denoted in green - all of which can help sustain or enhance marine life populations in adjacent waters. SMRs prohibit all takes and the other types allow some extraction of marine resources.

Some scientific studies support the concept of the spillover effect. Scientists in the Philippines, Kenya, and elsewhere measured catches before and after marine reserves were established. Once marine reserves were put in place, fish populations within *and* outside the reserves increased.

In 1999, the California Legislature passed the Marine Life Protection Act and by 2012 California had established a network of 124 different Marine Protected Areas (MPAs). Many factors were used to determine the placement of MPAs including the protection of species abundance as discussed in Lesson 4 (Shells That Sing and Dance), and to act as a network as demonstrated in Lesson 1 (Planktonic Playground). Others were located in places

Connections:
Art, mathematics, biology, economics, ecology, engineering

MPA Core Idea:

MPAs can sustain and restore marine life populations.

Vocabulary:
Biodiversity
No Take Zone
State Marine Reserve
spillover effect
replenish

Suggested extensions:

- Invite a fisherman into class to share and explain their livelihood.
- Have the students watch a film about the richness of the ocean and the importance of preserving it (see online resources below).
- Introduce Native American methods that support sustainability.
- Research fish species that are commonly eaten including those whose populations have been reduced. Using the Monterey Critters Cards

where fish stocks have been depleted. By placing MPAs near these areas, the hope is that over time fish populations can be replenished through the *spillover effect* and *restricted take zones*.

Suggested procedure:
Begin this lesson by introducing students to the locations and various kinds of MPAs by showing a map or holding up the large poster, "*The California Network of Marine Protected Areas*". If time allows, point out the various types of MPAs and mention some of the restrictions each has. *Note: specific information can be found in pamphlets found in the Toolkit and online.*

Break the students up into groups of four or five and have them gather around tables where each can have access to a bowl full of "fish". Explain to them that in this lesson they will be fishing in groups for popcorn using a spoon that represents a net or fishing pole. If no fish get in their cup then they will go hungry. If someone collects most or all of the "fish", then they have overfished. One group will not be allowed to fish as their bowl represents a State Marine Reserve (SMR) or *no-take zone*. The other groups (not a SMR) will "fish" within a 10 second interval from a favorite fishing spot (represented by a bowl). Be sure they know the activity is timed and clarify the procedure you will be using for having them end when time is up. You may want them to raise their hands once you blow a whistle or have a timer go off. You may also want to shout "STOP"!

Hand out spoons to each student to use as fishing poles. Hand out Dixie cups or other holders to use as boats.
Hand out a paper bowl with some popcorn in it to each group but don't let them gather from it until you give a signal. The amount of popcorn you want to begin with is up to you. Make sure you have enough popcorn left over after round 3 where you can overflow the SMR bowl. The smaller the bowl the easier it will be to do this. Explain the ground rules and the fact that if no fish are left in the bowl, then there will be no fish left to reproduce or replenish their bowl. The popcorn needs to be scooped with a spoon, not their fingers. No one should push or shove or steal someone else's "fish" – this will disqualify them.

Round 1: Students will have 10-seconds to "catch" as many fish (popcorn) as they would like and place them in their own boat (Dixie cup). After the round they can eat whatever is in their boat except of course those students who are in a SMR. Ask students what happened at the end of round 1. Did anyone go hungry? Did anyone take more than their fair share?

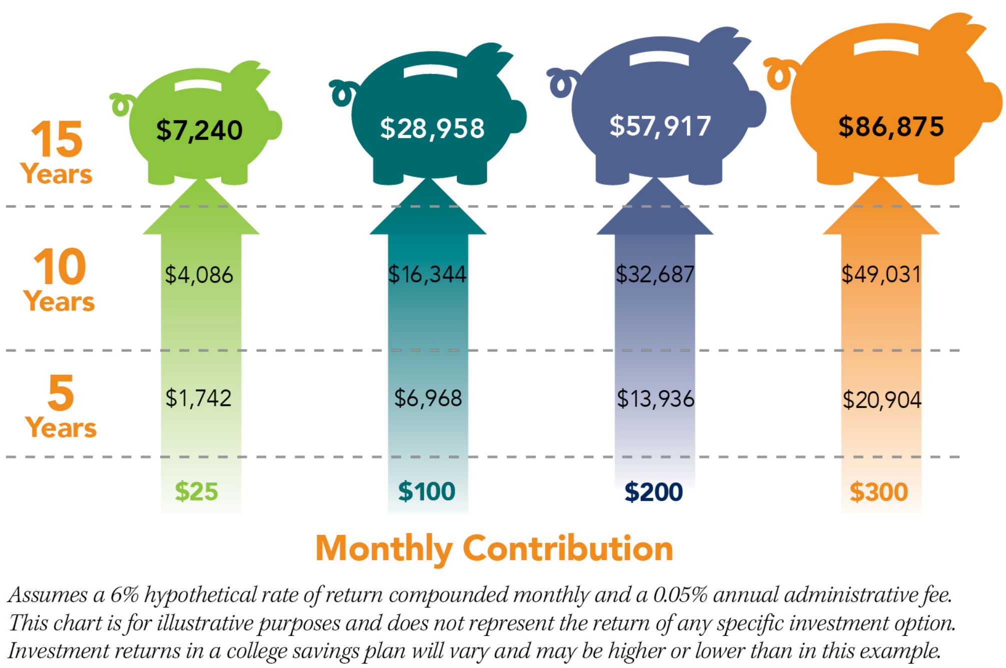
Round 2: Reproduce all fish left in each bowl 1 for 1 (example,

can be a useful way of approaching this.	if the bowl is ¼ full, now it will be ½ full, if the bowl is ¾ full, now it will be 1 ½ full, and if the bowl is empty they will have no fish left to reproduce). Remember to double what is left in the SMR bowl as well. Remind them that the popcorn is the model used for fish. If no fish survive, then none are left to reproduce. Repeat the first step for another 10 seconds. After the round, students may eat what they "catch". Ask what happened this time. Did anybody's method change? **Round 3:** Reproduce all fish in bowl 1 for 1 again. Give another 10 seconds. Students may eat what they "catch". Ask what happened this time. At the end of round three, groups will have varying amounts of popcorn in bowl but MPA group will have a huge amount of popcorn (likely will need 2 or 3 bowls to hold it all). Stand over by the group that is in the State Marine Reserve (SMR). Point out that they have tons of fish because it is a no-take zone. Not only do the populations increase in the reserve, but adjacent areas next to it can benefit as well. The spillover effect is a potential result of a successful MPA on its surrounding waters. That means that some of the additional larvae or fish produced can spread out beyond their bowl or fishing area. "Spill-over" 1/4 of the fish from the SMR (bowls) into the fishing boats (Dixie cups) of the SMR students. They can now all eat their fish (popcorn) including the students who are in the SMR group. Praise them for doing a good job if all went well. *Note: Please rinse all of the bowls and spoons for reuse before putting them back in the kit.* To conclude, explain that an MPA can act like a savings account (refer to image 1 below). When you put aside a little money every now and then and don't spend it, the account becomes much bigger because you continue to make interest on the money that is there. Additionally, be sure to have the students explain what a spillover effect is and how this phenomenon relates to MPAs (see information below for posters and additional information). If time remains, show the short video on the goals and purposes of MPAs using the Humboldt MPA Collaborative film (refer to online resources below). As a follow up activity, have the students draw out the spillover effect as it relates to this activity.
MPA Goal Connections: #2 To help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.	
Online Resources: Online North Coast MPA Tour. Gives information about each MPA in Humboldt and Mendocino	

Counties: https://tourbuilder.withgoogle.com/builder#play/ahJzfmd3ZWItdG91cmJ1aWxkZXJyEQsSBFRvdXIYgICA4OjqkQsM Humboldt MPA Collaborative: Short video on the purpose of MPAs specific to the North Coast of California. Includes a few local kids in it http://www.mpacollaborative.org/humboldt/ MPA Collaborative. *Safeguarding an Underwater Wilderness* ~ A good 10 minute video regarding California MPAs in general, their uniqueness, and their purposes. https://www.youtube.com/watch?v=xB_yqcfN7DE&feature=youtu.be Monterey Bay Seafood Watch for California 2018 http://www.seafoodwatch.org/-/m/sfw/pdf/guides/mba-seafoodwatch-west-coast-guide.pdf?la=en
Engage: Show the poster *The California Network of Marine Protected Areas* (MPAs) or the map of North Coast MPAs, both of which use different colors (a legend) to depict the different kinds of MPAs. Explain what the colors mean and what sorts of activities are allowed. **Explore:** Model the *spillover effect* in a fishing activity using bowls, spoons, cups and popcorn. **Explain:** Explain the benefits of having MPAs including State Marine Reserves (SMRs) where no-take, damage, injury or possession of any living, geologic, or cultural resource can be allowed. **Elaborate:** Explain to students that besides replenishing fish stocks in a no-take zone, adjacent areas can also benefit. One of the goals of MPAs is to sustain and restore marine life populations. **Evaluate:** After the students have modeled the spillover effect, have them draw the spillover effect as it relates to this lesson or have them explain verbally the benefit this phenomenon has. Ask how can MPAs act as a "savings account".

Teacher References:

Image 1: MPAs can act like a savings account.



Source: http://savingforcollegefund.com/

MPA Toolkit

For Humboldt and Mendocino Counties

UNIT 2

Grades 3-5

Lesson 6: "Dive In": Exploring MPAs through ROVs.

NGSS -- DCI (Disciplinary Core Ideas):

3LS2.C Ecosystem Dynamics, Functioning, and Resilience
3LS3.B Variation of Traits
3LS4.D Biodiversity and Humans
4LS1.A Structure and Function
5ESS3.C Human Impacts on Earth Systems

Time: 30 – 75 mins.

Toolkit Materials for the Teacher

- ✓ Images and other MPA Materials including videos and books.
- ✓ Online resources (see links)

Materials for the Students

- ✓ Tablets or access to a computer lab *
- ✓ Poster paper and colored pencils or markers (optional) *

*Not included in the Toolkit

Connections:
Language arts, mathematics, biology, ecology, engineering,

Learning Objectives: Students will answer questions about California Marine Protected Areas (MPAs) through an online PORTS slideshow. They will identify at least two purposes for MPAs including the fact they provide recreational and research opportunities.

Phenomena: Remotely operated vehicles (ROVs) provide a tool for marine scientific research.

Background information:
Marine Protected Areas (MPAs) can provide a variety of benefits to marine species by protecting their habitats. All MPAs restrict some sort of human activity. A State Marine Reserve (SMR) is a type of MPA where all extractive uses are prohibited - sometimes referred to as a "no-take" zone (refer to Lesson 5). Whereas a State Marine Conservation Area (SMCA) is a less restrictive type of MPA. Commercial and/or recreational fishing may be allowed in these areas with restrictions that provide some protection for animals, plants, and habitats (refer to image 1 below). Most MPAs allow forms of recreation including diving, boating, and surfing. A concept that hasn't been introduced thus far is the fact that MPAs also act as underwater laboratories. They provide natural classrooms and opportunities for exploration.

The MPA Management Program includes four focal areas: outreach and education, enforcement and compliance, policy and permitting and research and monitoring. Getting students to understand the importance of research and monitoring is the main objective in this lesson. In order to gain an appreciation of some of the tools used for oceanic research, the students will learn about Remote Operational Vehicles (ROVs) and participate in a mock citizen science project through an online PORTS (Parks Online Resources for Teachers and Students) slide show.

Here is the link:
http://www.ports.parks.ca.gov/mpa/introduction/story_html5.html

One the left side of the screen, scroll down to section 4 and click technology

MPA Core Ideas:
MPAs provide recreational, educational, and study opportunities.

The MPA network has clear objectives, effective management, adequate enforcement, and uses sound science.

Vocabulary:
MPA
ROV
data
management
transect
recreation

Suggested extensions:

- If time allows, have the students explore more sections in the PORTS program.
- Look at video footage from Remotely Operated Vehicles (ROVs) used in MPAs (refer to links below).
- Show videos of people exploring the deep places

on the link. The page is titled: **Using Science To Test Our Work**. This section begins by asking students how to set up an experiment. You may want to review the first part of this section together as it reviews the scientific method. Section 4.4 will introduce the idea of needing to collect **baseline data**. Baseline data is a measurement of all aspects of an MPA when it was first formed. After baseline data is collected there is **ongoing data collection**. After analyzing data, adjustments to where MPAs are placed or what they restrict may be made depending on the results. These types of ongoing adjustments are referred to as **adaptive management**.

As previously mentioned, one tool used to explore underwater habitats is through the use of **remotely operated vehicles** or **ROVs**. These tools are also known as underwater drones. They are robotic submarines that are tethered, most often to a ship, where "pilots" control through movement and actions. High definition cameras and still cameras are on the vehicles and record images of sea life, geology, and experiments. Section 4.5 in the PORTS online program is about ROVs specifically and has students move through the water as if they were operating a ROV or viewing the video footage from one. Here they conduct a simple citizen science project where they observe the numbers of copper rockfish along a transect. A **transect** is usually a line with selected data points along it. By observing and recording what organisms live along a transect or what structural features are observed, one can compare results to other similar places. Once preliminary data is recorded, one can go back and record changes that take place over time. For instance, one of the studies conducted in MPAs along the North Coast of California (in Humboldt and Mendocino Counties) happened throughout estuaries. In this study, researchers recorded baseline data. The main goals were to describe estuarine biodiversity and quantify the abundance and size of target species. Therefore, they set up transects and described physical characteristics (including discharge from rivers and sea surface temperature) and measured biodiversity along them. In other words – they asked the question: "what are the conditions like in these places and what lives there"? This sort of data collection not only helps determine what lives in a particular habitat but can also help monitor the effectiveness of management decisions among other issues.

Suggested procedure:
PART I:
Note: student access to a computer lab or tablets will be required for this lesson.

in the ocean such as subterranean canyons. • Have students collect data from water samples such as temperature, turbidity, and salinity. • Write a report on a fish. Many fish species can be found using *Reef Check California.*	The main objective in this lesson is for the students to understand that Marine Protected Areas (MPAs) can act as underwater laboratories. If you have time, begin this lesson by showing a short video on Northern California MPAs or one that shows footage from Remotely Operated Vehicles (ROVs) (refer to links below). Once they have seen a video, turn their attention to Marine Protected Areas (MPAs). Show them the "cartoon" of the various types of MPAs (see image 1 below). Using this image (or another of your choosing), have the students identify various recreational activities they observe (Answer: scuba diving, boating, fishing, and surfing). Write these activities down. Next, ask the students, "Besides offering fun places to visit for ocean enthusiasts or safe havens for wildlife, what is another purpose of a Marine Protected Area (MPA)?" Hopefully, they will make past connections from previous lessons, such as protecting cultural heritage or placing MPAs near each other to act as a giant network. Once you have discussed some of the benefits of MPAs, explain that in order to know how successful MPAs are, they need to be studied. Monitoring our oceans requires research. Explain that one great tool that is being used to explore our oceans is the used of **Remotely Operated Vehicles (ROVs)**. Show them a picture of a ROV (if you have not shown a video clip of one already). There is a good picture in the *Oceanpedia* book found in the Toolkit and in the Teacher References below. Decide how you want the students to proceed from here. For instance, you may want to have them do the online PORTS program with a partner as two pairs of eyes can be better than one and scientists often work in teams. Next, have the students connect to the Internet and pull up the PORTS program by clicking on it (see link above). Once they open the slideshow up, direct them to section 4: **Using Science to Test Our Work,** and explain what specific sections you would like them to perform. Once they are finished, compare results. Ask: "Was this exercise fun"? Next ask: "If they were a marine scientist, what question would they want answered"? Write down or further discuss some their responses. Conclude this lesson by having them draw a picture of a hypothetical Marine Protected Area. Be sure to have them put a person in their drawing and identify some of the benefits their MPA provides. <u>Optional Extension:</u> Feel free to steer students to portions of the

	slide show they have already learned about in this unit. Sections may include: 1.5) Information on Habitats, 1.8) Adaptations, 1.10) The MPA Network, 2.3) Humans and Fish, 3.3) Comparing MPAs to CA State Parks, 3.4) Creating MPAs, and 4.2) Monitoring, among others.

MPA Goal Connections:
#3 To improve recreational, educational, and study opportunities provided by marine ecosystems that are subject to minimal human disturbance, and to manger these uses in a manner consistent with protecting biodiversity.
#5 To ensure that California MPAs have clearly defined objectives, effective management measures, adequate enforcement and are based on sound scientific guidelines.

Online Resources:
Interactive PORTS video on MPAs
http://www.ports.parks.ca.gov/mpa/introduction/story_html5.html
MBARI (Monterey Bay Aquarium Research Institute): Remotely Operated Vehicles
https://www.mbari.org/at-sea/vehicles/remotely-operated-vehicles/
California MPA Multimedia resources
http://californiampas.org/outreach-toolkit/multimedia/videos-films-animations
Short video on Pt. Lobos MPA from the Monterrey Bay aquarium. Discusses kelp forest and deep waters.
http://californiampas.org/outreach-toolkit/multimedia/videos-films-animations/animations

Engage: Show video footage from a Remotely Operated Vehicle (ROV) cruising through the ocean.
Explore: Have the students perform an online citizen science project where they count fish from an ROV.
Explain: Explain that besides offering recreational opportunities, MPAs are also places people can go to do “science”. They are underwater laboratories.
Elaborate: Review the variety of purposes and benefits MPAs can have.
Evaluate: Have the students make a poster promoting the benefits of their own hypothetical MPA.

Teacher References
Image 1 – MPAs (source: Santa Cruz)

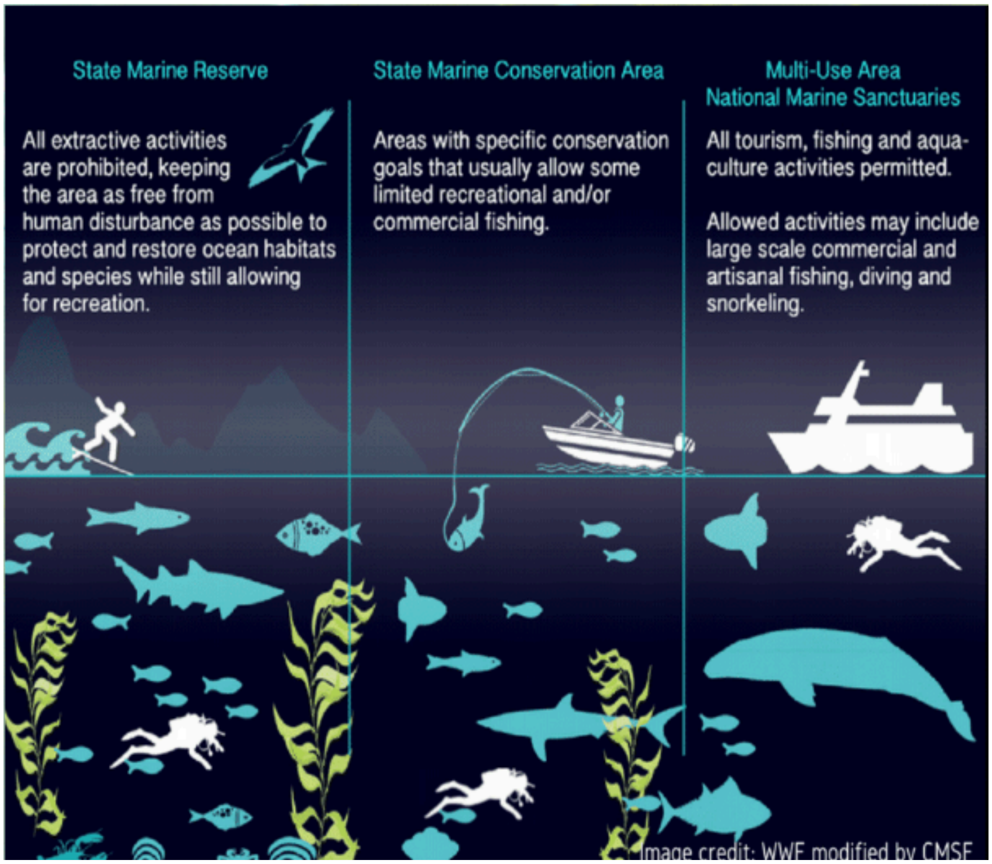


Image 2: Remotely Operated Vehicle (ROV) (Source: NOAA)

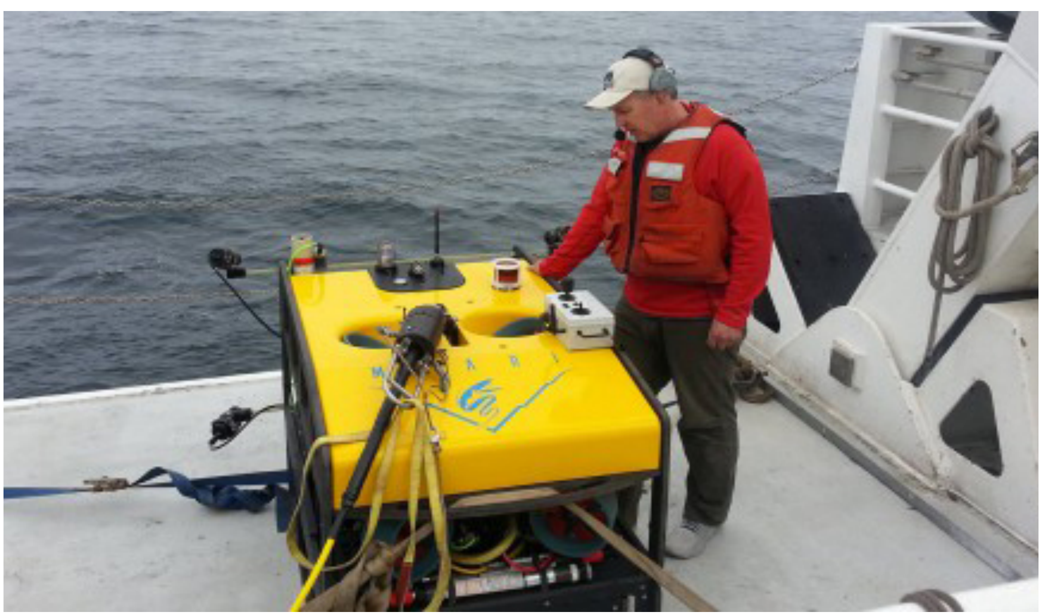
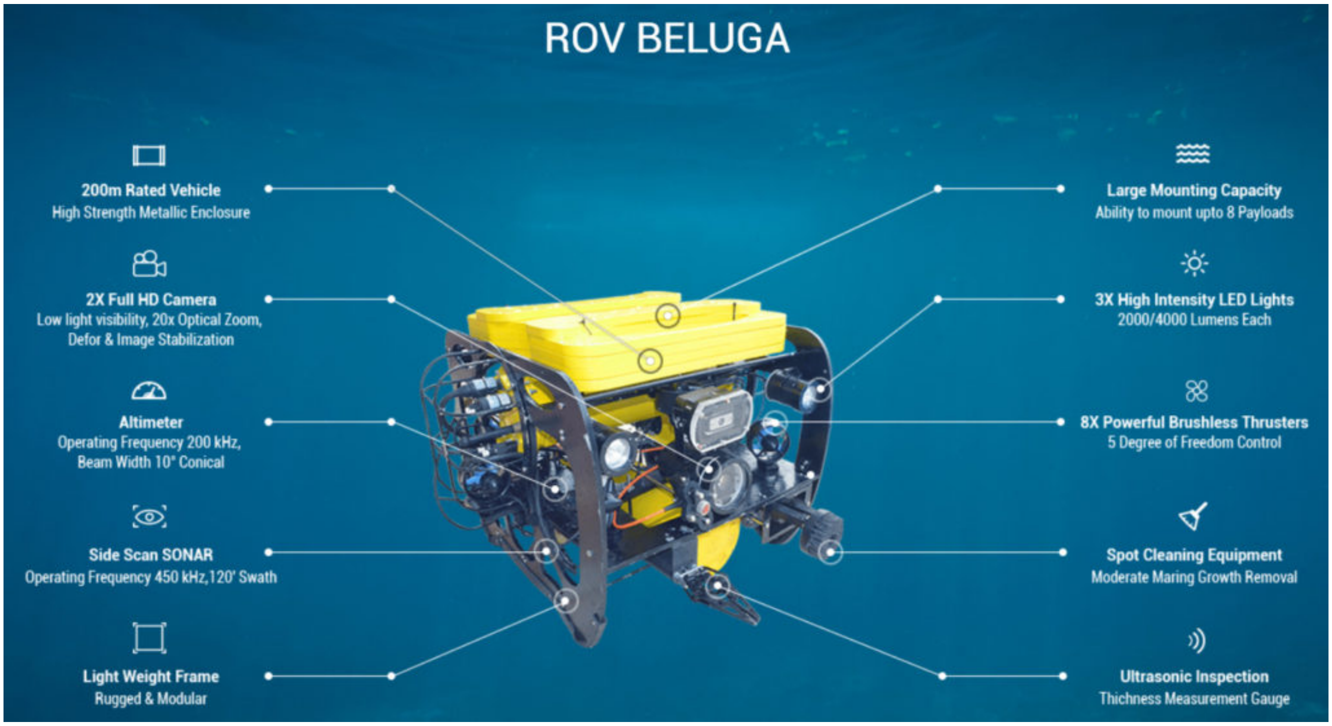
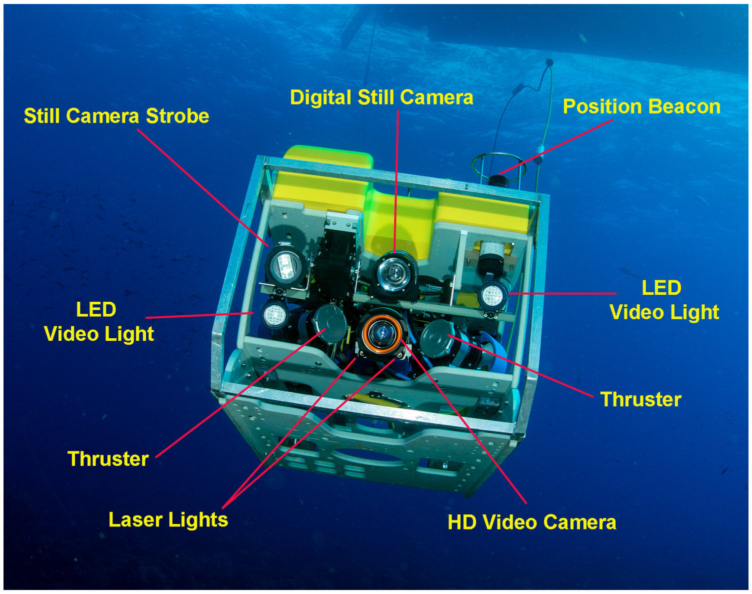


Image 3: Labeled ROVs also known as underwater drones.





Appendix A

MPA Glossary of Terms Unit 1 and Unit 2

Abalone: a mollusk with a flattened slightly spiral shell that has holes along the edge and is lined with mother-of-pearl.

Adorn: to enhance the appearance of especially with beautiful objects.

Area: a particular piece of ground or extent of space often set aside for special use.

Biodiversity: refers to the variety of species in a region; marine biodiversity refers to the variety in the ocean.

Biological: of or relating to biology or to life and living processes.

Blade (as it applies to kelp): a flat, leaf-like structure that grows out of a kelp's stipe.

Bladder (as it applies to kelp): a cavity found in various algae that contains gases and serves to keep the algae afloat.

BOFFF: Big, old, fat, fecund, female fish; larger, sexually mature female fish who are capable of producing more offspring than smaller, younger, female fish.

Carnivore: an animal that eats only other animals.

Characteristic (as it applies to biology): ways to describe organisms with things like multiple legs, stinging cells, tube feet, or having a hard shell.

Clam: a shellfish that lives in sand or mud and has a soft body surrounded by a hinged shell with two parts and that is often eaten as food. (Meriam)

Competition: the struggle between organisms of the same or different species for limited resources, such as food, light, or territory.

Consumer: an organism that must ingest or eat others to get their energy.

Crustacean: mostly aquatic invertebrates that includes crabs, lobsters, and shrimp.

Culturally: of or relating to culture.

Decomposer: an organism in a food chain that breaks down organic matter.

Dentalium: any of a genus (Dentalium) of widely distributed tooth shells.

Disperse: to cause to become spread widely.

Ecosystem: a biological community of organisms interacting with each other and with their physical environment.

Egg: a reproductive body produced by an animal and consisting of an ovum with its food-containing and protecting envelopes and being capable of development into a new individual.

Estuary: a passage where the tide meets a river current.

Fecund: fertile, producing or capable of producing new growth or offspring.

Fecundity: number of babies able to reproduce.

Fertile: capable of reproducing or of producing reproductive cells.

Food chain: the pattern of energy moving through a habitat from a producer through a series of consumers.

Food web: the interconnected feeding relationships within an ecosystem; composed of many food chains.

Fry (as it applies to fish): recently hatched or young fish.

Habitat: the natural environment of an organism that includes all it needs to stay alive, such as its home, food, shelter, and water.

Harbor seal: a seal with a mottled gray-brown coat and a concave profile, found along North Atlantic and North Pacific coasts.

Herbivore: an animal that eats only plants.

Heritage: something acquired from the past.

Holdfast: a part by which a plant (as a seaweed) or animal (as a tapeworm) clings (as to a flat surface or the body of a host).

Intertidal zone: of, relating to, or being the area that is above low-tide mark but exposed to flooding by the tide.

Invasive species a species that moves into an ecosystem and does harm to the other species living there.

Invertebrate: Animals that lack a backbone.

Juvenile: A young person, animal, or plant.

Kelp: Any of various large brown seaweeds.

Kelp Forest: Underwater ecosystems formed in shallow water by the dense growth of several different species known as kelps.

Keystone species: a species of plant or animal that produces a major impact (as by predation) on its ecosystem and is considered essential to maintaining optimum ecosystem function or structure.

Larva a developmental stage of an animal (after hatching from an egg) that appears different than the adult.

Life cycle: the life of an organism from birth to death; some organisms go through complex, many stage life cycles.

Management: the conducting or supervising of something.

Marine: of or relating to the sea.

Marine habitats: habitats found in the ocean, natural environments of organisms; in California primary habitats are sandy bottoms, rocky reefs, intertidal zones, kelp forest, and submarine canyons.

Marine Protected Area (MPA): an area of ocean/or ocean shoreline protected from human activities in order to conserve a natural resource or historically significant area; protections and restrictions on that area can vary, but almost all are still open to non-consumptive use, i.e. they can be visited but nothing can be taken or hurt in the area; also known as an MPA.

Meroplankton: temporary plankton; zooplankton in the egg or larva stage, that will live on the sea floor or become a powerful swimmer as an adult.

Model: a representation or example of an item or situation.

Mollusk a type of animal with a soft body and no backbone, such as an oyster, clam, mussel, snail, slug, or octopus.

Mussel: any of various edible saltwater mollusks with a long dark hinged double shell.

Network: an interconnected or interrelated chain, group, or system.

Ocean current: a tidal or non-tidal movement of lake or ocean water.

Omnivore: an animal that eats both plants and animals.

Organism: a living thing.

Photosynthesis: the process by which plants and algae convert energy from the sun into food.

Phytoplankton microscopic photosynthetic organisms that drift in the surface waters of the ocean. The beginning of most food chains in the ocean.

Plankton: Living organisms that cannot swim strongly and are carried around inside the ocean currents.

Planktonic: free-floating organisms moved by the tide or currents.

Population: the abundance of a particular species or group of species.

Prediction: an act of predicting.

Predator: an animal that hunts and eats other animals to survive.

Prey: an animal that is hunted and eaten by a predator.

Primary consumer an organism in a food chain that eats a producer.

Producer: an organism in a food chain that is able to make its own food using sunlight and chlorophyll.

Population all the members of one species in a particular area.

Recreation: a way of refreshing mind or body.

Regalia: the emblems and symbols (as the crown) of royalty.

Remotely Operated Vehicle (ROV): are robotic submarines that are tethered to a ship, where "pilots" control their movement and actions.

Replenish: to fill or build up again.

Rocky Reef: a chain of rocks or coral or a ridge of sand at or near the surface of water.

Sandy Beach: a sandy or gravelly part of the shore of a body of water.

Scavenger an animal that eats animals that are already dead.

Seal: any of numerous marine mammals that live mostly in cold regions, feed especially on fish, mate and give birth to young on land, and use short webbed flippers to swim and dive.

Sea lion: any of several large Pacific seals that have small ears on the outside of the body.

Secondary consumer an organism in a food chain that eats herbivores.

Seaweed: a plant-like organism growing in the sea.

Species a group of organisms that are physically similar and can produce offspring.

Spillover effect: overflow from one area to another; the spillover effect as it applies to MPAs is the ability for fish and other sea life to be replenished as populations move out of protected areas into adjacent areas.

Stipe: a stalk or stem, especially the stem of a seaweed or fungus.

Submarine Canyon: any of a class of narrow steep-sided valleys that cut into continental slopes and continental rises of the oceans.

Sustainable: a behavior that can be continued without having detrimental impacts.

Tertiary consumer an organism in a food chain that eats carnivores.

Tide pool: a pool of salt water left (as in a rock basin) when the tide recedes.

Top predator a predator in a food chain that no other consumer eats.

Transect: a sample area (as of vegetation) usually in the form of a long continuous strip.

Vertebrate: Species with a backbone.

Zooplankton: animals that drift in the ocean currents; different types are found at all depths from the surface down to the deepest depths.

Sources:

www.merriam-webster.com/

kids.britannica.com

oceana.org

hwww.mesa.edu.au

www.mbari.org

Appendix B

UNIT 2: GRADES 3-5
NGSS CURRICULUM ALIGNMENT:

Disciplinary Core Ideas:

3-LS1.1 From Molecules to Organisms: Structures and Processes: Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. (LESSON 3)

3-LS1.B Growth and Development of Organisms: Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (LESSONS 1, 3)

3-LS2.C Ecosystem Dynamics, Functioning, and Resilience: When the environment changes in ways that affect a places' physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into transformed environment, and some die. (LESSONS 1, 2, 4, 5, 6)

3-LS 3.A Inheritance of Traits: Many characteristics of organisms are inherited from their parents. Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (LESSON 3)

3-LS3.B Variation of Traits: Different organisms vary in how they look and function because they have different inherited information. The environment also affects the traits that an organism develops. (LESSONS 3, 4, 6)

3-LS4.B. Natural Selection: Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. (LESSON 4)

3-LS4.C Adaptation: For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. (LESSONS 3, 4)

3-LS4.D: Biodiversity and Humans: Populations live in a variety of habitats, and changes in those habitats affects the organisms living there (LESSONS 1, 2, 4, 5, 6)

4-LS1.A Structure and Function: Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (LESSON 1, 2, 3, 4, 6)

4-ESS2.E Biogeology: Living things affect the physical characteristics of their region (LESSON 4)

5-PS3.D Energy in Chemical Processes and Everyday Life: The energy released from food was once energy from the sun that was captured by plants (or algae) in the chemical process that forms plant matter (from air and water). (LESSON 2)

5-LS1.C Organization for Matter and Energy Flow in Organisms: Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. Plants acquire their materials for growth chiefly from air and water. (LESSONS 2, 3, 5)

5-LS2.A Interdependent Relationships in Ecosystems: The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms and therefore operate as decomposers. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. (LESSONS 1, 2, 3, 4, 5)

5-ESS3.C Human Impacts on Earth Systems: Human activities in agriculture, industry, and everyday life have had major effects on land, vegetation, streams, oceans, air, and even outer space.

But individuals and communities are doing things to help protect Earth's resources and environments. (LESSON 1, 2, 3, 4, 5, 6)

Science And Engineering Practices:

Analyzing and Interpreting Data: Use observations to describe patterns in the natural world in order to answer scientific questions.
Developing and Using Models: Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.
Planning and Carrying Out Investigations: Planning and carrying out investigations to answer questions or test solutions to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.
Obtaining, Evaluating, and Communicating Information: Read grade-appropriate texts and/or media to obtain scientific information to describe patterns in the natural world.
Constructing Explanations and Designing Solutions: Constructing explanations and designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.

Crosscutting Concepts:

Cause and Effect: Cause and effect relationships are routinely identified and used to explain change.
Patterns: Similarities and differences in patterns can be used to sort and classify, communicate, and analyze simple rates of change for natural phenomena.
Structure and Function: The shape and stability of structures of natural and designed objects are related to their functions.
Scale, Proportion, and Quantity: Natural objects exist from very small to the immensely large.
Systems and System Models: A system can be described in terms of its components and their interactions.