SUPPORTING MATERIALS 4

K-12 Curricular Materials

Alamitos Bay Olympia Oyster Restoration Field Trip Opportunities

Orange County Coastkeeper is a 501(c(3) non-profit organization, founded in 1999, whose long-term goal is to protect and preserve the region's water bodies and restore them to healthy, fully functioning systems that will protect recreational uses and aquatic life. In pursuit of this goal, Coastkeeper balances advocacy, education, restoration, research, and enforcement to increase awareness of environmental issues and reduce pollution of the region's watersheds and coastal waters.

In early 2012, Coastkeeper teamed up with Dr. Danielle Zacherl, Associate Professor in the Department of Biological Sciences at CSU Fullerton, to implement a native Olympia oyster restoration project in Alamitos Bay in Long Beach, CA. Oysters, which provide several ecological functions including function as a habitat for numerous marine species and improvement of water clarity. The project will restore native oysters, which have been severely diminished due to overharvest, in the Jack Dunster Marine Reserve in Alamitos Bay over the next four years.

Another important component of this project is public outreach and education. The overarching goal of this component is to provide an opportunity for local K-12 students to participate in a field trip to the Reserve to take part in hands-on scientific activities and encourage our future environmental stewards to get excited about science and hopefully become involved in the project in the long-term!

Goals

- To provide field-based STEM (Science, Technology, Engineering, and Math) education
- To increase environmental literacy through the study of local coastal issues
- To foster in our students environmental stewardship and community involvement
- To encourage students to explore science-related career opportunities.
- To promote sustainable restoration and conservation activities through an educated and concerned public.

Program Activities

- A Coastkeeper marine biologist will visit each class for a short presentation to introduce ecological concepts and fun facts about oysters prior to the field trip.
- Students participate in a one-day field trip to the Jack Dunster Marine Reserve to work with project scientists and carry out their own scientific experiments, including measuring water quality, learning about filter feeding organisms and demonstrating coastal ecological processes.
- Students will complete a worksheet during the field trip to take home for teachers to use to assess student performance.
- Coastkeeper will update our website with program photos and descriptions so students can share the experience with friends and family.

Need

Natural resource conservation is a major issue in today's society, especially in highly urbanized areas like Orange County. Restoration projects abound as numerous marine habitats and species are negatively impacted by human activities, particularly on land. Public education and concern is vital to the success of such projects, and the need for future environmental stewards is even more important. Unfortunately, most schools in the region lack the resources to bring this type of real-world environmental education to their students. Coastkeeper aims to continue our effort to provide students with hands-on science education that connects classroom curriculum to natural resource conservation issues in their community using local restoration projects to provide much-needed hands-on experience.

Audience Served

The native Olympia oyster restoration project, which is located in Alamitos Bay in Long Beach, CA provides a unique opportunity for local K-12 students to participate in a local conservation project, one that they can become involved in for many years. In addition, there is a particular need for STEM programs (Science, Technology, Engineering, Mathematics) in California schools. This project will incorporate aspects of each of these fields of study in a way that is fun and exciting for students, while teaching a comprehensive curriculum based on California Science Standards and Next Generation Science Standards that will build upon concepts taught in the science classroom. For this reason, Coastkeeper focuses on the following audience:

- K-12 students
- Classes include: Biology, Chemistry, Mathematics, Earth Science, AP Environmental Science, Marine Science, junior high science, AVID, Special Education, English Language Development
- Students who are interested in pursuing careers in an environmental field
- Anyone wishing to fulfill their need to help save the environment in any way possible!

Funding

The native Olympia oyster restoration project has been funded in whole by the NOAA Habitat Restoration Center and the State Coastal Conservancy. Support directly funds buses, materials, and the organization of lessons and field trips for students.

To get involved, please contact Amanda Bird **at 714-850-1965 or amanda@coastkeeper.org. Learn more at http://www.coastkeeper.org/wetlands-harbors-bays/oysters/**

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ORANGE COUNTY COASTKEEPER.

Typical Field Trip Outline

Preparation and Scheduling

Coastkeeper will coordinate field trip activities with all involved parties, including teachers and the City of Long Beach and/or other businesses/organizations that will provide permission for activities or contribute to field trip activities. We ask only that teachers coordinate with their respective school/district and order and confirm buses and substitute teachers, if necessary. Coastkeeper will provide directions, field trip schedule, and contact information to teachers, bus drivers and the school and will provide the required number of Coastkeeper liability waivers and parent information forms for all students attending the field trip.

Funding

Coastkeeper will either reimburse bus and substitute teacher fees to the school/district or pay these expenses directly, whichever is preferred. We ask that expenses be limited to one substitute teacher per field trip day. The number of buses needed will be coordinated between the teacher and Coastkeeper and will depend upon the number of students and availability of funding. Coastkeeper will fund all other educational expenses associated with the field trip including printing worksheets for students and supplies needed for field trip activities (e.g., pens, clipboards, water quality testing equipment, and other materials needed to perform filter feeder and marine life identification activities).

Typical Field Trip Schedule

- **One-month prior –** teacher coordinates field trip with school; recruits students to determine a final number of students to attend; and orders bus/buses based upon number of expected students.
- **Two to three weeks prior (if requested by teacher) –** Coastkeeper Marine Biologist visits all classes with students who will be participating to introduce the project and talk about related ecological concepts part of California Science Standards and Next Generation Science Standards; Coastkeeper provides liability waivers and parent information forms for students.
- **One week prior** – teacher/Coastkeeper confirms bus/buses; Coastkeeper confirms activities with involved parties.
- **Day of** –
    - Departure time will depend upon school location.
    - 9am – students and teacher(s) arrive at the Jack Dunster Marine Reserve in Alamitos Bay.
    - 9:30 – 11:30am – students and teacher(s) participate in hands-on activities at JDMR including water quality testing, marine life identification, filter feeder experiment activities, and other related activities, working directly with project marine biologists and documenting work on a worksheet developed by Coastkeeper.
    - 11:30am – 12:15pm – lunch at JDMR.
    - 12:30 – 2:00pm – Travel to the Colorado Lagoon to have lunch at a park adjacent to the lagoon and do a shell string building activity after lunch.
    - 2:00pm – students return to school.

Field Trip Goal: To learn and have fun "in the field"!

Alamitos Oyster Restoration Project Schools
Spring 2013

School:	City:	Teacher(s):	Class:	#Students In-class:	# Students field trips	Field trip date(s):
Helen Stacey Middle School	Huntington Beach	Tina Dandridge, Dana Faulkner	6th grade math (4), English as a Second Language (1), Special Education (1).	170	170	4/29, 4/28, 5/1, 5/2
Wilson High School	Long Beach	Georgia Cunradi	Earth Science	105	44	5/22
Lakewood High School	Lakewood	Stephanie Bauer	Odyssey Academy Marine Biology	110	30	5/20
Lakewood High School	Lakewood	Lindsay Bobo	Biology	122	40	5/29
			Totals:	**507**	**284**	

Coastkeeper Game Plan: Wilson HS Oyster Field Trip 05/22/2013

Georgia's Cell: **Amanda's Cell:**
Wilson HS: (562) 433-0481

Learning Objectives- Students will:

- Describe the importance of estuaries/wetlands, and how we can help protect this vital ecosystem
- Explore the ecological and economic roles of oyster habitat and function within a wetland ecosystem
- Explain how specific morphological traits allow the oyster to adapt to changes in the physical and chemical characteristics of the environment
- Understand how certain environmental and water quality parameters can affect the health of marine life, especially the growth and survival of filter feeders and associated organisms, and to determine how changes in these parameters may affect oyster habitat in Alamitos Bay.
- Identify benefits and values (e.g., ecological, economic, and social) of oyster and wetland habitats to humans, wildlife, and the Alamitos Bay ecosystem/food web

Field Trip:

9:00 Bus arrives at Jack Dunster Marine Reserve (JDMR) in Alamitos Bay (map below)

9:00 – 9:30: Introduction to JDMR, handout worksheets, divide students into 4 groups

9:30 – 11:30 (Revolving 40-minute stations):

Station 1: Filter Feeders and Estuarine Water Quality

- Observe and discuss real-time filter feeder action and the potential effects of ocean acidification on mollusks, and investigate filter feeder anatomy as it relates to the ability to obtain energy through filtration of nutrients and water from its surroundings. Students will perform water quality sampling from dock using various testing equipment, compare and discuss results, and briefly talk about how oyster morphology and function affects water quality and vice versa.

Station 2: Oysters as Essential Habitat

- Students will compare organism abundance and distribution between a mudflat populated with filter feeders (i.e, shell string) and an unpopulated mudflat (e.g., mud collected from bay floor) by identifying general groups of organisms; estimating abundance, biomass, and overall diversity; and discussing relationships among major taxonomic groups observed.

Station 3: Estuarine Biodiversity Assessment

- Students tour JDMR with a naturalist tour guide in search of the many species that are a part of the estuarine ecosystem and explore interdependent relationships.

11:30-12:15 Travel to nearby park and have lunch

12:15-1:15

Station 4: Building an "oyster restoration unit," or shell string! (at the park)

- Students construct their own shell strings made of dead oyster shell and rope, which will be deployed in the bay to help recruit oyster larvae throughout the spring and summer! **11:30-12:15** Eat Lunch

*Option: As a group, we will discuss the results of our station activities and the potential long-term effects of human activities on wetland and oyster habitats (e.g., climate change, coastal development, and natural resource consumption). Following group discussion, students will divide into the same 4 groups to design, evaluate, and refine a solution for reducing the negative impact of human activities on a wetland and oyster habitats and ways to sustain biodiversity and maintain the planet's natural capital. Students will provide reasonable explanations of what might happen as the basis of proposed engineering and/or public education solutions and make valid scientific claims for how these solutions should be designed and implemented to limit environmental impacts in the long-term. Each group will present their idea to the group and obtain feedback! ****We may prepare 4 different topics for each group to present to increase variety and discussion topics.**

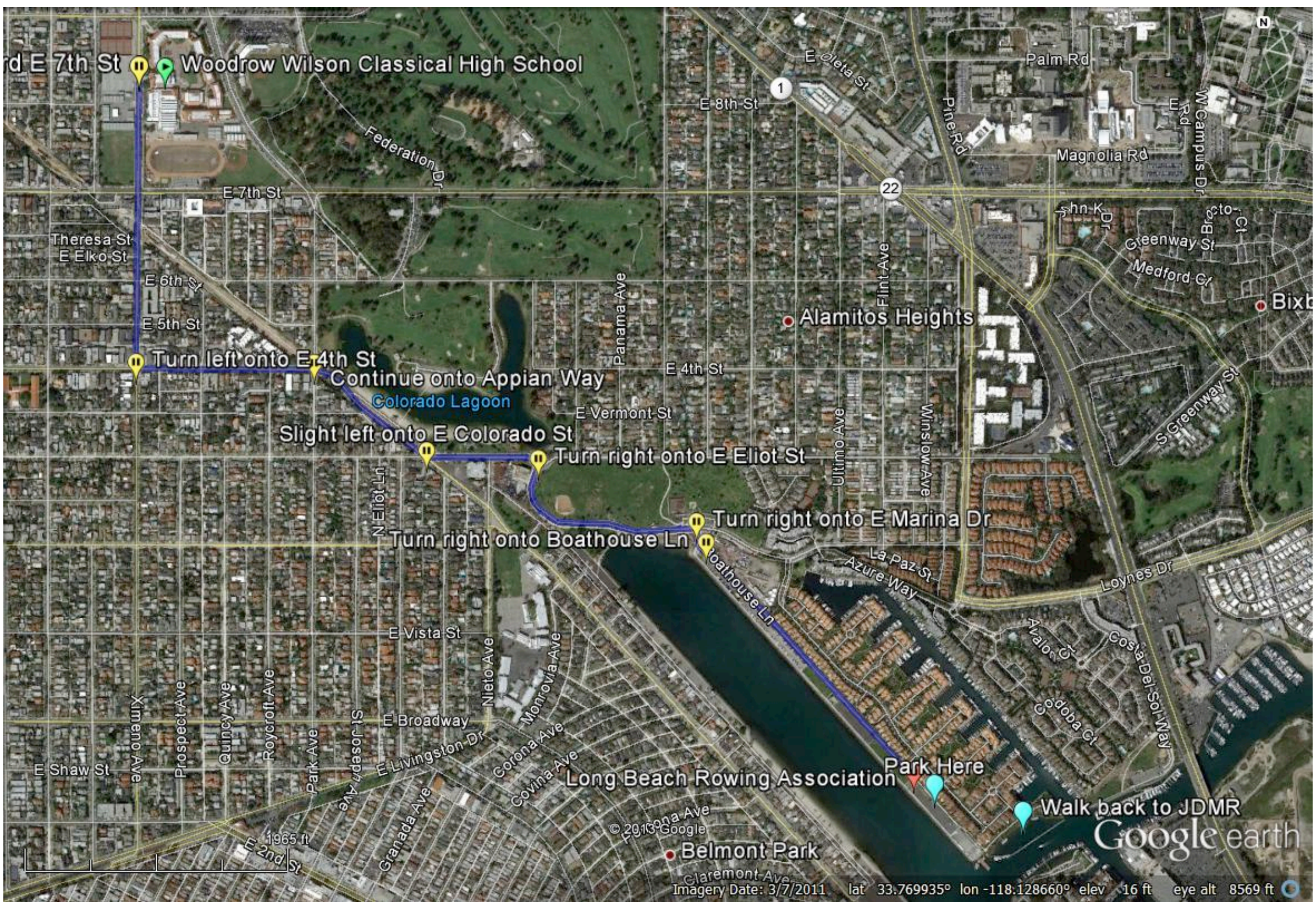
1:15-1:30 Reflect on the day and load on to the bus.

Directions to JDMR:
http://www.longbeach.gov/park/parks_and_open_spaces/parks/jack_dunster_marine_biological_reserve.asp

The Reserve is located just behind the Long Beach Rowing Association:
5750 Boathouse Lane
Long Beach, CA 90803

Directions from Wilson High School: ([Map Link](#))

1. Head south on Ximeno Ave toward E 7th St
2. Turn left on E 4th St
3. Continue on Appian Way
4. Slight left onto E Colorado St
5. Turn right onto E Eliot St
6. Turn right onto E Marina Drive
7. Turn right onto Boathouse Lane
8. Go all the way down and park on the right just in front of the Rowing Association



ACTIVITY 1:
The Role of Oysters as Filter Feeders

Purpose: This field activity engages students in observational research and builds their experience with a local estuarine organism, the oyster, and other filter feeders found in the bay through two challenges. It introduces one of the environmental issues facing estuarine habitats and filter feeding organisms – increased turbidity caused by a) too many nutrients leading to algal growth and b) sediment inputs from urban runoff and/or natural climatic events. Both lead to decreased water clarity and while excess nutrients and sediments can negatively impact this ecosystem, filter feeders are a critical component of the ecosystem's natural ability to improve water clarity. In addition, the second part of this activity addresses estuarine water quality and students will explore six parameters that are used by regulatory agencies to define the overall "health" of a body of water, including those aquatic organisms that reside in the water, including our oyster friends!

Time Duration: 20 minutes challenge #1; 30 minutes for each part (I and II) of challenge #2

Materials: (per student group of 3-4)

Challenge #1: (Large Group) Oyster Filtration Experiment

- 3 experimental and 3 control tanks/clear bins
- 2-10 single, live filter feeders
- Turbidity Observational Disks and Score Card
- Natural estuarine water
- Bay sediment
- Tablespoon measurer
- Timers

Challenge #2 (Small Groups): Oysters & Estuarine Water Quality

Part I – 3 groups of 3-4 students

- Secchi disk with PAR sensor (1 to share)
- YSI (1 to share) – DO, pH, salinity, temperature

Part II – 3 groups of 3-4 students

- Gloves
- Deionized water bottles
- Nutrient waste cups
- Turbidity tubes
- pH meter
- Salinity meter
- Nutrient test kits – phosphate and nitrate
- DO test kit
- Thermometer

Focus questions: Are oysters and other filter feeders effective in filtering particles from water? How might estuarine water quality impact oyster habitat? How are human activities related to oyster filter feeding capacity and water quality?

Objectives:

1. To observe and measure the filtering capacity of oysters and other filter feeders
2. To quantitatively measure important water quality indicators including, a) turbidity, b) dissolved oxygen, c) nitrogen, d) phosphate, e) pH, and f) salinity
3. To develop qualitative statements about the relationships between variables.

CA Science Standards (6th grade): 7a – 7e, 7f – 7h – Investigation and Experimentation.

CA Math Standards (6th grade): Number Sense 1.0, 2.0; Algebra & Functions 1.0, 2.0; Statistics, Data Analysis, and Probability 1.0, 2.0.

Teacher Preparation (READ FIRST): This activity is divided into two challenges. Start by dividing the group into three teams. As a LARGE GROUP, complete challenge #1 by having each of the three teams set up an experimental and control tank. This should be done before anything else as a large group to make sure that it is being carried out for the duration Activity 1. Once they have set up the challenge #1 experiments, split the teams up for challenge #2 (see below) so that half of the team is doing part I and the other half is doing part II. They should switch after the 30 minute-period for each part of challenge 2. Come back together at the end to discuss results. The half of each original team that starts at part I should continue to observe their experiments for challenge #1 and write down data as they complete the other challenges. The second half of the team will take over this task when they rotate to part I.

Challenge # 1: (Large Group) Oyster Filtration Experiment

Hooking the students*:* Before letting them start their experiments, compare three similar clear bins of bay water prepared in three ways: 1) Water from the bay kept near natural light, but at room temperature (avoid excess heating) to which was added a small amount of garden fertilizer 1-2 weeks prior to this activity, 2) Bay water with a handful of bay mud stirred in right then and there, and 3) Bay water with nothing added. Ask students to guess what is in each one just by looking.

- The bin with the algae water should be green after sitting in the sun for a period of time. Ask what has happened to this water. What might contribute to algae growth (natural and human factors).
- The bin with the sediment stirred in should be cloudy. Some of this sediment should settle to the bottom over time.
- The bin with the regular water should be clear. They should not have any evidence to guess what is in this bin but discuss potentials.
- Hold the Turbidity Observation Disks behind each one and have students practice ranking the turbidity using the Scoring Card.

Student Engagement:

- *What do we know?* Discuss the algae and sediment bins. Brainstorm with the students about how estuaries become turbid. For example, storms carry sediment from roads, construction sites, natural erosion of rock, and other sources into storm drains that run to estuaries. Nutrients from fertilizers miles inland are carried in water in the same way and leads to algae growth. In estuaries, seagrasses and salt marsh plants decay to become detritus. All of these factors contribute to turbidity.

- *What do we want to know?* Record questions that students have about oysters such as:
  - Can an oyster discriminate good and bad particles?
  - How much water can they filter?
  - How does excess fertilizer decrease the water quality of estuaries?
  - How do oysters feed?

- *What have we learned?* Discuss this after experiment.

Challenge #1 Procedures:

Students will investigate whether oysters are able to filter particulates from water while simultaneously investigating how efficiently they can do this (we assume that the oysters can filter but how efficiently is the ultimate question for them). Have them fill out their worksheets for this challenge as they go through the process of determining their research question, experimental design, setup and materials needed, and methods. Have them develop a hypothesis as a team before splitting up.

1. Each of the three teams will have one experimental and one control bin.
2. Make sure the bins are labeled (*experimental* and c*ontrol*) and that each has a laminated Turbidity Observation Disk taped to one side facing in towards the middle of the bin below the water line (marked).
3. Have students fill the their control bins and experimental bins with regular bay water.
1. To three experimental and control bins add 1 tablespoon of bay mud. This is a controlled variable.
2. To the three experimental bins add a different number of filter feeders (2, 4, and 10 for example).
3. Add no oysters to the control bins.
4. Record the time and turbidity score of each container at the start and every five minutes, reporting any other observations on the worksheet. Continue to record observations throughout the time it takes to complete the other two challenges. Once the first half of a team watching the experiment finishes part I, have the other half who has completed part II start where the first group left off.
5. Remove the filter feeders at the end and return them to the bay along with the water.
6. Have the two groups at each experiment combine data to complete their worksheets.
7. Discuss the results as a large group and complete the rest of challenge #1 discussion questions.

Understanding The Results:

The goal is to compare not only the difference in turbidity over time between the presence and absence of oysters but the rate at which sediment is filtered depending upon oyster density. By controlling all other variables (amount of sediment, volume of water, etc), it is easier to produce more accurate results. Make sure to discuss the results with students and talk about differences in the data produced among small groups and as a whole. Try to answer the questions posed at the beginning of the activity but also talk about how in science, you must break down your questions into simple experiments in order to eliminate error. Talk about how in nature, the numerous variables interact so that a good restoration project would need to consider each independently and as a whole.

Challenge # 2: (Small Group) Oysters & Estuarine Water Quality

Part I Procedures:

1. The groups starting with this challenge will simultaneously observe and record data for challenge #1 on the data sheet.
2. While doing this, lead each of the three groups through turbidity testing from the dock using the Secchi disk with attached PAR sensor. Make sure they take measurements of both the Secchi extinction depth and FOUR measurements with the PAR sensor:
   a. In air
   b. 1 foot below the surface of the water
   c. 1 foot above the bottom
   d. Mid-depth
3. Take THREE measurements using the YSI (DO, pH, salinity, temperature) at the following depths:
   a. 1 foot below the surface of the water
   b. 1 foot above the bottom
   c. Mid-depth
4. Record data and fill out the observation sheet. The students should average the readings from the PAR sensor and YSI for each parameter for all depths. Discuss why we would take readings at different depths and average those readings. Do they observe any differences in parameters at varying depths (e.g., salinity, DO, temp)? *They should!*

Part II Procedures:

1. These groups will not be observing the experiments but focusing on water quality testing.
2. Lead each of the three groups through testing for the following parameters using the appropriate field test kits/sensors (not YSI or Secchi/PAR):
   a. Nitrate
   b. Phosphate
   c. Dissolved oxygen
   d. pH
   e. Salinity
   f. Temperature
   g. Turbidity
3. Record data and fill out observation sheet.

Once students have rotated between parts I and II, come back together as a group to combine data and discuss results (See Understanding the Results – Challenge #1). Also discuss the differences, if any, observed between the student test kits and sensors from Part II with the YSI data from part I. Discuss the reasoning behind taking multiple measurements or averaging data from different depths.

Activity 1 Background

Oysters can provide a variety of **ecosystem services** (or benefits to the ecosystem) as filter feeders. A **filter feeder**, which is a plankton-eating organism that filters its food from the water, includes not only oysters but also many **bivalves** such as bay mussels and clams. Because these species live in the intertidal zone and are exposed to air and sun at low tide and covered by water at high tide, they have adapted to endure highly dynamic environmental conditions. However, they are not impervious to extreme changes in their environment, including those that are the result of human activities, such as water pollution from storm water runoff and harmful algal blooms that result from the input of excess nutrients from the watershed.

Water quality can be defined as the sum of all physical, chemical, and biological characteristics of a body of water. These characteristics are most often used to evaluate the "health" of a body of water, such as drinking water or water that we use for recreational or commercial purposes, such as rivers, streams, lakes and oceans. Water quality standards for many estuaries and water bodies, including Alamitos Bay, are based on many variables and affect each organism in different ways. In this lab we will focus on five important variables as they relate to the growth, productivity, and survival of filter feeders: turbidity, dissolved oxygen, pH, salinity, and nutrients.

1. **Turbidity**

Turbidity is a measure of water clarity or the amount of cloudiness due to particles suspended in the water, which can be affected by storm water runoff, pollution, dredging, nearby construction, agriculture, inclement weather, and algae or phytoplankton. Turbidity can be quantified by measuring the amount of light that can penetrate to depth using a Secchi disk, turbidity tube, or a sensor that measures light transmittance. Extremely high turbidity can affect the ability of filter feeders to obtain nutrients from water and the ability of fish gills to absorb dissolved oxygen. Alternatively, oysters help reduce turbidity!

2. **Dissolved Oxygen**

Dissolved oxygen (DO) is the amount of gaseous oxygen dissolved in the water. Oxygen is directly absorbed from the atmosphere or produced by aquatic plant and algal photosynthesis. DO is a good indicator of the ability of a water body to support aquatic life, for example, fishes absorb the oxygen dissolved in the water through their gills, which allows fish to "breathe." The amount of DO depends on the volume of water, velocity, temperature, altitude, suspended solids, and nutrient concentrations. For example, excess inputs of nutrients from the watershed lead to increased algae populations. Once the algae begins to die, it settles to the bottom of the water column where it undergoes decay that generates oxygen demand and consumption by decomposers. This process, known as **eutrophication**, can lead to hypoxic (low oxygen) or even anoxic (no oxygen) conditions under which most aquatic life cannot survive. Oysters help remove algae that can reduce dissolved oxygen levels. Most aquatic life requires dissolved oxygen content greater than 5 mg/L.

3. **pH**

pH is the "potential of hydrogen," a measure of the concentration of hydrogen ions (H+) in a solution, which measures the acidity or basicity of a solution. pH is measured on a scale of 0-14;

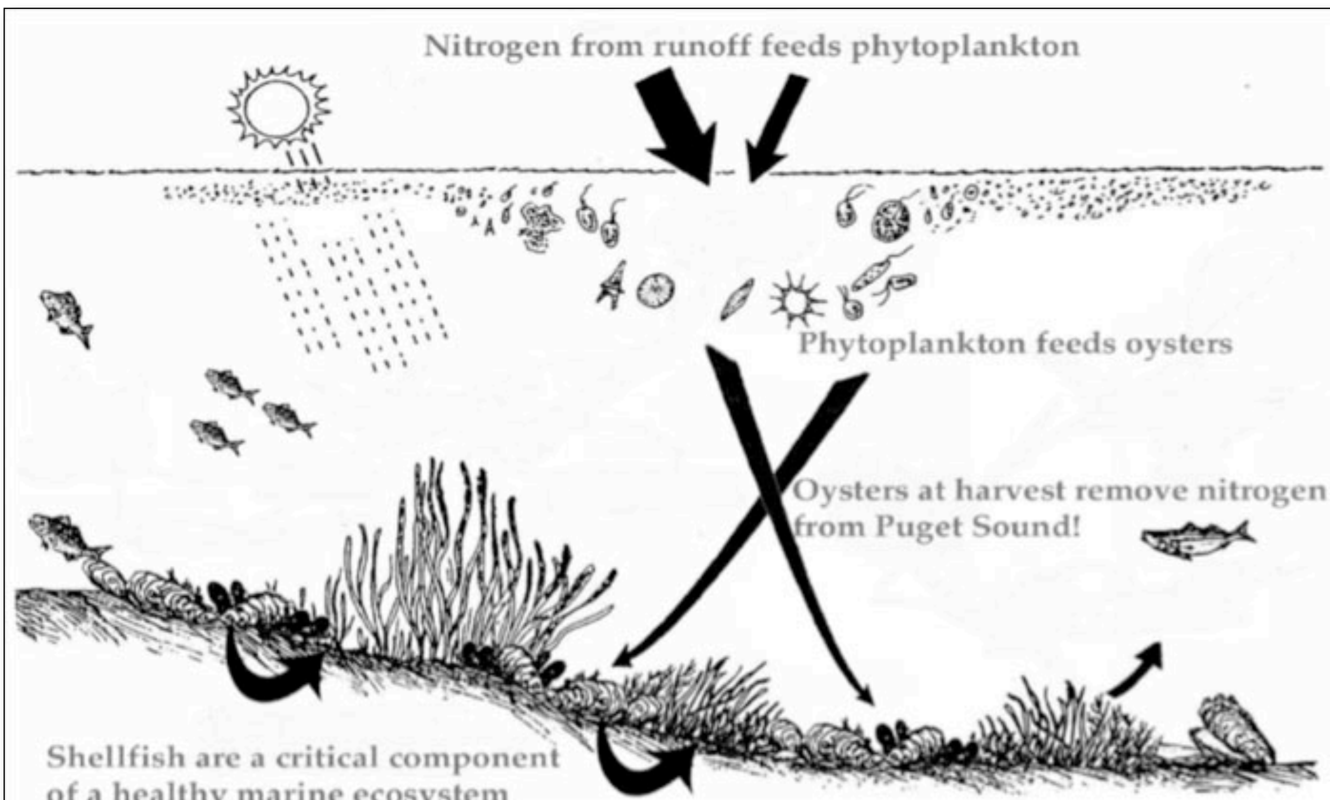
7 is neutral, below 7 becomes increasingly acidic and above 7 becomes increasingly basic. Human causes of pH change include sewage spills, concrete wastes, and fertilizer. The pH of a healthy, flowing water ecosystem required for the survival of most aquatic life, including oysters, ranges from 6.5 to 8.5.

4. **Salinity**

Salinity is a measure of the amount of dissolved salt in a body of water. Oysters can tolerate a wide range of salinities, but oyster filtration slows down when salinity falls below 20% of the oceanic value (30-50 parts per thousand (ppt)) to ~7.5ppt. Filtration stops when this drops below 10%. Alamitos Bay salinities range from 20 – 35 ppt.

5. **Nutrients**

Nitrogen is a nutrient that is a limiting factor for the growth of algae, which can increase turbidity and reduce dissolved oxygen, especially during the summer when higher temperatures lead to algae growth. Oysters help maintain the balance of nitrogen in the water through removal of algae for food and deposition of nitrogen into the soil where it is denitrified. On the flip side, each year toxin-containing harmful algal blooms can contaminate or kill vast amounts of filter feeders, particularly in the warmer months. Oysters also remove other nutrients such as **phosphorous**, another nutrient and animal waste product. Acceptable nutrient ranges typically vary among different water bodies based on inputs from human



sources.

Student Worksheet (Teacher's Copy)
Activity 1 – The Role of Oysters as Filter Feeders

Student Challenge # 1: Oyster Filtration Experiment

Choose an experiment that will allow you to investigate if oysters can effectively remove particulates from the water.

1. What is your team research question?

Answers vary but should be along the lines of: Can oysters remove particulates from water?

2. Describe your experimental design:

Set up an experimental tank and a control tank to see if oysters can filter out a discrete amount of sediment added. Students will work in three teams so there will be three experiments, each with a different number of oysters (experiment) but the same amount of sediment (control). All other variables will be the same.

3. Describe your setup and the materials you used:

Basically we will use small plastic bins ("tanks") prepared beforehand by marking the controls and experimental bins, marking the line to fill water up to, and taping a Turbidity Observation Disk to each.

4. Methods
   a. What data do you want to collect to answer this question?

   Turbidity 'score' at five minute intervals; (ideally) the time at which all sediment appears to have been removed over the 80-min period; students calculate the OFR and OFR (single) for their tanks and those values obtained by the other teams.

   b. What instruments or tools will you need to collect the data (including # of filter feeders used in the experiment)?

   Turbidity Observation Disk and Score Card; tanks; sediment from the bay; bay mussels; timer/phone.

5. Results: Complete Data Table

Data Table:

Time		Turbidity Score		Other observations
		Control	Experimental	
# Oysters: _____________		Amt. of Sediment: 20 grams		
Start time:				
5 min				
10 min				
15 min				
20 min				
25 min				
30 min				
35 min				
40 min				
45 min				
50 min				
55 min				

60 min				
65 min				
70 min				
75 min				
80 min				

6. Calculate the oyster filtration rate (OFR) for all oysters: ________________

$$OFR = \frac{\text{Amount of sediment added (grams)}}{\text{Time required to remove all sediment from water (min)}}$$

7. Calculate the OFR for a single oyster: ___________________

$$OFR\ (single) = \frac{OFR}{\#\ Oysters}$$

8. Combine group results:

Group #:	# Oysters:	OFR	OFR (single)
1			
2			
3			
	Average:		

*Average = sum of all results / # results

9. Calculate the percent difference of your results from each other group's results for OFR:
   a. Group ___ : _____________%
   b. Group ____: _____________%

$$\%\ Difference = \frac{\text{(first value – second value)}}{\text{(first value + second value) / 2}} \times 100$$

10. Calculate the percent difference of your results from each other group's results for OFR (single):
    a. Group ___ : _____________%
    b. Group ____: _____________%
11. Conclusion:
    a. How did the three different experiments compare? Use your data to explain any differences in results (e.g., OFR % difference and differences between OFR and OFR (single).

They should see a difference in the amount of time it takes for the oysters to remove particles between the tanks, time decreasing as oyster # increases. If not, we can chalk it up to the fact that maybe we need to use different numbers of oysters or different amounts of sediment! It's science!

    b. What did you learn about oysters and their filtering capacity? In your opinion, are oysters (or other filter feeders) effective in filtering particles from water?

Yes! They are able to filter water and remove sediment particles.

Student Challenge #2: Oysters & Estuarine Water Quality - PART I
For this part of the challenge, you will be investigating water quality using more advanced scientific equipment. Fill out your data sheet as you go and compare your results to Part II once you have completed both parts of the challenge!

Research Questions: (to discuss as a group before starting)

1. What water quality parameters are used to determine water "quality?" What are the acceptable ranges for these parameters? (complete the chart below)
   See chart.

2. What pieces of equipment will be used to measure these parameters?
   a. YSI – DO, pH, Salinity, Temp
   b. Secchi - turbidity
   c. PAR sensor – turbidity as a function of light transmittance

3. Results: Complete Data Table (**round to the nearest 100th if possible**)

Data Table

	Temperature (F)	**Dissolved Oxygen** (mg/L)	**Salinity** Parts per thousand (ppt)	**pH** (0-14)	**Secchi Depth** (meters)	**PAR** (lumens/ft2)
Acceptable Range for Alamitos Bay	50-72°F	>5.00 mg/L	25-35ppt	6.50 to 8.50	Varies	Varies
Total depth:						
In-air:	N/A	N/A	N/A	N/A	N/A	
1ft below surf:					N/A	
1ft above bottom:					N/A	
Mid-depth:					N/A	
AVERAGE:					N/A	

4. Conclusions:
   a. Briefly describe how your results compare to the acceptable range for Alamitos Bay. Do they fall within the range? If not, what might be the cause(s) of this variation?

They will most likely fall within the range but, if not, discuss with them the possibilities (see activity 1 background for potential causes of variation).

Student Challenge #2: Oysters & Estuarine Water Quality - PART II
In this part of the challenge, fill out the following observation sheet. Discuss how these observations might contribute to variations in water quality results. Carry out your tests using the equipment provided and record your results.

Conversions:
Celsius to Fahrenheit: (°C x 9/5) +32= °F
Fahrenheit to Celsius: (°F – 32) x 5/9= °C)

Weather Conditions:

Air temperature (to be taken with water temp):
______° F   _______° C

Weather in Past 24 Hours
☐ Storm (Heavy Rain)
☐ Showers (Intermittent Rain)
☐ Partly Cloudy
☐ Overcast
☐ Clear Sunny

Weather Now
☐ Storm (Heavy Rain)
☐ Showers (Intermittent
☐ Partly Cloudy
☐ Overcast
☐ Clear Sunny

Wind: _____________ (1= still= breezy, 3= strong)

Type of Water Sample (e.g., freshwater, saline, natural, urban runoff, etc.): ___________

Water Appearance

☐ Clear ☐ Milky ☐ Foamy ☐ Turbid ☐ Oily Sheen
☐ Light Brown ☐ Dark Brown ☐ Orange ☐ Greenish
☐ Other:_______________

Water Odor
☐ Sewage ☐ Rotten Eggs ☐ Chlorine ☐ Fishy ☐ None
☐ Other:_______________

1. Physical observations of…

Land: ____

Shore: ____

Water: ____

Wildlife: ____

3. Other observations at the site (ex: human activities, uses of the Bay, trash, etc.)?

____

Research Questions: (to discuss as a group before starting)

1. What water quality parameters are used to determine water "quality?" What are the acceptable ranges for these parameters? (complete the chart below)
   See chart.

2. What pieces of equipment will be used to measure these parameters?
   a. Nitrate and Phosphate nutrient test kits
   b. Dissolved oxygen test kit
   c. Salinity meter
   d. pH meter
   e. Turbidity tube
   f. Thermometer

3. Results: Complete Data Table (**round to the nearest 100th if possible**)

Data Table

	Temperature (F)	**Dissolved Oxygen (mg/L)**	**Salinity Parts per thousand (ppt)**	**pH (0-14)**	**Phosphate (mg/L) *nutrient**	**Nitrate (mg/L) *nutrient**	**Turbidity tube depth (meters)**
Acceptable Range for Alamitos Bay	50-72°F	>5.00 mg/L	25-35ppt	6.50 to 8.50	<0.1mg/L	<10 mg/L	Varies
Result:							

4. Conclusions:
   a. Briefly describe how your results compare to the acceptable range for Alamitos Bay. Do they fall within the range? If not, what might be the cause(s) of this variation?
   Same for Part I
   b. How do these results compare to that of Part I? (If you have not yet completed Part I, finish this after).
   Compared to the YSI/PAR, the test kits are less accurate, generally.

Activity 1 Final Discussion Questions

1. List three sources of increased turbidity in Alamitos Bay:

a. Sediment from storm water runoff (construction, natural erosion, streets)

b. Algae/plankton due to increased inputs of nutrients from watershed

c. Natural phenomena (e.g., storms, coastal erosion, a large sea lion swimming by…)

2. Briefly discuss how BOTH natural events and human activities contribute to these three sources of increased turbidity:
   See above examples. It is usually a combination, however, humans typically augment these natural occurrences.

3. Based upon your observations in Activity 1, are oysters and other filter feeders effective at removing particles from the water? Use your data from challenge #1 to describe HOW effective they are (for example, compare the results from your OFR to OFR (single) and determine if one oyster is more efficient than many).
   Yes!

4. You have been collecting data for an oyster restoration project today. Scientists collect this type of data on a regular basis throughout an entire restoration project. In your opinion, why is this an important part of restoration? What are we, as scientists, trying to find out using this data?

To monitor other variables related to the growth and survival of the species/habitat in question. You will need to factor out variables in trying to understand any fluctuations in the ecology of the species/habitat.

5. Finally, describe how you would use oysters to help improve the estuary. Think of an oyster's unique ability to filter water and provide habitat. Make sure to consider HOW you would implement your idea (the science AND communicating to the public).

Talk about Danielle's project. Laying a bed for oysters to recruit to and enhancing the success of recruitment by placing shell strings throughout the bay to eventually be transferred to the main bed at JDMR. The project not only involves the science but also has a substantial community education and outreach component.

ACTIVITY 2:
The Role of Oysters as Essential Habitat

Focus questions: What other estuarine species are associated with oysters? Does the presence/absence of oyster habitat affect overall biodiversity and species abundance? How are human activities related to the growth and survival of oyster habitat?

Objectives:
1. To identify other species (e.g., plants, animals, birds, invertebrates) associated with native oyster habitat and the estuarine ecosystem.
2. To quantitatively measure species diversity and abundance within an oyster bed using a subsample of the habitat.
3. To develop qualitative statements about the relationships between species associated with oyster habitat and the importance of oyster habitat in Alamitos Bay.

CA Science Standards: 7a – 7e, 7f – 7h – Investigation and Experimentation.

CA Math Standards (6th grade): Number Sense 1.0, 2.0; Algebra & Functions 1.0, 2.0; Statistics, Data Analysis, and Probability 1.0, 2.0.

Purpose: This field activity engages students in observational research and builds their experience with a local estuarine organism, the oyster, and other filter feeders found in the bay through two challenges. Students will identify species associated with estuarine and oyster habitat and explore the relationships between these species. The activity will show the importance of oyster habitat (and other associated habitats) for other intertidal and estuarine species and compare them with species found in habitats with no structure (e.g., oyster beds and seagrasses.

Time Duration: 40 minutes per challenge

Materials: (per student group of 3-4)

<u>Challenge #1: Oyster Habitat Community Diversity Assessment</u>

- 3 large plastic bins filled with bay water (to hold populated shell strings)
- Small bucket
- Petri dishes (for holding small organisms)
- Large plates (for holding large organisms)
- Tweezers
- Magnifying glasses
- Intertidal Species ID Card
- Student worksheet

<u>Challenge #2: Wetland Scavenger Hunt</u>

- Binoculars (to share)
- Wetland Species ID Card
- Student worksheet

Background: Oysters provide critical habitat for many intertidal species, including many economically important species. On the east coast, oyster reefs provide habitat for sea bass, snapper, anchovies, and flatfishes. Here on the west coast, native oyster beds are “functionally extinct,” meaning that the beds are not extensive enough to provide these ecosystem services, which is why many agencies, universities, and other non-governmental organizations are working to restore these essential habitats. Students will use a small subsample of oyster habitat to identify those species that are found in the cracks and crevice habitat formed by filter feeders as they stick together. They should observe that there are more species found in habitat with oysters and other filter feeders (and/or seagrasses) than in habitat that is unstructured. Students will also tour the Jack Dunster Marine Reserve to identify other wetland-associated species (e.g., birds, plants, animals) and human activities that might impact these habitats.

Challenge # 1: Oyster Habitat Community Diversity Assessment

Experiment Setup:

1. One to two weeks (or more) prior to the activity, find an area with natural oysters and filter feeders. Set out two milk crates (or similar structures) lined with fine mesh in the lower intertidal zone. Fill all of the bins halfway with bay sediment and put filter feeders in one of the bins (4-5 clumps).
2. Leave the bins out for two or more weeks to become populated with other species, including algae. If they are left out for long periods of time, make sure to check them regularly and remove any excess algae growth and fouling if necessary.

Challenge #1 Procedures:

1. Retrieve the bins for use in the activity and set the crates in large, shallow bins filled with bay water. You can pull out the mesh lining and place it in a dry bin.
2. Have the students search the oysters first for mobile, live organisms and use tweezers to gently place them in petri dishes or plates.
3. Next, filter out the sediment using a wire mesh sieve placed over a 5-gallon bucket (so sediment does not get everywhere) for other live organisms. Use the small bucket to pour small amounts of bay water over the mud to help filter it out. Place sediment species in separate petri dishes/plates.
4. Identify the organisms found in the oysters and those found in the sediment and record the numbers of each species or group of organisms found on the data sheet provided.
5. Place the oysters and mesh back in the crates with leftover sediment (add more sediment if necessary). Return to the water.
6. Estimate how many meters squared is covered by the oysters in the crates

***Alternative: Use Shell Strings**

1. Follow the same procedures for challenge #1, except you will only be removing organisms off the shell string and placing them in appropriate petri dishes and on plates for sorting and collecting mud to put in a second bin for identification and comparison between mudflat without oyster habitat and a shell string, which is a type of oyster habitat.
2. Return shell strings to hang from the dock to be repopulated.

Challenge # 2: Wetland Scavenger Hunt

Take the students on a walking tour of the Reserve making sure to point out native plant species and characteristics of those species that make them unique to this climate (e.g., drought-resistant characteristics). Observe birds, animals, and salt marsh habitat as well as human activities that may influence the habitat.

Student Worksheet
Activity 2 – The Role of Oysters as Essential Habitat

Student Challenge #1: Oyster Habitat Community Diversity Assessment
Pull up a shell string hanging from the edge of the dock to examine species diversity and abundance associated with oysters. Record your results as a small team below and work together as a class to discuss your results.

1. Complete the Data Table on the next page. Determine the general groups that the organisms fit into and tally each individual as you go.

2. Next, calculate the percent abundance of each group of organisms in the table below. **For algae or other plants, estimate percent cover.**

Group:	**Total # all species:**	**% abundance in shell string:**	**% abundance in mud:**
Algae (% cover)			
Bryozoans (% cover)			
Cnidarians			
Crustaceans			
Echinoderms			
Fishes			
Molluscs			
Polychaetes			
Sponges			
Tunicates			
TOTAL ALL GROUPS:			

***% abundance = # individuals in group / total # individuals ALL groups.**

Data Table:

Groups of Organisms	# or % cover in shell strings:	# or % cover in mud:
Algae		
Green algae		
Red algae		
Brown algae		
Bryozoans		
Cnidarians		
Hydroid		
Anemone		
Crustaceans		
Amphipod		
Isopod		
Crab		
Barnacle		
Echinoderms		
Brittle star		
Fishes		
Smelt		
Goby		
Perch		
Sculpin		
Flatfish		
Molluscs - Gastropods		
Nudibranch		
Sea slug		
Cone snail		
Bubble snail		
Limpet		
Sea hare		
Molluscs - Cephalopods		
Octopus		
Molluscs - Bivalves		
Native oyster		
Non-native oyster		
Native mussel		
Non-native mussel		
Clam		
Scallop		
Polychaetes - worms		
Porifera – Sponges		
Tunicates		
Colonial tunicate		
Stalked tunicate		

Student Challenge #2: Wetland Scavenger Hunt

Today you will observe several different inhabitants of Alamitos Bay, including plants, animals, and birds. Identify at least 10 organisms that reside here in the chart below. Then identify the role of each organism. *See the list of food web roles and relationships below.*

Organism	**Role**
Ex.: White egret	***Secondary Consumer (Carnivore)***
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	
11.	
12.	

Use the information above to draw a *rough draft* of a web that indicates the organisms listed above. Label each organism with its role in the food web. Then label each relationship.

Select *three abiotic factors* from the list provided and *describe their effects* on your food web.	
Abiotic Factors	**Impact on Food Web**
1.	
2.	
3.	

<u>Food Web Roles:</u>
Producer- Organisms, such as plants or photoplankton, that produce their own food; also called autotrophs.
Consumer- An organism that eats other organisms for food. Also called heterotrophs, different kinds of comsumers include carnivores, herbivores, and omnivores.
Primary consumer- An organism that occupies the second trophic level in a food chain; these organisms are herbivores and feed directly on producers.
Secondary consumer- A consumer that gets its energy from other consumers. These are often called carnivores.
Decomposer - An organism that feeds on dead material or excrement, breaking down complex organic compounds into simple organic or inorganic ones that are then available to enter the food web as nutrients.
Omnivore- An organism that eats both plants and animals.
Herbivore- An organism that consumes plants or photoplankton for energy; also known as a primary consumer.
Carnivore- An organism that consumes living animals or parts of living animals.
Autotroph- An organism that produces food molecules inorganically by using light by photosynthesis. This organism does not require outside sources of organic food energy for survival. Autotrophs are primary producers in all food webs.
Heterotroph- Any living organism that obtains its energy from organic substances produced by other organisms.

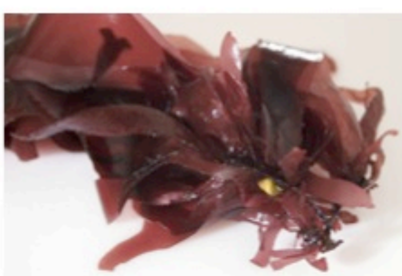
<u>Relationships:</u>
Mutualism- Association between two organisms of different species, whereby both benefit from the relationship; also called symbiosis.
Commensalism- Relationship between two species in which only one species benefits whereas the other is unaffected.
Parasite- An organism that feeds on or in another organism (called the host).
Host- A living organism that is being fed on by another organism (called the parasite).
Predator- A consumer organism that feeds on prey.
Prey- An organism that is consumed by a predator.

<u>Abiotic (non-living) factors:</u>
Space- An open area for a species to create a habitat.
Water- A basic chemical compound essential for the existence of all living organisms.
Dissolved oxygen- Microscopic bubbles of oxygen gas in a solution.
Temperature- a measure of <u>the</u> warmth or coldness of an object or substance with reference to some standard value.
Light- something that makes things visible or affords illumination: *All colors depend on light.*
pH- Scale from 0-14 used to measure the alkalinity or acidity of a substance; 7 is neutral, below 7 is acid, and above 7 is alkaline.
Salinity- Concentration of dissolved salts found in a sample of water; measured as total amount of dissolved salts in parts per thousand.
Turbidity- A measure of the cloudiness of water caused by suspended particles.

Green Algae

Ulva sp.

Red Algae



Dulse
Palmaria mollis

Red Cellophane
Porphyra cuneiformis

Red Spaghetti
Gracilariopsis sjoestedtii

Brown Algae

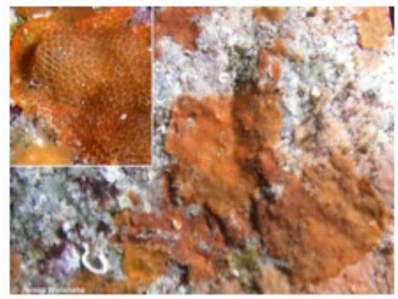
Giant Kelp
Macrocystis pyrifera.

Featherboa Kelp
Egregia menziesii.

Sinous seaweed
Colpomenia sinuosa.

Bryozoans – moss-like organisms

Zoobotryon verticillatum



Membranipora sp.

Cnidarians

Striped anemone
Haliplanella lucia

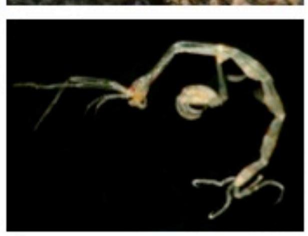
Common brown hydra
Hydra vulgaris

Crustaceans

Acorn barnacle
Balanus glandula

Striped shore crab
Pachygrapsus crassipes

Amphipoda



Skeleton shrimp
Caprella mendax

Echinoderms

Brittle star

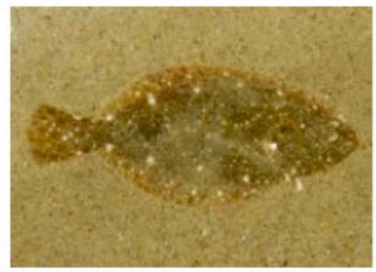
Fishes

Topsmelt
Atherinops affinis

Sculpin

Perch

Goby



Flatfish

Molluscs - Bivalves

Native species

Olympia oyster
Ostrea lurida

California mussel
Mytilus californianus

Speckled scallop
Argopectin ventricosa

CA Jack Knife clam
Tagelus sp.

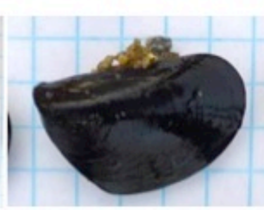
Non-native species

Pacific oyster
Crassostrea gigas

Japanese littleneck
Venerupis philippinarum

Quagga mussel
Dreissena rostriformis bugensis

Ribbed mussel
Geukensia demissa



Mediterranean mussel
Mytilus galloprovincialis

Asian date mussel
Musculista senhousia

Molluscs - Cephalopods

Two-spotted octopus
Octopus bimaculatus

Molluscs - Gastropods

Eelgrass sea hare
Phylaplysia taylori

Striped sea slug
Navanax inermis

Sea lemon (Noble dorid) nudibranch
Peltodoris nobilis

California cone snail
Conus californicus

Gould's bubble snail
Bulla gouldiana

Limpet

Polychaetes

Medusa worm

Spaghetti worm

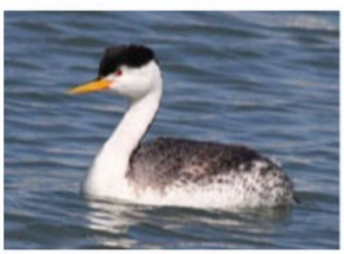
Porifera - Sponges

Tunicates

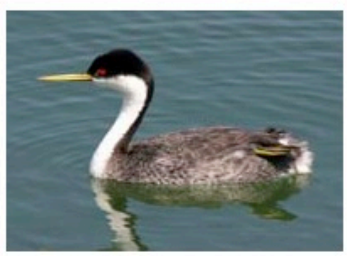
Pleated sea squirt

Club tunicate

Waterfowl



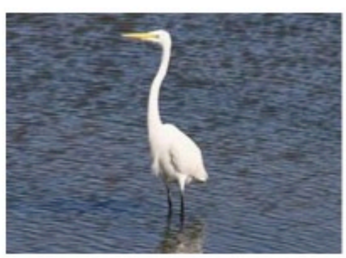
Clark's grebe
Aechmophorus clarkii



Western grebe
Aechmophoros occidentalis

Brown Pelican
Pelicanus occidentalis

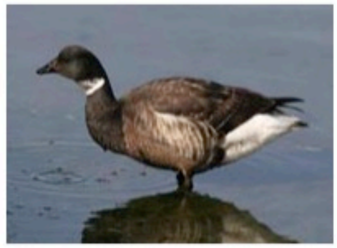
Cattle egret
Bubulcus ibis

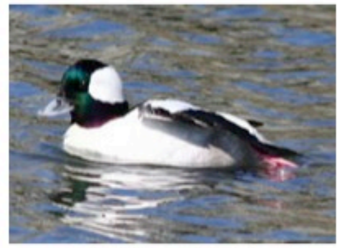


Great egret
Ardea alba

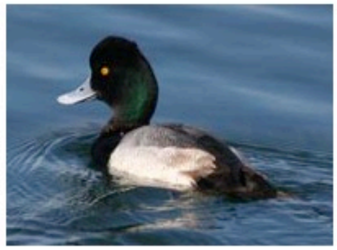
Snowy egret
Egretta thula


Great blue heron
Ardea herodius


Brant goose
Branta bernicla


Bufflehead duck
Bucephala albeola

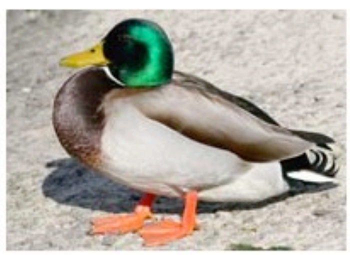

Brandt's cormorant
Phalacrocorax penicillatus

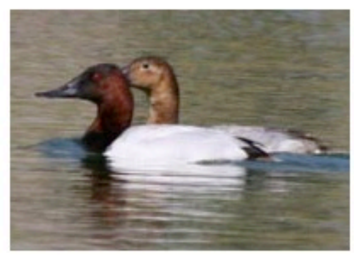

Lesser scaup
Aythya affinis


American coot
Fulica americana

Waterfowl


Belted Kingfisher
Megaceryle alcyon


Mallard
Anas platyrhynchos


Canvasback
Aythya valisineria

Birds of Prey

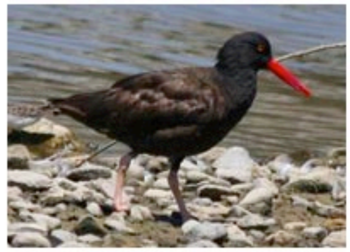

Red-tailed hawk
Buteo jamaicensis


Peregrine falcon
Falco peregrinus


Osprey
Pandion haliaetus

Shorebirds

Common tern
Sterna hirundo



Black oystercatcher
Haematopus bachmani

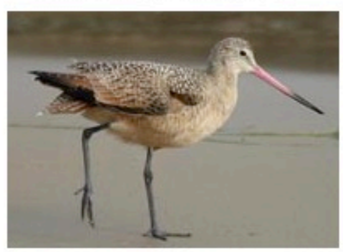
California gull
Larus californicus

Spotted sandpiper
Actitis macularia

Stilt sandpiper
Calidris himantopus

Shorebirds

Willet
Catoptrophorus semipalmatus



Marbled godwit
Limosa fedoa

Long-billed curlew
Numenius americanus

Whimbrel
Numenius phaeopus

Snowy plover
Charadrius alexandrinus

Salt Marsh Plants

Cordgrass
Spartina foliosa

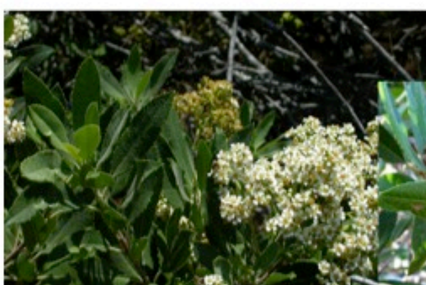
Pickleweed
Salicornia sp.

Salt grass
Distychlis spicata

Alkali heath
Frankenia salina

Eelgrass
Zostera marina

Coastal Scrub



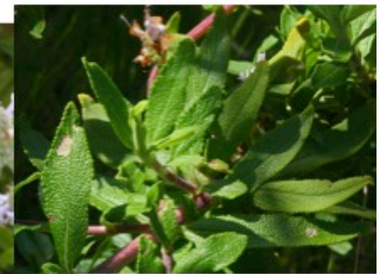
Toyon (Christmas berry)
Heteromeles arbutifolia
*jagged leaf edges

Sugar bush/sugar sumac
Rhus ovata
*round leaf edges

Island broom
Acmispon dendroideus

Goldenhead
Acamptopappus shockleyi

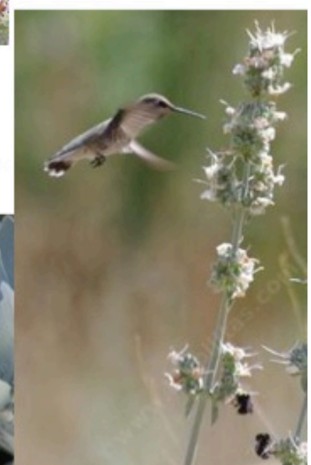
California sunflower
Encelia *californica*



Black sage
Salvia mellifera

Purple sage
Salvia leucophylla

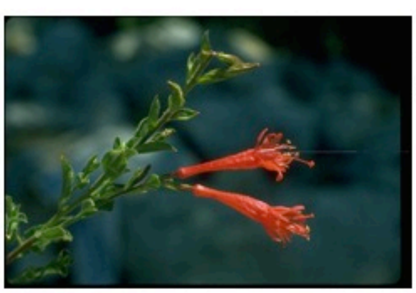
White sage
Salvia apiana
*very fragrant/large fuzzy leaves



Deergrass
Muhlenbergia rigens

California poppy
Eschscholzia californica

California sagebrush
Artemesia californica



California Fushia
Epilobium canum

Quail bush
Atriplex lentiformis

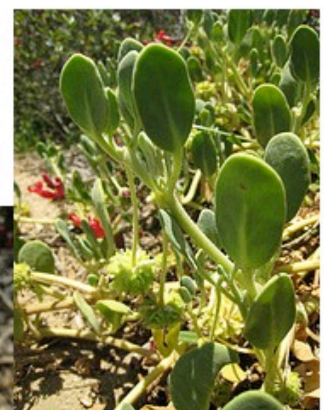
Lemonade berry
Rhus integrifolia

Chalk dudleya
Dudleya sp.

Golden yarrow
Eriophyllum confertifolium

California buckwheat
Eriogonum fasciculatum

Coyote brush
Baccharis pilularis



Red-sand verbena
Abronia maritima