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ECOL 564
Lesson plan

Marine Life in a Desert Community

a. Project title or topic of activity: Echinoderms: A marine community of the Sonoran Desert

b. Author(s) & date: Janel Michels and Anna Alderman Nov. 22nd, 2009

c. Summary of activity (approx. 100 words)
The main goal of this workshop is to familiarize students with the Sea of Cortez and echinoderms native to the Sea of Cortez. Students will observe various types of echinoderms in order to understand how echinoderms are classified. The food chain of echinoderms will be displayed and students will learn about algae in echinoderms' diets. Algae in food products will be explored in order to relate an echinoderm's diet to a student's diet. Students will be creative and make biological art with algae. Finally, the workshop will connect what they have learned to the Sonoran Desert through conservation groups and threats to the Sea of Cortez including human activity in the Sonoran Desert.

Elevator Speech: Our workshop, "A Marine Community in the Desert," is designed to connect residents and visitors in the Sonoran Desert to the ecological communities surrounding them. This workshop focuses on echinoderms that live in the Sea of Cortez and how the terrestrial Sonoran desert ecosystems are related to these coastal habitats. You will learn how to identify echinoderms, what they eat, where they live, what is being done to protect echinoderms, and how the human actions in the Sonoran Desert affect the coastal habitats of echinoderms.

d. Target audience: Middle School Students to Adults

e. Introduction/ Background

Sea of Cortez

The Sonoran desert is a unique environment thriving with diverse flora and fauna uncharacteristic of many other deserts. Unlike most deserts, the Sonoran desert consists of two rainy seasons and is one of the wettest deserts in the world. The Sea of Cortez is one of the main geographic features responsible for the amount of water the Sonoran desert receives (http://www.desertmuseum.org/center/seaofcortez/). The Sea of Cortez is sandwiched within the Sonoran desert because it is located between Baja California and Northern Mexico/ Southern Arizona. The close proximity of the Sea of Cortez and Sonoran Desert has made both

ecosystems interdependent on each other. Many of the marine communities of the Sea of Cortez are directly affected by Sonoran desert activities such as pollution, run off, and urbanization. Land activity directly affects the Sea of Cortez since the primary fresh water source of the Sea of Cortez comes from the Sonoran Desert.

The Sea of Cortez is home to over 4,800 species of marine invertebrate, 15% of which are endemic (originated and live only in one specific area) (Mangin 2006). Invertebrates make up over 95% of Sea of Cortez marine animals and one important phylum of invertebrates found in the Sea of Cortez is echinodermata or "spiny skin." Echinoderms include sea urchins, sea cucumbers, sand dollars, sea star, and brittle stars. Invertebrates are found in the rocky reefs, coral reefs, and at the ocean floor and are particularly prevalent because of the warm temperatures of the Sea of Cortez. The surface temperature of the Sea of Cortez will remain fluctuate throughout the year from 50°F to the upper 80°F depending on the season (Case et al 2002). This temperature supports the algae, plankton, and coral on which invertebrates feed (Gotshall 1998). During the summer months when the water temperature increases, echinoderms move to deeper, cooler waters or remain in intertidal zones where tides were consistently moving in fresh cooler waters. Common predators to invertebrates include fish, crabs, and mammals (including humans). A delicate balance between environmental conditions, food availability, and predators is necessary to have a healthy ecosystem for echinoderms.

Echinoderms & Algae

Echinoderms are necessary in the Sea of Cortez because they control the algae population; without echinoderms, algae would take over coral reefs, blocking reefs from their light supply and causing them to die. However, if there are too many echinoderms, algae populations could diminish too low which could result in decreased water quality. Functions of

algae include cleaning oceans through pollutant consumption and producing oxygen necessary for marine life and even human survival. Pollutants that algae consume are nitrates, phosphates and ammonia, which are all fish and animal wastes. Marine algae are also important because they provide nutrients for many animals. If algae were eliminated from the ocean, invertebrates such as sea urchins, brittle stars, worms, and shrimp would not fare well (New World Encyclopedia 2008).

Fortunately there are hundreds of species of macro algae that are a constant food supply for echinoderms. Some common species of algae in the Sea of Cortez include sargassum, green turf algae, codium and encrusting corraline algae (www.seacortez.com). The depth of the water determines where each species grows because of light absorption by the water. Water absorbs red wavelengths first, and green algae need the red wavelengths to grow. Therefore, green macro algae lives closest to the surface of the water. Green macro algae can be seen in depths up to sixty feet. After sixty feet, brown algae becomes more abundant. Brown algae can be seen to depths of a hundred feet. Red algae can survive in the deepest depths, reaching approximately two hundred feet (Feuerbacher 2009).

The availability of food for echinoderms dictates where they can live. Since algae, plankton, and microorganisms are present at all depths of the sea, echinoderms are located throughout the ocean's depth. Although echinoderms are throughout the ocean, many are observed by humans in the intertidal zone. The intertidal zone is the area between high tide and low tide. Intertidal communities can be found on sandy beaches, in bays and estuaries, and along rocky shorelines where rocks are covered and uncovered daily by the ocean. The rocky shores, such as in Puerto Peñasco, Mexico are some of the most diverse and highly populated intertidal zones in the world.

Echinoderm Habitat: Intertidal Zones

The intertidal zone can be a very harsh living environment for echinoderms since the water levels are constantly fluctuating. During a low tide, the temperature fluctuates and species are exposed to air, sun and predators. In addition, strong currents during high tide may carry them back to sea, removing them from their habitat. To help with these difficulties many echinoderm have special adaptative features. For example, sea urchins carve holes in the rocks and hide in these holes that provide moisture during low tide. Many organisms use rocks for protection. Sea Stars, brittle stars and sea cucumbers have tube feet, which allow them to stay attached to rocks and not be carried out to sea. Their flattened body also allows them to hide under rocks for protection.

Threats & Conservation

At present the ecosystem has allowed echinoderms to survive in the Sea of Cortez. Yet, small shifts in food, shelter, or prey can have a detrimental effect on the echinoderm community. Currently there are many threats that may disrupt the harmony of echinoderms in the Sea of Cortez. As the Sonoran desert becomes more and more populated, pollution is a growing concern in the Sea of Cortez. Runoff from regions as far north as Tucson and Phoenix is making its way to the Sea of Cortez. This runoff collects pollutants that then deposit into the ocean. Algae helps control pollutants by consuming nitrates, phosphates, and ammonia which are all animal and agricultural waste. Human pollution also leads to larger problems such as global climate change; as the temperature of the earth increases, the waters will increase in temperature and disrupt ecosystem balance. Echinoderms have not been able to survive at higher temperatures as seen during the El Nino warming (Wellington 1985).

Humans not only cause pollution, but humans have also commercialized the Sonoran

desert and exploited the ecosystem through over fishing. Urbanization has led to habitat disruption along the low tidal regions. Urbanization has also exacerbated the scarcity of water in the Sonoran desert. The Colorado river is being overused and no longer provides as much freshwater to the Sea of Cortez (Shiva 2002). Additionally, over fishing has altered the ecosystem by decreasing the number of predators on echinoderm which can lead to overpopulation of echinoderms.

There are many different nonprofit organizations that have recognized the threats toward Sea of Cortez marine life. Conservation groups like PANGAS are working to maintain the balance of the reef fish in the Sea of Cortez through hatcheries (http://pangas.arizona.edu/en/public). Other groups work toward conservation of the diverse marine life by monitoring the ecological conditions of the region (http://www.icfdn.org/funds/seaofcortez.htm).

f. Credit for Activity

The activities were developed by Janel Michels and Anna Alderman with the aid of various on line sources such as: Robert Fenner*;* www.wetwebmedia.com and http://www.navmetoccom.navy.mil/educate/neptune/lesson/social/algae.htm

g. Time for activity: each activity would constitute 1 class period (1hr)

h. Outreach Goals

Youth Learning Objectives:

- To understand where the Sea of Cortez is located in conjunction to where they live.
- To characterize the phylum Echinodermata by observing the different echinoderms.
- To identify where echinoderms fit into the food pyramid and to recognize similarities and differences between what we eat and what echinoderms eat.
- To observe how external stimuli (pollution, light) can affect echinoderms and their food sources.

Adult Learning Objectives

- To understand how the Sea of Cortez relates to the Sonoran desert and how each ecosystem affects the other.
- To understand the diversity of species in the Sea of Cortez and why conservation is so important to the region.
- To understand how various species are interconnected and depend on each other for survival in the Sea of Cortez.
- To understand how terrestrial and marine ecosystems exchange nutrients.

- To understand the human influence on the Sea of Cortez and learn about outreach organizations that promotes conservation.

j. Materials needed

- Echinoderms (brittle star, sea urchin, sea cucumber)
- Salt Water (packets available at pet stores)
- Aerator (if having echinoderms out of aquarium for long periods of time)
- Bucket or aquarium (clear Tupperware works well)
- Algae (green, red, brown)
- Art supplies (crayons, pencils, colored pencils)
- Manila file folders (cut to 5x7 size)
- Wax Paper
- Large Book or other flat weight
- Food products with algae (brownie mix, coffee creamer, vitamins, relishes, toothpaste) OR food labels printed out (see web link below)
- Plastic tubs for invertebrates and algae
- Maps of the Sea of Cortez and Sonoran Desert with rivers
- Map of US/ North America
- Echinoderm anatomy handouts
- Pictures of echinoderms (see powerpoint slides)
- Intertidal zone hand outs
- pH Paper or pH meter
- test tubes with lids OR test tubes and stir sticks
- Ammonia Test Solution (can be purchased from pet stores)
- Hydrometer (can be purchased from a pet store)
- Nitrate Test Solution (can be purchased from a pet store)
- Freshwater, salt water, "polluted waters"

k. Preparation and tips for presenter(s)

Echinoderm care

- Make sure you allow the echinoderms to acclimate to the new water environments
    - You can begin by slowly adding foreign water to the echinoderm container
    - As you add more and more water the echinoderm will adapt to the new environment.
    - You can also place echinoderm in a bag filled with water that it was in and place the bag in the new environment
        - The bag of water will slowly adjust to the temperature of the environment and soon the echinoderm can be placed in the new aquarium or environment.

Algae Art Activity

- When using algae for art activity make sure you try to shake off any excess water.
- Use a heavy weight (large books) for the pressing of the algae.
- The fewer the disruptions to the art the better for setting/ pressing

Algae in Food Activity

- To make the activity more interactive use both foods with and without algae. Students will have to hunt through the labels.

Pollutants: Chemical water testing

- To engage students more encourage them to bring in water samples to test such as fish tank water or water from a stream. If you live near an ocean collect samples from various places or depths.
- A polluted water sample can be easily made by adding ammonia, calcium nitrate, and table salt to water.

l. Step-by-step procedure for the activity

Meet an Echinoderm

This activity makes a good introduction to evolutionary trees and classification. It can also be used as an observation activity.

1. Get a variety of echinoderms (sea urchin, sea cucumber, star fish); live are preferable but if they are not available, pictures will work.
2. Have students make observations about the different echinoderms
3. Write down similarities and differences between the types of echinoderms
4. Define the word echinoderm (spiny skin) to enforce the similarities.
5. Show students an evolutionary tree (http://content.tutorvista.com/biology_11/content/us/class11biology/chapter10/images/img18.jpeg)
6. Locate where echinoderms are on an evolutionary tree.

Algae Art Activity (Adapted from lesson plan by Robert Fenner*;* www.wetwebmedia.com*)*

1. Select a 5x7 manila file folder
2. Make an artistic design with crayons.
3. Add any type of algae to the picture.
4. Try to dry off the algae as much as possible before adding it to the picture.
5. Once you are satisfied with your artwork, place a piece of wax paper on top of it.
6. Move your artwork to a spot where it will not be disturbed and place a heavy book on top of it.
7. Leave the artwork for 48hrs undisturbed; when dry place in picture frame and display artwork.

Algae in Food Products

(From Lesson Plan: http://www.navmetoccom.navy.mil/educate/neptune/lesson/social/algae.htm)

1. Collect a variety of food products such as those listed in table 1 (Not all food products should contain algae)
2. For frozen foods cut off the label or photocopy a label.
3. Have students search for algae on the label (they should not find it).
4. Introduce the food definitions: alginate, carrageenan, and beta carotene
5. Have students look for the new words on the labels.
6. Record the type of algae in each of the food products.

Pollutants: Chemical Testing of Waters

Test 1. High Range pH Test

Why test pH? pH is the measure of acidity of a solution. A pH reading of below 7.0 is considered to be a basic solution and a 7.0 solution is neutral. A pH higher than 7.0 is acidic. Marine fish and invertebrates require a pH between 8.2 and 8.4. Maintaining the aquarium at the proper pH ensures optimal water quality. The high range pH test measures pH from 7.4 to 8.8 in saltwater aquariums.

Directions for Testing High Range pH

1. **Rinse** a clean test tube with the **saltwater** to be tested (NOT freshwater)
2. Fill the test tube with saltwater to the **5 ml** line
3. Add **5 drops** of high range pH indicator solution, holding dropper bottle upside down in a completely vertical position to assure uniformity of drops
4. Cap the test tube and invert tube several times to mix the solution. Do not hold finger over open end of the tube, as this may affect the test results.
5. Determine the pH reading by matching the color of the solution against those on the High Range pH Color Chart. The tube should be viewed against the white area beside the color chart.
6. Record results in the data table
7. Poor saltwater from the tube into the waste container then **rinse** the test tube with **fresh water**

Test 2: Ammonia

Why Test ammonia? Fish continually release ammonia directly into the aquarium through their gills, urine and solid waste. Uneaten food and other decaying organic matter also add ammonia to the water. Ammonia in the tank may burn their gills (it is like spraying windex in your eyes) and makes it hard for them to breathe. Ammonia levels should be 0.

Directions for Testing Ammonia

1. **Rinse** a clean test tube with the **saltwater** to be tested (NOT freshwater)
2. Fill the test tube with saltwater to the **5 ml** line
3. Add **8 drops** from Ammonia Test Solution **Bottle #1** holding the dropper bottle upside down in a completely vertical position to assure uniformity of drops added to water sample.
4. Add **8 drops** from Ammonia Test Solution **Bottle # 2** holding the dropper bottle upside down in a completely vertical position to assure uniformity of drops added to the water sample.
5. Cap the test tube and **shake** for **5 seconds**. Do not hold finger over the open end of the tube, as this may affect this test results.
6. **Wait 5 minutes for the color to develop.**
7. Read the test results by matching the test solution against the Ammonia Color Chart. The tube should be viewed against the white area beside the color chart.
8. Record results in the data table
9. Poor saltwater from the tube into the waste container then **rinse** the test tube with **fresh water**

Test 3 Nitrite Test

Why test nitrite? Bacteria within the tank help control ammonia levels by eating it. In turn, after bacteria eat the ammonia, they produce nitrite as a waste product. High nitrite levels makes it harder for fish to breathe because it burns their gills (just like ammonia). Nitrite levels should be 0.

Directions for Testing Nitrite

1. **Rinse** a clean test tube with the **saltwater** water to be tested (NOT freshwater)
2. Fill the test tube with saltwater to the **5 m**l line
3. Add **5 drops** of Nitrite Test Solution, holding the dropper bottle upside down in a completely vertical position to assure uniformity of drops added to the water sample.
4. Cap the test tube and shake the tube for 5 seconds. Do not hold finger over the open end of the tube, as this may affect test results.
5. **Wait 5 minutes for the color to develop**
6. Read the test results by matching the color of the solution against those on the Nitrite color Chart. The tube should be viewed against the white area beside the color chart.
7. Poor saltwater from the tube into the waste container then **rinse** the test tube with **fresh water**
8. Record results in the data table

Test 4: Salinity

Why test salinity? Salinity is critical for fish to maintain their own internal salt concentrations. If salinity levels are too high, the fish won't be able to excrete (get rid of) the extra salt. Just like humans, if we eat too much salt in a given period of time, then we could have kidney failure and die. The normal range for salinity 32ppt – 37ppt. ppt = parts per thousand

Directions for Testing Salinity (Hydrometer)

1. Rinse the outside and inside of the hydrometer with freshwater to rid any old saltwater
2. Fill the hydrometer to the top with saltwater
3. Place the hydrometer on a level counter and read the number at eye level (your eyes should be in line with the floating arm)
4. Record results and pour saltwater back into the original saltwater container (you can do this because there are no test chemicals in the water).
5. Rinse the inside and outside of the hydrometer with freshwater

m. Images, work sheets, web links

- Echinoderm coloring pages at: http://www.enchantedlearning.com/subjects/invertebrates/echinoderm/
- Algae in Food Product Lesson Plan: http://www.navmetoccom.navy.mil/educate/neptune/lesson/social/algae.htm http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/education_lesson1.html
- Algae art lesson: http://www.aquarticles.com/articles/literature/fenner_macro-algae.html
- A good book on Sea of Cortez marine life with great pictures: Gotshall, D.W. (1998) Sea of cortez marine animals. CA: pg 82-104.
- Sea of Cortez marine life: www.seacortez.com
- Outreach link for Sea of Cortez Fund: http://www.icfdn.org/initiatives/SOC4_files/frame.htm
- Evolutionary Tree: http://content.tutorvista.com/biology_11/content/us/class11biology/chapter10/images/img18.jpeg
- Below attached worksheet for water chemistry activity (see Appendix A)
- Powerpoint pictures and information of presentation/ echinoderms (algae.ppt, echinoderm.ppt, habitat&threats.ppt)
- Poster: amarinecommunityinthedesert.ppt

n. Items for discussion (or conclusion)

Meet an Echinoderm

- What characteristics do all echinoderms have in common?
- What differences do echinoderms have?
- How do scientists use observation in classifying organisms?

Algae Art

- Where do artists get inspiration to create masterpieces? Where do you find inspiration?
- Prior to modern artistic tools (markers, paints, crayons, pencils), people still created art. How were they able to create artwork?
- In what other ways do people use nature for their benefit and enjoyment?

Algae in Food Products

- What chemicals are in the foods that you eat?
- Why are there so many ingredients in what you eat?
- Knowing what algae is used for in food products; predict other foods that might have algae in them.

Pollutants: Chemical testing of Water

- When you think of the ocean, it is usually clear, blue and clean like the Caribbean. However, fish have been using the ocean as their toilet for hundreds of millions of years. (Why do you think the ocean isn't overflowing with fish waste?)
- What other chemicals besides salt and fish waste do you think make up saltwater?

i. questions to participants

- How are marine animals connected to the sonoran desert?
- Have you ever seen an echinoderm (sea star) anywhere? Where do you think they live?
- How are you like an echinoderm?

- What do different echinoderms have in common?
- How do you affect the Sea of Cortez?
- Where can you go if you want to learn more?
- Where does water from the Sonoran Desert flow?
- How do people utilize the sea? Terrestrial animals?
- What do you think is a healthy environment for fish and marine animals?
- The intertidal zone is a common area to find star fish. What makes this region a good living environment for star fish?
- The Sea of Cortez is located in Mexico; how does this affect public policy surrounding the ecosystem?
- Based on the research related to El Nino warming, how do you think global warming will affect the life in the Sea of Cortez?

o. Assessment Questions

The following questions can be used as forms of assessments to gage student learning.

1. You are a deep sea diver and have just discovered a new type of Echinoderm (at least you think it is an echinoderm). Draw a picture of your echinoderm and make a list of characteristics that it has that makes you think it is an echinoderm.
2. Make a list of things that happen in Tucson that affect the ecosystem of the Sea of Cortez. For each item explain how it affects the Sea of Cortez.
3. After learning about the Sea of Cortez, create a nonprofit group with the mission of raising awareness of threats to the Sea of Cortez. What information would you want the public to know? Create a brochure, poster, or webpage to provide this information to the public.
4. Look through your pantry and refrigerator at home and find 20 products. Determine if they contain algae and what kinds of algae they have.
5. OH NO! The Sea of Cortez has just fallen victim to a huge chemical spill from a local industrial factory. All the echinoderms and algae need to be placed in a new habitat. You need to create this habitat. What would the habitat look like? Draw and describe the habitat in as much detail as possible.

p. Beyond the Activities

To extend this activity, students and teachers could begin studying water quality in their region and look at how water quality affects both terrestrial and marine life indigenous their region. A connection to the Tucson region would be to look at how environmental pollutants such as TCE (trichloroethylene) have contaminated the ground water in South Tucson. Students can research ways to correct environmental pollution.

To extend this activity from a biological approach, students could look at conservations efforts at the Sea of Cortez and take a field trip to study the intertidal zones, pollutants, and fishing threats

in the region. If a field trip is not a plausible option, a class could put together a fundraiser to raise money for conservation groups or adopt an animal or region in the Sea of Cortez.

The anatomy of echinoderms and other marine life could be studied through dissection. Dissection kits can be purchased at: Carolina Biological Supplies: http://www.carolina.com/

q. Web Resources

(see section m)

r. Additional References

Case. T.J., Cody, M.L., and Ezcurra, E. (2002) A new island biogeography of the sea of cortez. NY: 49.

Feuerbacher, Olin. Re: Questions for essay" E-mail to Anna Alderman. 26 Sept. 2009.

Feuerbacher, Olin. (2009) Sea of Cortez < http://www.seacortez.com/>.

Gotshall, D.W. (1998) Sea of cortez marine animals. CA: pgs 82-104.

Lea, Robert N. and Rosenblatt, Richard H. (2000) Observations On Fishes Associated With The 1997-1998 El Nino Off California. CalCOFI Rep., Vol. 41. pgs 117-129.

Mangin, K. (2006) University of Arizona guest lecture

Miller. R.J. and Colodey, A.G. (1983) Widespread mass mortalities of the green sea urchin in Nova Scotia, Canada. Marine Biology. Volume 73, Number 3. pgs 263-267.

PANGAS (2009) University of Arizona. < http://pangas.arizona.edu/en/public>.

Sanchez-Velasco et al. (2004). Fish larvae abundance and distribution in the central Gulf of California during strong environmental changes (1997-1998 El Nino and 1998-1999 La Nina). Deep Sea Research Part II. Volume 51. pgs 711-722.

Scheibling, R.E. (1984) Echinoids, epizootics and ecological stability in the rocky subtidal off Nova Scotia, Canada. Helgoland Marine Research. Volume 37, Numbers 1-4. Pgs 233-242.

Sea of Cortez (2009) Desert Museum <http://www.desertmuseum.org/center/seaofcortez>.

Sea of Cortez fund (2009) International community foundation < http://www.icfdn.org/funds/seaofcortez.htm>

Shiva, V. (2002) Third world traveler: water wars. South end press: pg 4.

Wellington, G.M.; Victor, B.C. (1985) El Nino mass coral mortality: a test of resource limitations in a coral reef damselfish population. *Oecologia*. 68: 15-19.

Solis-Marin et al (2005) Revista Biologia Tropical

s. Key words/ glossary

- Echinoderm: spiny skin; phylum that includes brittle stars, basket stars, sea urchins, sand dollars, sea lilies, feather stars, and sea cucumbers
- Endemic: Originated in and found only in a certain region
- Intertidal Zone: the area of a coast that is exposed to the air at low tide and is underwater at high tide

- Carrageenan: term for compounds extracted from species of red algae used in stabilizing and gelling foods, cosmetics, pharmaceuticals, and industrial products.
- Beta Carotene: a natural pigment from green algae used as a yellow-orange food coloring in food products and is currently believed to help prevent certain forms of cancer.
- Alginates: extracted from brown algae used to make water-based products thicker, creamier, and more stable over extreme temperatures and time, making the product last longer.
- English to Spanish vocabulary

English	**Spanish**
Sea of Cortez = Gulf of California	Golfo de California
Echinoderms	equinodermos
Starfish	Estrella de mar
Algae	algas
Desert	desierto
Coral Reef	los arrecifes de coral
Rocky Reef	rocosas arrecife
Intertidal Zone	zona intermareal
Sea cucumber	cohombro
Fishery	pesquería
Sea Urchin	Erizo de Mar
Endemic	Endémico
Sonoran Desert	Desierto de Sonora
Habitat	Hábitat
Ecology	ecologia
Nutrients	Nutrientes

t. Acknowledgement
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u. Assessment of Workshop
Various teaching strategies were used to help us meet our goals for the workshop. We provided an assortment of visual aides such as pictures of echinoderms, charts and maps for the public to browse as well as verbal explanations and guided exploration through touch tanks and algae scavenger hunts. Depending on how long and interested the public was about our topic, all or many of our goals were met. A few goals that we accomplished during every presentation included the observation and identification of different echinoderms and characterization of the phylum Echinodermata, how echinoderms they fit into the food pyramid, and how various species are interconnected and depend on each other for survival in the Sea of Cortez. Immediately when people came to our tables they were drawn to the echinoderms. As they were touching the echinoderms, we talked about their anatomy, where they live, what and how they eat, why they are important and how they are being affected within the Sea of Cortez.

Another goal that we met during every presentation included the recognition of similarities and differences between what we eat and what echinoderms eat. The algae scavenger hunt was a success with everyone regardless of age. They were able to make predictions about which food contained algae and they type of algae that was found in the food. The food pyramids and phylogeny visuals provided at the tables emphasized the interconnection and dependence on each other. Various maps and verbal explanation that were illustrated helped people learn where the Sea of Cortez is, how the Sea of Cortez relates to the Sonoran desert and how each ecosystem affects the other. Maps emphasized water flow to the Sea of Cortez, the location of the Sea of Cortez, the Sonoran Desert and surrounding states and countries. Verbal explanations were given about how things such as pollution and agricultural run off affect the marine ecosystem. Even though we only focused on echinoderms and algae, we emphasized the diversity of species within the Sea of Cortez through pictures and written posters at the tables. Depending on how long people stayed at our tables, we were able to discuss in more detail, why conservation is important to the region, how external stimuli (pollution, light) affect echionderms and their food sources and how humans influence on the Sea of Cortez.

v. Summary Evaluation and Recommendations (what worked and didn't work in your workshop? what would you keep, what would you change?; 50 points)

The workshop appeared to be overall a success in terms of teaching about echinoderms and similarities among the phylum echinoderm. Having a variety of live echinoderms that people could touch was a great way to engage the audience and get them interested in the topic. The public was drawn to the table due to the unique invertebrates that were presented.

As the public were drawn to the table of echinoderms, many people did not know where the Sea of Cortez was located (echinoderms were introduced as being from the Sea of Cortez). A modification was made in order to depict where the Sea of Cortez was located by having a map present at the table, initially the map was at another table. Many audience members were from the Sonoran Desert region (some were from as far as Canada) and having a larger map of North America with the Sea of Cortez labeled would have been helpful. It also might have been more helpful to have the poster on an easel so it was closer to reference and point to. The poster had maps of the Sea of Cortez, but since it was too far away it was hard to use the maps. Additionally at the echinoderm table, people constantly were asking what is that? Names were not put in front of the different echinoderms since the table was supposed to always be manned with a representative. Over the course of the workshop, it became important to have names in front on each echinoderm so people could easily read what species they were. For the next workshop the scientific name of each species should be included as well as directions for handling echinoderms.

The table with food products containing algae was set up to be interactive and required little from the workshop administrators. Generally there was a brief introduction and then the public was able to explore the food products; families were very interested in this and laughed and joked about eating algae. One thing that didn't work well was that there was not clear transition between the algae in food and echinoderms. Many people would come to the table and ask what these foods have to do with echinoderms; as soon as it was explained, the public understood the connection. Additionally this table provided additional information about conservation and threats to echinoderms. It worked well to have an activity with all the conservation information. Children could look at the algae in food activity while adults could read about conservation and threats.

The third able was set up to have algae art for kids. A few kids stayed and created art or colored pictures of echinoderms. The problem with this table was that the kids could not take their artwork with them since it had to be pressed for over 24 hrs. It was good to have different examples of algae but the art work was probably not the best activity. It might have worked better to have the algae out for people to touch and feel and then have coloring pages on echinoderms for kids. In a classroom setting the algae art would have worked better.

Overall, the food with algae and the live echinoderms were key to the workshop being successful. It was also important to have information about threats and conservation so those that were interested could get more information. The algae art activity should probably be excluded from future workshops that are not done in a classroom environment. Additional information could also be added to show a transition between the echinoderms and the algae in foods.

v. Refinement

After the conclusion of the workshop, it was noted that some of the connections between conservation and pollutants were weakly demonstrated. Overall the feedback showed that the public enjoyed the workshop and learned much from the presentation. After evaluating the effectiveness of each activity, it was decided that in redoing the workshop that an activity related to water pollution would help the public see the impact between human activities and marine life. The lesson plan was modified to include an additional activity or an activity that could take the place of the Algae art. Various samples of water ranging from fresh water to salt water would be collected and presented to the public for chemical testing. The water samples would be tested for nitrates, ammonia, salinity, and pH which are all indicators of pollutants (both biological pollutants from marine animals and agricultural runoff). This activity would help people see how pollution is tested and what chemicals are present in marine environments. This activity would also make for a bigger picture connection for the audience. Most audience members learned information about echinoderms and algae, but fewer audience members learned about conservation and threats. The water chemistry activity would hopefully address the educational objectives relating to conservation and threats and make the ecological message more of a presence in the workshop.

Table 1: Food products with Algae

Food	Carrageenan	Alginate	Beta Carotene
Brownie Mix		X	
Cheese			X
Chocolate milk	X		
Coffee creamer	X		X
Cottage cheese	X		
Egg Substitute			X
Evaporated milk	X		
Frozen Foods		X	X
Ice Cream	X		X
Baby Formula	X		
Margarine			X
Mayonnaise			X
Multi Vitamin			X
Relishes	X	X	
Salad dressing		X	X
Sour Cream	X		
Toothpaste	X		
Yogurt	X		

APPENDIX A

Name:_____

Name:_____

Name:_____

Date:_____

Period:____

Record your results in the data table below

Test	Actual Chemical Level	Recommended Chemical Range	Normal or Not Normal
High Range pH			
Ammonia			
Nitrite			
Nitrate			
Salinity			

Questions for pH:

1. What pH range is considered to be basic? Neutral? Acidic?

2. What other things besides saltwater do you think would be acidic?

3. What things do you think would be basic?

Questions for Ammonia:

1. Where does ammonia come from?

2. Why is it important for you to test ammonia in your tank? Explain IN YOUR OWN WORDS.

Questions for Nitrite:

1. Where does nitrite come from in the chemical cycle?

2. Why is it important to test? Explain IN YOUR OWN WORDS

Question for Nitrate:

1. Is nitrate more or less toxic for fish than nitrite?

Questions for Salinity:

1. What happens to the fish if salinity is too high in the tank? Explain IN YOUR OWN WORDS.

2. What is the mechanism you used to test salinity?

Conclusion Questions:

1. Which chemical tests were not normal?

2. Why do you think this is the case?

4. On a separate sheet of paper, draw your own diagram to represent the chemical cycle in the ocean.

Chemical cycle

- Fish are fed
- Fish waste is turned into ammonia
- Ammonia eating bacteria consume the ammonia
- The waste product of ammonia eating bacteria is nitrite
- Nitrite is eaten by a nitrite eating bacteria

- The waste product from nitrite eating bacteria is nitrate
- Nitrate is eaten by algae and other species of bacteria
- Algae turns the nitrate into energy using photosynthesis and the nitrate eating bacteria turn it into nitrogen gas which is bubbled out of the ocean

Intro to Inter tidal Zones

Objective:

1. Draw and label the various zones within the inter tidal habitat.
2. Describe several organisms that live within the inter tidal habitat and the challenges they face living within that habitat.

Standards: **Strand 4: Life Science. Concept 4: Diversity, Adaptation, and Behavior**

- Identify structural and behavioral adaptations. (SC08-S4C4)

  PO 1. Explain how an organism's behavior allows it to survive in an environment.

  PO 2. Describe how an organism can maintain a stable internal environment while living in a constantly changing external environment.

ELL Standards: Acquire English language vocabulary and use it in relevant contexts

Tasks:

1. Read the inter tidal article. On a separate sheet of paper, write the title "Inter Tidal Zones" Complete the following tasks:
   a. Describe several organisms that live within the inter tidal habitat and the challenges they face living within that habitat.
   b. Draw and label the various zones within the inter tidal habitat.
   c. Add the bolded words to your word bank paper making sure to define the words in your own terms and draw a picture to represent each word.
2. Color the inter tidal handout according to the key.
3. Choose at least one animal from each zone to construct out of clay. Begin constructing your animals.

Resources: www.http://ports/parks.ca.gov

http://omp.gso.uri.edu/doee/science/biology/inter4.htm or

http://omp.gso.uri.edu/doec/science/biology/inter4.htm

Where is the Intertidal Zone?

The **Intertidal Zone** is where the land meets the sea. It is the area between high tide and low tide. Intertidal communities can be found on sandy beaches, in bays and estuaries, and along rocky shorelines. The rocky shores are the most diverse and highly populated. In this area where rocks are covered and uncovered daily by the ocean, unique and diverse tide pool communities are formed.

The marine animals living in the intertidal zone are unique because of their ability to withstand exposure to air, severe and varying weather conditions and the force of the pounding waves. In spite of these challenges, it is still one of the most highly populated areas. The lowest levels of the Intertidal Zone are the most crowded with life and the higher, dryer levels are less populated. The organism's adaptations depend on where in the Intertidal Zone it will be found.

What are the different regions of the Intertidal Zone?

The Intertidal Community is composed of several different regions that differ depending on tidal and wave exposure and life within the zone. The different conditions in each region allow for a great diversity of marine life. This can also lead to a competition among organisms for limited space on the rocky shore.

The Intertidal Zone is divided into four specific regions:

1. **Splash Zone** – This zone has complete air exposure. Organisms are moistened by spray, highest tides and storm waves only.
2. **High Intertidal Zone** – This zone is covered and exposed twice daily during high and low tides.
3. **Mid Intertidal Zone** – This zone is exposed and covered by most high and low tides. Many creatures will require tidal rhythms.
4. **Low Intertidal Zone** – This zone is only exposed to air for a few hour monthly.

Each region in the Intertidal Community has organisms particular to that environment. Which region the organism can be found in depends on its ability to adapt to those surroundings. These organisms can include algae,, barnacles, sea urchins, mussels, crabs, sea stars, sea anemones, sponges, jellyfish, fish, lobster, shrimp, clams, and many more.

How do animals adapt to living in this community?

The Intertidal Zone is a very harsh living environment for organisms because its ever changing conditions. Animals in this zone are constantly facing challenges such as varying salinity, drying

out by wind and sunlight, predators, strong currents that carry them back to sea, and varying weather conditions. To help with these difficulties many organisms have special adaptation features. Some animals, such as sea urchins, carve holes in the rocks and hide in these holes that provide moisture during low tide. Mussels and other shell organisms will tightly close their shell to keep in moisture. Snails secrete a slime that gives them moisture during the long hours of low tide and anemones will fold in their tentacles to hold in moisture. Each of these techniques help the creatures from drying out. Many organisms use rocks to help with this problem. Sea Stars and anemones have suction cups, which allow them to latch onto rocks so they are not carried out to sea. Mussels use a thread-like substance called byssal threads that stick to the rocks. Anemones have a unique jelly-like body, which can withstand the crashing waves. For the same reason, sea stars have a strong leathery coating, and many shell organisms such as barnacles have hard shell covering. As stated previously sea urchins carve holes in rocks and can hide in these holes. Snails can also carve places for protection in rocks. Many other organisms, such as periwinkles and crabs, can hide in cracks and crevices of the rocks for shelter

Color Key for Zonation and Intertidal Life Worksheet

Splash Zone

Acanthina - browns

Bluegreen algae - green

Nerite - black

Isopod - tan

Acorn barnacles – cream or white

High Intertidal Zone

Cerith – black and white

Sun star – red and orange

Amphipod – tan or green

Chitons - black

Turban shell – green and white

Limpets – tan, browns

Rock oyster - white

Mid Intertidal Zone

Brittle star – most colors

Crab - oranges

Flatworm – white, browns or black with red, pink and blue polka dots

Mussel – browns and blacks

Cone shell – oranges, browns

Sponge – most colors

Padina - brown

Anemone – most colors

Sea cucumber – green with yellow dots

Chione - black

Tube worms – most colors

Melon snail - cream

Hermit crab – red or blue

Low Intertidal Zone

Gorgonian – most colors

Sargasum – brown or green

Nudibranch – most colors

Octopus - browns

Colonial anemone - green

Sea star – most colors

Spiney sea urchin - purple

Swimming crab - browns

Tower shell – brown and white

Cockle – orange and white

Sand dollar - purple

Scallop – pinks, oranges, yellows

Conch – white and brown

Build An Intertidal Zone

Objective:

1. Using sand, water and various types of rocks, design and construct a desk top inter tidal habitat labeling the various zones in the inter tidal habitat.
2. Design and construct various organisms that live within the inter tidal zones using clay and place them into the appropriate inter tidal zones.

Standards:

Strand 4: Life Science. Concept 4: Diversity, Adaptation, and Behavior

• Identify structural and behavioral adaptations. (SC08-S4C4)

PO 1. Explain how an organism's behavior allows it to survive in an environment.

PO 2. Describe how an organism can maintain a stable internal environment while living in a constantly changing external environment.

ELL Standards: demonstrate understanding of print concepts of the English language

Tasks:

Part One: Using your knowledge about the inter tidal zones (zones one, two three and four), create a desk top tidepool using sand, water and various types of rocks,

Part Two: Design and construct various organisms that live within the inter tidal zones using clay and place them into the appropriate inter tidal zones. What adaptations do these animals have that you think allow them to survive within this zone. Think about the special challenges they might face such as waves, temperature, predators, etc.