YESS

Youth Exploring Sea level rise Science

Educator Guide for the Sea level rise Lesson Series

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COUNTY OF MARIN

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Introduction

More than 160,000 Bay Area residents live in areas that will be vulnerable to sea level rise (SLR) within the next 50 years. Our communities will need to make difficult decisions about how land is used and developed, and possibly even when it is time to retreat from rising waters. Scientists and policymakers are urging educators to teach about climate change, so that the next generation will be equipped with the knowledge necessary to make these decisions. There is a continued need to better understand impacts of coastal inundation and community impacts from SLR. At the same time, teachers are grappling with the need to develop educational programs that rely less on textbook study and more on inquiry-based, hands-on learning experiences. This project answers these needs for increased climate literacy and a new way of engaging students by weaving together some of the most effective SLR citizen science initiatives, youth engagement, community planning, and experiential learning.

The original pilot of the YESS (**Y**outh **E**xploring **S**ea level rise **S**cience) project was funded with a California Coastal Commission Whale Tail Grant and additional support from Marin and San Mateo Counties. The project empowers Bay Area youth to engage directly in climate change solutions in their own communities. Through an experiential education program that incorporates hands-on science and digital storytelling, high school students explore how their lives will be impacted by sea level rise; create their own data and storytelling products; and contribute meaningfully to local science and policy decisions. YESS allows those who will be most impacted by climate change – young people – to have a voice on the issue and spark a broader conversation in the Bay Area about risk and resiliency.

Overview

Youth Exploring Sea level rise Science (YESS)

Part 1: Sea Level Rise 101

Students will build an understanding and define potential impacts of sea level rise in their community:

- The basic concepts of sea level rise and its relationship to climate change
- How storm events, king tides, and sea level rise fit together
- What communities in California are doing to plan for sea level rise, and how students can get involved

This section includes:

- An introduction to sea level rise related physics and chemistry concepts
- An introduction to communicating science
- Diagramming prior knowledge of sea level rise causes, processes and impacts
- Video and reading background on sea level rise causes and impacts
- Hands on activities with thermal expansion, heat capacity and glacial melting using available data to connect to own region
- Communicating findings and methods to the group
- An introduction to students' final project (public product)

Part 2: Collecting and Communicating Data

Students will ask questions and review available data to define data gaps for sea inundation:

- Current data available on sea level rise
- Data collection methods, making observations and data gaps
- Creating a scientific plan for collecting and contributing data
- Identifying prior efforts to counter sea level rise, current and future sea level adaptation needs in their community

This section includes:

- Communicating data and observations
- Measuring sea surface topography
- King tides project introduction
- Selecting relevant data, understanding maps, graphs and satellite images
    - Prior data collected on sea level rise
- Data gaps and collection methods
    - King Tides
    - Ground-truth Coastal Armoring
    - Understanding Community Impact through Interviews
- Project planning – students plan team projects of their own design
    - Including how they will communicate their data (may be split into separate lesson)

- Data collection – on own or part of field experience
- Develop presentation

Part 3: Contributing student generated data to sea level rise planning

Students will construct an explanation based upon evidence and present that explanation.

- Analyze and summarize collected data
- Identify successful approaches and recommendations for their study area
- Communicate and contribute their science to peers, the community, planners or scientists

This section includes:

- Student review, critique and revision of presentations for formal presentation to community or to post final project
- Who wants to know – opportunities for students to share their work with coastal planners and scientists
- Students complete evaluation

Teacher Preparation before beginning the lesson series

1. This lesson series consists of 4 classroom sessions: one 90-minute session, two 45-minute sessions, and one more 90-minute session. In addition, options for data collection field trips are included. The series is structured with homework for a flipped classroom, so that the Student Homework Assignments provide students with some background and preparation for the Classroom Session that follows. This lesson series also relies on students working in small groups to create their final presentations largely on their own time as homework. It is best to space out the Classroom Sessions to allow plenty of time in between for homework, data collection, and presentation development. You may want to budget additional time if you use traditional classroom instruction delivery.

2. Ideally, the students will do some fieldwork in small groups as part of their homework. Alternatively or additionally, a class field trip might be a good way for your students to collect data. You may want to take your class on a field trip either as a training run before or in lieu of having your students go out on their own to collect data.

3. We created this lesson series with the goal of directly engaging students with their local planning agencies, so that their data and observations become part of the planning process. Your local agencies may be able to provide or connect you with experts to meet you and your students at field sites or in your classroom to give an overview of the area, talk about the sea level rise concerns, and answer questions. Your agency contact may also be able to help you plan field trips, data collection activities, and final student presentations. Begin making plans to work with your local planning agency as soon as you can.

4. Determine the best option(s) for your students to share their final presentations – whether it be at a public meeting, in a library display, at an art show, or at another venue/event and make contact with the appropriate individuals to reserve a space or obtain a timeslot on an agenda. You may want to include students in the planning (or put them in charge) of this event. Please see the Appendix for suggestions for participating in existing events or help organizing something in your community.

5. Choose a rubric for grading presentations to share with students. The rubric will help students understand what is expected of their own presentations. There are a few options in the Appendix or use your own. Also provided is a citation for a document to help students understand a rubric if they have never used one.

5. Decide when you want to discuss with the students the overall scope of the project, including the final presentation. When you assign Part 1 Student Homework Assignment or during the Part 1 Classroom Session are both good opportunities.

6. You might suggest that students keep all their YESS project related notes, assignments, etc. in one notebook. This may help them organize their ideas and create their public product.

The Lessons

Part 1

Teacher Preparation (15-40 minutes)

1. Within Flipped classroom structure: Provide Part 1 Student Homework Assignment (see Appendix) to students to be completed before your first classroom session. Printable versions of the articles are provided in the Appendix because they do not always print correctly from the web. If homework is not an option, you may need to cover some of the content at the beginning of your first class period, depending on the science background of your students.

2. If your students have not had exposure to sea level rise, in addition to or instead of the homework, you may want to review thermal expansion and the impact of melting glaciers on sea level rise with students before proceeding. To assist with this, "Resources on Sea Level Rise & Climate Change" can be found in the Appendix.

3. Supplies needed for Engage activity (diagramming their understanding of sea level rise)
   Large paper for diagrams – 1 per group
   Colored markers, pencils, pens or crayons
   Post-it notes – a few post-it notes per student to give feedback

4. Choose one of the many thermal expansion activities to demonstrate for your class and gather the materials needed. See "Thermal Expansion Demonstration Examples and Ideas" in the Appendix for suggestions.

5. Make sure you have an internet connection in your classroom to access the following video or download a copy (if possible) as well as obtain technology to have everyone watch it (shared tablets, LCD projector, projection screen/flat screen monitor/television, etc.):
   NASA's Global Climate Change: Vital Signs of the Planet
   Go to http://climate.nasa.gov/climate-reel/
   Then navigate to "Oceans of Climate Change" video (3:49)

6. Review "Support for Creating a Melting Ice Demonstration" in the Appendix. It provides suggestions for running the activity and the materials that could be used. Obtain assorted materials and/or have students help you gather them.

7. Give each student one copy per of each of the following for Part 1 Classroom Session:
   Rubric that you've chosen to use throughout the project
   Guide to understanding rubrics, if needed
   Record the procedure for your melting ice demonstration, if you choose to use it
   Part 2 Student Homework Assignment

Part 1

Student Homework Assignment (40-50 minutes)

To be completed before Part 1 Classroom Session

See Supplemental Documents in the Appendix to find:

- Part 1 Student Homework Assignment
- Guiding Questions for Going UP
- printable version of the article: *Sea level rise: Global warming's yardstick*
- Guiding Questions for Sea level rise: Global warming's yardstick
- sea level rise glossaries

You may want to include a description of the overall goals of the YESS project with this homework assignment.

Supplemental Science Content Resources:

> *If you think your students will need more background on sea level rise or if you want to give them different articles than the ones above, see "*Resources on Sea Level Rise & Climate Change" *in the Appendix for some recommendations or use your own.*

An Overview of Sea Level Rise:

1. Students will need internet access and should watch this video and answer the guiding questions:

Going UP: Sea Level Rise in San Francisco Bay (13:30) – KQED video
https://www.youtube.com/watch?v=LDv021_zW-E
Guiding Questions for Going UP

2. Students should read this article and answer the guiding questions:

Sea level rise: Global warming's yardstick
December 11, 2014
By Rosalie Murphy, NASA's Jet Propulsion Laboratory
http://climate.nasa.gov/news/2201/
Guiding Questions for Sea level rise: Global warming's yardstick
(A hard copy of this article that can be provided to your students is in the Appendix.)

3. See Glossaries in the Appendix for English definitions of commonly used terms related to sea level rise. See the website below to download the Spanish version.

Sea level rise Glossary (Spanish)
https://www.meted.ucar.edu/glossaries/COMET_glos_en_es_v7a-06_12.zip)

Part 1

Classroom Session (about 90 minutes)

Introduction to sea level rise and communicating science

1. Engage - Have students work in small groups to create a drawing that explains their understanding of the causes and impacts of sea level rise. They should include appropriate labels and directional arrows to show cause and effect, describe processes and provide clarification. Set this aside until later in this classroom session.

2. Start the thermal expansion demonstration. Have students make predictions about what they think they will observe by the end of the classroom session. Most of these demonstrations require a little bit of waiting time to let the water warm up and expand, if you've chosen one with wait time, you can move on to the next activity and check back later.

3. Show Josh Willis' heat capacity demonstration video as an example of how a science concept can be demonstrated and explained in a way that a general audience can understand. It is called "Oceans of Climate Change" (3:49) from NASA's Global Climate Change: Vital Signs of the Planet website: http://climate.nasa.gov/climate-reel/. (*Dr. Willis often shows this demonstration in-person at his lectures to help him explain heat capacity, which is an important concept to understand in his climate change talks.)*

Allow students some practice with the presentation rubric that will be used to assess their work by having them complete it as they watch the video. You may want them to watch the video twice – once for content and once to fill out the rubric.

4. Explore - Have students work in small groups to figure out how they would create a similar demonstration and explanation of the impact of iceberg (sea ice) vs. glacier (land ice) melt on sea level rise for another high school student or community member. Make sure they take detailed notes and make drawings of the final version of their demonstration to make sure that they can replicate it later if they wish to use it as part of their final public product.

5. Wrap up the melting ice activity and/or check on the thermal expansion demo, whichever it makes sense to do first given your time constraints and the demo that you chose.

Explain - When you wrap up the melting ice activity, students should write down what they decided upon by taking notes or filling out the "Record the procedure for your melting ice demonstration" sheet. They can share what they have done by pairing up and sharing, show their demonstration to the whole class – or make a video (live action, animation), write a poem, song, limerick, etc. to be shared at a later time – perhaps in their final public project.

6. Wrap up the discussion of sea level rise causes and effects, including having groups revise their initial drawings of how sea level rise occurs and answer any lingering questions.

7. Evaluate – Have students view other groups' drawings, add questions they (and you) have about the diagrams (post-it notes are a good way) and allow time for groups to work together to revise their own drawings again, if needed. Save the drawings for later use.

8. This is a good time to share an overview of the YESS project with students (if you haven't already) so they have an understanding of what to expect for the next classroom session. The goal is for them to decide how to contribute to the understanding of sea level rise in your area by collecting data about the coast and contributing their findings.

9. Introduce homework in preparation for next session "Part 2A Student Homework Assignment".

Part 1

Optional Extensions

1. Some related concepts that could be explored here are topography, elevation, contour lines, and reading and understanding maps.
A drawing activity combined with the glacier ice melt activity can help them start thinking about viewing the earth from above to prepare them for looking at aerial photos, satellite images, and the GIS layers in sea level rise model(s). A topography lesson adapted from US Geological Survey (starting on page 5) can be found at
http://omp.gso.uri.edu/ompweb/doee/teacher/pdf/act16.pdf

2. Other concepts that could be explored are changes in coastline, not just because of the change in sea level height, but also because of erosion and how natural and manmade structures affect erosion.
A place to start:
"West Coast Shoreline Change Over the Last Century: Results from the USGS National Assessment of Shoreline Change Studies"
http://www.fws.gov/pacific/climatechange/meetings/coastal/pdf/sessionc/Richmond_USGS_Historical%20Shoreline_Change_West_Coast.pdf

3. Technologically inclined students can try to follow the directions in this blog to create an overlay to show sea level at a different elevation in Google Earth.
http://freegeographytools.com/2007/high-resolution-sea-level-rise-effects-in-google-earth

Part 2A

Teacher Preparation (10-30 minutes)

If students do not complete "Part 2A Student Homework Assignment", you may need to set aside some extra class time to talk about how sea level height is measured with satellites, tide gauges, and buoys. The ice breaker may offer you the opportunity to discuss satellite and tide gauge data (and data from other instruments that you choose to include) and how the data from these instruments show us that sea level is rising.

1. Ice breaker Materials:
Ideally you would want each student to have one, unique image (in hardcopy). We have put together a pdf with a generic set of printable images for you to use (available as a separate electronic document) or you can use the Resources in the Appendix to create your own set of images for use in this activity.

2. Make sure you have an internet connection to show the students the Our Coast Our Future (OCOF) website or have students explore it on their own or in small groups. If you need help with Our Coast Our Future see "Our Coast Our Future (OCOF) - Tutorials" in the Appendix.

3. Depending on how much experience your students have with models, you may want to add more content and background information for them. If you need resources on climate models see "Resources on Climate Models" in the Appendix.

4. Depending on how much background your students have with the impacts of sea level rise, you may want to add more content and background information for them. If you need resources on the impacts of sea level rise see "Resources on Sea level rise impacts" in the Appendix.

5. Depending on the kind of data that your students will be collecting, you can adapt your introduction to fit your students' projects. This version of the lesson series includes two different kinds of data collection protocols for your students to follow: King Tides photo documentation and community interviews. Work with your agency partner to determine which of the two types of data would be more useful to the community and more helpful to your students.

   a. For King Tides photo documentation, you can show your students (or have them explore on their own) examples of extreme high and low tide photos on the Flickr Group website and/or show them the Liquid website and the Liquid app. Work with your local agency partner to decide where best to submit your data. Some examples of existing databases for King Tide photos are:
      Flickr Group for the California King Tides Project
      https://www.flickr.com/groups/cakingtides/
      Liquid app and website (for iPhone and Android version coming soon)

https://itunes.apple.com/us/app/liquid-mobile-data-collection/id1008989518?mt=8
https://getliquid.io/

b. For community interviews, you may want to show your students (or have them explore on their own) some online resources of interviews and resources for interview questions, such as Climate Stories which is a website that has writing prompts to help people tell interesting stories or NOAA Fisheries' website about collecting Local Fisheries Knowledge (LFK) through interviews. Interviews could be submitted to a local agency that is interested in the information.

Climate Stories
http://www.climatestoriesproject.org/tell-your-story.html
NOAA Fisheries: Using Interviews
http://www.st.nmfs.noaa.gov/lfkproject/07_UsingInfo.htm

6. Depending on the kind of data your students will be collecting, you will need to provide them copies of the following from the Appendix:

California King Tides Project Protocol
Student Data Collection Plan: King Tides
Interview Protocol & Sample Questions
Interview Consent Form
Student Data Collection Plan: Interviewing Community Members
Part 2B Student Homework Assignment

7. If you are planning a class field trip, now is a good time to finalize your plans and prepare an information sheet about the trip for your students.

Part 2A

Student Homework Assignment (30-40 minutes)
To be completed before Part 2A Classroom Session

See Appendix for Part 2A Student Homework Assignment sheet, printable versions of the articles, and corresponding guiding questions.

See Glossaries in the Appendix for English and Spanish definitions of commonly used terms related to sea level rise.

Some of the ways sea level height is measured:

1. Students should read and complete the Guiding Questions for:

   Just 5 questions: Sea surface topography – how do we measure sea level height
   Interview by Jeanette Kazmierczak, NASA's Jet Propulsion Laboratory, August 4, 2015
   http://climate.nasa.gov/news/2318/

   Reading between the tides: 200 years of measuring global sea level
   https://www.climate.gov/news-features/climate-tech/reading-between-tides-200-years-measuring-global-sea-level

2. Students will need internet access and should explore NASA JPL's Sea Level Viewer interactive website and complete the Guiding Questions:

   Start here:
   http://climate.nasa.gov/interactives/sea_level_viewer
   Below where is says "Data Activity", click on the image that says Sea Level Viewer. After the new window opens and loads, click on "OVERVIEW" to view a brief history of the satellites that measure sea level height (1:30). Then click on any of the boxes on the right of the Sea Level Viewer to learn more.

3. See Glossaries in the Appendix for English definitions of commonly used terms related to sea level rise. See the website below to download the Spanish version.

   Sea level rise Glossary (Spanish)
   https://www.meted.ucar.edu/glossaries/COMET_glos_en_es_v7a-06_12.zip)

Depending on your focus, you may want to include one or more of the resources below in addition to or instead of the resources provided above.

Supplemental Science Content Resources:

Argo buoys are also an important way to monitor sea level height
http://www.argo.ucsd.edu/About_Argo.html
http://www.argo.ucsd.edu/How_Argo_floats.html
http://www.argo.ucsd.edu/global_change_analysis.html

Information about Argo buoys for an elementary school audience, but is a good example for something students may want create http://imos.org.au/argoanimation.html

Another way to see sea level rise – by long term monitoring in the intertidal zone: http://www.eeb.ucsc.edu/pacificrockyintertidal/target/target-species-rock.html

How art helps us know. "Works Of Art Shed New Light On Climate Change." ScienceDaily, 20 November 2008. www.sciencedaily.com/releases/2008/11/081119084841.htm

Breakthroughs in measuring and understanding sea level rise from 2005 – includes links to animations (.mpg) of change in sea level, change in sea surface temperature, glacier retreat, ARGO buoy. The animations might take a long time to download. http://www.nasa.gov/vision/earth/environment/sealevel_feature.html

"How do we Know: Sea Level Rise" video (1:59) - How the satellites work to measure sea level height: https://vimeo.com/12059554

From IPCC: Technical, but short & concise explanation of why sea level rises, how much, how we know, and predictions for the future. https://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-5-1.html

Eyes on the Earth 3D (to visualize sea surface height) http://eyes.jpl.nasa.gov/eyes-on-the-earth.html

How do we know climate is changing? from National Geographic http://www.nationalgeographic.com/climate-change/special-issue/?utm_source=Facebook&utm_medium=Social&utm_content=link_fb20151015ng-climatechange&utm_campaign=Content&sf14173808=1

Part 2A

Classroom Session (about 45 minutes or more)
Types of data that can be collected to better understand local impacts of sea level rise and selecting one focus area for their project

1. Engage: Ice breaker

-Each student receives one image (satellite photo, aerial photo, king tide photo, example of coastal armoring, photo of a community member, carbon cycle diagram, sea level rise impacts, etc.).

-Everyone needs to find at least one other person that has a "matching" or related image (same location but different data, same kind of data but different time and/or place, etc.). It doesn't really matter how they "match", it is an exercise in being observant, creative, and thoughtful in using prior knowledge. Students need to be able to explain the reason for their match.

-Once students find their "match", those people get together and make up a 2 or 3 sentence story about how the images relate to each other, not just a description of what is shown in the picture.

-Have each group share their short story. They may also want to share one question they have based on their image or the activity.

2. Discuss Our Coast, Our Future mapping tool and models

Explore and discuss the OCOF mapping tool

-Give students a tour of the map as you (or a designated student) use the computer, but have them give input on what to click on, ask them what it shows, have them give suggestions about what layers they want to see/activate, etc. and go through some scenarios. Students may want to use this model to support them in creating their final presentations.

-If you have time and enough computers (2 or 3 students per computer will work), have them watch one or both of the tutorials (if they have not already) and/or play with some scenarios on their own.

3. What is a Model?

After exploring the OCOF model with your students or having them explore a few minutes in small groups on their own, ask them how they would describe a model and modeling.

The basics are:

-Models are information (wind data, topography, etc.) translated into mathematical equations or numerical approximations. What you get out of models (such as OCOF) are flood/storm projections+uncertainty.

-"All models are wrong; some models are useful." –George Box, statistician

-The more information (physical modeling of processes instead of just static data) you put into a model, the more accurate it can be.

-Models are used to help understand what is happening now (using what we know has happened in the past and the knowledge we have about current on-going processes) and predict what could happen in the future.

Transition from thinking and talking about large scale models to the local scale and transition to the topic of impacts. Here is a short blurb about why large scale models are bad at helping us predict the small, local scale sea level rise and impacts:
http://sealevel.climatecentral.org/basics/local
Fortunately, precise local models are being developed and the students' work can help in ground-truthing those models

4. What are some of the Impacts of sea level rise?

While looking at flood scenarios in OCOF, it is a good time to talk about some impacts of sea level rise. You can refer back to some of the icebreaker images, have students create a particular scenario in OCOF or think of their own local concerns about sea level rise.

The basics are (and there are many more):

- accelerated beach erosion rate
- greater incidence of cliff failures
- landward translation of coastal flooding and inundation
- dangerous navigation conditions
- beach/shore safety compromised
- saltwater intrusion into coastal aquifers
- impacts on coastal jobs and economies such as tourism
- loss of wetland habitat
- flooding of roads, homes, and businesses

A good movie to show in class or assign for homework, particularly for Bay area residents:
Our Bay on the Brink "The Water at Bay" video (7:45)
http://ourbayonthebrink.org/minidoc/

This is a good document that highlights "sea level rise and coastal damage" as one of the five key messages for our region (Southwest USA: Arizona, California, Colorado, Nevada, New Mexico, and Utah)
http://nca2014.globalchange.gov/report/regions/southwest#statement-17102

Briefly introduce your students to citizen science, if they have not heard of it already.
Here is a TED talk that might help: Citizen Science: Chandra Clark (18:48)
https://www.youtube.com/watch?v=U7XOcB6_TWw

5. Introduce the types of data needed and the methods used to collect that data to help with understanding the local impacts

I. Photographing the King Tides

Background info:

What are King Tides? http://california.kingtides.net/resources/
"California King Tides: Snap the Shore, See the Future" (3:56)
http://california.kingtides.net/

"Science on the Spot: Watching the Tides" (6:24) tides, tide gauges
http://ww2.kqed.org/quest/2010/12/10/science-on-the-spot-watching-the-tides/
Urban Tides Community Science Initiative: http://dornsife.usc.edu/uscseagrant/urban-tides-initiative/

Protocol:

The protocol will depend on what you've decided upon with your local agency partner.

If you do decide to utilize the California King Tides Project or the Urban Tides Initiative, the protocol is below.

a. The protocol for collecting data for the California King Tides Project is included in the Snap the Shore video above, but it is also in a document called "California King Tides Project Protocol" in the Appendix and includes information from the Flickr website. You may want to discuss how are the photos used: http://california.kingtides.net/how-are-king-tides-photos-used/

b. The protocol for collecting data for the Urban Tides Community Science Initiative are very similar and can be found in a document called "Urban Tide Community Science Initiative" in the Appendix. The main difference is how and where to submit the photos. To help your students plan their data collection, there is a handout called "Student Data Collection Plan-Tides" in the Appendix.

Data submission:

Again, this will depend on what you've decided upon with your local agency partner.

If you do decide to utilize the CA King Tides Project or Urban Tides Initiative, the students will submit their data (as described in the protocol documents above) to:

a. the Flickr.com website (California King Tides Project)
b. the Liquid phone app or website (Urban Tides Community Science Initiative)

II. Interviewing community members

Background info & Protocol:

The "Interview Protocol & Sample Questions" were adapted from NOAA Voices from the fisheries: http://www.st.nmfs.noaa.gov/voices/

Although, the History Channel focuses on different topics in their interview protocols, the basic procedure and considerations are similar and may be helpful: http://www.history.com/images/media/interactives/oralhistguidelines.pdf

The interview consent form is adapted from the NOAA Voices form and can be found in the Appendix.

To help your students plan their data collection, there is a handout called "Student Data Collection Plan-Interviews" in the Appendix.

Here is an example of an interview with Anote Tong, the President of Kirabati: *Anote Tong: My country will be underwater soon – unless we work together* (21:15) https://www.ted.com/talks/anote_tong_my_country_will_be_underwater_soon_unless_we_work_together?language=en

Data submission:

Students can enter data in:

A Google form that your students can develop. This will help them look at all the data across multiple interviews. Each group can develop their own interview

questions and form or all the groups conducting community interviews can work together to create one set of questions and one form. Here is an example: https://docs.google.com/forms/d/1bMohtzMKoBIlRmJo4N5-C4PIw7JUTKp0jteRjAfgEcQ/edit
A possible public presentation could be to analyze the data and create a visual communication product, such as a word cloud, for example: http://scienceblogs.com/gregladen/2015/02/17/climate-scientists-vs-climate-science-deniers-in-word-clouds/
OR
Work with your local agencies to see who would be the best person or department to make use of the information gained from the interviews.

III. Assessing Coastal Armoring *TO BE ADDED IN THE FUTURE*

6. Divide students into small groups (if you have not already) and have them choose which kind of data they want to collect.
Provide each team with the appropriate worksheets:
California King Tides Project Protocol
Urban Tides Community Science Initiative Protocol
Student Data Collection Plan: King Tides
Interview Protocol & Sample Questions
Interview Consent Form
Student Data Collection Plan: Interviewing Community Members
Have students start developing their plan in class and have them finish it for homework, if they need additional time.

7. Part 2B Student Homework Assignment is to finish their data collection plans and collect data before Part 3 Classroom Session. You may want to see their final plans before they go out to collect data. Data collection may be done on their own in their small groups or on a class field trip – or both.

Have students complete handout Part 2B Student Homework Assignment.

Part 2A

Optional Extensions

What data are available on sea level height and sea surface temperature? Which are most useful for studying sea level rise? Which are useful for understanding climate change overall?

Suggestions of places to look for data:
NASA missions:

GRACE	http://grace.jpl.nasa.gov/
Aquarius	http://aquarius.nasa.gov/
Jason	http://sealevel.jpl.nasa.gov/missions/
SWOT (2020)	http://swot.jpl.nasa.gov/

NASA Data Archive Center:

PODAAC http://podaac.jpl.nasa.gov/

Argo Floats

http://www.argo.ucsd.edu/Uses_of_Argo_data.html
http://www.argo.ucsd.edu/global_change_analysis.html

Ocean gliders

http://imos.org.au/oceangliders.html

Other models to investigate:

Climate Central's "Mapping Choices" & "Risk Zone Map"
http://sealevel.climatecentral.org/

NOAA Digital Coast is a model you can explore. Launch it from this website:
http://coast.noaa.gov/digitalcoast/tools/slr

What other public data can your students find?

Part 2B

Teacher Preparation (10 minutes)

Each student needs one of each handout (they can all be found in the Appendix):

- Tips for creating an effective presentation
- Tips on how to practice your presentation
- Presentation rubrics, if students do not already have them in hand

If students will do research on the internet, provide them with some resources about how to evaluate the credibility of websites. The following are a few suggestions:

- "5Ws evaluation form" from Oksana Hlodan that can be found in the Appendix
- "Help Vetting Websites" from COSEE-West that can be found in the Appendix
- "Evaluating the Credibility of Websites" from LiteracyTA that can be found at: http://www.literacyta.com/ecoach/evaluating-credibility-websites

If possible, provide internet access to help them answer questions related to the science in their presentations or look up maps or other resources they may need.

Part 2B

Student Homework Assignment (time will vary)

1. Students should complete and carry out their field data collection according to the plans they have created. You may want to review and approve their final draft before they carry out their plan.

2. They should follow the protocol provided and/or data should be collected as a class on a field trip.

3. Have students reflect on their data collection experience. They should each make sure their data collection notes are complete and write up their personal notes and thoughts after their data collection. What went well? What would you have done differently? What new questions do you have?

Part 2B

Classroom Session (about 45 minutes or less)

Analysis and synthesis of collected data
Have students discuss and/or complete Part 2B Student Homework Assignment, if not completed as homework.

1. Have your students meet in their groups and discuss what they have learned or observed. Let them know that they will share out their preliminary results and ideas. Have groups pair up and share their findings and field experiences and/or, if you have time, have each group share with the whole class. Prior to presenting, you may want to remind them to reference the presentation rubric that you've given to them.

2. Have your students work in their groups to think about what questions they have about sea level rise, the impacts of sea level rise, the data they collected, their data collection methods/experience, and how their data fits into the big (and local) picture. Did they see anything that concerned them? What do they think is going on based on what they saw? How do they come to that conclusion? What further questions have they developed based on their observations? How can the data they collected play a role in science and policy?

Remind them that they are trying to develop a presentation (a story) out of all that they have learned.

3. See if they can do the research to fill the gaps in their knowledge/story. You can provide them the resources in this lesson and supplemental documents.

If students do research on the internet, provide them with a couple of documents about evaluating the credibility of websites. Remind them to look for locally referenced answers.

Resources for evaluating the credibility of a website:
"5Ws evaluation form.doc" from Oksana Hlodan
"Help Vetting Websites.doc" from COSEE-West
"Evaluating the Credibility of Websites" from LiteracyTA
http://www.literacyta.com/ecoach/evaluating-credibility-websites

4. Students may want to refer back to the OCOF mapping tool and compare what they found with what the mapping tool shows, reminding them that many models show large scale, big picture forecasts, but not the small scale impacts so well. http://data.prbo.org/apps/ocof/

5. If there's time, start creating presentations.

Part 3

Teacher Preparation (time will vary)

1. You may need to set aside extra class time for them to put together their presentations, if they are not done as homework.

2. Now is a good time to finalize presentation/event plans and prepare an information sheet about it for your students.

If you are preparing for a Gallery Walk, please refer to the following two documents in the Appendix:

- Gallery Walk Guidelines
- Gallery Walk Worksheet
  - You should use the Gallery Walk Worksheet to help outline the prompts that you want students (and other guests) to discuss with each group they meet.

Part 3

Student Homework Assignment (time will vary)

1. Students should finish creating their group presentations
   - Have students consult the same presentation rubric you have been using.
   - Give students "Tips for creating an effective presentation" (from the Appendix) or similar guidelines for creating a presentation
   - Remind your students that they have created some resources that they may want to use (or edit for use) in their final presentations:
     - Drawing/explanation of how sea level rise occurs
     - Demonstration of melting ice that they developed

2. Students should practice giving presentations
   - Give students "Tips on how to practice your presentation" (from the Appendix) or similar guidelines for practicing a presentation

   Here are some examples of well done presentations that you may want them to consider:

   NASA's Global Climate Change: Vital Signs of the Planet
   Go to http://climate.nasa.gov/climate-reel/
   Then navigate to "Oceans of Climate Change" video (3:49)

   Two young scientists break down plastic with bacteria (9:20)
   https://www.youtube.com/watch?v=ay-y3tSYGYw

   Citizen Science: Chandra Clark (18:48)
   https://www.youtube.com/watch?v=U7XOcB6_TWw

   Sea level rise – fact & fiction: John Englander (11:02)
   https://www.youtube.com/watch?v=TH8Q8Ki9fCA

   TED Ed: The secret to rising sea level (1:15)
   http://ed.ted.com/featured/3KsJMLba

   Anote Tong: My country will be underwater soon – unless we work together (21:15)
   https://www.ted.com/talks/anote_tong_my_country_will_be_underwater_soon_unless_we_work_together?language=en

Part 3

Classroom (or at event venue) Session (time will vary)

The goal is to have students communicate to the community their findings and the implications of their findings for their study site. The community members include parents, local politicians, decision makers, government scientists, peers, etc.

The content of the day will depend on how you and your students choose to present your public products in your community.

If you have time, do a gallery walk in preparation for the event and have students give feedback to each other.

If appropriate, have students fill out presentation rubrics for fellow students' presentations to provide some constructive feedback.

Part 3

Optional Extensions

1. Now that students see some of the future problems that we need to deal with, maybe they will want to work toward a career to help with solutions.

Here are some ideas for exploring climate-related careers:

Role playing climate-related careers in learning about and discussing global warming
https://www.koshland-science-museum.org/sites/default/files/uploaded-files/Global%20Warming%20Webquest.pdf

Utah Education Network
http://www.uen.org/climate/careers.shtml

2. Write future news stories

For example: Write a story, 20 years in the future as if we did nothing to adapt to sea level rise and write a story, 20 years in the future as if action were taken to adapt to sea level rise.

An example of this is a National Geographic article published in October 2004 about what might happen if a major hurricane hit New Orleans:
http://ngm.nationalgeographic.com/ngm/0410/feature5/

And then Hurricane Katrina hit that area in August 2005 and this is a National Geographic special edition about Katrina that includes that 2004 article:
http://ngm.nationalgeographic.com/static-legacy/ngm/katrina/

3. Write 'Letters to the Editor'

Appendix

Resources for Teacher Preparation

Planning public presentations

The goal of the public presentations is to have students communicate to the community their findings and the implications of their findings for their study site. The community members include parents, local politicians, decision makers, government scientists, peers, etc.

There are many ways to accomplish this and you will need to decide how this will best work for you and your students. Here are some options:

1. Identify audience members that would be interested in your subject(s) and main message.

Some suggestions:
Your California Representatives: http://findyourrep.legislature.ca.gov/
City Council Members
County Supervisors
Municipal Planners
Municipal Water District representatives
Coastal Commission representatives
Property managers at coastal parks, marina operators, etc.
Neighborhood and Community leaders
Leaders from environmental organizations
Parents
Teachers
Principals
Girl Scouts, Boy Scouts, 4-H Club members, Boys & Girls Club, etc.
Local press
Government scientists
Other local students

2. Decide whether you want to plan your own event or participate in an event that someone else is organizing.

Plan your own event
A Gallery walk held at your school site (or nearby location) could be a good way to share a lot of student projects with a lot of people. See "Use a Gallery Walk Guidelines" and "Gallery Walk Worksheet".

Possible venues:
Schools
Churches
Libraries
Community/Senior/Youth/Cultural Centers
Museums (art, science, history, cultural, etc.)
Convention Center

City Hall
City, County, State or National Parks or Beaches
Marine Reserves
Visitor Centers

Find an event

Resources to find events:
Calendar of events in local newspapers or magazines
Check community event calendars in your area – neighborhood, city, county, state level
National Oceanic and Atmospheric Administration (NOAA) events
National Aeronautics and Space Administration (NASA) events

Types of events that might be appropriate:
Earth Day
Coastal Clean Up day (or local waterway clean up)
sea fair/festival
harbor/boating safety event or scuba show
tall ship or sailing gathering
after school programs
film festivals – make a film and enter it or see if there is space for a booth or demonstration
library programming
art walk
public meeting (California Coastal Commission, city/county commission)
(Presenting at a closed-door board meeting may not be as productive or informative for your students.)

If there is limited space or time at the event you are attending, hold a gallery walk prior to the meeting/event to decide as a class which group(s) will make the public presentation.

- Decide how many and which presentations should advance
- Have students revise and refine their projects by utilizing the 'critical friends' protocol
    Buck Institute for Education: Critical Friends Protocol Overview video:
    https://www.youtube.com/watch?v=79Nqw3Q7SV8
    Critical Friend Toolkit:
    http://education.qld.gov.au/staff/development/performance/resources/readings/critical-friend-toolkit.pdf
    Critical Friends: Building a Culture of Collaboration:
    https://www.teachingchannel.org/blog/2015/01/14/building-a-culture-of-collaboration/
- Have the top group(s) give presentation(s) in public setting(s)

Planning public presentations: Suggestions (SF Bay Area, CA)

Compiled by Lauren Armstrong, lkarmstrong@marincounty.org

POSSIBLE EVENTS for student presentations or video screenings

BayWAVE (Countywide Vulnerability Assessment)

- March-May 2016, Specific dates TBD.
  Project updates on vulnerability assessment to City Councils (San Rafael, Larkspur, Corte Madera, Novato, Mill Valley) and Marin County Council of Mayors and Councilmembers

- Wednesday, March 16 or 23, 2016
  Marin County Board of Supervisors hearing (every Wednesday)

- May 2016
  Shore Up Marin, City of San Rafael and Marin County (potentially) co-host public workshop in Canal neighborhood on flood vulnerability and emergency preparedness

Other

- Tuesday, April 24, 2016
  Climate Action Plan community meeting in San Rafael

- Tuesday, March 1 through Thursday, March 3, 2016
  Marin County Science Fair (Bay Model)

- Wednesday, April 20, 2016
  Earth Day Marin

C-SMART (West Marin)

- Monday, February 29, 2016 (date to be confirmed)
  Planning Commission/Public meeting on proposed Local Coastal Program Amendment (LCPA)

- Saturday, April 30, 2016 (date to be confirmed)
  Board of Supervisors takes action on LCPA, submit to California Coastal Commission

POSSIBLE VENUES for art displays

Marin County Libraries
http://www.marinlibrary.org/locations

Point Reyes Library gallery space (Branch Manager: Bonnie White)
11431 State Route One, Point Reyes Station CA 94956
415-663-8375, http://www.marinlibrary.org/library-location/point-reyes-library

Art Works Downtown
1337 Fourth Street, San Rafael, CA 94901

(415) 451-8119, www.artworksdowntown.org

Marin County Civic Center, 2nd floor hallway
10 Ave of the Flags, San Rafael, CA 94903
(415) 473-6800

Marin Health and Wellness Center
3240 Kerner Blvd, San Rafael, CA 94901
(415) 473-4300, hhsfacilitiesmanagement@marincounty.org

La Placita
Outdoor market runs every Sunday from May 10th to September 27th from 10:00am to 5:00pm
3240 Kerner Blvd, San Rafael, CA (in the parking lot of the Marin Health and Wellness Center)
http://www.laplacitacm.org/

San Geronimo Valley Community Center
6350 Sir Francis Drake Blvd, San Geronimo, CA 94963
(415) 488-8888, http://www.sgvcc.org

Romberg Tiburon
3150 Paradise Dr, Tiburon, CA 94920
(415) 338-1111, http://rtc.sfsu.edu/

Point Reyes National Seashore
1 Bear Valley Rd, Point Reyes Station, CA 94956
(415) 464-5100, http://www.nps/gov/pore/index.htm

Golden Gate National Recreational Area, Marin Headlands Visitor Center
948 Fort Barry, Sausalito, CA 94965
(415) 331-1540, http://www.nps.gov/goga/marin-headlands.htm

Marine Mammal Center
2000 Bunker Rd, Sausalito, CA 94965
(415) 289-7325, http://www.marinemammalcenter.org/

San Francisco International Ocean Film Festival
http://oceanfilmfest.org/

Gallery Walk Guidelines

Students share their work and obtain feedback from peers and in some cases members of the community.

In Advance:

1. Review with students in advance how to phrase constructive recommendations. Let students know how they will be evaluated during the gallery walk.

2. Designate space for student products, such as hanging drawings, visual representations, poster projects, computers to view slide shows or videos, etc.

3. Provide chart paper, sticky notes (optional) and writing instruments by each student product for viewers to record their comments and questions. This allows students to gain valuable insights in how they might want to improve their project before presenting them further.

Beginning the Walk:

4. Direct students, individually or in groups, to each start at a different station and to rotate around the room viewing the work presented. Guide the students to provide feedback to the creator of the work. (Assigning a rotating scheme and announcing when to rotate helps ensure students stay on task and stay dispersed.) Have viewers write directly on the chart paper or write on a sticky note they post on the chart paper. Comments might start with "I especially like… because…" "I wonder why…" "One thing I learned was…" "Your work impacted me because…" "Your next step might be to…"

Students are required to record at least one thought about what they liked or admired and one comment about what they wondered, thought could be improved or would recommend as a next step for each work displayed.

After the gallery walk:

5. If time allows gather the viewers and ask them to share their impressions, identify similarities and differences among a collection, and discuss what are some of the themes expressed. Provide time for each group to review and discuss comments they received as a team.

Management strategies:

If students are rotating in groups, have them select a recorder for the group at each station and together they discuss and agree upon comments before posting their thought or have them each write their own comments. For individual student accountability, you may also have the students record their own responses on a worksheet, use different colored markers or put their initials below what they wrote.

Recommendations for common concerns with Gallery Walks
http://serc.carleton.edu/introgeo/gallerywalk/challenges.html

Gallery Walk Worksheet

Name ____ **Date ________________**

Prompt #1: (type prompt here)

My response: ____

____

Prompt #2: (type prompt here)

My response: ____

____

Prompt #3: (type prompt here)

My response: ____

____

Prompt #4: (type prompt here)

My response: ____

____

Prompt #5: (type prompt here)

My response: ____

____

Prompt #6: (type prompt here)

My response: ____

____

Rubric Suggestions

From the Buck Institute for Education:
9-12 Presentation Rubric (Common Core State Standards Aligned)
http://bie.org/object/document/9_12_presentation_rubric_ccss_aligned

6-8 Presentation Rubric (CCSS Aligned)
http://bie.org/object/document/6_8_presentation_rubric_ccss_aligned

There is also a creativity and innovation rubric for 6-12
http://bie.org/object/document/6_12_creativity_innovation_rubric_non_ccss

From Edutopia:
Common Rubric for 9^{th} and 10^{th} grade English
https://www.edutopia.org/pdfs/stw/edutopia-stw-assessment-high-sch-DYO-analytic-writing-rubric.pdf

From LiteracyTA:
The following are specific to their lesson about creating one's first powerpoint presentation.
Overview page of lesson with links to "Rubric" and "Condensed Rubric"
http://www.literacyta.com/literacy-skills/high-5-presentation#/step-3
*Direct link to "Rubric"
http://www.literacyta.com/sites/default/files/skill-in-action/1404/formalpresentationrubric.pdf
*Direct link to "Condensed Rubric"
http://www.literacyta.com/sites/default/files/skill-in-action/1404/high-5-speech-rubric.pdf

You may also want to provide this document or something similar to your students who have not used a rubric before:
From LiteracyTA:
Overview page of lesson with link to "Reading Rubrics"
http://www.literacyta.com/literacy-skills/high-5-presentation#/step-3
*Direct link to "Reading Rubrics"
http://www.literacyta.com/sites/default/themes/literacyta/images/skill-in-action/understanding-your-rubric.pdf

*To utilize the direct links to items on LiteracyTA, you need an account. You can get a trial account for 7 days for free when you first sign up. You can see the overview pages without an account to see how their lessons are set up.

Part 1 Supporting Documents

Teacher Resources

Thermal Expansion Demonstration Examples and Ideas

Here are some examples of thermal expansion demonstrations:
http://www.windows2universe.org/teacher_resources/teach_thermalexpand.html
http://cosee.umaine.edu/cfuser/resources/tr_sea_level.pdf
http://www.cosee-west.org/glaciers/ThermalExpansionActivity.pdf
http://www3.epa.gov/climatechange/kids/documents/sea-level-rise.pdf (has both thermal expansion and melting glacier demos)

Additionally, here is a way to demonstrate thermal expansion with very few pieces of equipment.

Materials (per set up):

- 1 plastic test tube
- 1 clear straw
- a small ball of clay, enough to plug/seal the top of the test tube
- a little more water than would fill the entire test tube
- a drop of food coloring for the water (makes the water easier to see in the clear straw)
- insulated thermos with hot water
- 1 ultra fine sharpie or dry erase marker

Set up (refer to the photo):

1. Fill the test tube with lightly colored water

2. Put the clear straw in the test tube

3. Seal the top of the test tube around the straw so that the only place water could escape is through the top of the straw

4. Add a little more water to the straw so that the water level is above the clay

Procedure:
1. Mark the bottom of the meniscus of the water in the straw.

2. Place all but the top of the test tube in container with warm water (like a water bath) or use warm hands to warm up the water in the test tube.

3. Make a prediction as to what should happen with the water.

4. Check the height of the water in a few minutes (before the water starts to cool down!).

Alternatively, you may choose to create a basic demonstration yourself, perhaps with equipment you already have. Here are some ideas:
For each set up, you will need:
(1) heat source:
- -Warm hands
- -Hair dryer
- -Put test tube in warm water bath - hot tap water or electric kettle to get warm water bunsen burner or hotplate

(1) container:
- -Flame/Heat tolerant glassware (like pyrex) if you are using a Bunsen burner or direct flame
- -If using lower temperature heat source, you can use any plastic or glass test tubes or narrow, tall containers

other equipment:
- -Markers to mark water level in container
- -Data sheet

optional:
- -Thermometers to measure water temperature inside container

Teacher Resources

Support for Creating a Melting Ice Demonstration

Facilitate your students in developing a demonstration that shows the difference in the change in sea level height when glaciers melt as compared to when icebergs melt.

Here are some thoughts on materials that can be provided to students for use in this activity and some hints about over all construction of a model. Provide hints to students or not as the need arises.

Some general hints:
- A demonstration that uses less liquid water will show the impact more dramatically.
-Also, in thinking about using this demo again later: A smaller set up means it takes less room to store, it is less expensive to purchase equipment, less ice required, less water required, sea level rise can be more noticeable (depending on how it is set up).

Some things to consider for each of the main ingredients in this demonstration:

Ice:

-Can use any shape ice, but if you have time some teachers have their students quantify the volume or weight of ice that is used and look at how much it affects sea level rise – cubes might be easier than ice chips for volume measurement and size consistency.
-Can freeze food coloring in ice to show the movement of the melting ice as it goes into the model. If you don't make your own ice, you can add a little food coloring on top of the land ice that you put in your model and you'll get a similar affect as it melts.
-optional: method/instrument to quantify ice such as a scale

Sea Level/coastline:

-Container (could just be a container with water in it to simulate sea level or it could have dry land with water to create a coastline).
-Recommend clear, 4 to 8 ounce size (mozzarella/salsa/hummus/ziplock) containers
-Each group should use two identical containers, if possible.

Constructing a coastline:

-Depends on whether you want it to be permanent or changeable/modifiable as to the type of material you use in your model. Modeling clay (use non-drying, but not the foamy stuff like Model Magic), plasticine, oil based modeling clay

-If your students have time, they may choose to build a coastline that looks like an actual stretch of coastline near them.

Tools:

-Something to measure a change (or lack there of) in the water level in both containers: clear ruler, measuring tape, etc.

-Possible to measure level from outside or inside container as long as it is consistent

-Marker to mark starting and ending sea level

-Have students create and fill in a data sheet

Heat source: (optional but will increase rate of melting if time is short)

Lamp

Location in direct sunlight

Here are some examples of melting glacier demonstrations:

Sea Ice, Glaciers, and Sea Level Rise
http://www.cosee-west.org/Mar2109/Sea%20Ice%20Glaciers%20and%20sea%20level%20rise%20lesson.pdf

Thermal expansion, glacier melt, greenhouse effect, and topography lessons
http://omp.gso.uri.edu/ompweb/doee/teacher/pdf/act16.pdf

The New York Times Learning Network Lesson Plan
Ice Breakers: A Lab Experience About the Effects of Global Warming on Icecaps
http://www.cosee-west.org/glaciers/NYTimes_IceBreakers.pdf
data sheet: http://www.cosee-west.org/glaciers/Sea_Ice_Sheet_Ice_Exp.pdf

US EPA lesson plan with both thermal expansion and melting glacier demos
http://www3.epa.gov/climatechange/kids/documents/sea-level-rise.pdf

Here are some resources about inquiry-based activities:

Overview of inquiry: http://scied.ucar.edu/inquiry

http://www.hent.org/sue/Scientific%20Inquiry%20Process.htm

http://www.p21.org/news-events/p21blog/1296-10-tips-for-science-teachers-adapting-to-the-next-gen-science-standards

NSTA: http://www.nsta.org/about/positions/inquiry.aspx

Annenberg Learner: https://www.learner.org/workshops/inquiry/resources/faq.html

Teacher Resources

Resources on Sea Level Rise & Climate Change

Getting the Picture: Our Climate Change, interactive climate education resource website
http://gettingthepicture.info/

Simple explanation of the causes of sea level rise
http://sealevel.climatecentral.org/basics/causes

Sea level rise, NOAA (*very short, video & transcript*)
http://oceantoday.noaa.gov/globalvslocalsealevel/

Sea level rise in the bigger context of climate change, NOAA (*very short, video & transcript*)
http://oceantoday.noaa.gov/stateoftheclimate/

"Big Shelves of Antarctic Ice Melting Faster Than Scientists Thought" 2015, emphasizes precariousness of ice sheets
http://www.npr.org/tags/395537206/sea-level-rise

SoCal connected KCET interviews with Dr. Joshua Willis, a climate scientist at the Jet Propulsion Laboratory in Pasadena, on what climate change and rising seas mean to the California coastline and filmmaker Jeff Orlowski on a key principle in his new documentary on climate change, "Chasing Ice" -- that seeing is believing. (26:46)
http://www.kcet.org/shows/socal_connected/content/episodes/november-20-2012.html
Just the Willis interview, KCET (4:27)
http://www.kcet.org/shows/socal_connected/content/interview/what-climate-change-and-rising-seas-mean-to-the-california-coastline.html

Clue into Climate: Facing our Future, Book 4, KQED
https://itunes.apple.com/us/book/clue-into-climate-facing-our/id932658240?mt=13

National Research Council - downloadable book "Climate Change: Evidence, Impacts, and Choices" (also Spanish) https://nas-sites.org/americasclimatechoices/more-resources-on-climate-change/climate-change-lines-of-evidence-booklet/
And/or watch 26 minute video called Climate Change: Lines of Evidence
http://dels.nas.edu/Materials/Booklets/Lines-of-Evidence2

Interesting for big picture of teaching of climate change, for teachers
http://learning.blogs.nytimes.com/2014/04/02/teaching-about-climate-change-with-the-new-york-times/?_r=0

NOAA state of the coast, five lessons – why communication is important to science, how do coastal ecosystems benefit the U.S., how do coastal resources contribute to our economy, what kinds of things can be measured that provide an indication of the health of the coastal ecosystems, how climate change is expected to affect the vulnerability of coastal communities http://stateofthecoast.noaa.gov/features/lessonplans.html

Climate Action plan for Marin County
http://www.marincounty.org/~/media/files/departments/cd/planning/sustainability/climate-and-adaptation/execsummarymarincapupdate_final_20150731.pdf?la=en

"Are conservation organizations configured for effective adaptation to global change?"
http://web.utk.edu/~parmswor/FrontiersArmsworth2015.pdf
Armsworth lab http://web.utk.edu/~parmswor/economics.html

The Water at Bay (7:45) from Our Bay On The Brink, impacts of sea level rise and flooding
http://ourbayonthebrink.org/minidoc/

Student Worksheets

Student Homework Assignment

to be completed before class on: ___________

An Overview of Sea Level Rise

You will need:

access to the internet and YouTube to watch the video

either internet and web browser access or printed copy of the article "*Sea level rise: Global warming's yardstick*"

a copy of "Guiding Questions for ***Going UP: Sea Level Rise in the San Francisco Bay***"

a copy of "Guiding Questions for **Sea level rise: Global warming's Yardstick**"

a copy of "Sea Level Rise Vocabulary" in English and/or Spanish

(Spanish version is available for download: https://www.meted.ucar.edu/glossaries/COMET_glos_en_es_v7a-06_12.zip)

1. Watch this video and answer the guiding questions:

Going UP: Sea Level Rise in San Francisco Bay **(13:30) -** KQED video
https://www.youtube.com/watch?v=LDv021_zW-E

2. Read this article and answer the guiding questions:

Sea level rise: Global warming's yardstick
December 11, 2014
By Rosalie Murphy, NASA's Jet Propulsion Laboratory
http://climate.nasa.gov/news/2201/

3. Use the English and/or Spanish Sea Level Rise glossaries (and other reliable resources) to help you better understand the video and the article and throughout this project.

The Spanish version is available for download here:
https://www.meted.ucar.edu/glossaries/COMET_glos_en_es_v7a-06_12.zip

Student Worksheets

Guiding Questions for Going UP: Sea Level Rise in the San Francisco Bay
KQED Quest
https://www.youtube.com/watch?v=LDv021_zW-E

1. Who and what will sea level rise affect in coming years?

2. What are the two main questions that scientists have about sea level rise?

3. Why does sea level rise in places like Alviso, CA raise issues like environmental justice?

4. How much sea level will rise depends largely on what?

5. As the planet warms up, what happens to the sea water that causes the sea level to rise?

6. What is the other main contributor (from climate change) that causes sea level to rise?

7. Another major concern is that sea level rise will combine with other forces of nature to causes even higher sea level. Name at least one of those other forces of nature?

8. A 2009 report said that sea level could rise in the bay area by how much by the year 2100?

9. Name one ‘hard’ solution and one ‘soft’ solution for adapting to sea level rise.

10. What is it going to take to adapt to sea level rise?

11. What might happen if we don’t do anything to adapt to sea level rise?

12. Who is working on the problem?

Article: Sea level rise: Global Warming's yardstick

FEATURES | December 11, 2014 http://climate.nasa.gov/news/2201/

Sea level rise: Global warming's yardstick

By Rosalie Murphy, NASA's Jet Propulsion Laboratory

One of the Argo array's buoys begins collecting ocean temperature data after a science team deploys it in the Atlantic Ocean. Credit: Argo / University of California, San Diego.

Global sea levels have been ticking steadily higher by about an eighth of an inch (3.2 millimeters) each year since scientists began measuring them two decades ago. That's why Carmen Boening, a research scientist at NASA's Jet Propulsion Laboratory in Pasadena, California, was so shocked in 2010 and 2011, when she saw a quarter-inch (five-millimeter) drop in sea level – a sudden reversal of the trend.

Key points

Credit: Jocelyn Augustino/FEMA

- Global sea levels have risen by 8 inches in the last 130 years.
- Sea level measurements help tell us about our changing climate because they are the sum of heat the ocean absorbed and water added from melting glaciers and ice sheets.
- About 90 percent of the heat trapped in the Earth's atmosphere is eventually absorbed by the ocean. Heat causes water to expand, which increases sea level.
- There are some natural variations in sea level caused by weather patterns, like El Niño, that move water around from region to region.

"We knew that either the sea was cooling, or there was less water in the ocean," Boening said. Like metal, water contracts when it cools. "So we used NASA'sGRACE mission, which basically weighs water to tell us how much is present in different parts of the world, both in the ocean and on land. We found there was actually less water in the ocean."

Water can't just vanish. If it leaves the ocean, it has to show up somewhere else in the water cycle. Sure enough, Boening's team found huge amounts of precipitation and flooding in Australia and South America. GRACE data suggested lots of water had evaporated from the ocean during the 2011 La Niña event. Then other wind patterns pushed the precipitation to Australia.

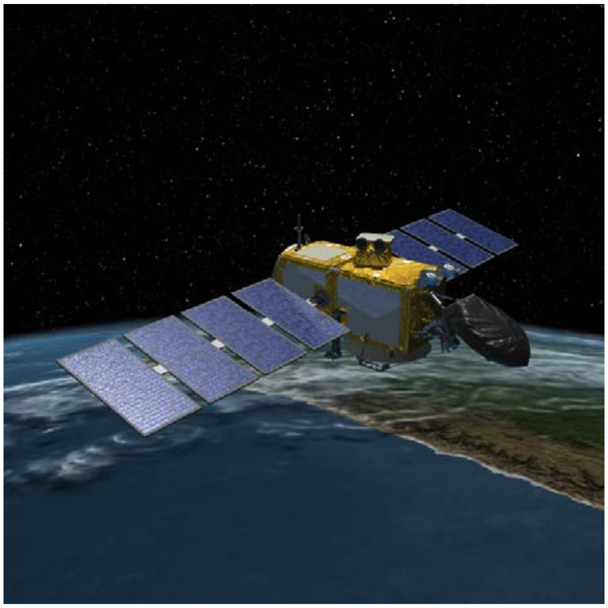
"It had to be a combination of all these events at once, and that's why the drop was so large," Boening said. "But at some point, it had to run off into the ocean. That's what happened next."

A few months later, the ocean returned to the previous year's levels and the upward trend resumed.

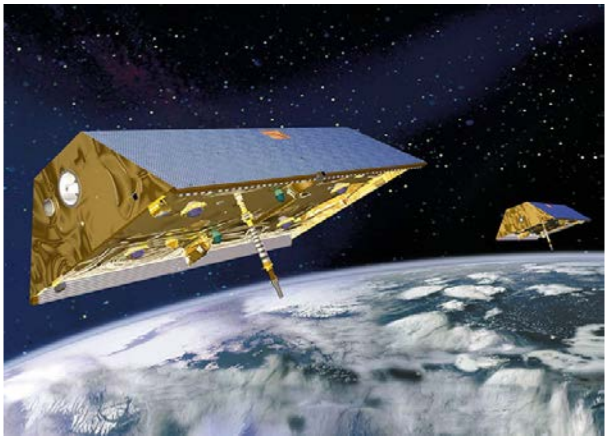
How NASA measures sea level

Global sea levels have risen by about 8 inches in the last 130 years. It might not sound like much – but the ocean covers about 70 percent of Earth's surface and holds about 99 percent of its water. A tiny rise or fall involves a lot of water.

"Sea level rise is the yardstick for global warming," said Josh Willis, a research scientist at JPL. "It's the ruler by which we measure how much human activity has changed the climate. It's the sum of the extra heat the ocean has absorbed and the water that's melted off of glaciers and ice sheets."



The Ocean Surface Topography Mission (OSTM)/Jason-2 measures sea surface height. Credit: NASA



The GRACE twin satellites make detailed measurements of Earth's gravity field. Credit: NASA

Willis leads NASA's Jason missions, satellites that measure sea level and ocean surface topography, or variations in ocean surface height at different areas around the globe. This variation is driven in part by deeper currents and weather patterns like El Niño, La Niña and the Pacific Decadal Oscillation. These patterns move huge amounts of water from some regions of the ocean to others, pushing some parts of the surface downward and others upward.

The GRACE twin satellites make detailed measurements of Earth's gravity field. Credit: NASAThe Gravity Recovery and Climate Experiment (GRACE) mission, which helped Boening and Willis track water during the 2011 La Niña, collects data using twin satellites orbiting Earth together. When the lead satellite encounters a slight change in Earth's gravity, the force pulls it a little further from its partner. The second satellite measures the distance between them to estimate the strength of Earth's gravity.

The planet's gravity changes because different amounts of mass have piled up at different places. There's a lot more Earth in the Himalaya, for example, than in the Mississippi Delta. Similarly, when water coalesces in a certain part of the ocean, it tugs on GRACE's satellites a little harder.

But changes on land also play a role. For example, Greenland's ice is melting. "As the land loses mass, its gravitational pull is not as strong, so it's losing its ability to attract water," Boening said. Though melting land ice from Greenland and glaciers account for about two-thirds of sea level rise to date, "sea level around Greenland is actually going down."

Mass, height and heat

The ocean is also gaining heat. Small heat transfers happen constantly at the ocean's surface and, eventually, the ocean swallows most of the heat greenhouse gases have trapped in Earth's atmosphere. That heat warms the whole ocean, causing it to expand.

Expansion seems simple, but measuring it is a challenge. "Over 90 percent of the heat trapped inside Earth's atmosphere by global warming is going into the oceans," Willis said. Temperature data from 19th-century ship, compared to a set of 3,600 buoys measuring ocean temperature today, confirms that the ocean – especially its upper half – has warmed since 1870.

In the bottom half of the ocean, though, it's harder to tell. Buoys measure only about halfway to the bottom, a depth of about 1.25 miles (2,000 meters). Over many decades, ocean currents pull water from the surface of the ocean toward its depths. Scientists have assumed the deep ocean has been warming, too – but a new paper by Willis and other JPL scientists found no detectable warming below that 1.25-mile (2,000-meter) mark since 2005.

"We can't see heat in the deep ocean yet. The effect has been too small over our ten years of data, and the ways the ocean can get heat down deep are very slow. It might take a hundred years," Willis said. "We still have to rely on the data and not our simulations to figure out what's going on in the deep ocean. So we have some more scientific work to do."

On the other hand, another paper from the same journal found that earlier studies drastically underestimated warming in the Southern Ocean, since the 1970s. New estimates suggest it absorbed anywhere from 25 to 58 percent more heat than previous researchers thought. Scientists will continue learning more about the ocean's intricacies, correcting assumptions and revising old estimates. But Willis warns against losing sight of the strong global trend toward rising sea levels.

"The picture is very simple," he said. "The ocean heats up and causes sea level rise. Ice melts and causes sea level rise. We can see the results at the shoreline."

This feature is part of a series exploring how NASA monitors Earth's water cycle. Other ocean missions include Aquarius, which measures the ocean's salinity to offer scientists clues about evaporation and rainfall patterns and changes in the ocean's density, which can drive circulation patterns. The Surface Water and Ocean Topography (SWOT) mission will improve topography measurements at the coast after its 2020 launch. Learn more about all of NASA's Earth science missions.

Student Worksheets

Guiding Questions for Sea level rise: Global warming's yardstick
http://climate.nasa.gov/news/2201/

1. What are two reasons that sea level could drop?

2. Explain the overall sea level height trend over the last 20 years and how 2010 and 2011 sea level height readings fit in that trend.

3. How much has the global sea level risen in the last 130 years?

4. What does Dr. Willis mean when he says that sea level rise is the yardstick for the global warming?

5. Name at least two of the weather patterns that move large amounts of water around the planet.

6. What do the 3600 buoys measure and how does that information help us understand sea level rise?

7. What are two reasons that sea level could rise?

8. Name one area where scientists don't have as much data as they would like.

9. What are the three instruments and/or missions discussed in this article that contribute data to the study of sea level height?

Student Worksheets

Record the procedure for your melting ice demonstration

Explain your demonstration in detail so that someone else can use your directions to replicate it and/or so that you can replicate it again weeks or months from now.

Group members: ____

1. What equipment, images, or other resources did you use in your demonstration?

2. What are the steps of your demonstration? You can number and explain them below: Please include drawings or take photos, etc. Please include an explanation for why you chose the steps that you chose.

3. Are there any changes you need to make and why? What other resources would you like to have?

4. What else do you want to explain about your demonstration? What advice do you have for someone trying to repeat your demonstration?

Part 2A Supporting Documents

Teacher Resources

Resources on Climate Models and Modeling

A recorded webinar "Engaging Youth in Sea Level Rise Adaptation Planning and King Tides help communicate climate change impacts" will be available online?

Powerpoint from USC Sea Grant on Sea Level Rise and models: http://dornsife.usc.edu/assets/sites/291/docs/King_Tides_info/USCSG_SLR101.pptx.pdf

An interactive that can help in understanding the complexity of all that goes into a climate model: http://www.ucar.edu/news/features/climatechange/ccsm-illus.jsp

Modeling Sea Level Rise, 2012 Nature Education: http://www.nature.com/scitable/knowledge/library/modeling-sea-level-rise-25857988

Koshland Science Museum. A detailed online slideshow: What is a model? How do you test it? What causes climate change? How do we forecast the future? https://www.koshland-science-museum.org/explore-the-science/interactives/how-do-climate-models-work

Sea-Level Rise Modeling Handbook: Resource Guide for Coastal Land Managers, Engineers, and Scientists, 2015, commissioned & funded by the Southeast Climate Science Center for the benefit of the Landscape Conservation Cooperatives and Department of the Interior land managers and biologists, department-wide. "The goal of the project was to effectively produce a document that was an easy magazine-type read of an understanding of the science and simulation models related to sea level rise impacts on coastal ecosystems." - Tomas W. Doyle, USGS National Wetlands Research Center, Lafayette, LA. Download here: http://pubs.usgs.gov/pp/1815/pp1815.pdf

The USGS webinar from 2014 is here that preceded the release of this document and explains some of the science that is contained in the document: https://nccwsc.usgs.gov/webinar/332

Teacher Resources

Resources on Sea level rise Impacts

Climate Central, short and succinct "Impacts" http://sealevel.climatecentral.org/basics/impacts

NOAA's National Ocean Service & NASA's Jet Propulsion Lab Sea Level Rise learning module
http://oceanservice.noaa.gov/education/sea-level-rise/welcome.html

What is sea level rise and how will it affect you?
http://california.kingtides.net/what-is-sea-level-rise/

"Sea Level Rise", National Geographic
http://ocean.nationalgeographic.com/ocean/critical-issues-sea-level-rise/

Rising Seas, National Geographic, by Tim Folger, photographs by George Steinmetz "As the planet warms, the sea rises. Coastlines flood. What will we protect? What will we abandon? How will we face the danger of rising seas?"
http://ngm.nationalgeographic.com/2013/09/rising-seas/folger-text

AAAS Global Climate-Change Video (9:59), John Holdren and others talking about the impacts of human climate change
https://www.youtube.com/watch?v=khmFBUrM2ko

This is how rising seas will reshape the face of the United States, Washington Post
http://www.washingtonpost.com/news/energy-environment/wp/2015/10/12/this-is-how-rising-seas-will-reshape-the-face-of-the-united-states/

"Impacts of Sea-Level Rise on the California Coast", Pacific Institute Sea Level Rise report 2009
http://pacinst.org/publication/the-impacts-of-sea-level-rise-on-the-california-coast/

San Francisco Bay Conservation and Development Commission "Living with a Rising Bay"
http://www.bcdc.ca.gov/BPA/LivingWithRisingBay.pdf

Teacher Resources

Find your own ice breaker images

GRACE satellite mission (study changes in planet's water and ice sheets):
    http://www.jpl.nasa.gov/missions/web/grace.jpg
Jason 2 satellite mission (study ocean surface topography):
    http://www.jpl.nasa.gov/missions/web/ostm.jpg
OCO2 satellite (study carbon dioxide sources and sinks):
    http://www.jpl.nasa.gov/spaceimages/images/wallpaper/PIA18375-1920x1200.jpg
Google search for images of tide gauges
King Tide photos from their website:
    https://www.flickr.com/groups/cakingtides/pool/
NASA images from Earth Missions:
    http://www.nasa.gov/topics/earth/images/index.html
Images, graphs, or charts from the IPCC reports:
    http://www.ipcc.ch/
Document pages 91-103 (not the PDF page numbers) have types of coastal armoring:
    http://www.dbw.ca.gov/csmw/pdf/WCGA_CoastalStructures_Berry_Ruggiero.pdf
Argo (floats/buoys that measure temperature at depth)
    http://www.argo.ucsd.edu/
    http://www.argo.ucsd.edu/statusbig.gif
    http://www.argo.ucsd.edu/float_design.html
    http://www.argo.ucsd.edu/operation_park_profile.jpg
National Data Buoy Center
    http://www.ndbc.noaa.gov/
National Buoy Data Center – California map:
    http://www.ndbc.noaa.gov/?lat=36.100000&lon=-126.200000&zoom=5&type=oceans&status=r&pgm=&op=&ls=n
El Nino 2009-10 & 1997-98:
    http://sealevel.jpl.nasa.gov/images/ostm/newsroom/features/images/201006-3c-large.jpg
Mean sea level:
    http://sealevel.jpl.nasa.gov/images/ostm/newsroom/features/images/201006-3b-large.jpg
Atmospheric CO2 concentration:
    http://www.jpl.nasa.gov/spaceimages/images/largesize/PIA20039_hires.jpg
Cover of IPCC report:
    http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_cover_A.pdf
Carbon cycle, NOAA:
    http://www.esrl.noaa.gov/gmd/outreach/carbon_toolkit/images/carbon_cycle.jpg
Water cycle:
    http://earthobservatory.nasa.gov/Features/Water/images/water_cycle.jpg
Sea level rise:
    http://oceanservice.noaa.gov/facts/slr-climate.jpg

Student Worksheets

Student Homework Assignment

to be completed before class on*:*__________

You will need:

print copy or web access to ***Just 5 questions: Sea surface topography***
a copy of "Guiding Questions ***Just 5 questions: Sea surface topography***
print copy or web access to ***Reading between the tides: 200 years of measuring global sea level***
a copy of "Guiding Questions for ***Reading between the tides: 200 years of measuring global sea level***"
web access to explore **Sea Level Viewer**
a copy of "OCOF Tutorial"

1. Read the two following articles and answer the guiding questions:

Just 5 questions: Sea surface topography
Interview by Jeanette Kazmierczak, NASA's Jet Propulsion Laboratory, August 4, 2015
http://climate.nasa.gov/news/2318/

Reading between the tides: 200 years of measuring global sea level
https://www.climate.gov/news-features/climate-tech/reading-between-tides-200-years-measuring-global-sea-level

2. Explore this website and answer the guiding questions:

Sea Level Viewer - NASA JPL and California Institute of Technology
"OVERVIEW" is a video about satellites that measure sea level rise (1:30)
"MISSIONS" will show you the objectives of the first 3 satellites in the Jason series.
Jason-3 just launched on January 17, 2016 and will collect data to add to the long term data set that exist from the previous three satellites.
"GLOBAL VIEW" highlights five examples when these satellites have helped us visualize and understand what is happening on our planet.
"Latest View" shows data from 2013
"Large El Nino" video (0:50)
"Hurricane Katrina" video (1:10)
"Indian Ocean Tsunami" video (0:45)
"La Nina" video (0:42)
http://climate.nasa.gov/interactives/sea_level_viewer

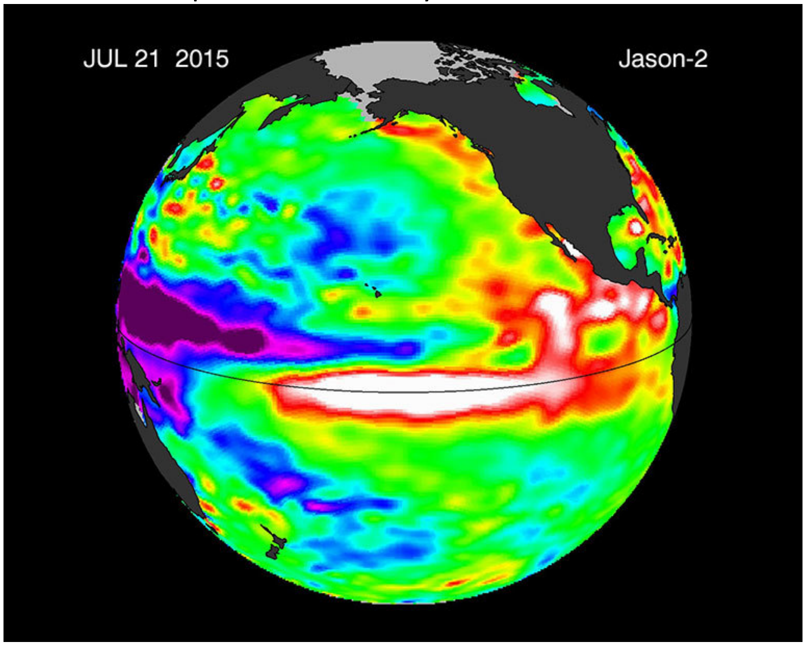
3. Follow the directions in the Our Coast Our Future (OCOF) Tutorial to familiarize yourself with the model that planners are using to help them make decisions about sea level rise adaptation.

Article: Just 5 Questions: Sea Surface Topography

FEATURES | August 4, 2015 http://climate.nasa.gov/news/2318/

Just 5 questions: Sea surface topography

Interview by Jeanette Kazmierczak,
NASA's Jet Propulsion Laboratory



This image is a 10-day average of sea surface height anomaly data from the OSTM/Jason-2 satellite, centered on July 21, 2015. The difference between what we see and what is normal for different times and regions are called anomalies or residuals. Green indicates normal sea level heights, while yellow and red indicate areas that are higher than normal. Credit: NASA. View larger image: http://sealevel.jpl.nasa.gov/images/latestdata/jason/2015/20150721P.jpg

Dr. Josh Willis

Affiliation: NASA's Jet Propulsion Laboratory. Willis started at JPL as a Caltech Postdoctoral Scholar and is now the project scientist for Jason-3. He has been awarded the American Geophysical Union's Ocean Sciences Early Career Award (2011) and the Presidential Early Career Award for Scientists and Engineers (2009).
Expertise: Estimating regional and global ocean warming and sea level rise; role of the ocean in Earth's climate system; understanding large-scale changes in the ocean and its circulation.
Education: Bachelor's and master's degrees in physics. Doctorate in oceanography from the Scripps Institution of Oceanography, University of California, San Diego.

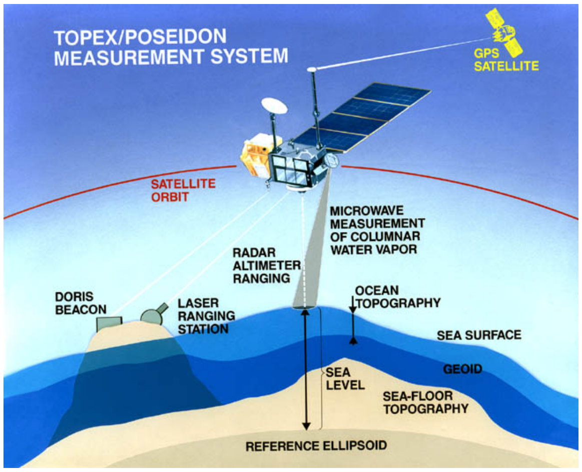
More information about Josh Willis: https://science.jpl.nasa.gov/people/Willis/

Earth's seas and oceans have high and low points, just like Earth's continents have hills and valleys. The difference is that sea surface topography is affected by temperature, currents and underwater mountains and trenches. Scientists like Josh Willis are working to understand how sea level rise, warming oceans and sea surface topography will interact and affect our planet as our climate continues to change.

1. What is sea surface topography and how do we measure it?

Sea surface topography is the height and shape of the ocean's surface. Certain parts of the ocean are taller than others because of currents or, in some cases, because of underwater mountains that pile up the ocean water. The most comprehensive way to measure topography is from space. You fly a satellite over the ocean and shoot the surface with a radar wave. Then you wait for the wave to bounce off the ocean and come back. By measuring the time it takes the wave to go down and come back, you can tell how far away the ocean is from the satellite. So as it flies, the satellite will trace out the topography of the sea surface.

2. How big are these topographic features? Do they stay in the same place, or do they move around?



These things happen over many miles. For example, a large variation in sea surface height can range by a few feet in a few miles. The surface topography that is caused by underwater mountains, which would then create a hill at the ocean surface, or by an underwater trench, which would cause a valley—those stay in the same place because the mountains on the sea floor don't move around. But the topographic features that are there because of currents move around and are the ones oceanographers tend to be the most interested in. Those variations in sea surface topography are caused by ocean currents that tilt the sea surface.

3. How do temperature and global warming affect sea surface topography?
Typically, warm water takes up more space than cold water—it's less dense. When we observe a high sea level, oftentimes it's because there's warm water not just at the surface but down deeper as well.

So sea level is rising for two different reasons. One is because glaciers and ice sheets all over the world are melting and the extra water raises sea levels. But also sea levels are rising because the ocean is absorbing almost all of the extra heat trapped by greenhouse gases. But the extra heat doesn't go in the ocean evenly everywhere. Some places are getting more heat than others, and this can cause changes in ocean currents, and it also means that sea levels rise faster in some places than in others.

4. What role do regional variations in sea level play in weather and climate?
Changes in sea level tell us where the warm water is and where oceans carry warm water around. In places where the warm water is at the surface, it can have a big impact on weather and climate. One example of that is the El Niño phenomenon, which involves a bunch of warm water that is normally in the West Pacific moving to the East Pacific. When it does that, it disrupts the jet stream and causes weather patterns to change all over the United States and sometimes all over the world. One of the main ways we monitor El Niño is by looking at sea level measured by satellites.

5. What are the big questions that scientists are asking about ocean topography right now?
One big question is "What's going on at the smallest scales?" Our satellites are really good at telling us when the entire North Pacific gets warmer or when a big El Niño is running from the West Pacific to the East Pacific. But the smaller things—like eddies, really sharp boundary currents and natural mixing in the ocean—are too small for the current generation of satellite altimeters to see. But in 2020, NASA and the National Center Space Research (CNES), the French space agency, will launch SWOT, which stands for Surface Water and Ocean Topography. And this new satellite will measure the sea surface topography with incredibly high resolution. Every kilometer will have its own measurement of ocean height. We expect to see lots of new things and understand the physics of the ocean a whole lot better because of SWOT.

Student Worksheets

Guiding Questions for Just 5 questions: Sea surface topography

NASA's Jet Propulsion Laboratory

http://climate.nasa.gov/news/2318/

1. Explain one similarity and one difference between sea surface topography and topography on land.

2. Why do some sea surface topographic features move around?

3. Is the ocean absorbing heat from the atmosphere evenly? What is one way we can tell?

4. In a scenario where it is reported that there is a mass of warm water is moving from the western Pacific to the eastern Pacific, is it because the satellite data showed higher or lower than normal sea surface topography in the east? What is the name of the phenomenon that is associated with this movement of warm water?

5. What is one shortcoming of the current satellites that are observing sea surface topography? What is planned to overcome this shortcoming?

Article: Reading between the tides

Climate.gov science & information for a climate-smart nation

https://www.climate.gov/news-features/climate-tech/reading-between-tides-200-years-measuring-global-sea-level

Reading between the tides: 200 years of measuring global sea level

Author: Amy Dusto

Monday, August 4, 2014

Global warming and the rising sea levels that come with it may bring to mind catastrophic coastline destruction during storms and mass relocation to higher grounds—or at the very least, a good reason to reevaluate beachfront flood insurance policies. But before we can prepare for whatever impacts a more voluminous ocean may have on civilization, we need an accurate measure of just how high the sea level is, and just how fast it's rising. NOAA's on that.

Cartoon crew

Modern install

Cartoon of a typical tide gauge installation crew, c. 1950s, by Chief Boatswain Clarence E. Petersen, U.S. Coast and Geodetic Survey. Photo of staff from the NOAA shipRainier installing a tide gauge near Castle Cape, Alaska, on June 25, 2014. Both images from the NOAA Photo Library.

Gauging average global sea level is trickier than sticking a ruler in the depths and noting the day-to-day or year-to-year changes. That's because the ocean doesn't have one steady level. Tides and currents constantly flow up and down, while tectonic forces move land masses relative to the water, for a few of many factors.

Since scientists first began seeking sea level measures more than 200 years ago, their methods have come a long way. Here's a look at the technologies climate and marine scientists have used for the job of tracking Earth's tides and average level, then and now.

The highs and lows of tide gauges

Checking the automatic tide gauge at Port Protection, Prince of Wales Island, Alaska, 1915. Photo from NOAA Photo Library.

In 1807, at Thomas Jefferson's request, the U.S. government began a systematic survey of the coastline to map the new nation and facilitate maritime commerce. (Even older records exist from a few locations around the world.) Because the coastline changes with the tides, that meant the surveyors also needed to begin measuring changes in the coastal water levels. At first they used tide staffs, essentially tall wooden rulers that had to be read manually. Many tide staffs were placed in stilling wells, a long metal tube with an open end beneath the water that minimizes the effects of passing waves. An observer noted the water level relative to a fixed point on the land.

A U.S. Coast and Geodetic Survey work party calibrating a tide staff against a land-based benchmark on Cat Island, Southeast Alaska in 1915. Original from NOAA Photo Library.

It wasn't until 1851 in San Francisco that the U.S. Coast and Geodetic Survey first deployed a self-recording tide gauge. Invented by Joseph Saxton, the gauge had the same stilling-well setup, but also included a pen resting on a rotating paper drum. The drum used clock springs to keep the paper rotating at a constant rate (to keep track of time), while the pen, attached by a wire-and-pulley system to a float inside the well, moved up and down with the tides. As the pen bobbed with the float, it traced a graph of the changing water level across the paper-covered drum.

A Coast and Geodetic Survey officer (B. H. Rigg) checking a tide gauge on western Greenland as part of the MacMillan Arctic Expedition in 1926. Original photo from NOAA Photo Library.

"They worked well when they worked," says Mark Bushnell, an oceanographic consultant at CoastalObsTechServices, LLC, and a former NOAA oceanographer. "The past two directors of NOS/CO-OPS [the National Ocean Service Center for Operational Oceanographic Products and Services] like to quote Alexander Dallas Bache, the second superintendent of the Coast Survey, 1854: 'It seems a very simple task to make correct tidal observations; but, in all my experience, I have found no observations which require such constant care.'"

The early tide gauges were expensive and difficult to maintain—and if they stopped working, the local tide observer would have to contact Coast Survey field parties by mail to inform them. Then it could be several weeks before repairs were made. Several other types of tide gauges arose in the following decades, each gradually improving on the amount of manual labor required, the cost or the accuracy of the data collection. For one thing, scientists later replaced analog gauges with punched-paper tape systems that computers could read and tabulate.

(left) To read the tide gauge at Cape Mordvinof on Unimak Island, Alaska, in 1939, scientists had to descend a 60-foot ladder suspended by wires and stakes. (right) Scuba divers check a cliffside tide staff in Glacier Bay, Alaska in 2010. Historic photo from NOAA Photo Library. Modern photo Ensign Patricia Raymond, NOAA Corps, via the NOAA Photo Library.

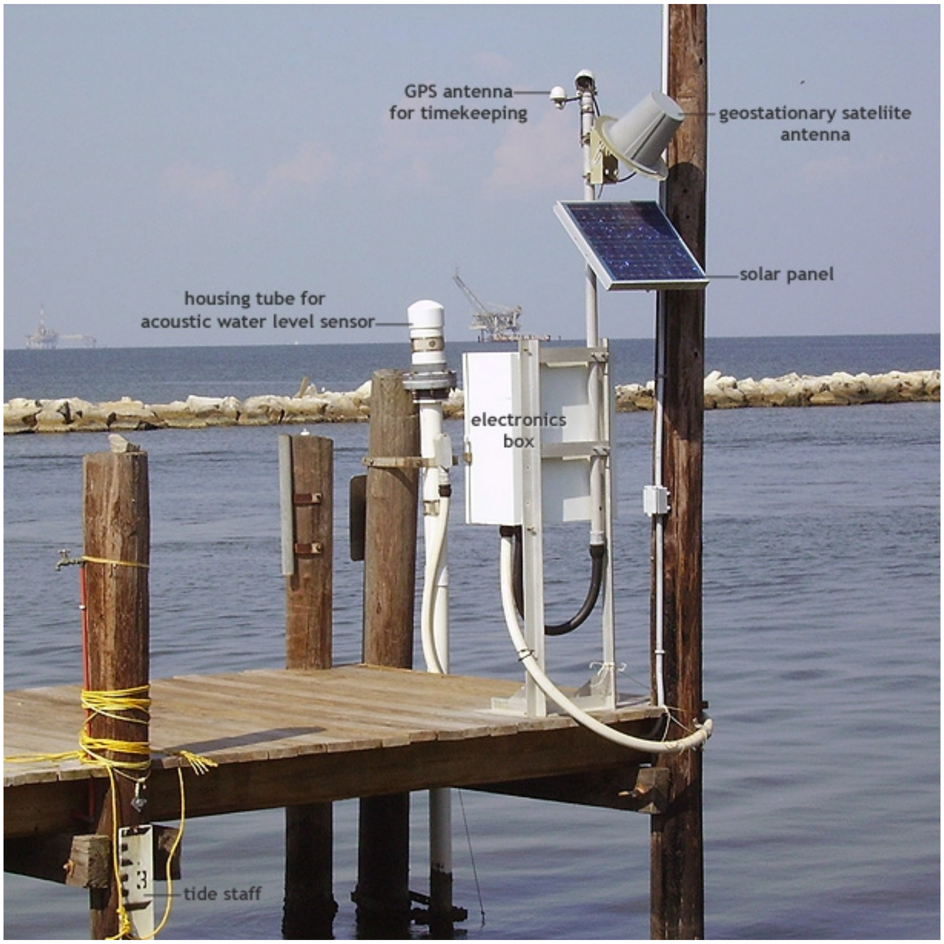
Microwaves and GPS

Jumping ahead over the invention of the automobile, DNA's discovery, and the development of manned spaceflight, the newest sea level measuring tools being deployed today use radar—in the form of microwaves—to measure the distance from a fixed point above the water to its surface. They are often mounted off the ends of piers. "There are no moving parts, nothing in the water to corrode, and they're impervious to things like water density or air temperature gradients that affect other technologies," Bushnell says.

A microwave radar attached to a bridge over the Dog River in Alabama. The radar, encased in the white plastic housing in the foreground, sends a pulse of microwave energy down toward the water surface and listens for the echo. The higher the water, the quicker return echo. NOAA photo courtesy Morgan McHugh.

NOAA is in roughly the first year of a four-year project to replace most of the sensors in its 210-strong network covering the nation and many U.S. territories with microwave sensors, says Steve Gill, chief scientist at NOS/CO-OPS. Most of the older sensors were installed in the early ‘90s and work similarly, but use sound waves instead of microwaves—and therefore must be enclosed in protective tubes that extend into the water. The microwave sensors, in contrast, can operate without any protection from waves, noise or weather. NOAA will operate both types of sensors side by side for several months before disassembling the old sensors to check for any discrepancies in the data, Gill says.

Compared with the old technologies, the microwave sensors are more reliable and much cheaper to install and maintain—no boats, divers or regular manual attention required. However, the data they provide is only marginally more accurate. In fact, the accuracy of the monthly mean sea level observations—which most climate scientists use as a starting data point when looking at long-term ocean trends—as calculated using measurements from the microwave sensors is almost exactly the same as what scientists calculated using tide gauges in the 1800s, Bushnell says. That’s a testament to the painstaking, detail-obsessed work done by generations of tide gauge observers, technicians taking care of the equipment, and NOAA analysts putting together the results from all the nation’s gauges every month, according to Gill.



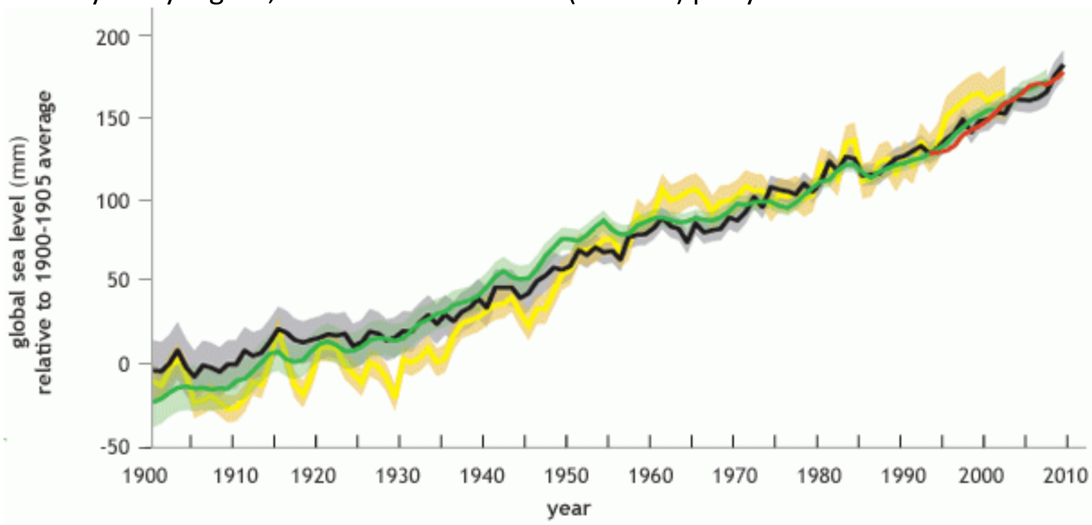
A NOAA water level monitoring station with an acoustic sensor on Dauphin Island, Alabama. A small GPS antenna enables precise timekeeping—not elevation tracking—and a second antenna transmits data to geostationary satellites. Photo courtesy Morgan McHugh.

Oceanographers are also developing continuous GPS systems—which relay location information all the time rather than occasionally—to measure sea level while taking into account a factor they hadn't understood well until recently: the motion of the land. That activity may seem subtle to locals, but it can change the relative distance between the water's surface and the old benchmark (a fixed reference point on land nearby) significantly in just a few years. Scientists have been correcting tide gauge records for that movement using statistical models of the Earth's movement for decades, but continuous GPS will provide a more accurate estimate of local vertical land motion so that absolute sea level change can be better estimated from tide gauge records.

"The next big thing will be a GPS mounted directly on the microwave sensor, reducing and eventually eliminating the need for benchmarks [on land]," Bushnell says. Scientists are also developing GPS buoys that can measure sea levels offshore, potentially covering more of the oceans than coastlines, Gill adds. Since 1993, satellite altimeter missions have been providing highly accurate sea level measurements far out at sea, too, though their paths don't cover polar areas, he says.

What our tools are telling us

Taking information from both tidal records and satellites into consideration, the latest report from the Intergovernmental Panel on Climate Change concluded that sea level rose around 0.07 inches (1.7 millimeters) per year between 1901 and 2010 and that between 1993 and 2010, the rate was very likely higher, more like 0.13 inches (3.2 mm) per year.



Multiple data sets (different colored lines) of global mean sea level compared to the 1900-1905 average, and with all time series set to have the same value in 1993, the start of the satellite altimetry record (red line). Shading shows uncertainty ranges. Adapted from panel d of Figure SPM.3 in IPCC AR5.

Gill says we have to be careful about how much of the recent decades' acceleration we attribute to global warming and how much to natural variability. The acceleration could be coming from more rapid melting of ice sheets or increasing ocean heat content, but two decades is also within the time frame over which natural climate oscillations can influence trends in global sea level.

Helping researchers separate natural variability and long-term change is one NOAA's motivations for making its sea level data available to the public and researchers around the world. But scientists aren't the only people who need accurate methods of measuring water levels, Bushnell adds. There are commercial applications, too, for shipping, shoreline development, and natural resource extraction. For example, as the Arctic thaws, ships will need more frequently updated data about water levels in the Northwest Passage, he says, which is "not an easy place to install gauges."

References & Links

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Student Worksheets

Guiding Questions for Reading between the tides: 200 years of measuring global sea level
https://www.climate.gov/news-features/climate-tech/reading-between-tides-200-years-measuring-global-sea-level

1. When did the U.S. government begin a systemic coastline survey that included tide gauges? Why was this done?

2. Choose two of the types of tide gauges discussed in the article and explain how each tide gauge works. Give one similarity and one difference between the two devices.

3. What is one advantage of the newest tide gauges over past versions?

4. How will scientists check for discrepancies between the newest tide gauges and ones that are currently installed?

5. What are two new innovations in measuring sea level height that involve GPS?

Student Worksheets

Guiding Questions for Sea Level Viewer

NASA JPL and California Institute of Technology

http://climate.nasa.gov/interactives/sea_level_viewer

“OVERVIEW” is a video about satellites that measure sea level rise (1:30)

1. What is a driving force of climate?

2. What does sea surface height tell us?

3. Name at least two reasons why it is important to have this series of satellites (Topex/Poseidon, Jason-1, and Jason-2) observing the global sea surface height?

“MISSIONS” will show you the objectives of the first 3 satellites in the Jason series. Jason-3 launched on January 17, 2016 to add to the long-term data set that exists from the previous three satellites.

4. Choose any two of the objectives listed and explain how each is related to understanding sea level rise.

“GLOBAL VIEW” highlights examples when these satellites have helped us visualize and understand what is happening on our planet. Please note that “Latest View” shows data from 2013.

5. Choose one of the four videos (Large El Nino, Hurricane Katrina, Indian Ocean Tsunami, La Nina) and watch it. If you were to summarize the video for someone who had not watched it, what are the three most important pieces of information that you would tell them? Please write them on the back.

Student Worksheets

Our Coast Our Future (OCOF) - Tutorials

INTRODUCTION

"Climate change will increase sea levels, shoreline erosion, and the frequency and intensity of coastal flooding in many regions of the San Francisco Bay Area. To protect communities and ecosystems, managers and planners need locally relevant tools that help them understand vulnerabilities and plan for action."

"Our Coast, Our Future (OCOF) is a collaborative, user-driven project focused on providing San Francisco Bay Area coastal resource managers and planners locally relevant, online maps and tools to help understand, visualize, and anticipate vulnerabilities to sea level rise and storms."

OCOF contains an interactive map with data layers showing areas that are flood-prone, wave height, current velocity, flood duration, some photos of what the coastline looks like during King Tides, rivers, streams, protected areas, coastal armoring, etc. This allows someone to look at the interactions between King Tides, storms, and sea level rise all at once or individually.

For more information about this project and tool, please see:
http://data.prbo.org/apps/ocof/uploads/documents/OCOF_one_pager_portrait_FINAL_110212.pdf
Frequently asked questions about OCOF are answered here:
http://data.prbo.org/apps/ocof/index.php?page=faq-ocof

The Coastal Storm Modeling System (CoSMoS) was developed by the U.S. Geological Survey (USGS) and is the modeling approach used in OCOF to estimate sea level rise and storm surge scenarios for the San Francisco Bay Area. Frequently Asked Questions about CoSMoS are answered here: http://data.prbo.org/apps/ocof/index.php?page=cosmos-faq

TUTORIAL VIDEOS

There are two short videos (2:47 and 6:50 minutes) to help you familiarize yourself with the project and the tools that are available on the website. When you are listening to both videos, remember that they are made for policy/decision makers.

1. Watch the OCOF Online Tool Overview (2:47) to get an overview of the project.
https://www.youtube.com/watch?v=nbg3221NYf0&feature=youtu.be
2. Then watch the "Our Coast Our Future Web Tool Tutorial" (6:50).
https://www.youtube.com/watch?v=aJbLtfg0Mco&feature=youtu.be
For this video, you may want to have the map open so that you can follow along.
To open the map, go to this website http://data.prbo.org/apps/ocof/index.php?page=flood-map and click "ok" when you will see a Disclaimer about the mapping tool.
Start the second video and feel free to pause it as you interact with the map to see how it works. You don't need to be able to do everything in the video, but it will give you an idea of what kinds of things you (and policy/decision makers) can do with the tool.
Part 2A Supporting Documents

King Tides Photographs

California King Tides Project Protocol

Watch the video describing the project and the protocols.
Go to this website http://california.kingtides.net/ and watch the video created by the *Thank you Ocean Report* called "California King Tides: Snap the Shore, See the Future" (3:56).

Go to the Flickr website to see some of the photos that others have taken and submitted.
https://www.flickr.com/groups/cakingtides/pool/
Can you tell if it is high tide or low tide in the photos? How can you tell? Is there something for reference (a pier, dock, building, trees, breakwall, cars, what else)?
Which photos do you think best show the extent of the high/low tide on the coast? What about the photos makes them good at conveying that?

1. Make a data collection plan for your project. "Student Data Collection Plan Tides" may help your students with this task.

Here is the protocol in writing so you don't have to keep going back to the video:
2. Choose a location in which you can/will survey. Taking into account transportation to and from the location and what locations might give you a good perspective to take a photo of the waterline. The project is looking for a variety of photos that show impacts on roads, airports, neighborhoods, schools, etc.

3. Plan the date and time according to the highest (and lowest tides) for the season.

This website may have the locations and king tide times listed for you to choose from: http://california.kingtides.net/plan/ .

If not, then try figuring it out from NOAA's tide predictions website: http://tidesandcurrents.noaa.gov/tide_predictions.html?gid=235

Be sure to look up high tides for your particular area because the timing of the tides varies slightly depending on location.

The key dates in 2015-2016 for King Tides are:
Tues Nov 24 - Thurs Nov 26, 2015 (second highest this season, near 6 pm for lowest)
Tues Dec 22 – Thurs Dec 24, 2015 (highest of this season, near 4:15 pm for lowest)
Thurs Jan 21 – Fri Jan 22, 2016 (near 4:45 to 5 pm)

4. What do you need to take with you? Group member(s)/friend(s), camera, phone? What else do you need to plan or take with you? (journal to record weather conditions and other observations.)
Make sure your camera is set to the correct DATE and TIME so that the metadata for the image is accurate. Turn on the camera's GPS, or your smartphone's GPS ,if it has one.

5. If you plan to take both high and low tide photos of the same place, how will you remember where and what direction you took the first photo to be able to come back later and take a

second photo so that they are easily comparable? Using a GPS on your phone and physical structures to identify will help you return to the same location. Write how you remember in your plan.

6. Create a data sheet to keep track of the data you collect. You will want to make sure to include the information in step 7 below as well as a way to record a photograph's number so that you can match all that data to the correct photograph.

7. Safely go to the coast and take photos. Take and follow your plan as best as you can.
Be careful during high water and/or stormy conditions.

8. When you are done taking all of your photos, log into your own (or your class's) Flickr.com account, upload all the photos that you want to submit.
When uploading photos, make sure to add descriptions to them that include:
-the date and time taken
-the geographic location (GPS location, is very helpful, if possible) include a description of your location such as in front of the parking structure.
-direction the camera was facing (use compass)
-if the photo is a low-tide comparison, please include that information
-what the tide height was above chart datum (for example, +3.7m)
-tag your photos with appropriate words like: "King Tide", "King Tide 2015", "Fisherman's Wharf", "Sausalito", etc.
Then go to: https://www.flickr.com/groups/cakingtides/ , click on "add photo" and it will allow you to share photos from your account to the King Tides Flickr albums.

Other Resources:
A video about why ocean tides exist:
"What Physics Teachers get wrong about the Tides!" from PBS Space Time (The first 7:10 is the basics, but a total of 9:10 of the video about tides, then they talk about other things)
https://www.youtube.com/watch?v=pwChk4S99i4

Here is a similar project with sets of images that might help one imagine what iconic places look now and what they will look like after sea level rise:
http://www.climatecentral.org/news/american-icons-threatened-by-sea-level-rise-in-pictures-19547

"Staying Safe Along the Shore" from USC Sea Grant:
http://dornsife.usc.edu/assets/sites/291/docs/Urban_Tides_Contest/Staying_Safe_Along_the_Shore.pdf

Urban Tides Community Science Initiative

You can help document the impacts of rising sea levels in your community.

From the Urban Tides website and flyer:

You can engage in meaningful science. Visualizing today's risks enables community leaders and local governments to set priorities as they plan strategies that will help the region adapt to the future impacts of sea level rise. Images also provide critical information to help ground truth and calibrate scientific models used to identify vulnerable locations along our coast.

- Urban Tides is a yearlong community based science effort to document tidal lines, coastal flooding and erosion.
- Working with scientists, we have designated a series of beach and wetland locations where photographs are needed the most.
- We welcome photos from any location, day and time; high tide, low tide, king tide.
- Simply join the Urban Tides dataset online, download the mobile app on your phone, then snap and upload your photos. You may also upload photos using a computer.
- It's your coastline! Your observations about how and where it is changing will help further the collective dialogue about how we can adapt to rising seas. #UrbanTides

Complete instructions can be downloaded here, but are listed below as well:
http://dornsife.usc.edu/assets/sites/291/docs/Urban_Tides_Contest/UrbanTides_Instructions_maybefinal.pdf

Join the database, download the mobile app, and upload your photos. You may also upload photos using your desktop computer.

1. Visit https://getliquid.io to join the Urban Tides database, which is hosted by Liquid. To set up your account, establish a username and password. Then sign into the new account.
2. On the homepage, select and join the Urban Tides Community Science Initiative dataset.
3. Using an iPhone: go to the App store to download and install the "liquid mobile data collection" application. Open and login to the app. Since you already joined the dataset on your computer, the Urban Tides dataset will open when you login.
4. Select 'new record'. You will take each photo* using the camera icon on this form. Fill in all required data in the form, then press 'submit'. You are done!
5. If using a desktop computer to upload a photo, instead of an iPhone, then enter the Urban Tides dataset on the Liquid website. Click on 'add record'. Use the camera icon to upload each photo* from your desktop. Fill in all required data in the form, then press 'submit'.

*Please read below for more guidance on filling out the form and taking a photo that will provide the best possible data.

Guidance for taking a picture:

1. Working with scientists, we have designated a series of photo site locations that will provide good data for this initiative. Use the 'Photo Locations' Google map: http://bit.ly/1T2GJHG to identify your photo location of choice.

2. Once you arrive at the location*, take a few moments to watch the water. Find the highest wet water line in the sand. Then, take two steps or strides landward from the water line. Take the photo facing parallel to the shoreline. Include some sort of structure or feature in your picture, such as a pier, jetty, breakwater or dock, for perspective. This will help scientists better identify the water line.
3. Ideally, you'll want your picture to catch the wave as it reaches the water line again. This definitely requires some patience and luck that no one walks through your picture just as the wave hits the highest point! But, even pictures that show the water line and some water from the waves are still very useful. When you are ready – take your picture!
4. If using the iPhone app, you must take the photo using the camera icon in the data entry form.

*Important: If you will be uploading your photo from a computer, use your phone's compass to take a GPS location in latitude and longitude before you change locations.

Guidance for filling out the form to provide the best possible data for each photo:
Using the iPhone app:

1. Location: Click on "Use Current Location" so that you get the most accurate location of the picture. This button will auto populate the latitude and longitude. This is a required field.
2. Location Description: Please be as descriptive as you can about your location. This is a required field. Examples of how to populate this field include:
   a. At 3rd Street in Manhattan Beach, 15 feet back from high water line, standing in front of a berm
   b. At Ballona Lagoon
3. Orientation: Use your phone's compass and then select the orientation from the drop down menu in the form. This is a required field.
4. Date: This will auto populate on your iPhone. This is a required field.
5. Time: This will auto populate on your iPhone. This is a required field.
6. General Comments: This is the field to provide anything that you find interesting about your photo or information you feel is important to convey. This is not a required field.
7. Photographer's Name: When you sign up for the app, we will have your email information. If you would like your name associated with the image, please enter your name here. This is not a required field.

Student Data Collection Plan: King Tides

Who will go?

When (date and time)?

Where are you going?

How are you getting there and back?

How will your group members get in touch with each other for last minutes changes or locating each other on-site?

What equipment do you need to bring? Make sure you know how to use it and that the batteries are charged.

How many data points (photographs) are you collecting?

What is the basic plan for collecting data?

What plans do you have to ensure you and your team are safe while in the field?
SAFETY: Never turn your back on the ocean. Check the weather where you will be and dress appropriately. Where nonslip shoes. Move slowly over wet surfaces. Be aware of cliffs that may crumble or logs/driftwood that may move with only a little bit of water.
What is the plan if you have an emergency? How else can you be safe?

Don't forget to take your datasheet and take detailed notes!

Community Interviews

Interview Protocol & Sample Questions

Traditional coastal economies are being transformed or replaced in California due to a variety of factors including changes in coastal development, beach access, population growth and sea level rise. The rich body of knowledge of historic users of the coast including fishermen, naturalists, long-term residents and coastal managers and others can help to inform us about the changing coastline. This knowledge is at risk of disappearing as people leave the area and as the population ages. As we approach ecosystem based management it is important to understand the interconnectedness of habitats and human influences on the area. Documenting and preserving historical, cultural and environmental knowledge can be done through photography and through personal interviews. It is important to collect the rich diversity of voices that are represented in our community. Through this process you have an opportunity to increase our awareness and understanding of the coastal marine environment by exploring the natural ecology and its connections to the social, cultural and economic factors.

Before you start:

1. Develop a team (2 or 3 students)

2. Identify the resources you will need – (video camera, tablet or smart phone, paper and pencil, prepared questions, contacts of individuals to interview)

3. Identify the individuals in the community who are a good resource for the information you want to collect about the changes in the coast and sea level rise. Ask long term residents, other people at your school, your family, others who might know of someone who has observed the changes or relies upon the coastline for the livelihood and check in the newspaper or library for possible sources. Some possibilities include
    a. wharf manager or yacht club
    b. Coast Guard
    c. fishermen
    d. land managers – sanctuary, port, community
    e. historical society
    f. artists, naturalists, boaters, coastal farmers
    g. newspaper writer, television reporter
    h. others

4. Research changes in sea level rise in the area so you are more informed before you develop questions, get to know the area and determine what you want to know. Some information that coastal planners are interested in knowing are:
    Where are people currently seeing flooding and impacts?
    What do they think will happen and what will be needed in the future?

Put yourself in the shoes of a coastal planner. What other information might you want to know?

5. Develop guiding/essential questions
    a. Create open-ended questions allowing for a conversation and more than a yes or no answer.
        i. for example " I would like to hear about…. Or please tell me how you came to know…
    b. Remember to ask for background information – how long have you lived along the coast?, when did you first become interested in…?
    c. Develop questions that will put the interviewee at ease rather than personal questions such as how old are you.
    d. Try not to have leading questions, where you already set up the answer to lead in one direction or another.

6. Together with your team, determine do's and don't suggestions for interviewing –for example
    a. Prior to the interview, divide up roles and responsibilities in the group –
        i. note taker - records exactly what is said or as close to what is said as possible. You can also record the interview with permission, but note taking helps to capture important topics.
        ii. Interviewer - keeps the discussion going, asking deeper questions.
        iii. Photographer - obtains permission and takes video or photos.
    b. When you schedule an appointment be certain to agree to a time and location for the meeting. Arrive on time.
    c. Thank the interviewee for their time and identify who each of you are, where you are from, why you are conducting interviews, and with who and how the information will be shared
    d. Obtain permission to take notes and a photo of the interviewee. Please remember anyone doing an interview has the responsibility of **obtaining informed consen**t from all interviewees. Using a signed release is a great way to be certain you gain that consent. Turn in your signed consents to your teacher to keep on record.
    e. **Be a good listener** allow your interviewee time to think about the questions and formulate answers. Confirm your understanding of what is shared.
    f. Always remain interested and focused on your interviewee and allow for moments of silence.
    g. Be certain you provide information about how the interviewee can contact you. Share a copy of your summary or notes and finished project.
    h. Thank the person you interviewed for sharing their knowledge and for their time. Follow up with a thank you note soon after the interview.

7. Prior to the interview practice your interview techniques on someone at school and on someone in your family.

8. Create a checklist of what you need to take with you and what you want to ask including the consent form before you schedule your interview.

9. Schedule your interview in advance. Follow up to make certain the day, time and location will work as it gets closer. Make certain to be on time.

10. Following the interview.

    Review and summarize your notes and any footage shortly after the interview so you don't forget important details.

    Discuss how it went with someone who wasn't part of the interview.
    a. What did you learn or discuss?
    b. What surprised you the most?
    c. What difficulties did you experience doing the interview?
    d. Which role was the most comfortable for you and why?
    e. How would you evaluate the success of the interview?
    f. What would you have done differently to make the interview better?
    g. What would you like to follow up about with others to find out more details or how would you like to change your questions?

11. Summarizing your data
    Transcribe your interview, writing exactly what was said. Include identifying information (interviewee's name, location of interview, date, time, who was the interviewing team, purpose, etc.)
    Supplement you notes with any photos that were taken.
    Determine how and where would be an appropriate place to share the interview.

Interview Consent Form

The interview you are about to participate in is one piece of the YESS Marin curriculum provided through a CA Coastal Commission Whale Tale Grant. The program is designed to provide students with first-hand knowledge about sea level rise impacts in their community, and the people affected.

This consent form is to be read and signed by both the Student Team and the Interviewee prior to starting an interview. For more information on the YESS Marin program being implemented in your community, please contact:
Teacher's Name: ________________________________ Phone Number: _________________

School: ____

Student Team: please read then print and sign your name below.
As a Student Project Team, we are committed to treating others with respect and being truthful in the recount of this interview. We will give proper acknowledgement or credit for all original contributions to our project work. We will ensure permission is granted by the interviewee before taking any photographs or recordings, publishing or posting on the web any elements of this interview.

Student Project Team Name: ____

Team Member Names (please print)   Signatures   Date

____

____

____

____

Interviewee: please read and sign your name below.

As an interviewee, I understand that I have been invited to participate in a YESS Marin interview to help students capture the rich stories, traditions, and knowledge that define my community's legacy.

By signing this consent form, I agree that I am a voluntary participant in this YESS Marin project and have granted my permission before any photographs or recordings are taken, or any content is published or posted on the web following this interview. I understand that the information I provide will be used solely for educational purposes, and I agree to that use.

Interviewee Name (print): ____

Signature: _________________________________ Date: ________________________

THIS SIGNED CONSENT FORM SHOULD BE KEPT ON FILE BY THE TEACHER NAMED ABOVE.
A COPY SHOULD BE SUBMITTED TO YESS Marin @ WITH THE FINAL PRESENTATIONS.
INTERVIEWEE MAY KEEP A COPY FOR PERSONAL RECORDS, IF DESIRED.

Student Data Collection Plan: Interviewing Community Members

Who will go?

With whom are you meeting (do you have their contact information)?

When (date and time)?

Where are you meeting?

How are you getting there and back?

What do you need to bring? Make sure you know how to use any equipment you are using, the batteries (if applicable) are charged, and bring extra writing instruments and paper, just in case.

Other planning notes:

Don't be late to your appointment. Don't forget to take your consent form, interview questions, and dress appropriately!

Part 2B Supporting Documents

Student Worksheets

Student Homework Assignment

to be completed before class on: ___________

1. Complete your Data Collection Plans with your group (if you have not already finished them). Make sure you consult all the resources provided and do some research on your own, if needed.

2. Collect all the supplies and equipment that you need.

3. Carry out your plan to collect data with your group. (This may be as part of a class field trip and/or in your small group).

4. Reflect on your data collection experience. As a group, make sure your data collection notes are complete. Individually, you should each write up your personal thoughts and notes after completing the data collection. What went well? What would you have done differently? What new questions do you have?

Tips for creating an effective presentation

Compiled by Gwen Noda

Here are some things to consider when creating a presentation, besides trying to include all the items in the rubric for your assignment (or whatever the content of your presentation might be).

First, write an outline of the essential things to include in your talk – before you create any slides or find cool photos or images. Make sure to include the content that is covered in the assignment rubric. Strongly structured outlines also include an introduction, list of arguments/evidence, interesting points, and a take home message for your audience or closing summary. Know your audience in advance and plan to address why your presentation matters to them and why they should care.

Keep it simple and stay on message. Everything you show and talk about should be relevant to your message and project.

Start thinking about what items (digital or physical objects) will best help convey your ideas and message to your audience. Consider if a live demonstration or short video would be relevant, engaging, and possible during your presentation (Do you have enough time for it? Do you have the technology/equipment and space for it?). If relevant and done well, demonstrations and videos can be more engaging than powerpoint slides with text and images alone.

Begin your presentation with a brief summary of what you will be talking about. You are letting the audience know what to expect

Try to "hook" everyone in with something interesting (and relevant!) at the beginning of your talk. It could be a striking photo, a very short video, an interesting fact, a demonstration, or a question that you ask the audience (and solicit some answers or opinions).

Involving your audience during your presentation will keep your audience engaged. You could use any of the ideas for a "hook" that are mentioned above. However, if you do engage your audience, be prepared to get them back on track if they wander off topic. You don't want to lose valuable time and possibly the attention of the rest of your audience if you get off topic and if only one or two audience members are engaged.

Organize yourself and help orient your audience. Make a table of contents or brief outline on a single slide and place it early in your presentation. It will show your audience what you're going to cover in your presentation (the basic structure and topics). Keep it simple. This is especially helpful for long presentations or if you think your topic is complicated or contains a lot of information. Make sure to follow your outline!

If you are going to use slides, cover one topic at a time – the images and words on the slide, should be what you are talking about. If you need to talk about something, make a slide. If you don't need to talk about something, don't make a slide (and don't talk about it). If you have multiple points to make, show one at a time. If you put too many points on one slide, people may get distracted from what you are actually saying because they are reading ahead to the next point.
- Important ideas, charts, tables, and photos should each get their own slide
- It's might be relevant to show a detailed or complicated map, graph or chart, but make sure you convey the main message of the image and what the image represents. The title of the slide at the top or across the bottom of the slide are good places to (briefly) explain the point of including that slide.
- Don't write paragraphs on your slides; use bullet points - and visuals, where appropriate. You can use the presenter's notes in powerpoint or note cards if you need more reminder for yourself of what you are going to say.
- Use images sparingly and only use them if they help you illustrate a point. Maximum of between 1 to 4 photos/graphics per slide (depending on how much text you also have) is probably enough. Try to avoid clipart unless it makes a point relevant to your presentation. If you use someone else's photograph, drawing, chart, table, etc., give credit to your source. You can do it on the slide in small writing at the bottom or save all the credits for a slide at the end of your presentation.
- Keep it simple
- Don't add too many effects (such as fades, swipes or other slide transitions) because you risk distracting your audience – unless you are trying to make a specific point about being distracted! Even one effect per slide can get distracting or annoying to your audience. Many great presentations have no special effects or slide transitions at all.
- Keep the slide background template consistent (you may want to change the background slide color when you change topics, but don't randomly select different colors for all your slides).
- Make sure all your text and images can be seen clearly and stand out against the background of your slide. You want the slide to be easy to see, read, and understand from a distance. If you put text on top of a photograph, make sure all the text contrasts with all the colors of the photo that it is overlaid upon.
- Make sure there is contrast between the color of your font and the background color.
- Generally, people prefer to look at text written in a san serif font (like Arial, Helvetica, Calibri) that can be easily read.
- Text should be easy to read at a glance from far away, so make sure your font is large enough (probably 32 point or larger, but it depends on which font you choose).
- Align your text to the left or right.

Remember, you as the presenter are the focus, not the slides. The slides are one of many tools you can choose from to help you make your point or get your message across to your audience, so give some thought to how you speak, what you say, and how you move around the room. You don't want to sound monotone like you are reading from a page (so you probably should not be reading straight from your slides or notes - although you may refer to them). Typically, there shouldn't be whole sentences on your slides for you to be reading from anyway!

Finish strong. Make sure you clearly state your point/summary both verbally and visually (this could just be a short statement on a slide or an image or two). You might also finish with a challenge or question for your audience to keep them thinking and engaged with your topic beyond the presentation itself.

Keep to the time frame you were allotted.

If you want to see some slides and presentations that are short and engaging, watch some TED talk videos.
- Note Simon Sinek's very simple (chart paper!) visuals. What do you think about his gestures and his pacing?
https://www.ted.com/talks/simon_sinek_how_great_leaders_inspire_action?language=en
- See how Jill Bolte Taylor uses a slideshow and a preserved human brain in her presentation. How does the pacing of Jill's story about her stroke add to the drama?
https://www.ted.com/talks/jill_bolte_taylor_s_powerful_stroke_of_insight?language=en
- Have a look at the short video clips of unusual animals that are pieced together for the entire presentation, the use of reverse, slow motion video replay, and a little bit of text in David Gallo's video. Did that engage you? How about his jokes?
https://www.ted.com/talks/david_gallo_shows_underwater_astonishments?language=en

Resources:
"10 Tips for More Effective PowerPoint Presentations"
http://www.lifehack.org/articles/featured/10-tips-for-more-effective-powerpoint-presentations.html

"How to Give a Great Presentation: Timeless Advice from a Legendary Adman, 1981"
https://www.brainpickings.org/2012/12/20/writing-that-works-roman/

"High 5 Presentation" Lesson from Literacy TA
http://www.literacyta.com/literacy-skills/high-5-presentation
(Basic lesson for developing your first presentation, includes rubric, and a sheet to help students understand the rubric.)

Tips on how to practice your presentation

Compiled by Gwen Noda

When you think all the parts (slides, visual aids, props, script/talking points, etc.) of your presentation have been completed, practice it!

Learning/Remembering your talk will probably depend on your individual style. To help you remember what you are going to say, summarize the main points of your talk and remember those instead of trying to remember a script, word for word. If the goal is ultimately to present without using a script, then practice without a script. If you really need to follow a script (you are quoting someone or performing a skit, etc.) and if you are an auditory learner, it may help to make an audio recording of what you will say and play that back to yourself to help you learn it. If you are visual learner, you may need print yourself one page of notes or create note/flash cards to study.

Find the story you are trying to tell. Often a presentation is easier to deliver when you can remember the overall story you want your audience to hear and know. Every good story has a beginning, middle, and end, so make sure yours does too and that the parts flow logically from one section to the next.

Go through all the motions of your presentation**,** including performing your demonstrations, finding/showing any visuals that you have, rotating with your group members to take turns in front of the podium (if there will be one), etc. Stand up when you practice (unless you know you will be sitting down). Stand (or sit) up straight and look towards the audience. Consider a dress rehearsal where you wear the clothes you think you will wear to your presentation. If you can, practice at the location where you will actually give your talk (or in a similar space). It will help you get a feel for the layout of the room and the acoustics. If you cannot practice at the actual location of your presentation, try to at least see the location in advance. If you will need an electrical plug and/or digital connector, make sure you know where these are and that they work.

Speak out loud so that you can find and adjust awkward phrases or wording. Try to project your voice and enunciate your words. Try to modulate your voice so that you are not speaking in monotone – it will help the audience stay engaged.

Time your practice presentations so that you can make sure that you will stay within your allotted time. Try to plan your talk to be a little shorter than your allotted time to allow for any delays or questions that might come up. Try to pay attention to your pace. You may be talking too quickly or too slowly for an audience to understand or keep up with you. Slide changes usually cause speakers to pause, but not always. Pauses give your audience a chance to think about what you have said and can subtly indicate that you are moving on to a new point or idea, so make sure to incorporate them in the appropriate places. The organization of the content in your presentation may help with this.

If you will be graded using a rubric, review the rubric criteria in advance and ensure that you meet the established standards.

First, practice by yourself to get over some of the nervousness of speaking out loud. Take the opportunity to experiment with volume, pacing, gestures, and staging. Make notes to yourself as you practice. You may want to record yourself and view the video by yourself to get a different perspective.

Don't be afraid to revise and refine your presentation. During practice sessions, you may find that you have some awkward phrases, rough transitions from one idea to the next, or find that your visuals are not visible to those in the back of the room, etc. Good work takes time, thoughtful reflection, and critical editing. Don't be hard on yourself if the first few times through the presentation isn't perfect. With a little work, you can create a compelling presentation that you are proud to perform before your audience. Be sure to leave yourself some time before your presentation in case you find you need time to further edit or refine it with time to practice it again.

At this point, you may want to use the "critical friend" protocol (ask your teacher about this) to get some feedback or help you make decisions about what gestures, visuals, etc. to include or eliminate. Then practice with your pet, stuffed animals, or the mirror as your audience.

When you seem to be giving your presentation pretty smoothly, then try presenting to some family, friends, and/or fellow students! Practice your whole presentation from beginning to end. Even if you make a mistake, recover and continue.

Be rested and prepared for your presentation, even if you are well practiced, being tired reduces the efficacy of your presentation. Build in time to arrive early in case unexpected obstacles delay you from arriving at the presentation time.

Resources:
"8 Effective Ways to Practice a Speech"
http://www.ragan.com/Main/Articles/8_effective_ways_to_practice_a_speech_47643.aspx

"Speech Preparation #8: How to practice your presentation"
http://sixminutes.dlugan.com/speech-preparation-8-practice-presentation/

"8 Steps to Practicing a Presentation"
http://www.drmichellemazur.com/2012/03/practice-presentation-speech.html

Website/Resource Evaluation Using the 5Ws

This form will help evaluate content, not design or navigation. Use one form per evaluation.

Your name: Date:

Topic search (e.g., stem cells):

Site/web page name/title:

Site/web page URL:

Instructions: The top score is 10 points. Circle **one** for each question:

Y = yes = 2 points S = somewhat = 1 point N = no = 0 points

WHO? Does the author have good credentials, e.g., expertise, relevant education? Look for the author bio or link to the bio. If it's not provided, do a search on the author. If author is an organization, check its mission statement or purpose.	Y=2 S=1 N=0
WHAT? Is the content credible (seems trustworthy)? Examine the purpose, facts, and sources. Consider if info is first or second-hand. See if facts and sources are documented (references, citations). Check links to see if they lead to quality pages.	Y=2 S=1 N=0
WHEN? Is it clear when the info was posted or updated? Look for dates in the copyright, near the page title, home page, etc. Try a few suggested links to see if they still work.	Y=2 S=1 N=0
WHERE? Is the sponsor/producer credible for the topic presented? Look in "about us," "contact us," or home page. Ensure sponsorship is stated. Do a search to see if other web sites that link to this one are quality sites (good sites usually review their suggested links).	Y=2 S=1 N=0
WHY? Should I use the info on this site/page? Consider whether the site/page is better than others for what you need. If you're not sure, check the same info on a few other web sites and compare.	Y=2 S=1 N=0
TOTAL POINTS:	

COMMENTS:

Developed by Oksana Hlodan 2006-7, based on evaluation guidelines suggested by Kathy Schrock at http://school.discovery.com/schrockguide/eval.htm

Beware of fake and pseudoscience websites

From COSEE-West

BEWARE of websites that claim to contain science information or science research…
Some websites claim to be based on peer-reviewed science, but they are completely made up or have twisted the data, graphs or charts to fit their own conclusions (not the ones of the researcher who gathered and published that data). Some websites contain pseudoscience and some are spoofs or jokes. Please help your students be careful about what they believe and cite from the internet.
This is not intended to be a complete list, merely a place to start.

Sites that help people recognize bogus/bad science:
National Center for Science Education: A site that defends the teaching of evolution in public schools. They also have background information on the "Intelligent Design" movement.
http://www.natcenscied.org/default.asp
Bad Science: A website dedicated to correcting scientific misinformation. It contains common misconceptions and their correct explanations. It links to a number of different sites, including "Bad Meteorology" and "Bad Astronomy."
http://www.ems.psu.edu/~fraser/BadScience.html
Quackwatch: A website dedicated to educating the public on how to avoid being taken in by pseudoscientific claims, quack cures and nonsense. Mainly focused on human health issues, there are some articles on science in general.
http://www.quackwatch.com/
Committee for the Scientific Investigation of Claims of the Paranormal (CSI):
http://www.csicop.org/resources

Here are some website that present themselves seriously, that look legitimate, but upon further investigation are either intentionally showing misleading information, bad science, incomplete science or are tongue-in-cheek.
CO2 Science: A site that take graphs from peer-reviewed scientific papers and comes to different conclusions about carbon dioxide and global warming. There are even lesson plans on this site.
http://www.co2science.org/about/center_staff.php
Church of the Flying Spaghetti Monster: A humorous, satirical website. They claim to be a "real," robust religion "with millions, if not thousands of devout worshippers."
http://www.venganza.org/
The Endangered Pacific Northwest Tree Octopus: A website based on a fictional animal. It's a good example of information that sounds valid, but that really isn't.
http://zapatopi.net/treeoctopus/
Dihydrogen monoxide: A spoof website that advocates for the ban of dihydrogen monoxide aka H2O aka water.
http://www.dhmo.org/facts.html

Part 3 Supporting Documents

Student Worksheets

Student Homework Assignment

1. Complete your public presentations with your group (if you have not already finished them). Make sure you consult all the resources provided and do some research on your own, if needed. Remember to look back on all the lessons that you have done related to this project. You may want to use or modify and use something you have created.

Refer to the following document for some hints on practicing presentations:

Tips for creating an effective presentation

2. Collect all the supplies and equipment that you need for your presentation.

3. As a group, divide up the presentation: Who will do or say which parts? How will you transition between speakers? Practice your presentation more than once.

Refer to the following document for some hints on practicing presentations:

"Tips on how to practice your presentation"

Answer Keys

Part 1

Guiding Questions with Answers for Going UP: Sea Level Rise in the San Francisco Bay

KQED Quest

https://www.youtube.com/watch?v=LDv021_zW-E

1. Who and what will sea level rise affect in coming years?

    (00:37-00:52)
    Everyone who lives, works, plays near the bay/ocean
    Airports, freeways, schools, hospitals, homes
    (9:00-9:08)
    For Hayward (HASPA) – water treatment plant, ponds, PG&E transmission lines, sewer

2. What are the two main questions that scientists have about sea level rise?

    (1:00)
    How much it will rise?
    How fast it will rise?

3. Why does sea level rise in places like Alviso, CA raise issues like environmental justice?

    (3:00-3:30)
    Alviso is predominantly Hispanic, many out of work, climate sensitive class, more likely to be without cars, speak little or no English
    In the bay area, more people that are low income, communities of color/minority communities are at risk from sea level rise than elsewhere in California

4. How much sea level will rise depends largely on what?

    (3:42-3:51)
    How much carbon we pump into the atmosphere

5. As the planet warms up, what happens to sea water that causes the sea level to rise?

    (4:06-4:15)
    water expands as it gets warmer

6. What is the other main contributor (from climate change) that causes sea level to rise?

    (4:15-4:27)
    climate change shrinks glaciers, melts polar ice

7. Another major concern is that sea level rise will combine with other forces of nature to causes even higher sea level. Name at least one of those other forces of nature?

    (4:58-5:36)
    two high tides per day, especially around new or full moon
    pacific storms push water up and atmospheric pressure drops
    El Nino temporarily raises sea level along CA coast

8. A 2009 report said that sea level could rise in the bay area by how much by the year 2100?
   (5:37-5:52)
   20 to 50 inches

9. Name one 'hard' solution and one 'soft' solution for adapting to sea level rise.
   (2:05-2:18)
   hard = levee in Alviso
   (6:43-7:06)
   soft = wetlands – act as sponge/buffer as long as accumulation keeps up with sea level rise
   (9:44-10:12)
   hard = riprap – broken up concrete
   soft = tidal marshland – let it soak up water

10. What is it going to take to adapt to sea level rise?
   (8:14-9:18)
   unprecedented cooperation between overlapping jurisdiction, competing interests
   public agencies, HASPA
   finding common ground between stakeholders
   (10:15-10:32)
   money, political will
   (11:14-11:50)
   Govenor Schwarzenegger: Plan A is reduce emissions, Plan B is build infrastructure

11. What might happen if we don't do anything to adapt to sea level rise?
   (11:50-12:27)
   schools at risk, health care facilities
   EPA regulated sites where we've dumped bad stuff, risk inundation and moving contaminants into the water of the bay

12. Who is working on the problem?
   (12:30-12:20)
   SF Bay Conservation and Development Commission competition – innovation sea level 130 entries, 18 countries submitted ideas for Plan B
   For Plan A: California, USA, the globe, me?, you?

Part 1

Guiding Questions with Answers for Sea level rise: Global warming's yardstick
http://climate.nasa.gov/news/2201/

1. What are two reasons that sea level could drop?
   The sea was cooling, less water in the ocean

2. Explain the overall sea level height trend over the last 20 years and how 2010 and 2011 sea level height readings fit in.
   overall, sea level has been rising over the last 20 years
   2010 and 2011 were a sudden, temporary reversal in the trend

3. How much has the global sea level risen in the last 130 years?
   8 inches

4. What does Dr. Willis mean when he says that sea level rise is the yardstick for the global warming?
   Sea level rise tells us how much human activity has changed the climate

5. Name at least two of the weather patterns that move large amounts of water around the planet.
   El Nino, La Nina, Pacific Decadal Oscillation

6. What do the 3600 buoys measure and how does that information help us understand sea level rise?
   Temperature, as water warms up, it expands, causing sea level rise

7. What are two reasons that sea level could rise?
   Ocean heats up and expands
   Ice melts and adds water to the ocean

8. Name one area where scientists don't have as much data as they would like.
   Deep ocean (below the buoys)
   Coastal ocean regions (when the SWOT mission is launched, it should help with that)

9. What are the three instruments and/or missions discussed in this article that contribute data to the study of sea level height?
   Jason, GRACE, buoys

Part 2A

Guiding Questions and Answers for Just 5 questions: Sea surface topography

NASA's Jet Propulsion Laboratory

http://climate.nasa.gov/news/2318/

1. Explain one similarity and one difference between sea surface topography and topography on land.

   Both have high points and low points

   Sea surface topography is affected by temperature, salinity, currents, underwater mountains & trenches

2. Why do some sea surface topographic features move around?

   If the features are caused by currents, then they might move if currents move or change direction

3. Is the ocean absorbing heat from the atmosphere evenly? What is one way we can tell?

   No

   Sea levels rise faster in some places than others

4. If it is reported that there is a bunch of warm water moving from the western Pacific to the eastern Pacific, is it because the satellite data showed higher or lower than normal sea surface topography? What is the name of the phenomenon that is associated with this movement of warm water?

   Higher

   El Nino

5. What is one shortcoming of the current satellites that are observing sea surface topography? What is planned to overcome this?

   It is hard to tell what is happening on small scales and near the coast

   the SWOT satellite should help measure sea surface topography in coastal areas with very high resolution

Part 2A

Guiding Questions and Answers for Reading between the tides: 200 years of measuring global sea level

NOAA Climate

https://www.climate.gov/news-features/climate-tech/reading-between-tides-200-years-measuring-global-sea-level

1. When did the U.S. government begin a systemic coastline survey that included tide gauges? Why was this done?

    1807
    map the nation, facilitate maritime commerce

2. Choose two of the types of tide gauges discussed in the article and explain how each tide gauge works. Give one similarity and one difference between the two devices.

    Tide staffs – tall rulers in stilling wells, read manually relative to fixed point on land
    Self-recording tide gauge – like tide staff, but with pen on a rotating drum that recorded tides
    Several others after that improved on manual labor required, cost, and accuracy
    Sound wave tidal gauges – sends sound wave, listens for echo, records time between
    Microwave radar tide gauge – sends microwave pulse, listens for echo, records time between

3. What is one advantage of the newest tide gauges over past versions?

    More reliable, cheaper to install and maintain

4. How will scientists check for discrepancies between the newest tide gauges and ones that are currently installed?

    They will install new ones next to the old ones and record data from both to see how the readings compare

5. What are two new innovations in measuring sea level height that involve GPS?

    Continuous GPS provide a more accurate estimate of local vertical land motion
    GPS on buoys can measure sea level offshore

Part 2A

Guiding Questions and Answers for Sea Level Viewer
NASA JPL and California Institute of Technology
http://climate.nasa.gov/interactives/sea_level_viewer

"OVERVIEW" is a video about satellites that measure sea level rise (1:30)
1. What is a driving force of climate?
   Heat from the ocean

2. What does sea surface height tell us?
   Sea surface height reflects the amount of heat stored in the water.
   Higher sea surface height indicates warmer water; Lower sea surface height indicates cooler water.

3. Name at least two reasons why it is important to have this series of satellites (Topex/Poseidon, Jason-1, and Jason-2) observing the global sea surface height?
   Provided first global perspective on El Nino and La Nina
   Help predict weather events and El Nino of 1997
   Help track climate change

"MISSIONS" will show you the objectives of the first 3 satellites in the Jason series. Jason-3 launched on January 17, 2016 to add to the long-term data set that exists from the previous three satellites.
4. Choose any two of the objectives listed and explain how each is related to understanding sea level rise.
   Three-year global view, provide a 5-year view, extended time series = long-term data set to track change over time across the globe
   Improved understanding of ocean currents, ocean circulation and variation of = currents change ocean surface topography
   Improved forecasting of global climate = sea level is global warming's yardstick
   Improved forecasting of El Nino, open ocean tide models = both can increase sea level locally, temporarily and combine with each other and sea level rise to create coastal flooding, etc.
   Measure global sea level change, ocean surface topography = direct measurement of sea level height

"GLOBAL VIEW" highlights examples when these satellites have helped us visualize and understand what is happening on our planet. Please note that "Latest View" shows data from 2013.
5. Choose one of the four videos (Large El Nino, Hurricane Katrina, Indian Ocean Tsunami, La Nina) and watch it. If you were to summarize the video for someone who had not watched it, what are the three most important pieces of information that you would tell them? Please write them below.

Large El Nino = el nino is abnormal warming of surface waters in eastern tropical pacific; appears every 3-7 years; affect weather all over world; extra large one in 1997-98 – most intense in more than 100 years and triggered fires, floods, disrupt fisheries & agriculture; 40 ft waves for surfers; frequency of El Nino and La Nina have important implications to global change

Hurricane Katrina = formed Aug 2005; satellites forecasted growth and intensity; Jason measures sea level height – higher sea level can mean warmer water; Katrina evolved quickly, speed increased dramatically; pass over warmer water made the storm more intense and pass over cooler water made it less intense; spaced-based observations are critical for predicting the intensity of hurricanes

Indian Ocean Tsunami = Dec 2004, 9.0 earthquake near Sumatra; caused tsunami; first time satellites observed tsunami, info being used to improve tsunami computer models and develop early warning systems

La Nina = intermittent climate event, unusually cold water in eastern and central pacific; La Nina means drier and warmer in SE USA, colder wetter in NW USA, increased hurricane activity in Atlantic; prolonged one in 1998-2001 = serious drought for western USA, preceded one of the deadliest hurricane seasons on record

Correlations with Standards

Next Generation Science Standards & Common Core

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

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth's systems.

ELA/Literacy –

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

WHST.9–12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics –

MP.2 Reason abstractly and quantitatively.

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

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

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

ELA/Literacy –

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

WHST.9–12.2.a–e Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
Mathematics –
MP.2 Reason abstractly and quantitatively.

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

ELA/Literacy –
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Mathematics –
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.

HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

ELA/Literacy –
RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
RST.11-12.8.a–e Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
Mathematics –
MP.2 Reason abstractly and quantitatively.
S-ID.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).
S-IC.1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population.
S-IC.6 Evaluate reports based on data.

Glossaries

Bilingual Spanish/English

Here is a link to the COMET Glossary of Meteorology and Hydrology Terms (bilingual English/Spanish)
https://www.meted.ucar.edu/resources_gloss.php
Either click on the first link under COMET or if you want to download it directly, use this link:
https://www.meted.ucar.edu/glossaries/COMET_glos_en_es_v7a-06_12.zip

English

Sea Level Rise

A **adaptation** – adjustment in natural or human systems in response to current natural hazards and actual or expected climate change impacts. (Modified from IPCC, 2007) (1)

adaptation planning – Actions taken to help communities and ecosystems moderate, cope with, or take advantage of actual or expected changes in weather and climate conditions.

altimetry - a technique for the measurement of the elevation of the sea, land or ice surface. For example, the height of the sea surface (with respect to the center of the Earth or, more conventionally, with respect to a standard “ellipsoid of revolution”) can be measured from space by current state-of-the-art radar altimetry with centrimetric precision. Altimetry has the advantage of being a measurement relative to a geocentric reference frame, rather than relative to land level as for a tide gauge, and of affording quasi-global coverage. (2) The Jason series satellites use altimetry to measure sea surface height.

anomalies – departures of temperature, precipitation, or other weather elements from long-term averages at a given location.

armoring - the placement of fixed engineering structures, typically rock or concrete, on or along the shoreline to reduce coastal erosion. Armoring structures include seawalls, revetments, bulkheads, and rip rap (loose boulders). (1)

B **bathymetry -** the measurement of depths of water in oceans, seas, and lakes; also the information derived from such measurements. (1)

beach nourishment - the practice of adding sand or sediment to a beach from an outside source, usually to combat the effects of erosion and/or maintain the beach at a desired width

berm – a geomorphological feature usually located at mid-beach and characterized by a sharp break in slope, separating the flatter backshore from the seaward-sloping foreshore. (3)

breakwater - an offshore structure (such as a wall or jetty) that, by breaking the force of the waves, protects a harbor, anchorage, beach or shore area. (4)

buffer area - a parcel or strip of land that is designed and designated to permanently remain vegetated in an undisturbed and natural condition to protect an adjacent aquatic or wetland site from upland impacts, to provide habitat for wildlife and to afford limited public access.

C **California King Tides Project** - About: http://california.kingtides.net/
Plan your shoot: http://california.kingtides.net/plan/

carbon dioxide (CO_2) – a naturally occurring gas, also a by-product of burning fossil fuels and biomass, as well as land-use changes and other industrial processes. It is the principal anthropogenic greenhouse gas that affects the earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1. (2)

Centre National d'Etudes Spatiales (CNES) - https://cnes.fr/en/web/CNES-en/3773-about-cnes.php

climate – the composite or generally prevailing weather conditions of a region throughout the year, averaged over a series of years. A description of aggregate weather conditions; the sum of all statistical weather information that helps describe a region including temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. (2)

climate change – climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

climate feedback – an interaction mechanism between processes in the →climate system is called a climate feedback, when the result of an initial process triggers changes in a second process that in turn influences the initial one. A positive feedback intensifies the original process, and a negative feedback reduces it. (2)

climate model (hierarchy) – a numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and accounting for all or some of its known properties. The climate system can be represented by models of varying complexity, i.e. for any one component or combination of components a hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical or biological processes are explicitly represented, or the level at which empirical parametrizations are involved. Coupled atmosphere/ocean/sea-ice General Circulation Models (AOGCMs) provide a comprehensive representation of the climate system. There is an evolution towards more complex models with active chemistry and biology. Climate models are applied, as a research tool, to study and simulate the climate, but also for operational purposes, including monthly, seasonal and interannual climate predictions. (2)mathematical model for quantitatively describing, simulating and analyzing the interactions between the atmosphere and underlying surface (e.g., ocean, land and ice).

climate prediction (or climate forecast) – is the result of an attempt to produce a most likely description or estimate of the actual evolution of the climate in the future, e.g. at seasonal, interannual or long-term time scales. (2)

coast – a strip of land of indefinite width (may be several kilometers) that extends from the shoreline inland to the first major change in terrain features. The part of a country regarded as near the coast. This is a region of constant change.

coastal armoring – physical structures that protect the shoreline from coastal erosion, such as seawalls, revetments, breakwaters, and sandbags. (3)

coastal erosion – the wearing away of land or the removal of beach or dune sediments by wave action, tidal currents, wave currents, or drainage. A combination of episodic inundation events and relative sea level rise will serve to accelerate coastal erosion. (1)

coastal plain – any lowland area bordering a sea or ocean, extending inland to the nearest elevated land, and sloping very gently seaward. (4)

coastal strand – a plant community that grows along the shore in loose sand just above the high tide line. Many plants that grow in this area are endemic to the strand. (3)

coastal zone – the transition zone where the land meets water; the region that is directly influenced by marine hydrodynamic processes. Extends offshore to the continental shelf break and onshore to the first major change in topography above the reach of major storm waves.

contour interval – the predetermined elevation difference between any two contour lines.

contour line – imaginary lines connecting points between places of the same elevation.

current - the horizontal movement patterns in bodies of water; in coastal areas, currents are influenced by a combination of tidal (flood and ebb) and non-tidal (wind-driven, river flow) forces. (4)

D **delta** – a low relief landform composed of sediments deposited at the mouth of a river that commonly forms a triangular or fan-shaped plain of considerable area crossed by many channels from the main river; forms as the result of accumulation of sediment supplied by the river in such quantity that is not removed by tidal or wave-driven currents. (4)

dike – a wall generally of earthen materials designed to prevent the permanent submergence of lands below sea level, tidal flooding of lands between sea level and spring high water, or storm-surge flooding of the coastal floodplain. (4)

dune - a mound or ridge of sand or other loose sediment formed by the action of wind and waves. (3)

E **ecosystem** – a system of interacting living organisms together with their physical environment. The boundaries of what could be called an ecosystem are somewhat arbitrary, depending on the focus of interest or study. Thus the extent of an ecosystem may range from very small spatial scales to, ultimately, the entire Earth. (2)

El Niño-Southern Oscillation (ENSO) - El Niño, in its original sense, is a warm-water current which periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. This oceanic event is associated with a fluctuation of the intertropical surface pressure pattern and circulation in the Indian and Pacific oceans, called the Southern Oscillation. This coupled atmosphere-ocean phenomenon is collectively known as El Niño-Southern Oscillation, or ENSO. During an El Niño event, the prevailing trade winds weaken and the equatorial countercurrent strengthens, causing warm surface waters in the Indonesian area to flow eastward to overlie the cold waters of the Peru current. This event has great impact on the wind, sea surface temperature and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many other parts of the world. The opposite of an El Niño event is called La Niña. (2)

erosion – the process by which wind, water, or other natural agents wear something away, such as rock, soil, or sand. (3)

estuary – a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with freshwater from land drainage; an inlet of the sea reaching into a river valley as far as the upper limit of tidal rise, usually being divisible into three sectors; (a) a marine or lower estuary, in free connection with the open sea; (b) a middle estuary subject to strong salt and freshwater mixing; and (c) an upper or fluvial estuary, characterized by fresh water but subject to daily tidal action; limits between these sectors are variable, and subject to constant changes in the river discharge. (4)

extreme weather event – is an event that is rare within its statistical reference distribution at a particular place. Definitions of “rare” vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile. By definition, the characteristics of what is called extreme weather may vary from place to place. An extreme climate event is an average of a number of weather events over a certain period of time, an average which is itself extreme (e.g. rainfall over a season). (2)

F **flooding** – the temporary submergence of land that is normally dry, often due to periodic events such as storms, see also inundation. (4)

fossil fuels – fuels that when burned produce greenhouse gases and take thousands to millions of years to form include coal, petroleum and natural gas.

G **Geographic Information System** – a geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. (See www.esri.com/what-is-gis/index.html.) (1)

glacier – a mass of land ice flowing downhill (by internal deformation and sliding at the base) and constrained by the surrounding topography e.g. the sides of a valley or surrounding peaks; the bedrock topography is the major influence on the dynamics and surface slope of a glacier. A glacier is maintained by accumulation of snow at high altitudes, balanced by melting at low altitudes or discharge into the sea. (2)

global sea level rise – caused by a change in the volume of the world's oceans due to temperature increase, deglaciation (uncovering of glaciated land because of melting of the glacier), and ice melt. (1)

global warming – an increase in the average temperature of the Earth's atmosphere, great enough to cause changes in the global climate. This change occurs globally such as the interglacial warming period the earth experienced after the last Ice Age. The current increase is brought about by increased levels of greenhouse gases due to effects of human industry and agriculture. Expected long-term effects are sea level rise, flooding, melting of polar ice and glaciers, fluctuations in temperature and precipitation, drought, heat waves and forest fires.

Greenhouse effect – Greenhouse gases effectively absorb infrared radiation, emitted by the Earth's surface, by the atmosphere itself due to the same gases, and by clouds. Atmospheric radiation is emitted to all sides, including downward to the Earth's surface. Thus greenhouse gases trap heat within the surface-troposphere system. This is called the *natural greenhouse effect*.
Atmospheric radiation is strongly coupled to the temperature of the level at which it is emitted. In the troposphere the temperature generally decreases with height. Effectively, infrared radiation emitted to space originates from an altitude with a temperature of, on average, -19°C, in balance with the net incoming solar radiation, whereas the Earth's surface is kept at a much higher temperature of, on average, +14°C.
An increase in the concentration of greenhouse gases leads to an increased infrared opacity of the atmosphere, and therefore to an effective radiation into space from a higher altitude at a lower temperature. This causes a radiative forcing, an imbalance that can only be compensated for by an increase of the temperature of the surface-troposphere system. This is the enhanced greenhouse effect. (2)

g**reenhouse gas** – greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds. This property causes the greenhouse effect. Water vapor (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine and bromine containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). (2)

"ground truth" – a set of measurements that are more accurate than the measurements from the system or model you are testing. Verification of geographic attributes with field based measurements.

H **Hayward Area Shoreline Planning Agency (HASPA)** – http://user.govoutreach.com/hayward/faq.php?cid=11038

I **iceberg** – a large floating mass of ice, detached from a glacier and carried out to sea. When an iceberg melts, it does not contribute to sea level rise (as opposed to glaciers, see above).

ice cap – a dome shaped ice mass covering a highland area that is considerably smaller in extent than an ice sheet. (2)

ice sheet – a mass of land ice which is sufficiently deep to cover most of the underlying bedrock topography, so that its shape is mainly determined by its internal dynamics (the flow of the ice as it deforms internally and slides at its base). An ice sheet flows outwards from a high central plateau with a small average surface slope. The margins slope steeply, and the ice is discharged through fast-flowing ice streams or outlet glaciers, in some cases into the sea or into ice-shelves floating on the sea. There are only two large ice sheets in the modern world, on Greenland and Antarctica, the Antarctic ice sheet being divided into East and West by the Transantarctic Mountains; during glacial periods there were others. (2)

ice shelf – a floating ice sheet of considerable thickness attached to a coast (usually of great horizontal extent with a level or gently undulating surface); often a seaward extension of ice sheets. (2)

infrastructure – the basic physical and organizational structures and facilities of a community or region including roads, buildings, power supply, waste water treatment facilities, etc. that are needed for a community to function properly.

inundation – water covering normally dry land is a condition known as inundation. (1)

Intergovernmental Panel on Climate Change (IPCC) – is a scientific intergovernmental body set up by the World Meteorological Organization (WMO) and by the United Nations Environment Programme (UNEP) to provide the decision-makers and others interested in climate change with an objective source of information about climate change.

L **La Niña** – See: El Niño-Southern Oscillation. (2)

levee – a manmade structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to provide protection from temporary flooding.

M **managed retreat -** the planned removal or movement of structures in order to allow the rising sea level to inundate or erode the land immediately inland from the current shoreline. (3) Example is Pacifica State Beach (coastalmanagement.noaa.gov/initiatives/shoreline_ppr_retreat.html)

mean sea level – sea level measured by a tide gauge with respect to the land upon which it is situated. Mean Sea Level (MSL) is normally defined as the average Relative Sea Level over a period, such as a month or a year, long enough to average out transients such as waves. (2)

N **NASA** – National Aeronautics and Space Administration

NOAA – National Oceanic and Atmospheric Administration

P **Pacific Institute** – http://pacinst.org/

Pacific Decadal Oscillation (PDO) - a long-lived El Nino like pattern of Pacific climate variability. In the 20th Century the PDO events persisted for 20 – 30 years while ENSO events last 6 – 18th months.

projection – a forecast of a future level or situation based upon data and modeling

R **radar** – an instrument useful for remote sensing of meteorological phenomena; operates by sending radio waves and monitoring returning wave by such reflecting objects as raindrops within clouds.

relief – the change in elevation between two points.

riprap (also rip-rap or rip rap) – loose boulders placed on or along the shoreline as a form of armoring. (4)

resilience - the capacity of a system, community, or society potentially exposed to hazards to adapt, by resisting or changing, in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures. (SDR, 2005) (1)

risk - the probability of harmful consequences or expected losses (death and injury, losses of property and livelihood, economic disruption, or environmental damage) resulting from interactions between natural or human-induced hazards and vulnerable conditions. (SDR, 2005) (1)

S **saltwater intrusion** – displacement of fresh or ground water by the advance of salt water due to its greater density, usually in coastal and estuarine areas. (4)

satellite – remote sensing is the collection of data on land use, industrial activity, weather, climate, geology and other processes through Earth observations from satellites in outer space.

sea level – the average height of the ocean measured between high and low tide.

sea level rise (sometimes abbreviated SLR) – is the rise and fall of sea levels throughout time in response to global climate and local tectonic changes; the long term increase in the mean sea level resulting from a combination of local or regional geological movements and global climate change, such as sinking of the land, increased volume of the ocean due to thermal expansion, or addition of water to the ocean from melting glaciers.

sea surface temperature (sst) – temperature of the ocean's surface used in collaboration with other data to predict an El Nino occurrence.

sea surface topography – the shape of a surface including its relief. It is influenced by both gravity and ocean circulation.

sea wall – a structure, often concrete or stone, built along a portion of a coast to prevent erosion and other damage by wave action; often it retains earth against its shoreward face; a seawall is typically more massive than (and therefore capable of resisting greater wave forces than) a bulkhead. (4)

setbacks – the distance a building or other structure is set back from a given location, such as a bluff edge. (3)

shallow coastal flooding – the inundation of land areas along the coast caused by higher than average high tide and worsened by heavy rainfall and onshore winds (i.e., wind blowing landward from the ocean). Places like Charleston, South Carolina, and Savannah, Georgia, experience impacts from shallow coastal flooding several times a year because of coastal development and lower elevation. (1)

sluice gates – a mechanism used to control water flow in a channel or through an opening

storm surge -The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place. (2)

subsidence - Land subsidence is a gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials. Subsidence is a global problem, and in the United States, more than 17,000 square miles in 45 states, an area roughly the size of New Hampshire and Vermont combined, have been directly affected by subsidence. **(1)**

T **thermal expansion** – in connection with sea level, this refers to the increase in volume (and decrease in density) that results from warming water. A warming of the ocean leads to an expansion of the ocean volume and hence an increase in sea level. (2)

tidal freshwater marsh – A marsh along a river or estuary, close enough to the coastline to experience significant tides by non-saline water; the vegetation is often similar to a nontidal freshwater marsh. (4)

tide gauge - a device at a coastal location (and some deep sea locations) which continuously measures the level of the sea with respect to the adjacent land. Time-averaging of the sea level so recorded gives the observed Relative Sea Level Secular Changes. (2)

tide – the alternating rise and fall of the surface of the ocean and connected waters, such as estuaries and gulfs, that results from the gravitational forces of the Moon and Sun; also called astronomical tides (see tides, astronomical). (4)

topographic map – a map that shows the shapes and elevations or heights of the land with contour lines. Contour lines connect points of equal heights.

U **uncertainty** - An expression of the degree to which a value (e.g. the future state of the climate system) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors in the data to ambiguously defined concepts or terminology, or uncertain projections. Uncertainty can therefore be represented by quantitative measures (e.g. a range of values calculated by various models) or by qualitative statements (e.g., reflecting the judgement of a team of experts). See Moss and Schneider (2000). (2)

V **vulnerability** – susceptibility of people, property, and resources to negative impacts from hazard events. (1)

W **watershed** - The area of land, typically delineated by mountain ridges, from which water flows into the same place. (3)

weather – is the specific condition of the atmosphere at a particular place and time. It is measured in terms of such things as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from hour-to-hour, day-to-day, and season-to-season. Climate is the average of weather over time and space. A simple way of remembering the difference is that climate is what you expect (e.g., cold winters) and 'weather' is what you get (e.g., a blizzard).

wetlands – those areas that are inundated or saturated by the surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils; wetlands generally include swamps, marshes, bogs, and similar areas. (4)

Sources:
Definitions gathered from these websites:
(1) NOAA Coastal Inundation Glossary:
http://coast.noaa.gov/digitalcoast/inundation/glossary
(2) Intergovernmental Panel on Climate Change Glossary
http://www.ipcc.ch/ipccreports/tar/wg1/518.htm
(3) California Sea Grant Coastal Armoring Glossary
https://caseagrant.ucsd.edu/project/explore-sandy-beach-ecosystems-of-southern-california/glossary
(4) US EPA
http://iaspub.epa.gov/sor_internet/registry/termreg/searchandretrieve/glossariesandkeywordlists/search.do?details=&vocabName=Coastal%20Sensitivity%20Glossary

FEMA
http://www.southeastcoastalmaps.com/Pages/glossary.aspx

US Army Corps of Engineers
http://www.gpo.gov/fdsys/pkg/CZIC-gb450-6-g56-1972/html/CZIC-gb450-6-g56-1972.htm

Also, for coastal armoring, please see:
Extended Glossary on pages numbered 91-103.
Page long definitions with descriptions, images, cost, impacts, typical settings/conditions:
http://www.dbw.ca.gov/csmw/pdf/WCGA_CoastalStructures_Berry_Ruggiero.pdf

Shoreline Management Types, from NOAA
http://coastalmanagement.noaa.gov/initiatives/definitions.html