Scientists & Educators Learning from One Another – Coastal Change:
July 7 – 12, 2014
VIMS Eastern Shore Lab, Wachapreague VA

DAY 1 Monday – Arrival & Orientation Day

9:15 a.m.	Those who are carpooling from VIMS Gloucester Point campus meet instructors and depart for VIMS Eastern Shore Lab in Wachapreague (bring lunch, eat on road)
1:00 pm	**All participants arrive at VIMS lab**, check into dorm
2:00	*Welcome and Introductions *Icebreaker (time permitting) *Pre-test
2:30	*Workshop goals, agenda, housekeeping (Carol) – 30 mins *MWEE intro (Carol) – 1 hr *Habitat introduction and water quality introduction (Kevin); *Data Collection Methods: water quality test kit & field equipment demonstrations, sign up for gear and data manager tasks (Kevin, Carol & Lisa)
6:00 (18:00)	Group Spaghetti Dinner at Lab Dorm
6:45 (18:45)	"Lifestyles of the Wet & Muddy:" Nat. Geographic program filmed in Wachapreague
7:30 (19:30)	Class dismissed: free time
9:00 (21:00)	Quiet time

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DAY 2 Tuesday - Ocean-Side Field Studies I & Classroom Resources, GK-12 Fellow

Oceanside Tides, Wachapreague Dock: Low tide 11:17am

6:00 – 7:00 am	Breakfast
7:30	Depart for Nickawampus Creek for: water quality, sediments, trawl, dredge Tidal creek environment & biodiversity
9:30	Relocate to East Wye mudflat
9:45	Mudflat – story of coastal change, mudflat succession Biological sampling, water quality, seds
11:15	Depart for Lab
11:45 am	Arrive back at Lab: secure samples, clean and stow gear Process and analyze field samples; collate data.
12:15 pm	Lunch
1:00 pm	Biodiversity: measuring biodiversity & critter ID lab (Carol)
2:30 pm	Break
2:45 pm	GK-12 Fellow research: Annie Murphy (30 min)
3:15 pm	GK-12 Fellow lesson: Annie Murphy - lesson plan (60 min)
4:30 pm	Process and analyze field samples; Collate field data
5:15 pm	Review of the day & classroom/field applications
5:15 pm	Begin prep for Seafood Dinner
6:30 pm	Seafood Dinner
7:15 pm	Clean up, then free time
10:00 pm	Quiet time

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DAY 3: Wed - Bay Side Studies w/ Victoria H. - & Classroom Resources, GK-12 Fellow

Bayside Tides, Harborton: High tide 6:15am, low tide ~12:16 pm

6:00 - 7:30 am	Breakfast
7:30	Depart dock for Harborton
8:00	Arrive Harborton, load vessels, depart for Scarborough Island
8:30	Scarborough-Finney Island Channel water quality & trawl SAV bed Victoria Hill – re: sea grass research
9:45	Travel to Fisherman's Rest
10:00	Go ashore for salt marsh observations, beach geology activities, water quality Snacks on beach
11:15	Depart Fisherman's Rest
11:20	Pungoteague Creek: plankton tow - V.Hill & J. Ivory research reference
11:45	Arrive back at Harborton boat ramp, unload vessels, drive back to ESL
12:15 pm	Arrive at ESL, clean and stow gear, secure samples, clean up, change clothes
12:30 pm	Lunch
1:30	Victoria Hill: Research: measuring polar climate change using bio-optics of plankton & suspended particles; activity: albedo effect demo
3:15	Break
3:30	GK-12 Fellow research: Jami Ivory (30 min) Role of live vs dead plankton in ocean economy
4:00	GK-12 Fellow lesson plan demo: Jami Ivory (60min.) Measuring live vs dead plankton
5:00	Process and analyze field samples; Collate field data
5:45	Review of the day & classroom/field applications Discussion: how to adapt a research study into a lesson plan
6:30	Dinner on your own, cook at the Dorm if you wish Free time
10:00	Quiet time

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DAY 4	**Thursday – Art Schwartzchild, UVA Coastal Research Center** **E. Shore ecosystems &the changing shoreline,** **TNC Nassawadax & Hog Island** **Classroom Resources, GK-12 Fellow**
6:00 – 7:00 am	Breakfast; prep for field day (make lunch, pack coolers, and gather gear)
8:00	Depart for TNC Brownsville Farm, Nassawadox Dr. Art Schwarzchild – ecosystem services & coastal change TNC Staff – tour of Brownsfille Farm property, Via ABCRC vessels to Hog Island, hike across island, habitat zonation
2:00 pm	Depart for ESL
2:45 pm	Arrive back at Lab
3:15 pm	GK-12 Fellow lesson plan – Sam Lake, part 1
4:45	Break
5:00 or	*Estuaries 101* overview and York River Activity – or Tues. (Lisa) *Healthy Water/Healthy People* overview (Carol) >>.here or Fri
5:45	Review of the Day and classroom/field applications Work on individual/school action plans
6:30	Dinner on your own, cook at the Dorm if you wish
10:00 pm	Quiet time

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DAY 5: Friday : Ocean-Side Field Day II & Classroom Resources, GK-12 Fellow

Oceanside Tides, Wachapreague Dock: High 8:08am, Low 2:13 pm

6:00 - 7:30 am	Breakfast; Pack for field day
7:30	Safety instruction, load vessels
7:45	Depart for Atlantic Ocean station
8:15	Ocean station: water quality & offshore observations
8:45	Cedar Island: lagoon-side seining, biodiversity
9:15	Cedar Island: beach/dune profiling activity & shoreline plant zonation (2 teams)
10:30	Cedar Island: ocean side walk Beach/wave interactions, coastal erosion & migration of barrier islands
11:30	Depart Cedar Island
12:00 noon	Lunch at dorm
1:00	GK-12 Fellow research presentation: Sam Lake: (30 min.)
1:30	GK-12 Fellow Lesson Plan: Sam Lake (60 min.)
2:30	Break
2:45	*Healthy Water/Healthy People* overview (Carol)
3:15	Process and analyze field samples; Collate field data
4:15	Review of the Day, classroom/field applications Work on individual/school action plans
6:00	Dinner on your own, cook at the Dorm if you wish
10:00 pm	Quiet time

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DAY 6 Saturday - Summary/Applications/Reflection

6:00 – 8:30 am	Breakfast, pack personal gear, clean dorm Pack field gear, clean lab
8:30	Individual or School lesson action plan/application reports Review and discussion of field activities, oceanography content, etc.
10:00	Roundtable discussion on classroom integration
11:00	Ideas for follow-through communications and sharing Post-test, evaluation and graduation
12:00 pm	Quick lunch and head for home or to your next adventure!

What is a MWEE?

Meaningful watershed educational experience

Photo by Rich Mason, USFWS

Bay or stream outdoor experiences that:

- **Are an integral part of the instructional program & aligned with learning standards**
- **Are part of a sustained activity**
- **Consider the watershed as a system**
- **Involve external sharing & communications**
- **Are enhanced by natural resources personnel**
- **Are for all students**

See a complete MWEE slide show at www.chesapeakebay.net

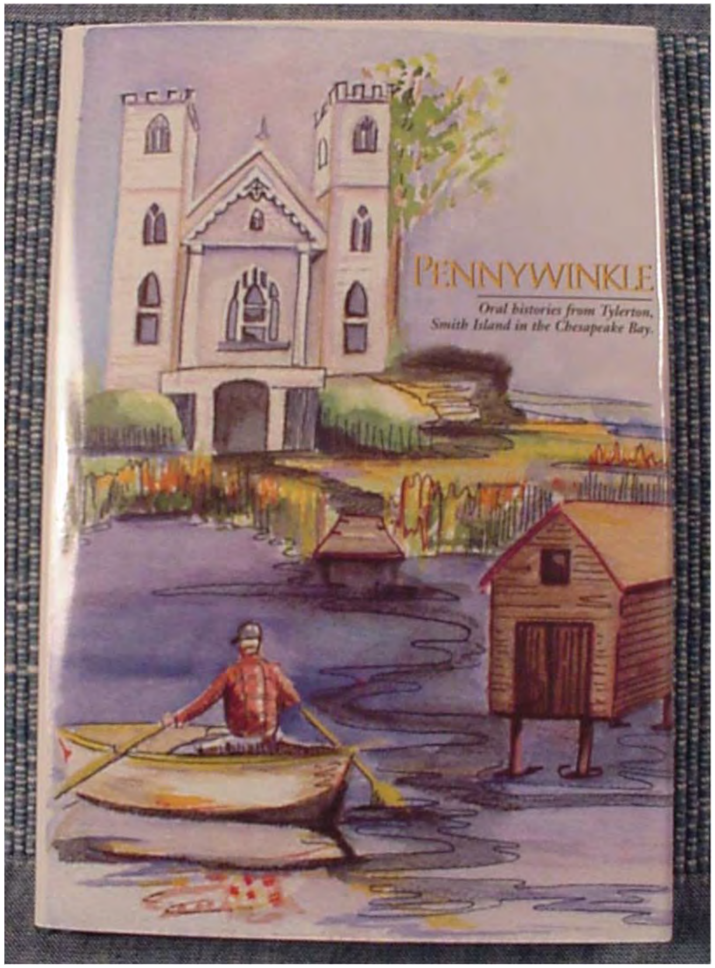
Why conduct a MWEE?

- ♦A commitment of the Chesapeake Bay 2000 Agreement & <u>newly signed</u> Chesapeake Watershed Agreement 2014 – identified in 2 goals: Environmental Literacy & Stewardship/Community Engagement
- ♦Endorsed by Virginia DOE as a curriculum requirement – Meaningful watershed (Bay or stream) outdoor experiences for every student in elementary, middle & high school.
- ♦Supported/facilitated by: NOAA Chesapeake Bay Office; Environmental Education Office of VA Department of Conservation & Recreation; VRUEC and numerous agencies, institutions and non-profit organizations.
- ♦MWEEs can integrate with SOLs and STEM education objectives
- ♦VA State Education, Environment Roundtable & other reports indicate: student involvement in project-based activities results in better ability to apply science.

Experiences are <u>investigative or project oriented.</u>

- **Experiences include activities where questions, problems, and issues are investigated by the collection and analysis of data (mathematical and qualitative)**
- **Electronic technology, such as computers, probeware, and GPS equipment, is a key component of these kinds of activities.**

Social, economic, historical, and archeological questions, problems, and issues that are directly related to Bay peoples and cultures.



These experiences should involve:

- **fieldwork,**
- **data collection and analysis, and**
- **directly relate to the role of the Bay (or other bodies of water) to these peoples' lives.**

Caveat:

Experiences such as tours, gallery visits, simulations, demonstrations, or "nature walks" may be instructionally useful… but, <u>alone do not</u> constitute a <u>meaningful</u> experience as defined by NOAA Chesapeake Bay Office.

MWEEs have Three Phases:

1. Preparation:

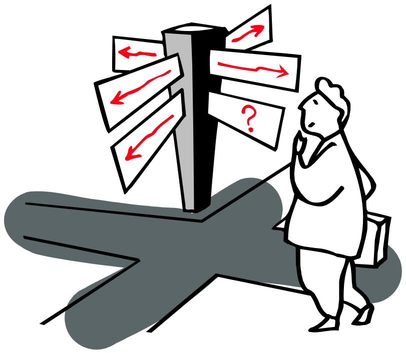
background on the question, problem, issue
student/team assignments
management & safety preparation

2. Action:

one or more outdoor experiences
make observations, collect data
active student involvement

3. Reflection:

refocus on the question, problem, issue
analyze data, conclusions reached
evaluate results
assess activity and student learning



PREPARATIONS PHASE:

Set Your MWEE Objectives…

- **Environmental monitoring:**

  use technology; take measurements and record weather, water quality, soil parameters; human impacts on the environment

- **Habitat diversity:**

  recognize different habitats and and characterize their environmental features, distribution of indicator organisms

- **Ecology of the food web:**

  recognize different trophic levels, measure abundance/diversity, show relationships between levels of the food web

- **Biological diversity & classification:**

  recognize and classify organisms, quantify diversity, describe anatomy and adaptations

PREPARATIONS PHASE:
MWEE Planning
When and Where

- Environmental factors
- Site suitability
- Site access
- Safety

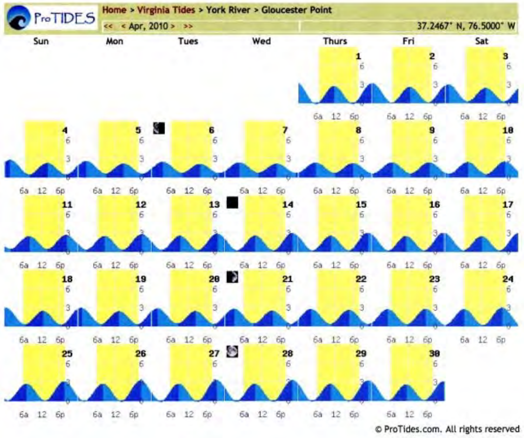
Environmental Factors

- **Weather/Season**
  - **Temperature**
  - **Biological diversity**
  - **Waves & currents**

    stream flow, lake/pond levels

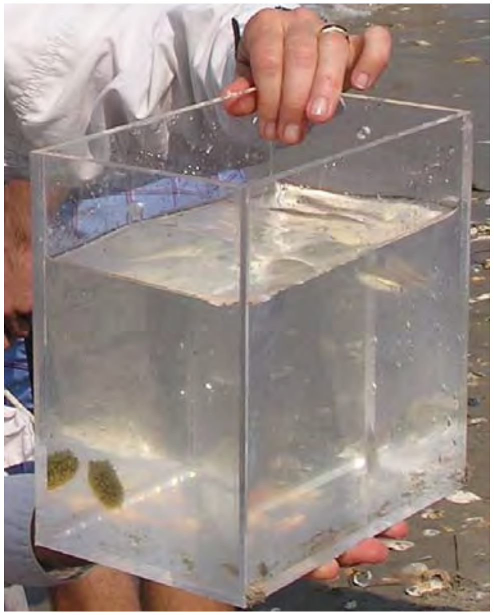
- **Tides**
  - **Tide tables or**

    tide calendar



MWEE Conservation: Field Trip Etiquette

- ★ Observe first & look more than you touch
- ★ One gentle fingertip
- ★ Keep aquatic life in the water
- ★ One animal at a time in your observation container



- ★ Return all organisms to their original habitats. Put rocks, logs & other objects back in their original positions
- ★ Plants - please pinch, don't pull!
- ★ Avoid collecting wildlife – but if you do, be responsible
- ★ Do collect trash, conduct a site clean-up

A closer look

Investigative or experimental design activities in which students or groups of students:

- **use equipment,**
- **take measurements, and**
- **make observations for the purpose of making interpretations and reaching conclusions.**

Project-oriented experiences, such as:

- restoration,
- monitoring, and
- protection projects, that are problem solving in nature and involve many investigative skills.

Models for Field Investigation

See: Ryken, et al. 2007. Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Process.

- **Descriptive investigations:**

Involve describing and/or quantifying parts of a system.

What kind(s), how many, how often, when?

- **Comparative investigations:**

Involve collecting data on different populations/organisms or under different conditions (e.g. times of the year, locations) to make a comparison.

Is there a difference between locations, times, groups?

- **Correlative investigations:**

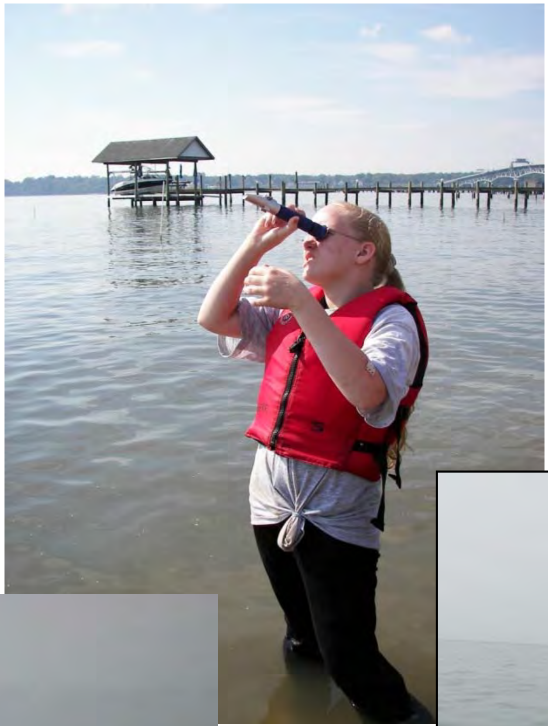
Involve measuring or observing two variables and searching for a relationship.

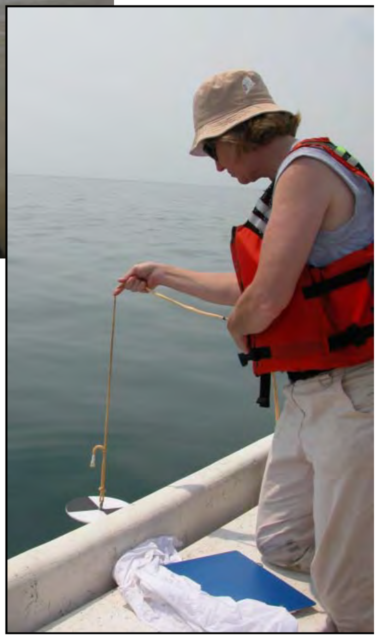
Is there a relationship between two variables?

♦**Descriptive investigations:**

Involve describing and/or quantifying parts of a system.

What kind(s), how many, how often, when?





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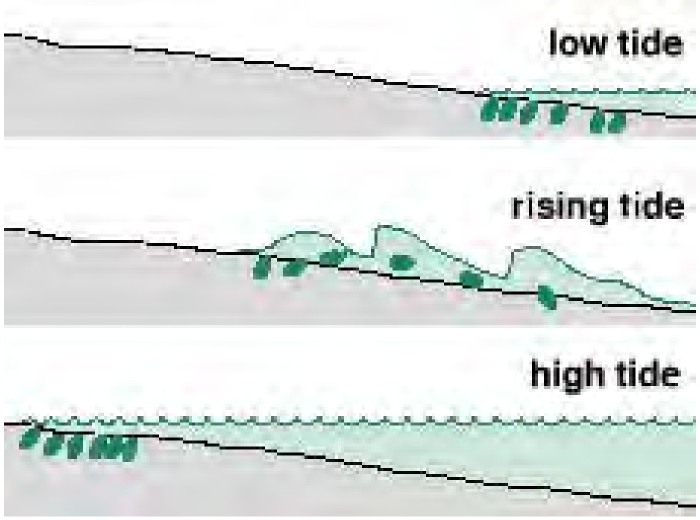
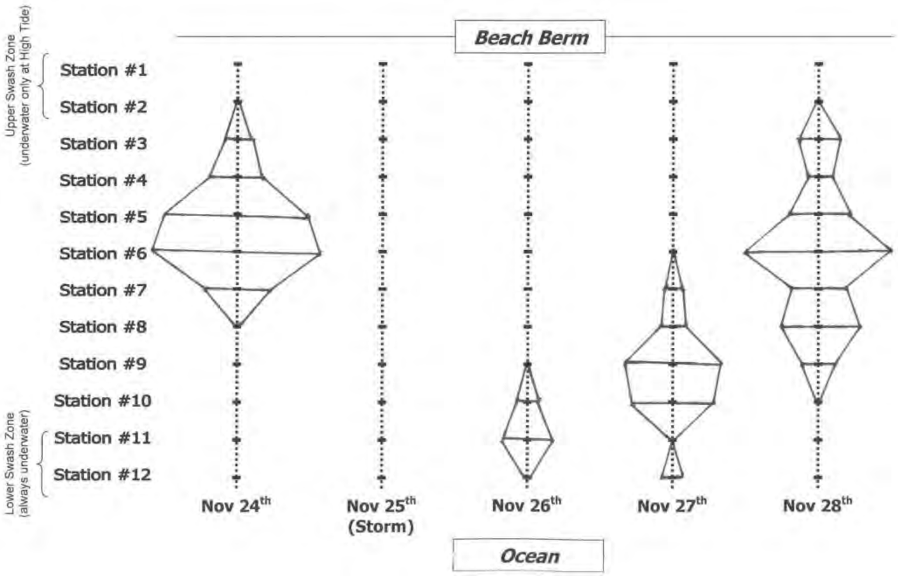
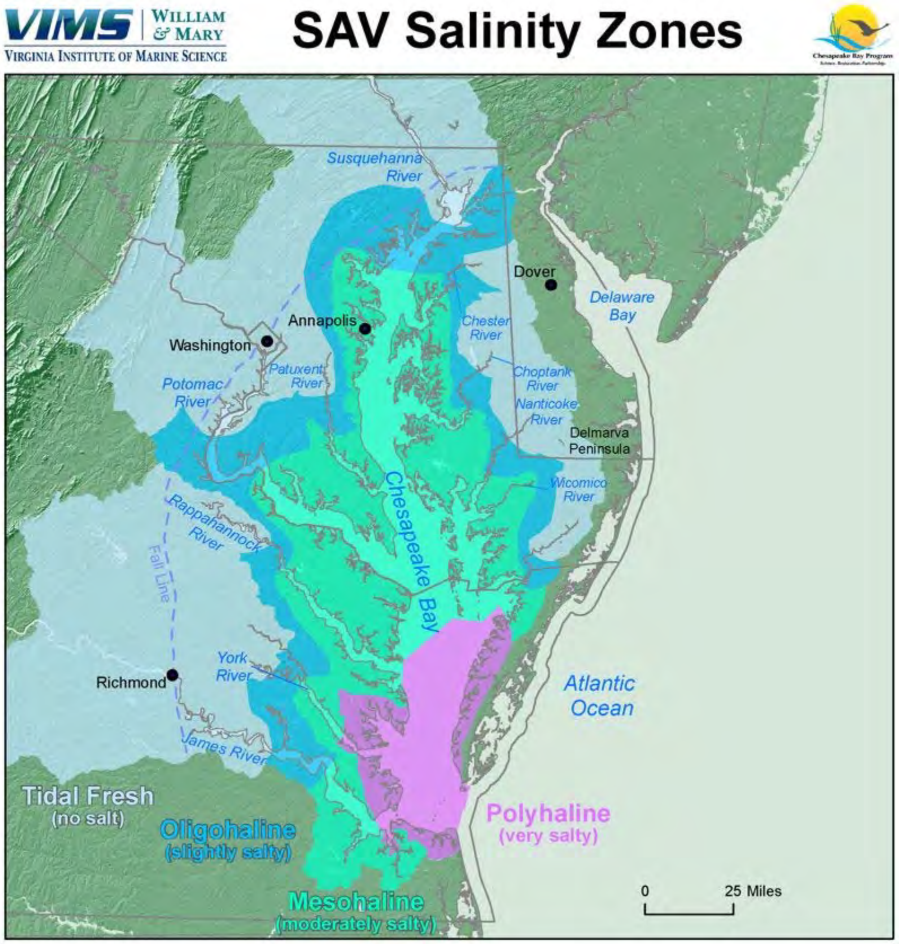




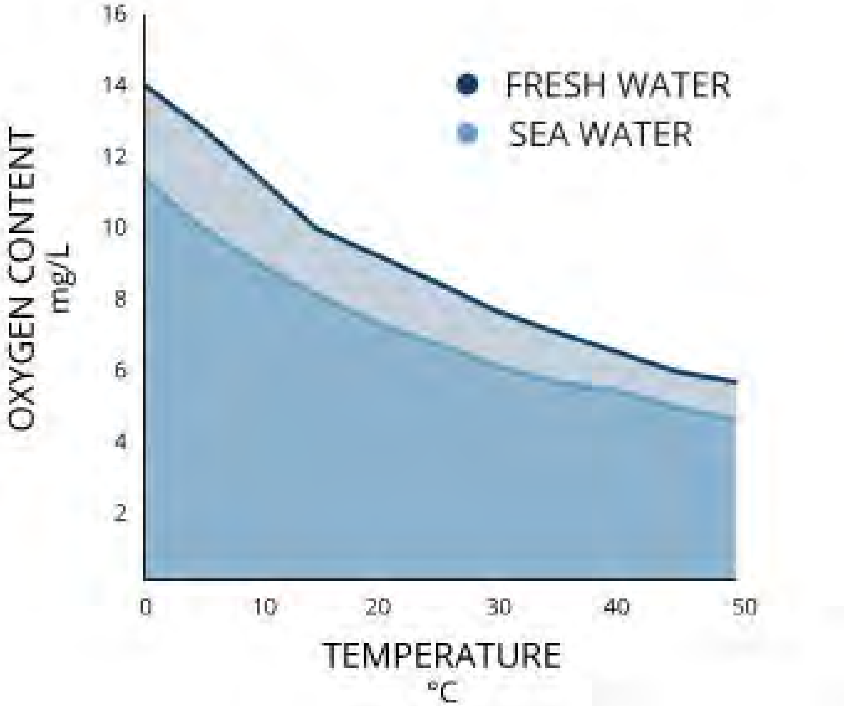
♦**Correlative investigations:**

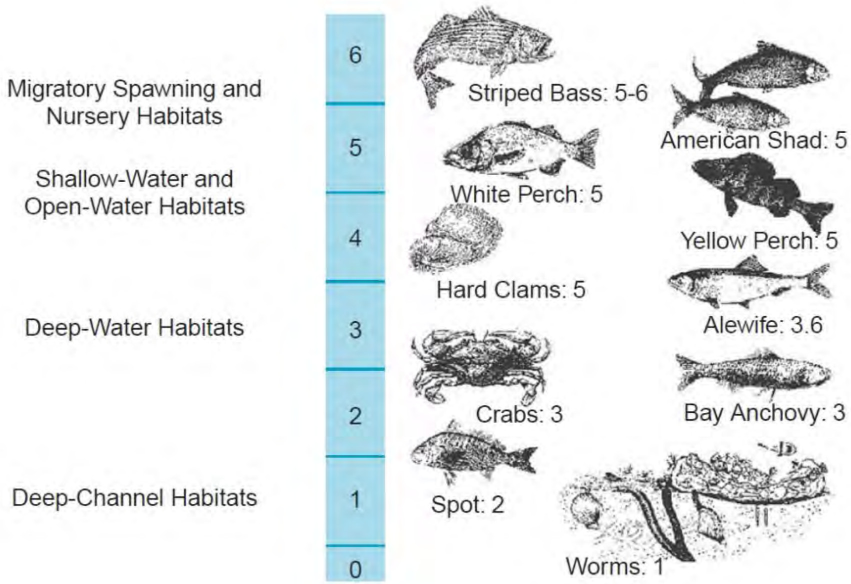
Involve measuring or observing two variables and searching for a relationship.

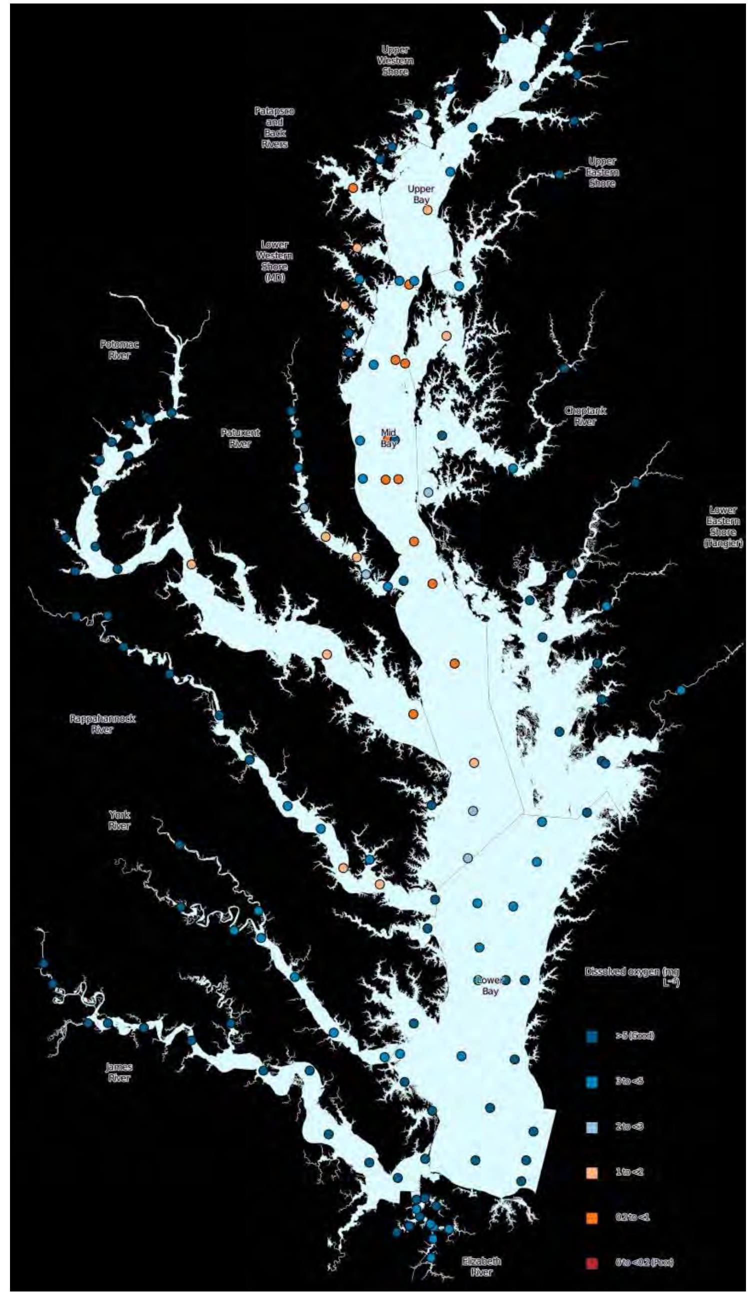
Is there a relationship between two variables?



Marine Life Distribution vs. Dissolved Oxygen







MWEE examples and ideas?

NOAA Chesapeake Bay Office - /www.chesapeakebay.net
Classroom ideas: www.chesapeakebay.net/teachersschools
Bay Backpack: www.baybackpack.com/
Bay Restoration project ideas: www.chesapeakebay.net/bayrestoration

Phytoplankton Monitoring Network – www.ncddc.noaa.gov

LiMPETS - http://limpetsmonitoring.org/

Project Serve & Learn - http://pbl-online.org/

The Globe Program - http://classic.globe.gov/projects

World Water Monitoring Day - www.worldwatermonitoringday.org/

Healthy Water, Healthy People – projectwet.org/water-resources-education

Bridge & Scuttlebutt –
www.marine-ed.org & www.marine-ed.org/scuttlebutt.html

Funding for MWEEs

VA DOE – Learn & Serve Virginia Grants

VA DEQ/VRUEC Classroom Grants

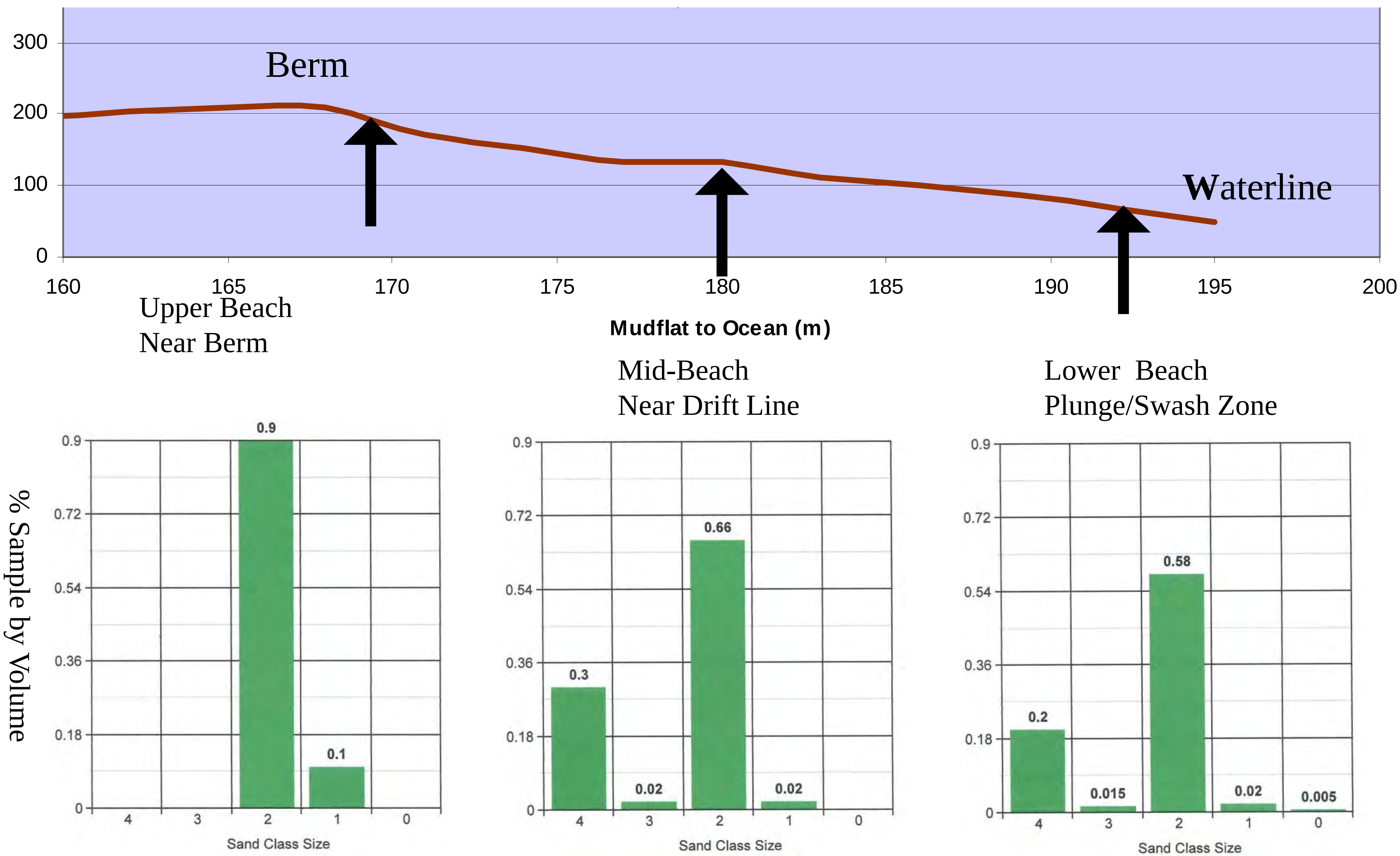
Virginia Environmental Endowment

Chesapeake Bay Restoration Fund

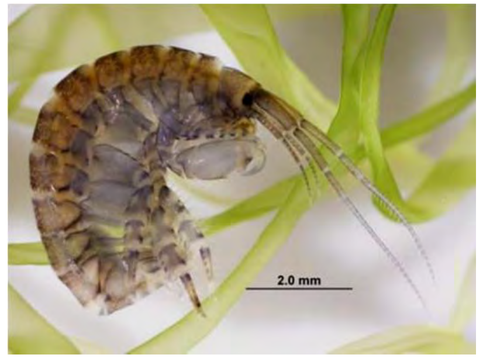
Mid-Atlantic Marine Education Association

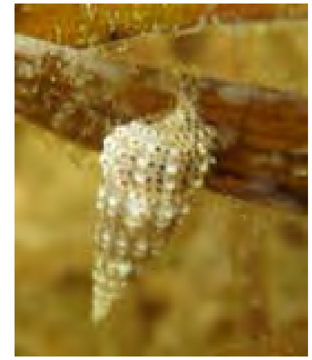
NOAA Office of Education B-WET Grants

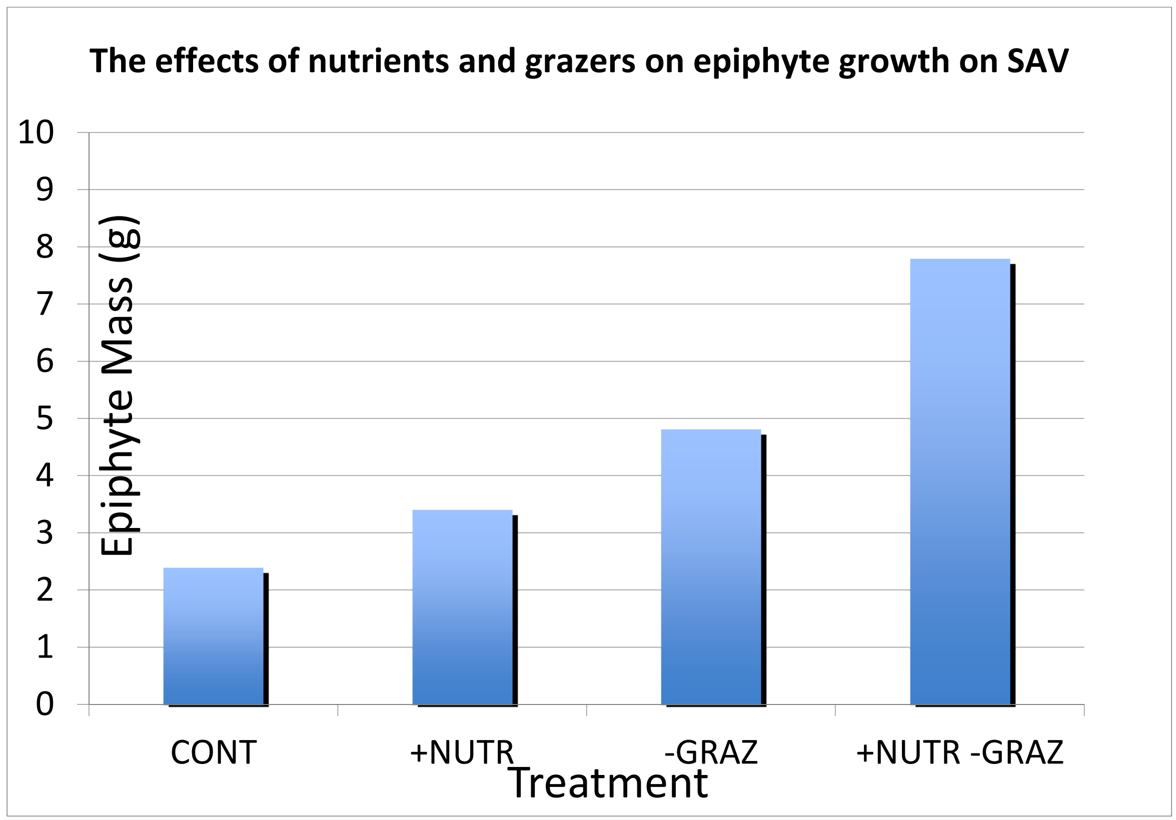
Cedar Island Atlantic Beach
Sand Size Frequency Profile



Epiphyte research results
from VIMS graduate student, Matt Whalen.







An Introduction to the Natural and Not-So-Natural History of Coastal Change in Virginia: Habitats & Water Quality

Virginia Coastal Ecosystems Field Course
VIMS Eastern Shore Lab – July 7, 2014

Kevin Goff
Marine Education Specialist, VIMS
Ph.D. Candidate, W&M School of Education

VIMS | William & Mary
Virginia Institute of Marine Science

Sea Grant Virginia

NOAA

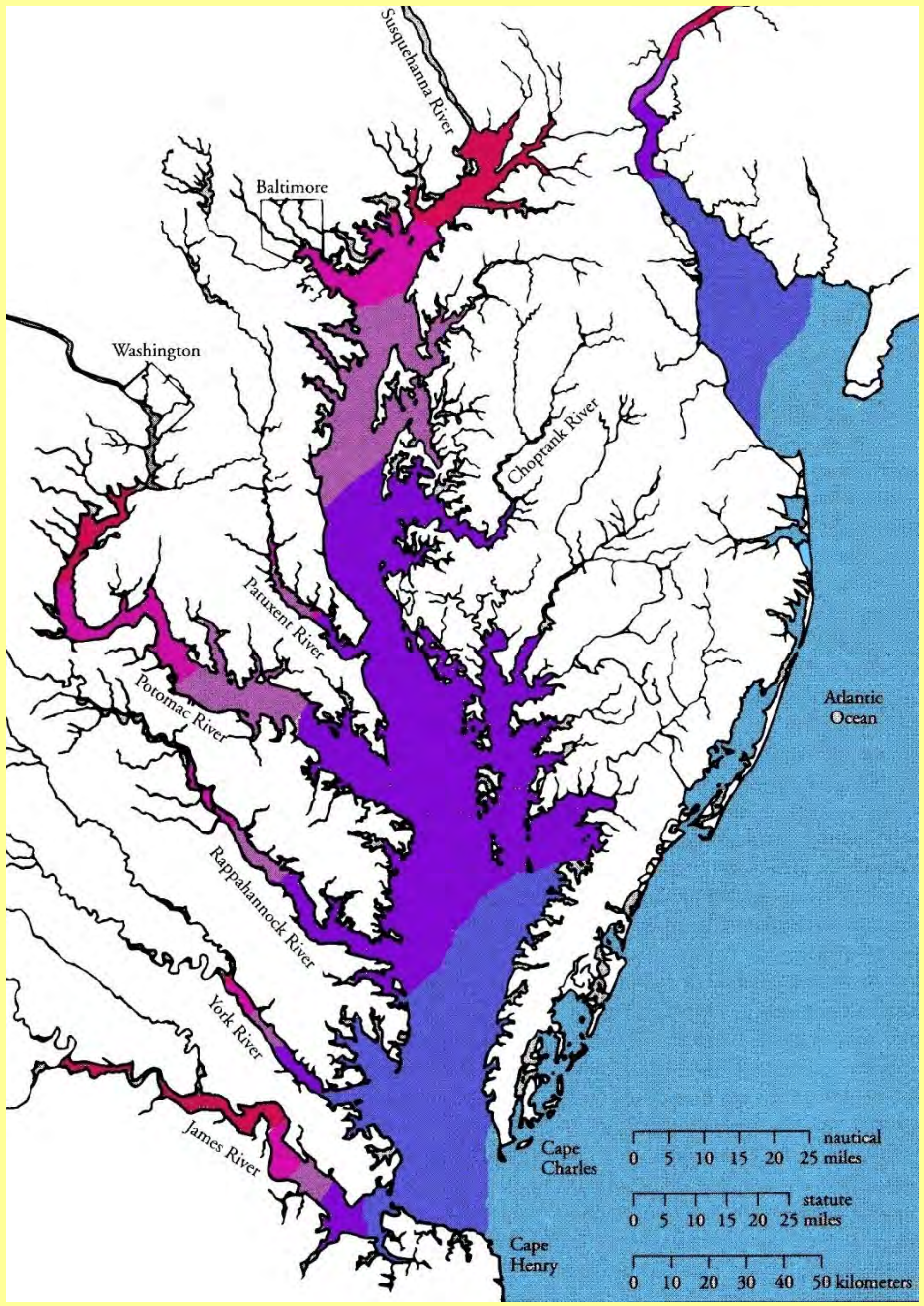
Natural History of Coastal Change…

Chesapeake Bay

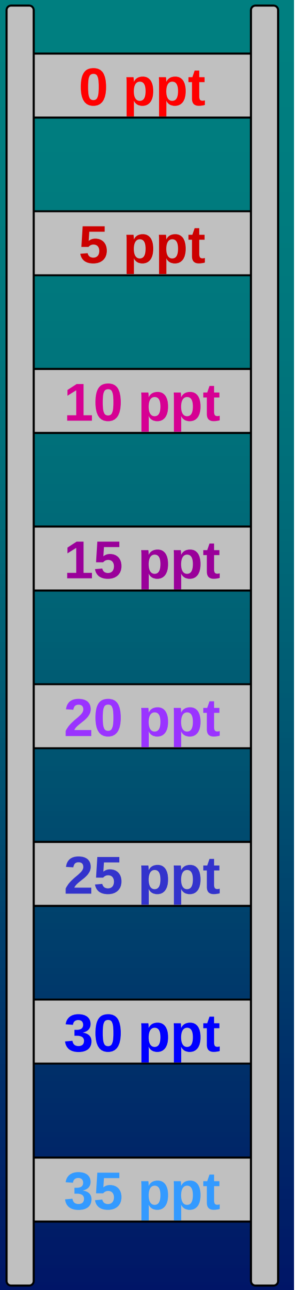
- Largest, most fertile estuary in North America
- Length: 200 miles (north to south)
- Mean Depth: 7 m (21' ...very shallow!)
- Major rivers: 19
- Smaller rivers & creeks: 400+
- Shoreline: 11,000+ miles
  (more than entire west coast of U.S.)
- Plant and animal species: 2700
- Human population: 17,000,000
  (in Chesapeake watershed)

Water Quality Parameter #1: Salinity

- "parts per thousand" (ppt = % x 10)
- Ocean: ~ 35 ppt
- Estuary = partly enclosed body of water where freshwater rain runoff mixes with saltwater from the sea
- Main factor governing species distributions
- Stratification (layering of water column)



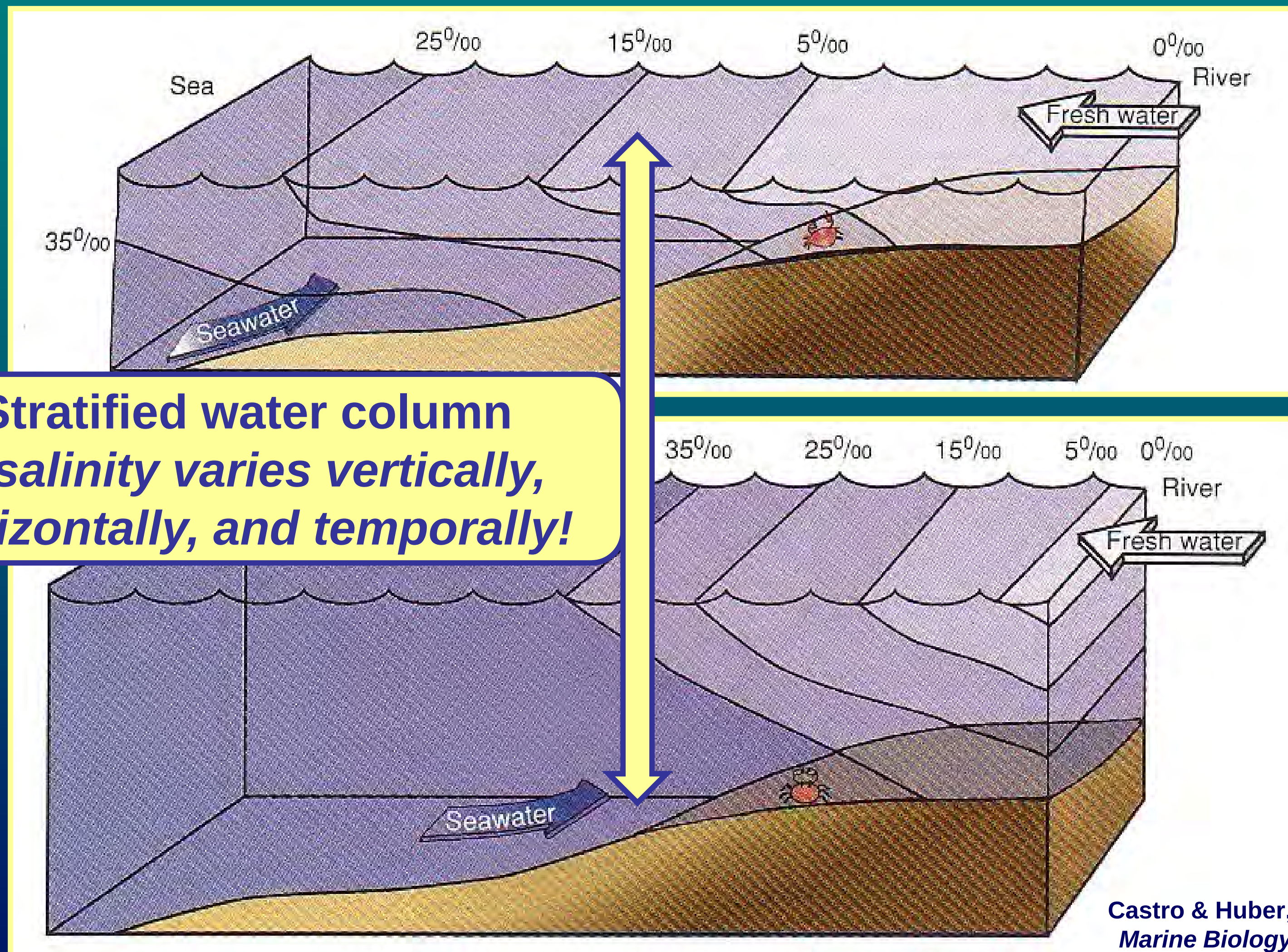
Background map from Murdy et al, *Fishes of Chesapeake Bay*



Salinity "ladder" shifts up and down the estuary with daily tides, episodic rainfall events, droughts, etc. ...ceaseless CHANGE!

Ebb tide / Heavy Rainfall

Flood tide / Storm surge / Drought

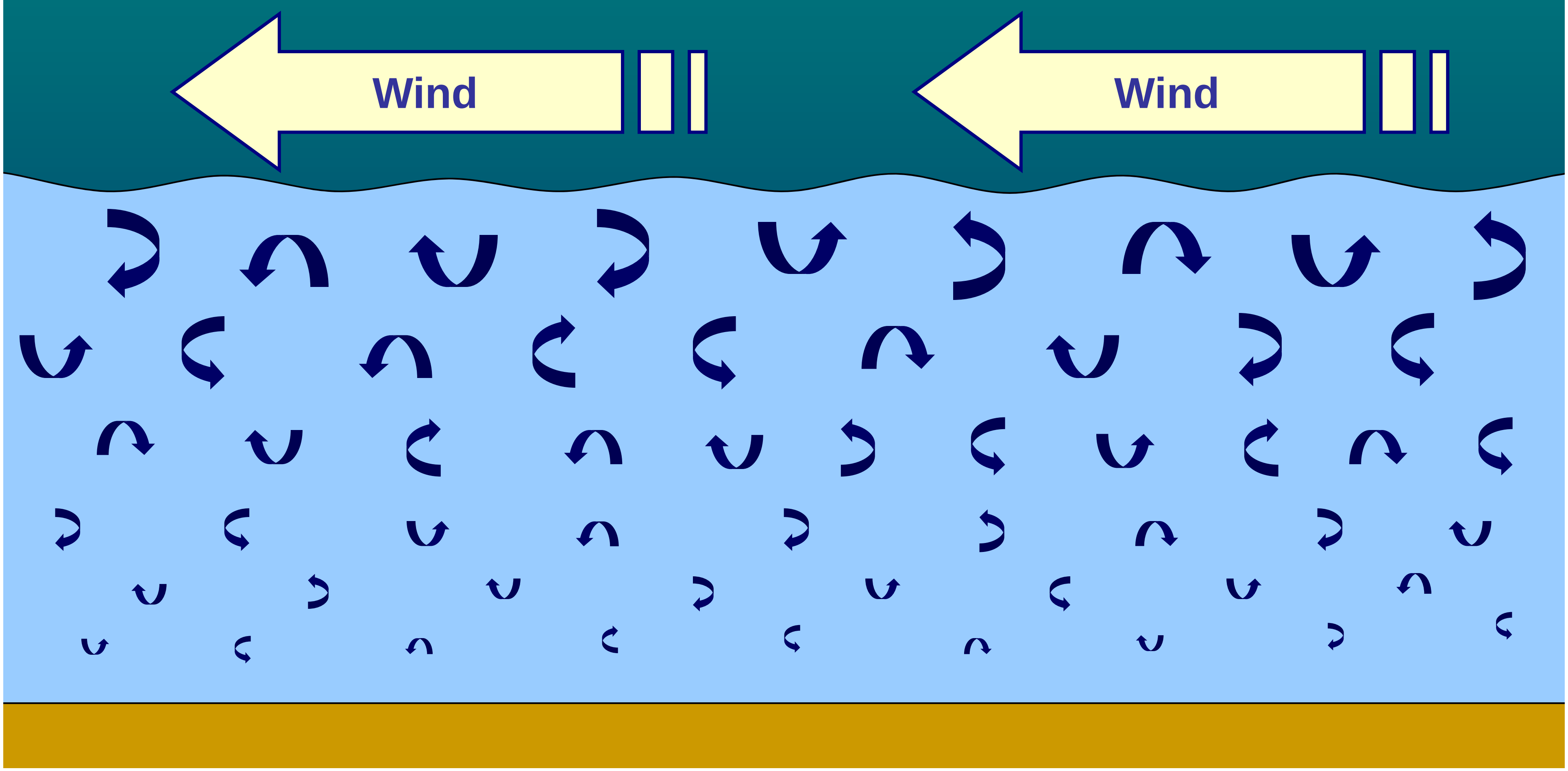


Stratified water column
…salinity varies vertically, horizontally, and temporally!

Castro & Huber, ***Marine Biology***

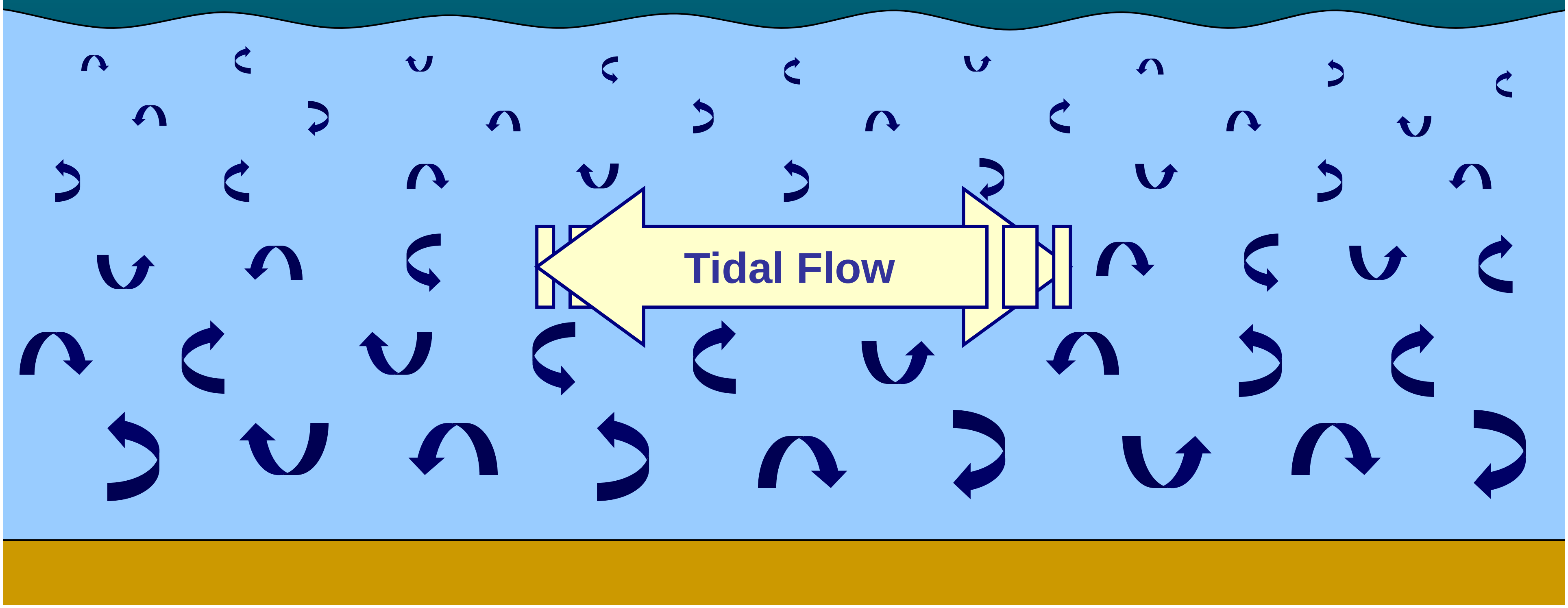
Vertical Mixing #1: Wind

Top-down mixing (turbulence weakens with depth)   *...more change...*



Vertical Mixing #2: Tidal Currents

Tides flow in and out twice daily, generating turbulence
(especially via friction with seafloor: bottom-up)



The Nation's #1 Estuary for Seafood

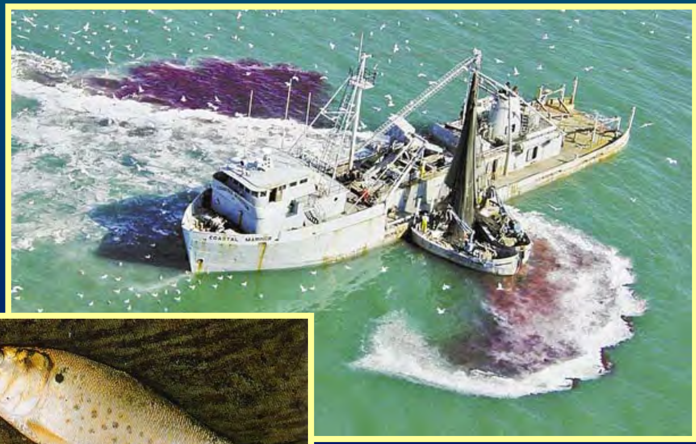
(second only to Atlantic and Pacific oceans)



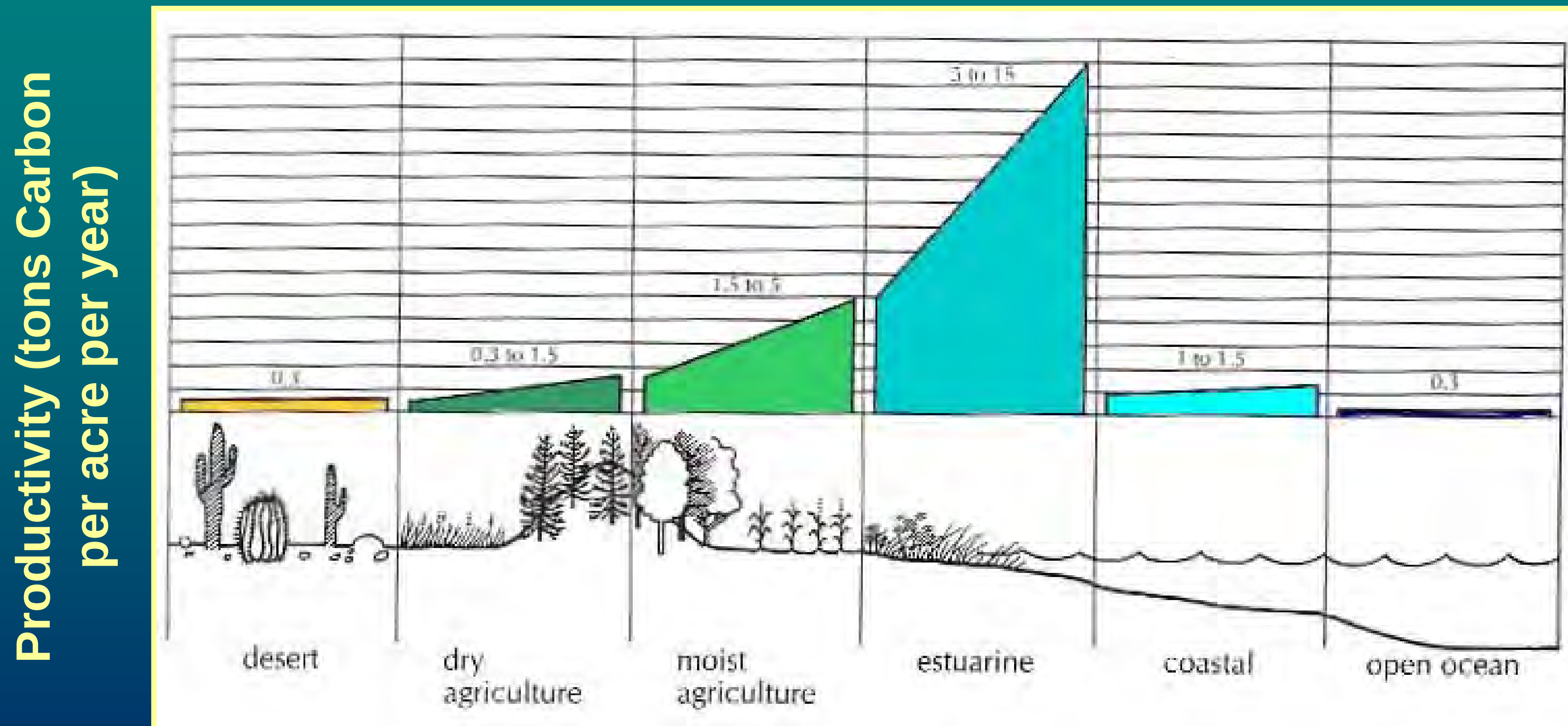









Exceptionally High Productivity

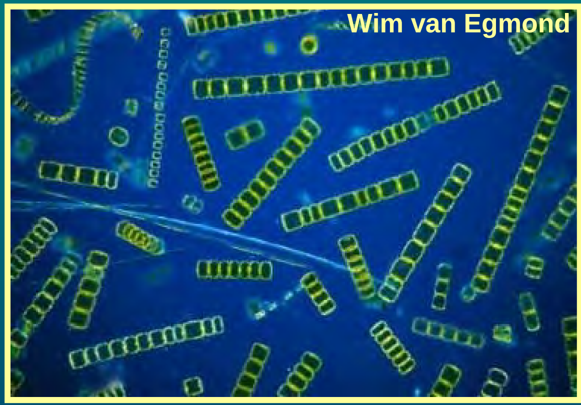


Modified from C. P. White, *Chesapeake Bay: A Field Guide* (adapted from Teal & Teal 1969)

FAR more productive than the ocean, which ecologists classify as a “desert” ...a NUTRIENT desert.

What makes Chesapeake Bay so extraordinarily productive?
(vs. oceanic "desert")

1. **Terrestrial runoff:** Nutrients (PO_4, NO_3, etc. ..."fertilizer") stimulate <u>phytoplankton</u> growth
2. **Marshes:** Vast volumes of food in the form of <u>detritus</u> (decaying organic matter) flushed by daily tides into neighboring estuary



3. **Shallow & sunlit water column:** Nutrients regenerated via bacterial decomposition mix from seafloor to sunlit surface. Also, shallow water column permits growth of underwater grasses (SAV): food and habitat.
4. **Vertical mixing:** Because shallow, wind and tidal turbulence can stir nutrients to surface

High Quality Habitats: Shoals & 3-D Structures

Shelter for smaller animals and juveniles (vs. “0” dimensional ocean)

Sandy beach & shoal

Oyster Reefs

SAV meadows

Saltmarsh

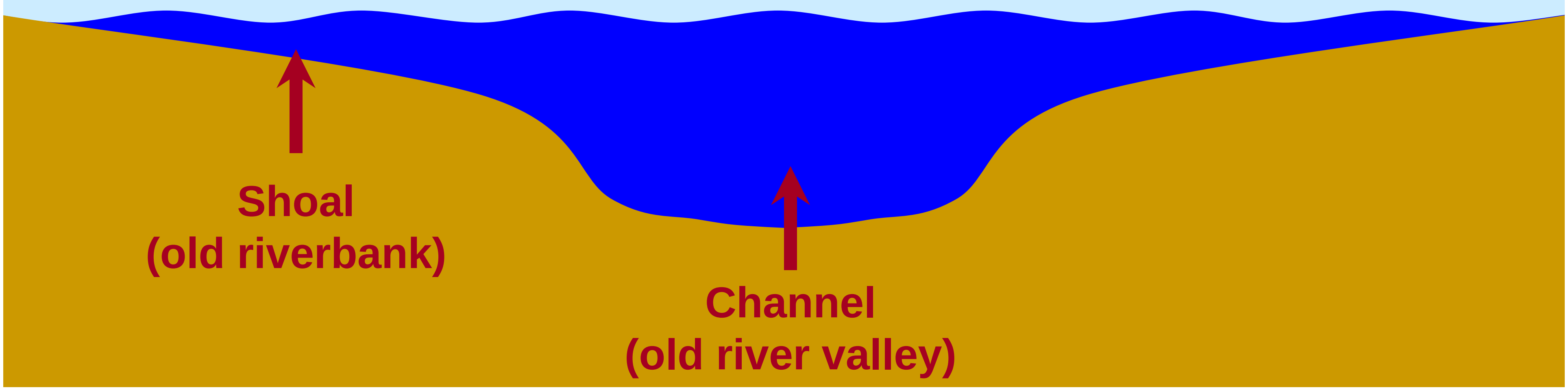
Intertidal Mudflat

Riparian forest: fallen trees

ALL of these essential features – shallowness, terrestrial influence, presence of 3-D habitats, etc. – are a direct consequence of the Bay's natural history ...a history of RECENT CHANGE.

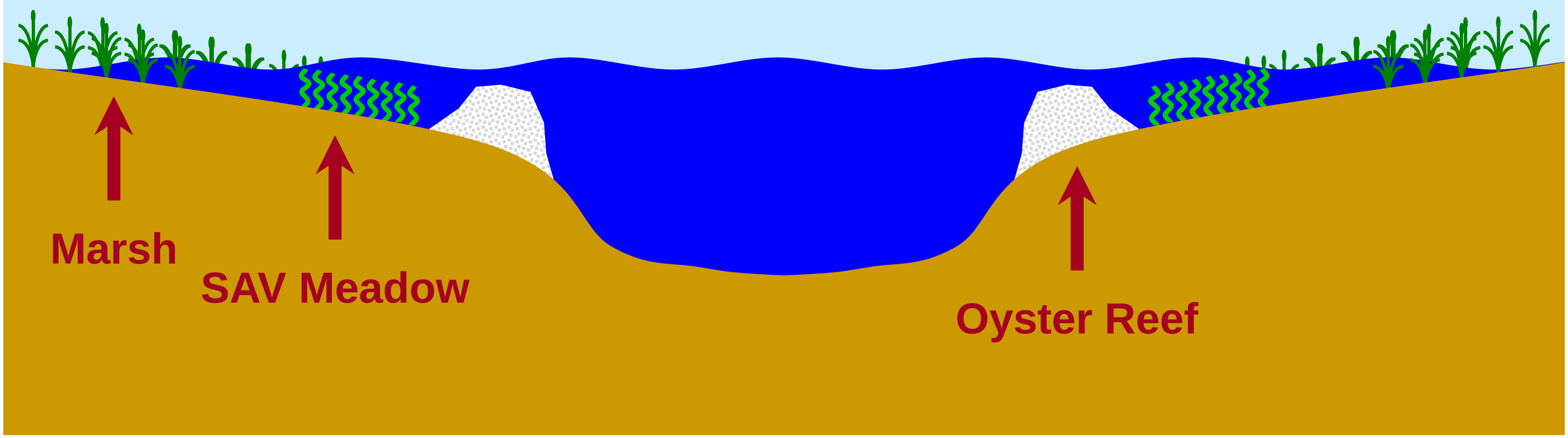
"Drowned river valley" = estuary formed after ice age, when sea level rose and flooded the banks of the old, narrow river

RESULT: a deep channel flanked by broad shoals



New habitats emerge on the newborn, brackish shoals:

- intertidal **marshes**, **mudflats**, **sandy beaches**
- **submerged aquatic vegetation** **(SAV meadows)**
- **oyster reefs**
- **riparian forest / falling trees** on retreating shorelines



Barrier Islands

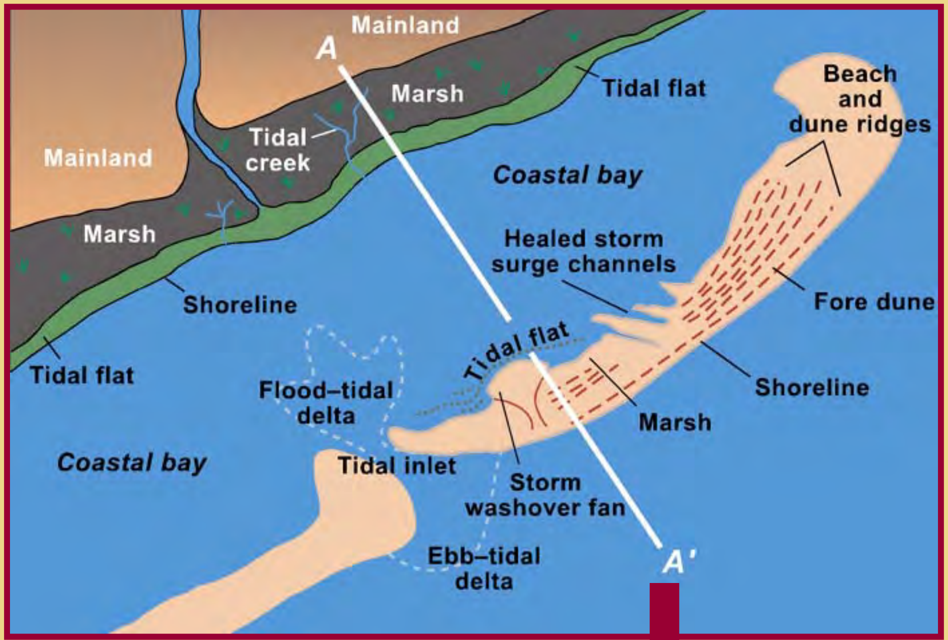
- Long, narrow, sandy islands or spits parallel to coast
- Formed as sea level rose after ice age
- Relentless CHANGE is the rule…

Satellite images from NASA

Cedar Island, just off Wachapreague, May and December 2009

...what in the world is going on here??

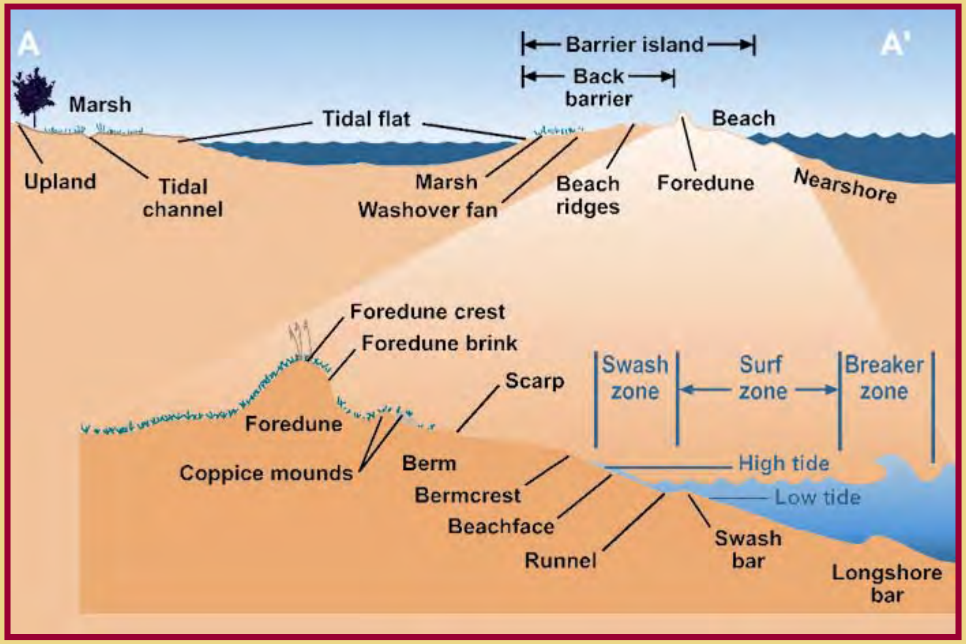
Beach and B.I. Anatomy



Aerial view

Wachapreague Inlet:
key vector for SW transport b/w
ocean and lagoon/saltmarshes

Cross-section along
transect from A to A'



Signatures of ever-shifting sand:
ebb and flood tide deltas,
overwash fans, storm surge
channels, bars, berms, and dunes.

Water Quality Parameter #2: Dissolved oxygen (D.O.)

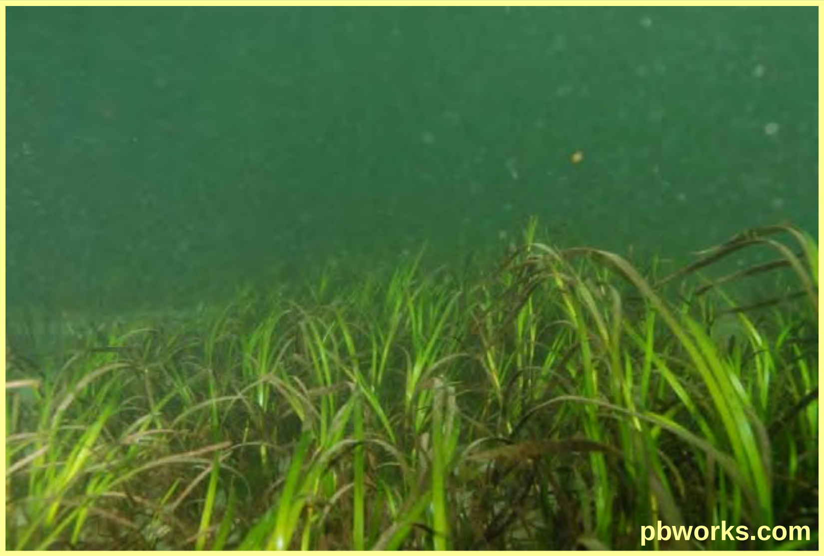
- “parts per million” (ppm; or mg/L)
- Saturation point inversely proportional to temperature (cold water: ~13 ppm max)
- <5 ppm: stress... <3 ppm: lethal “hypoxia” (0 ppm = “anoxia”)
- Source: photosynthesis (also atmospheric diffusion)
- Removal: bacterial decomposition (also animal respiration)

Water Quality Parameter #3: pH (acidity/alkalinity)

- 0-14 (unitless)
- FW naturally acidic, SW basic
- Lowered by bacterial decay

Mudflats and marsh floors: ANOXIC and ACIDIC due to intense bacterial decay of organic matter (detritus)

Thought question: What role might burrowing animals play here? (fiddlers, worms, bivalves, etc.)



Turbidity is primary limiting factor for SAV

Water Quality Parameter #4: Turbidity

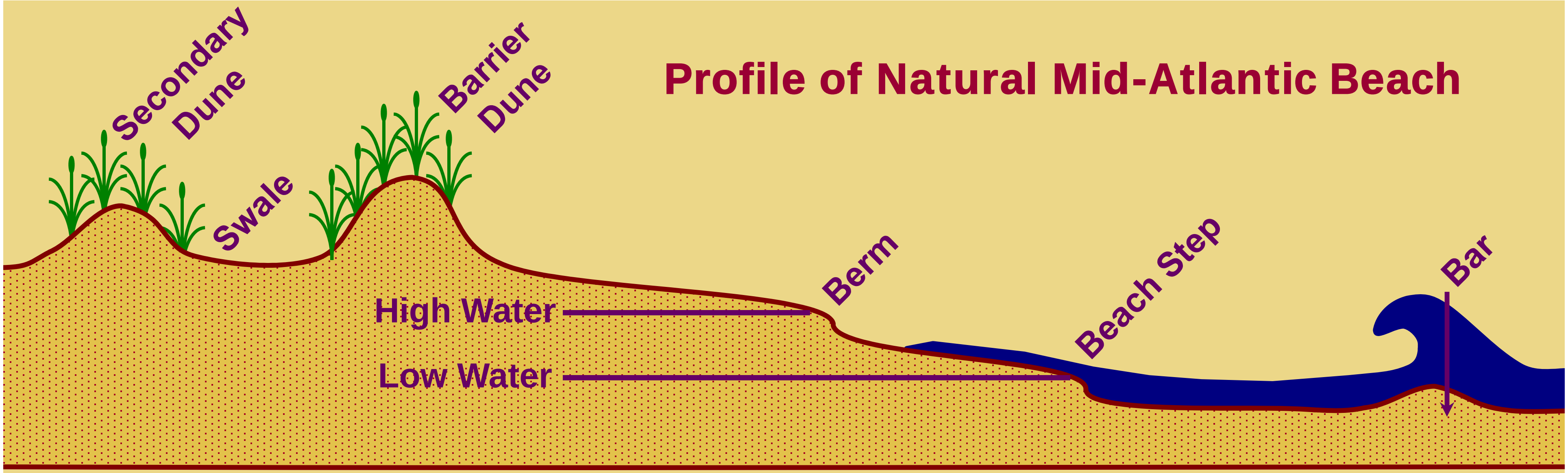
- Secchi depth (also NTU's)
- Suspended particulates: phytoplankton and sediments
- Photic zone ≈ Secchi x 2 (why?) (portion of water column with enough sunlight for photosynthesis)

Water Quality Parameter #5: Temperature

- 0-28°C (32-82°F)
- Influences EVERYTHING...
  - Spawning and migrations
  - D.O. saturation
  - SAV health/distribution
  - Metabolism/production/decay

Temperature fluctuates wildly in intertidal habitats (mudflat, beach, marsh) ...a major stress on animal denizens

Profile of Natural Mid-Atlantic Beach



Life's a Beach!

Supratidal Zone

(above high tide: always dry)

- Extreme heat
- Wind, shifting sand
- Exposure to predators (nowhere to hide)
- Food/water scarce

Intertidal Zone

(between tides: dry, wet, dry, wet...)

- Waves, shifting sand
- Tides: alternating exposure to air/water
- Food plentiful, but only as tiny particles
- Some predators

Subtidal Zone

(below low tide: always underwater)

- Strong currents, shifting sand
- Lots o' predators

(similar stresses affect marsh and mudflat fauna) →

Our Ephemeral Estuary and Transient Coastline

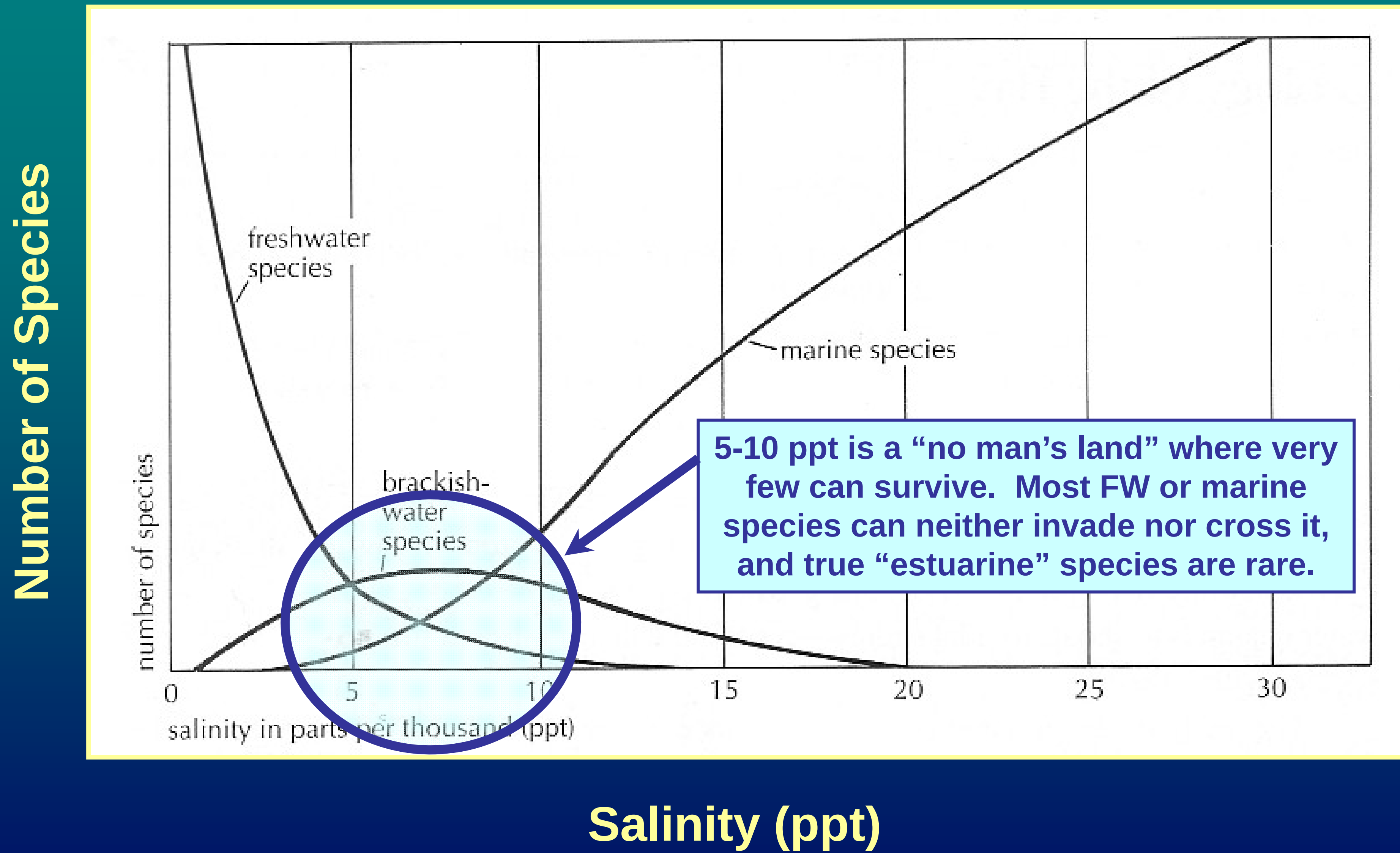
Over geologic/evolutionary time, Virginia's Chesapeake Bay, broad shoals, marshes, mudflats, SAV meadows, oyster reefs, and barrier islands are mere newborns: ***dynamic, ephemeral habitats.***

The same things that make them so FERTILE and ATTRACTIVE to wildlife also make them UNSTABLE hence STRESSFUL:

- shallow water
- terrestrial runoff
- wind-, tide-, and density-driven movements of water and sediment
- steep gradients and relentless shifts in salinity, temperature, D.O., etc., across both TIME and SPACE

Who can survive – and take advantage of – such tough environments???

Species Diversity in Chesapeake Bay



Graph from C. P. White, *Chesapeake Bay: A Field Guide* (adapted from Mclusky 1971)

Opportunistic Species

Each new "Bay" forms during BRIEF interglacial episodes, so few species are already "pre-adapted" to invade the brackish environment

Even the blue crab isn't fully adapted for life in an estuary
...they must return to sea to hatch out their young!

By nature, opportunists tend to be:

- Resilient, flexible, and adaptable
- Tolerant of changing/wide-ranging conditions
- Generalists (vs. specialists) with diverse diets (even omnivorous)
- Migratory: wanderers who seek opportune places to live/breed/feed

Mostly generalists
(and a few TOUGH specialists)

Blue Crab: … Beach…

…: Oyster …SAV, etc.

Moral: Our coastal ecosystems, and the wildlife that inhabits them, are resilient and adaptable. Given half a chance they'll thrive and survive…

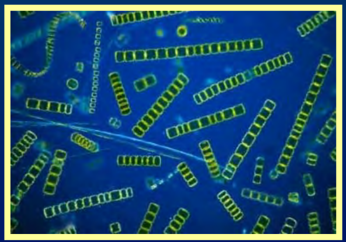
Ghost Crab: Sandy Beach – Supratidal Zone, Dune

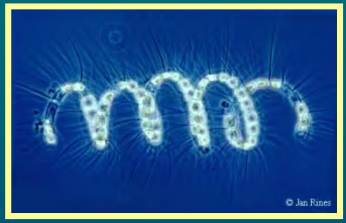
Mole Crab: Sandy Beach – Intertidal Zone

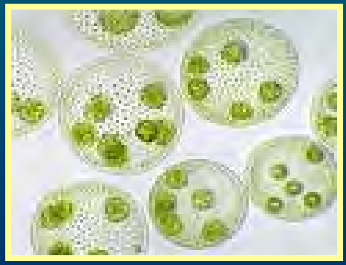
Not-so-natural History of Coastal Change…

Anthropogenic Coastal Change #1: Eutrophication

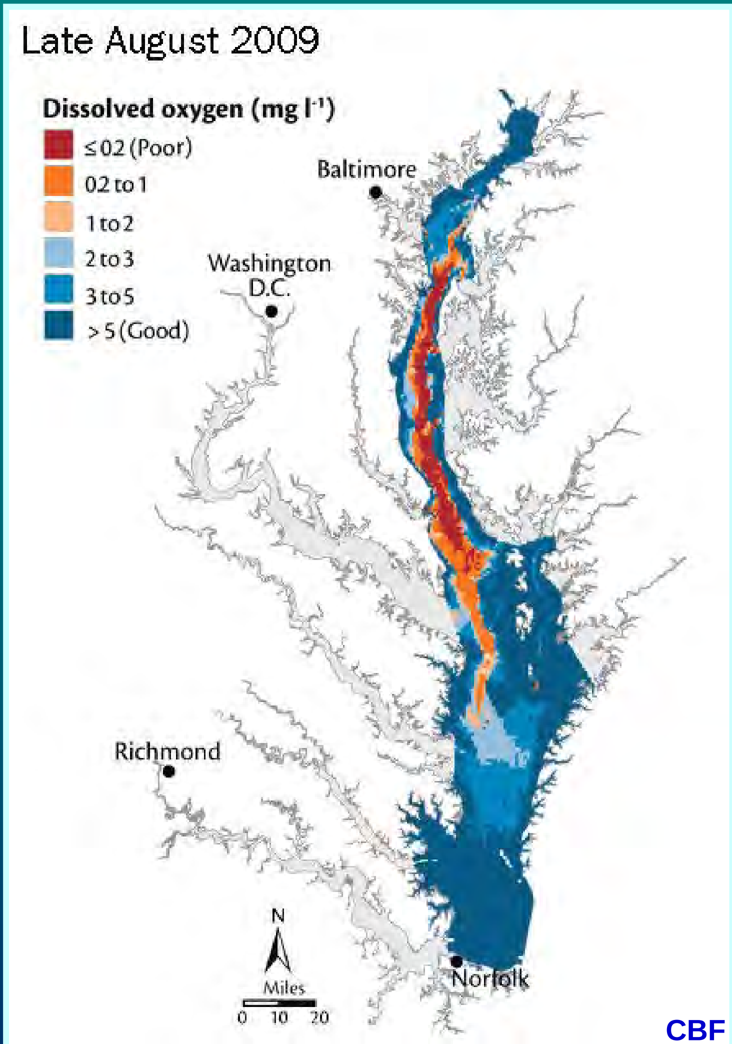
= excessive growth of phytoplankton, due to over-fertilization from nutrient pollution
(mainly nitrogen from lawns, farms, wastewater, even cars)







All photos by Wim van Egmond except helical species by Jan Rines

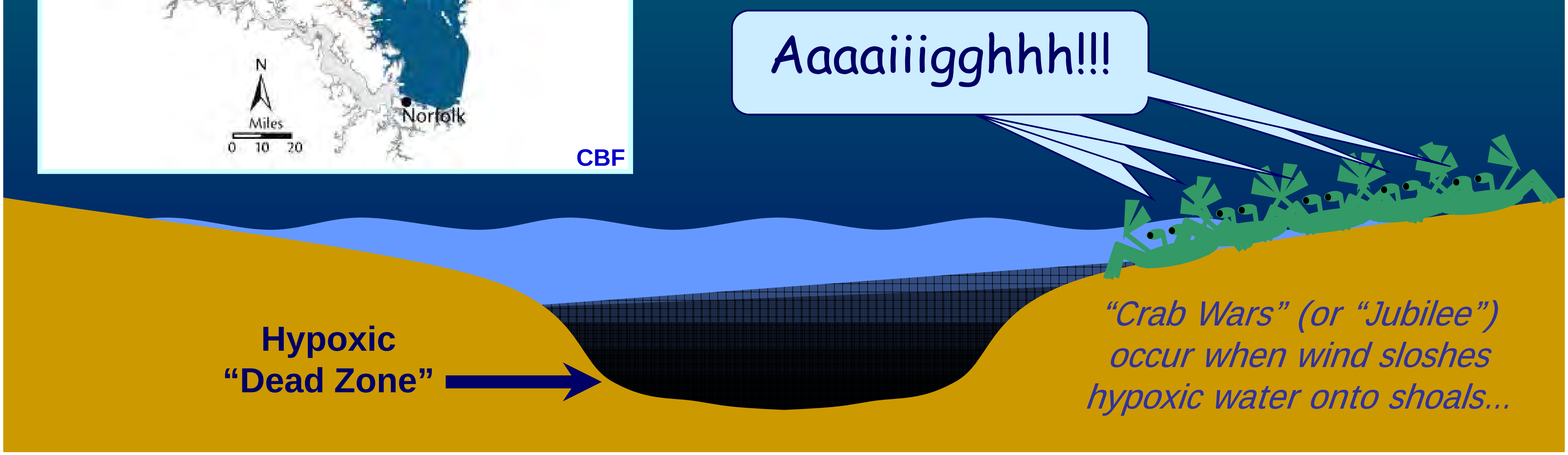


<u>Two consequences</u>:

(1) Benthic hypoxia: plankton dies, sinks, and bacterially decomposes, consuming D.O.

(2) Shading of SAV

Blue crab molting in SAV



Anthropogenic Coastal Change #2: Loss of 3-D Habitat

Wetlands: 25-50% of pre-colonial acreage
(filled in for farmland, waterfront real estate, etc.; new threat: accelerating sea level rise)

SAV Meadows: 15-30% of pre-colonial acreage (increased turbidity: algae, epiphytes, and sediment; new threat: rising summer temperatures)

Oyster Reefs: ~2% of pre-colonial biomass
(over-harvesting and two diseases: MSX and dermo)

Riparian Forest/Fallen Trees: ???% of pre-colonial area
(waterfront development)

Anthropogenic Coastal Change #3: Escalating Water Temperature

Anthropogenic Coastal Change #4: Accelerating Sea Level Rise

Consequences TBA...

Team Assignment

Type of Coastal Change:

- Team #1: Eutrophication
- Team #2: Loss of 3-D Habitat
- Team #3: Global Warming / Rising Water Temperature
- Team #4: Accelerating Sea Level Rise

During the week, gather knowledge and take field notes on your species of coastal change. Saturday morning make a BRIEF presentation (10 minutes MAX)

...causes, consequences, complex ecological interactions, changes on coastal geology/ecology, etc. This is INFORMAL, for review and closure. No need for powerpoint, props, visuals, etc. Honest!

Another dynamic and challenging Wachapreague Habitat

Human wildlife in the ESL habitat must be(come) well adapted for…

Early morning migrations

Harsh classroom assignments

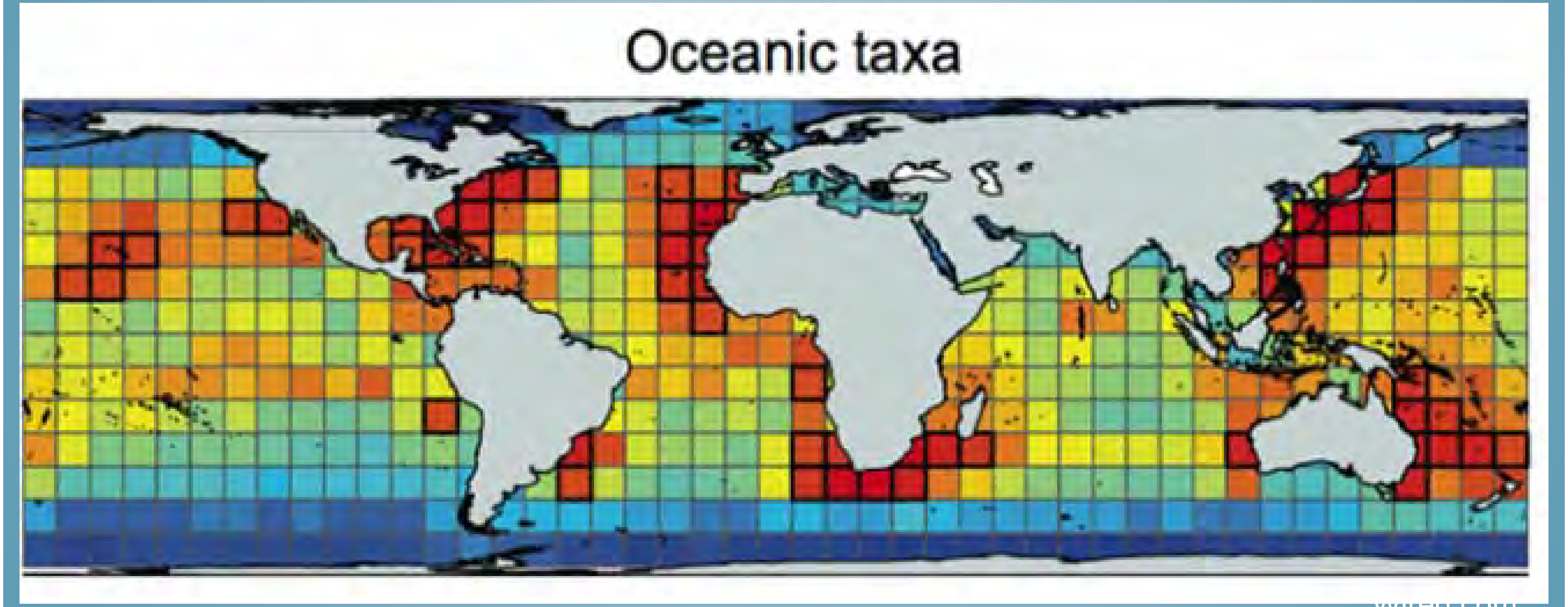
Long-term exposure to extreme lab activity

Fluctuating food type and availability

...and fierce predators!

Be resilient and
flexible out there,
brothers and sisters!

CLASSIFICATION & MEASUREMENT OF MARINE BIODIVERSITY



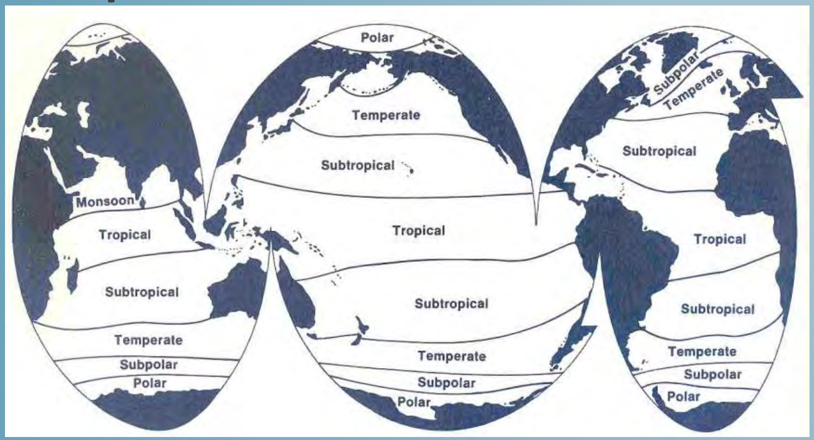
Wired.com

Scientists can classify the diversity of living things in different ways

HABITAT: Where does it live?

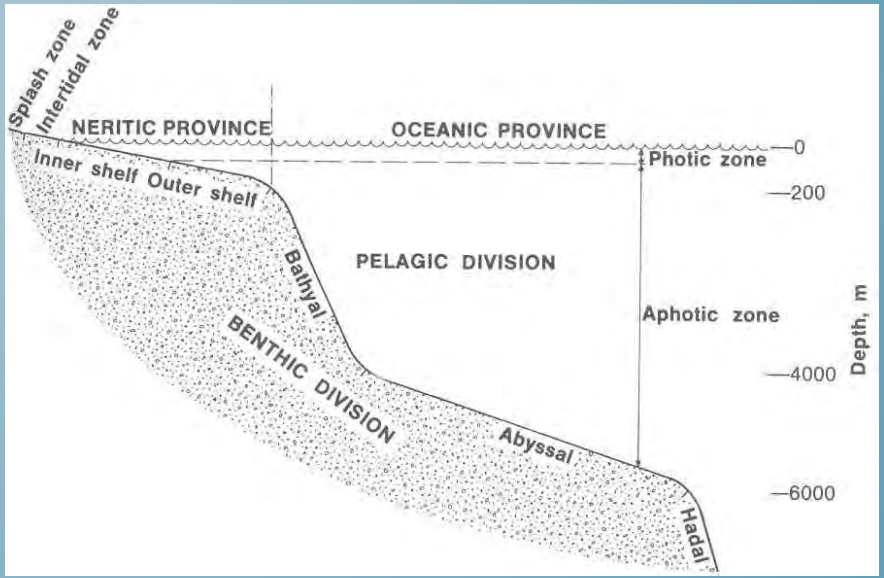
Ocean biomes & below

Temperature & latitude



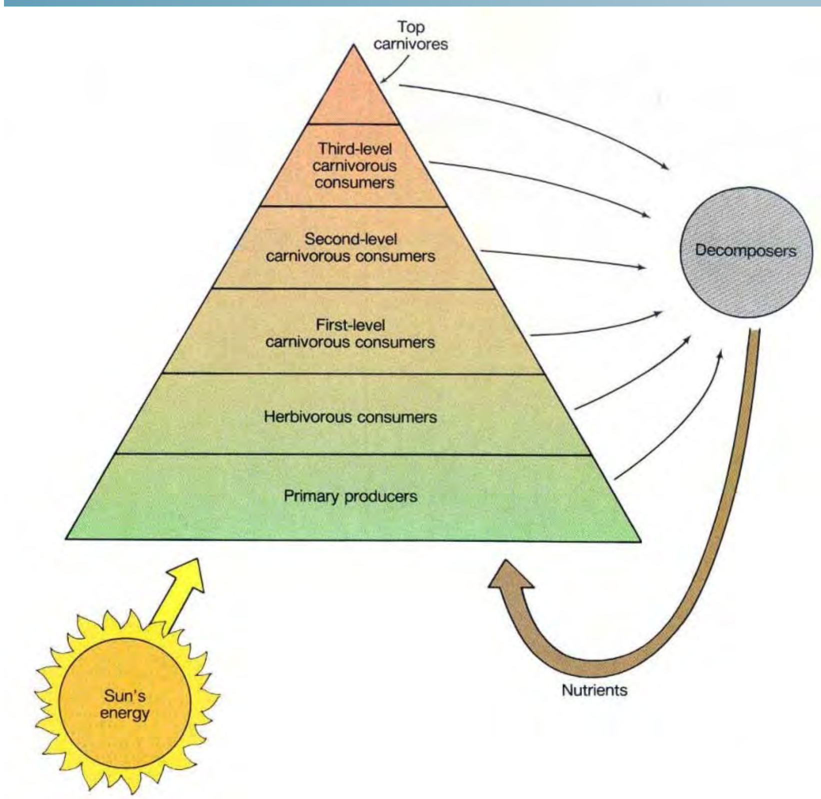
Sumich, 1980.

Seafloor vs. Water Column, Distance from Shore, Depth



On a Finer Scale: Mid-Atlantic, Shoreline to Barrier Island

TROPHIC CLASSIFICATION: Where does it get energy?



ROLE IN THE FOOD WEB

- **PRODUCERS**: convert raw materials into energy-rich chemicals using light or chemical energy
- **CONSUMERS**: obtain energy by consuming other organisms

♦ **Herbivores:** feed on producers

♦ **Carnivores (predators):** feed on other animals; many levels & sizes

♦ **Scavengers: feed on dead remains of animals**

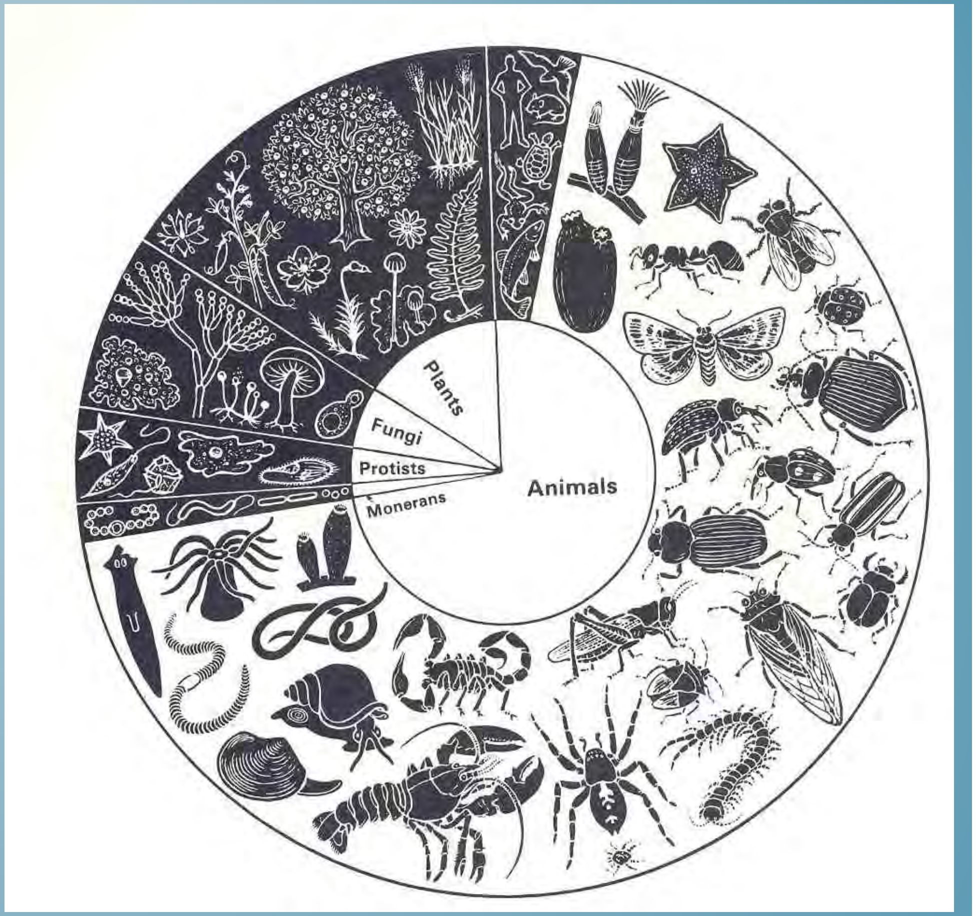
♦ **Filter & suspension feeders** filter/collect minute particles from the water, may eat both plant & animal matter

♦ **Sediment or detritus feeders** collect small particles of organic matter on/in the seafloor, may eat both plant & animal matter

♦ **Decomposers** breakdown the wastes, dead tissues of plants & animals, extracting energy & releasing raw materials back into the environment

BIOLOGICAL CLASSIFICATION: What Is It (anatomically)?

What is its body design/plan?
= suite of distinguishing
anatomical features



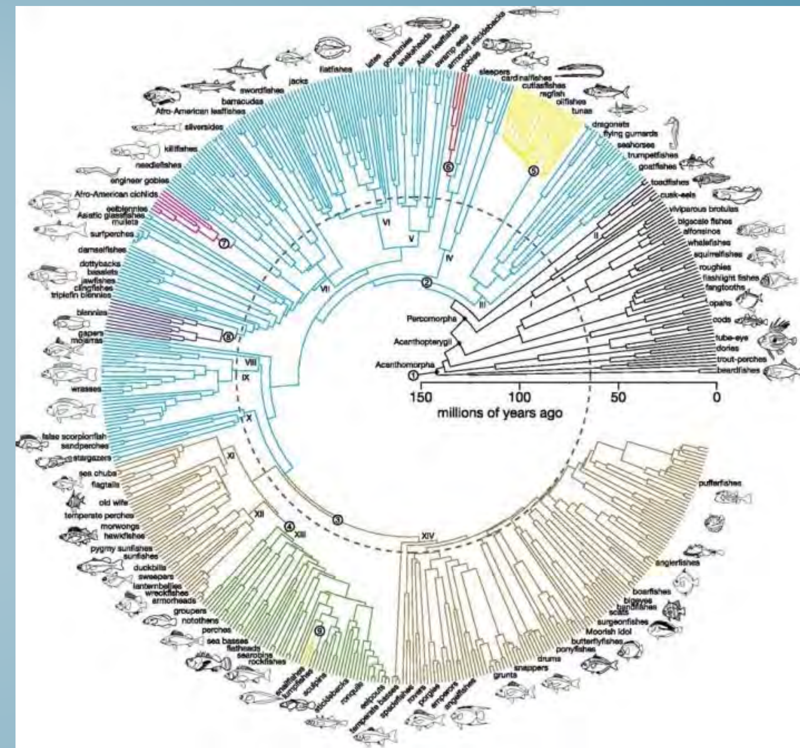
Pearse & Buchsbaum, 1987.

Biological classification & relationships are organized in hierarchical levels of similarities and differences:

Kingdom
Phylum
Class
Order
Family
<u>Genus</u> = the Scientific name or "binomial",
<u>species</u> in Latin or Greek (underlined or italics)

GENETIC CLASSIFICATION

What Is It (genetically)?



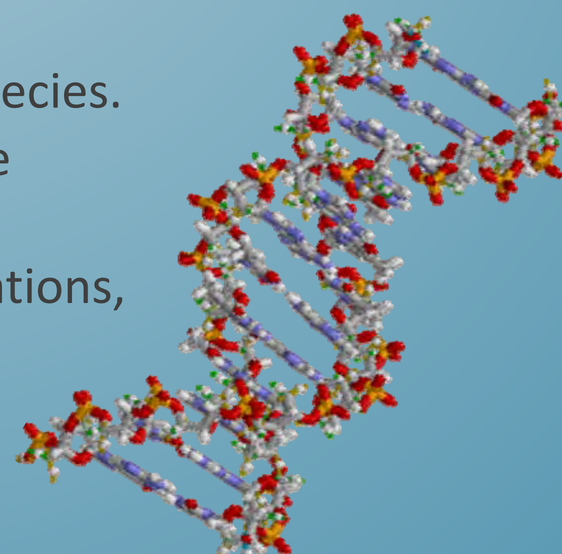
Near, et al. 2013. PNAS

Phylogenetics:

- The study of evolutionary relationships among groupings of organisms (e.g. taxa, species, populations),
- Discovered through molecular sequencing data and morphological data matrices.

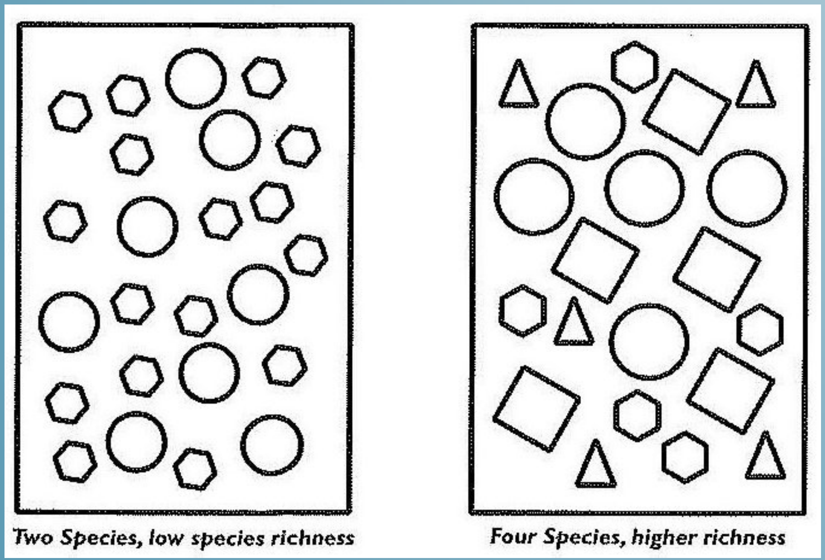
Genetic diversity: variety of genes within a species.

- Each species is made up of individuals that have their own particular **genetic** composition.
- This means a species may have different populations, each having different **genetic** compositions.

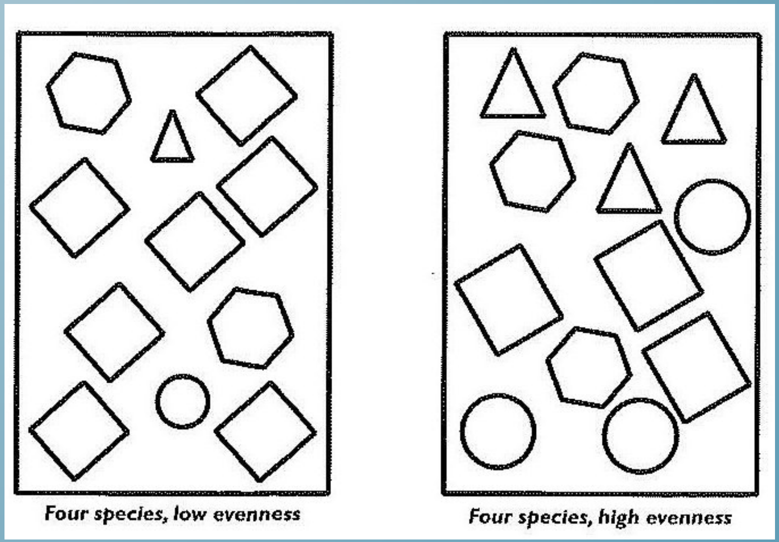


Measuring and comparing species diversity:

- **Species richness** = **how many different kinds of species**, total number of species observed in a given area sampled.



- **Evenness or dominance** = **abundance of each species**, relative dominance of a species within the area sampled.



Council for Environmental Education, 2002..

Compare 2 habitats:

<u>Habitat A has 10 species</u>:
90 individuals of 1 species &
1 each of 9 other species

<u>Habitat B has 10 species</u>:
1 individual of each of
10 different species

Richness?
Habitat A & B both have 10 species,
the same species richness

Evenness?
Habitat A has
"low evenness"
or "high dominance"

Habitat B has
"high evenness"
or "low dominance"

BIODIVERSITY INDICES

INCLUDE BOTH SPECIES RICHNESS & EVENNESS

- **Simpson's Index** $$D_S = \frac{N\,(N-1)}{\Sigma\, n_i\,(n_i - 1)}$$

(sometimes known as Simpson's Inverse or Reciprocal Index)

- **Shannon-Wiener Index** $$H' = N \ln N - \Sigma\,(n_i \ln n_i)$$

Where:

N = the total number of individuals of all species

n_i = the number of individuals of species i

Global Issues

Social, Political, Economic and Environmental Issues That Affect Us All

Home | About | Issues | World News

You are here: Home → Issues → Articles → Climate Change Affects Biodiversity

Climate Change Affects Biodiversity

by Anup Shah | This Page Last Updated Sunday, January 19, 2014

The link between climate change and biodiversity has long been established. Although throughout Earth's history the climate has always changed with ecosystems and species coming and going, *rapid* climate change affects ecosystems and species ability to adapt and so biodiversity loss increases.

From a human perspective, the rapid climate change and accelerating biodiversity loss risks human security (e.g. a major change in the food chain upon which we depend, water sources may change, recede or disappear, medicines and other resources we rely on may be harder to obtain as the plants and forna they are derived from may reduce or disappear, etc.).

Biodiversity and Climate Change, Convention on

Project WILD®

http://www.projectwild.org/

VIRGINIA
Department of Game
& Inland Fisheries

- 34 lesson plans
    - Multidisciplinary approach
      -Concepts
      -Skills
        - Environmental awareness
          -Identifying parameters & issues
            - Documenting environmental conditions
              -Data collection methods
                - Participatory democracy
                  -Roles of government branches
                  -Role/advocacy of stakeholders

SELECTED LESSONS:

- A Place for Every Living Thing
  - Importance of biodiversity & inventorying biodiversity, (also see Appendix E. on Inventory Methods)
- To Breathe or Not to Breathe
  - Determine effects of salinity & temp on O2 in water
- Color Me A Watershed
  - Impacts of population growth & development on land use & watershed
- Then and Now
  - Compare land use, visualize urbanization over time
- What Do People Think?
  - How to survey community members on a issue of concern

Measuring Biodiversity - practice

Quadrat (0.5 x 0.5 m) – count all individuals,
sort by species (no need for names)

Record N = total number of different species
n_1 = number of species 1, n_2 = number of species 2, etc.

Characterize biodiversity of your site re: richness & evenness

1. Calculate the Simpson Diversity Index using the formula on page 233 of Science & Civics

2. Use the Shannon-Weiner Index calculator to derive that figure

Comparing Simpson Diversity Index & Shannon-Weiner Ind

Sample	N = # Species	Simpson Diversity	Shannon-Weiner Index	Evenness
Higher richness	5	5.50	1.605	0.9975
Lower richness	2	2.50	0.655	0.9457
High evenness	4	5.85	1.386	1.00
Lower evenness	4	1.94	1.034	0.7456

"The Daily Catch: A Fisheries Management Game"

By: Annie Murphy

Adapted from Smithsonian *National Museum of Natural History:*
http://ocean.si.edu

Developed for
Partnership between Educators and Researchers for Enhancing Classroom Teaching
(GK-12 PERFECT)
Year 5, 2013-2014
Virginia Institute of Marine Science, College of William & Mary

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Grade Levels: 9-12

Time Required: 90 minutes

Main Concept:
The game incorporates natural and anthropogenic controls on fish populations, highlighting many factors that influence population growth.

Learning Objectives:
Students will learn the importance of fisheries management within an environmental, social, and economic context.

VA Standards of Learning addressed:

BIO.7 The student will investigate and understand how populations change through time. Key concepts include
- a) evidence found in fossil records;
- b) how genetic variation, reproductive strategies, and environmental pressures impact the survival of populations;
- c) how natural selection leads to adaptations;
- d) emergence of new species; and
- e) scientific evidence and explanations for biological evolution.

BIO.8 The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems. Key concepts include
- a) interactions within and among populations including carrying capacities, limiting factors, and growth curves;
- b) nutrient cycling with energy flow through ecosystems;
- c) succession patterns in ecosystems;
- d) the effects of natural events and human activities on ecosystems; and
- e) analysis of the flora, fauna, and microorganisms of Virginia ecosystems.

LS.7 The student will investigate and understand that interactions exist among members of a population. Key concepts include
- a) competition, cooperation, social hierarchy, territorial imperative; and
- b) influence of behavior on a population.

LS.8 The student will investigate and understand interactions among populations in a biological community. Key concepts include

a) the relationships among producers, consumers, and decomposers in food webs;
b) the relationship between predators and prey;
c) competition and cooperation;
d) symbiotic relationships; and
e) niches.

LS.10 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic, change over time, and respond to daily, seasonal, and long-term changes in their environment. Key concepts include

a) phototropism, hibernation, and dormancy;
b) factors that increase or decrease population size; and
c) eutrophication, climate changes, and catastrophic disturbances.

LS.11 The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include

a) food production and harvest;
b) change in habitat size, quality, or structure;
c) change in species competition;
d) population disturbances and factors that threaten or enhance species survival; and
e) environmental issues.

ES.6 The student will investigate and understand the differences between renewable and nonrenewable resources. Key concepts include:

c) resources found in Virginia;
d) environmental costs and benefits.

ES.10 The student will investigate and understand that oceans are complex, interactive, physical, chemical, and biological systems and are subject to long- and short-term variations. Key concepts include:

e) economic and public policy issues concerning the oceans and the coastal zone including the Chesapeake Bay.

Materials:

- Worksheet (5 pages, includes rules of the game and thinking questions) – 1/student
- Role Cards (name tags) and datasheets including (# in parentheses = # copies per group):
  - Commercial Watermen (3),
  - Recreational Fishermen (1),
  - Policy-Maker (1),
  - Fisheries Scientist (1)
- Graduated Cylinder (100ml)
- Measuring spoons (varying sizes)
- Funnel

- Beans
- Fish Factor Cards
- One cup labeled 'Bay'; measure 200ml beans placed in the Bay
- One cup labeled 'Extra'; about 100ml of beans
- Additional cup to help with counting (for Fisheries Scientist)
- Calculator

Management Notes:

This lesson is written to accommodate groups of 6 students. If groups deviate from 6 members adjustments must be made in order to maintain a balanced fish population for multiple rounds (i.e. increase or decrease starting fish population, price per fish, number of commercial watermen, etc.). The game works best with 6 students: 3 watermen, 1 recreational fisherman, 1 policy-maker, and 1 fisheries scientist. Maintaining these numbers is best, so having a student act as 2 commercial watermen or having the students pair up to play a single role would work if groups are not exactly 6 students.

Additionally, the size of the beans used will drastically alter the game, its best to use pinto beans. Since the money made is calculated on a per fish basis, small beans cause the fishermen to make a lot of money while larger beans (less can fit in the scoop) result in lower net income. If the bean size is different than an average pinto bean the initial price per fish should be altered and/or the initial number of scoops allowed to harvest. Currently the numbers used (details below) are fixed so after the first round the commercial watermen are not happy, as they have not reached their minimum amount of money they must earn to survive. This helps to initiate the dialogue among the various stakeholders.

Background Information for Teacher:

This fisheries management game demonstrates the conflicts that arise among various stakeholders when managing natural resources. The activity may be applied to a number of basic scientific concepts including natural resource management, population growth and limitations, fisheries science, and environmental science.

Fish populations are controlled by a number of natural and anthropogenic factors which cause fluctuations in the numbers of fish. Like populations of other organisms (including humans), fish numbers can shift based on a number of different intrinsic and extrinsic factors. These factors can either be density dependent (i.e. competition for food, disease prevalence, predation rate, etc.) or density independent (i.e. floods, changes in climate, precipitation, temperature, etc.). In addition to natural variation due to environmental factors, commercial fish populations can be greatly impacted by fishing pressure and pollution.

Before beginning the activity it is helpful to teach some basic concepts about population growth and carrying capacity. In an ideal scenario, the population growth curve is made up of four main components: Lag phase, when the population is small and numbers increase slowly; Exponential growth; Deceleration, when the population size begins to reach its carrying capacity and limiting factors begin to slow population growth; and Stable equilibrium, where the population size has reached its capacity for growth. This growth curve illustrates a typical k strategist organism, such as many commercial fish. The size of the population when it reaches equilibrium depends on the intrinsic and extrinsic factors, including the anthropogenic stressors such as fishing and pollution.

The object of the game is to maintain a healthy "beanfish" population while promoting an economically stable commercial fish industry.

<u>Vocabulary:</u>
Carrying capacity; exponential growth curve; intrinsic and extrinsic factors; fisheries management; natural mortality; moratorium; waterman; regulation; k strategist; r strategist; predation; competition; equilibrium; anthropogenic stressors; environmental resistance; carrying capacity

<u>Lesson Procedure:</u>

This lesson uses a game in which the students act as different stakeholders to teach the basics of fisheries management, emphasizing the social, economic, and ecological conflicts that often arise when managing natural resources. The game can be complicated as there are a number of 'rules' to follow and keep track of. Therefore, it is highly recommended that the class go through a round together before breaking into groups and playing.

Prior to introducing the game have the students look at the "Bottle Model" diagram which illustrates the factors that increase or decrease fish populations. The students should work in pairs to answer questions 1 and 2 on their worksheet. Ask the students to share some ideas of events they came up with that may make the 'faucets' in the model flow faster, and how these events would affect the fish population (if the faucet flows faster the population decreases). Natural reproduction and restocking will replenish the fish population.

Next, introduce the game. The game demonstrates how humans, fish populations, the environment, and policies interact and influence each other. In the game each member of the group will represent a different stakeholder: commercial watermen, recreational fishermen, policy-makers (or lawyer), and fisheries scientists. The pinto beans in the cup (the bay, estuary, ocean, river) represent the beanfish. Each round is meant to be one year or fishing season.

During each round the <u>commercial watermen and recreational fishermen</u> are allowed to harvest a set number of scoops, which is determined by the policy-maker at the end of the previous round. The fishermen calculate how much money they made that round and determine if they have made enough to survive (record values in data table). The recreational fisherman represents 25 fishermen and must determine if his or her catch is satisfactory. They must divide the total number of fish they caught by 25 to determine how many fish each fisherman they represent caught. If each person catches about 2 fish they are content (although more is always better!).

After the fish are harvested, <u>the fisheries scientist</u> calculates how many fish are left in the bay, using a graduated cylinder, and then doubles this number to simulate natural reproduction for that year. So, for example if the volume of beans after harvest is 100ml, the final volume after reproduction will be 200ml. The scientist then compares how much the population increased or decreased from the previous round to determine how he or she will advise the policy-maker.

Next the fishermen and scientist consult with <u>the policy-maker</u> to convince him or her to change the legal limit of fish that can be caught the next year. Typically the fishermen will want more scoops or to be able to use larger scoops while the scientist is more cautious and attempts to have the catch limit reduced for the next round.

Once the policy-maker has decided the new rules for the next round, a fish factor card is drawn from the pile. The fish factor card describes a random event that may drastically affect the fish population and the results of the game. The fish factor cards include both environmental events that may alter fish populations directly as well as economic events that shift the price per fish or the amount the commercial watermen can catch.

Remind each member of the group to fill out the data chart that is specific to their role, one row per round or year.

Specific rules of the game:

- The commercial watermen must make $6,000 each round to make a living. If a watermen makes <$6,000 for 3 rounds (does not have to be consecutive), then he/she is out of business. Surplus from good rounds can carry a waterman through times of shortage. So, if a waterman makes $6,500 in one year, $500 can be used to make up for a bad catch in another round.
- Recreational fishermen represent 25 people each. For each person to catch a fish, the recreational fishermen needs to catch at least 25 beans in a round.
- If the instructions on the fish factor card drawn at the end of the round conflict with the policy-maker's laws, the card overrides the policy-maker. Otherwise, both the card and the policy-maker's decision apply for the next round.
- Make the most of the rules and regulations! Come up with creative solutions (number of scoops, size of scoops, etc) as you come across challenges in managing the fish stock!

To start the game (demo in front of the class):

- Choose 6 volunteers to play initially in front of the class and assign each person a role (3 commercial watermen, 1 recreational fisherman, 1 policy-maker, 1 fisheries scientist)
- Go through a full round, explicitly instructing each student what to do
- Start with 200ml of beanfish in the bay
- Commercial watermen take 3 teaspoons of beanfish each (count and calculate your income)
- Recreational waterman takes 1 teaspoon (count and calculate how many fish per person were caught, given that you represent 25 people)
- Scientist measure the volume of beans left in the bay and double this number to represent reproduction (calculate by what percentage the population increased or decreased from the start of the round)
- Policy-maker listen to the advise of all stakeholders and make a decision on how policies will change for next round.
- Choose a fish factor card!

Discussion Questions:

1. Summarize the results of the game. What trends did you see in the beanfish population over time (increase, decrease, stable, etc)?

2. Of the scenarios that happened (Fish Cards) during the game, which can we control? Look back at the "Bottle Model" and circle the factors that humans can control through various actions. Under each circled factor, provide an example of an action that humans could do to decrease the flow from the faucet.

3. What were 3 events, actions, or decisions in the game that most influenced the health of the fishery?

4. Although this was only a game that modeled real-life, it gives you a good sense of the challenges, cooperation, and compromise involved in fisheries management. What other factors might influence populations and harvest besides human activity?

5. This game deals with a very real issue: the role of laws in fisheries management. Think about how regulations affected the watermen and recreational fishermen in your game. How did the regulations affect the fish population?

6. Write a persuasive statement to a classmate explaining whether or not you think we need laws, such as those you saw in the game, to manage fisheries. Use examples and evidence from the 'Bottle Model', the game, and any prior knowledge you might have to support your points.

Assessment:

- As the goal of the game is to establish a stable beanfish population while maintaining a fishery that keeps everyone in business, the game could be a contest to see which group could get through the most number of rounds without the beanfish population collapsing and without any watermen going bankrupt.
- The students will be expected to fill out their data charts and answer the discussion questions on their worksheet.
- After the groups have finished (either their beanfish population collapsed or ran out of time), a class discussion following the questions on the worksheet would be helpful in reinforcing the concepts on population dynamics that the game incorporated.

Lesson Extension:

- Other fisheries related issues could be added to the game.
  - For example, the concept of bycatch could be incorporated into the game by adding different colored beans to the bay. A penalty could be put in place for catching non-target species and the commercial watermen could lose money as it costs time and money to disentangle gear.
  - Different gear or fishing methods could be simulated during the game by changing the teaspoons to different types of scoops such as forks, chopsticks, small cups, etc. A rule could be implemented that if a fisherman has enough

money he or she could purchase more efficient gear (a small cup for example) to use.
    - Aquaculture would add a twist to the economics of the game. Adding an aquaculturist as a stakeholder may alter the policies.

- A data analysis exercise may be helpful in reviewing the concepts the students learned. The data tables could be converted into graphs to show how the population of fish changed over time or how the fishermen's incomes varied through the rounds. By graphing the data certain time points may stand out as showing large shifts in population. These time points will likely correlate with certain fish factor cards or drastic policies put in place by the policy maker.

References:

http://ocean.si.edu

http://ocean.si.edu/sites/default/files/lesson_plans/%5Buser%5D/Net%20Results%20Lesson%20Plan.pdf

This lesson plan is developed as part of a GK-12 project funded by the National Science Foundation under grant no. DGE-0840804 to the Virginia Institute of Marine Science. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

The Daily Catch **Name:** ________________________________
Fisheries Management Game

Part 1.
Study the "Bottle Diagram" (last page). This model represents the interaction between ways in which species are removed and replaced in the Chesapeake Bay. Each faucet is a limiting factor on the fish population. Together these faucets represent environmental resistance and human-caused factors.

1. Pick one of the faucets in the model; describe an event that could make it flow faster. *For example, an event such as a heat wave could reduce the amount of oxygen in the water and increase natural mortality.*

2. If the event you described did occur, what would happen to the population (increase or decrease)? Would the population be able to return to its original level after the event? How?

Part 2.
Start off with a demonstration of the game with the entire class.
Divide into groups of 6 people. You will play a game that shows how people, fish populations, the environment, and laws interact and influence each other. In the game you will represent some of the people – lawmakers, scientists, watermen, and recreational fishermen – who influence and are affected by fisheries regulations, which ultimately affect fish populations. We will also see how natural factors, such as environmental conditions affect fish populations.

Preparing for the Game:
Each person will receive a Role card that includes a chart to fill out during the game. Read your role description carefully. Explain your role to your group and listen as each member of the group explains their roles.

Game Setup:
Gather the rest of the game's materials:

- ✓ Group of 6 people =
  1 lawyer, 1 scientist, 3 commercial watermen, 1 recreational fisherman
- ✓ Graduated cylinder (for the fisheries scientist)
- ✓ Measuring spoons (commercial and recreational watermen share a set)
- ✓ Funnel (to avoid a huge mess!)
- ✓ One cup labeled "Bay"; **<u>Measure 200 ml of beans and put in the Bay</u>**
- ✓ One cup labeled "Extra" – with about 100ml of beans
- ✓ Another cup to help the scientist

Playing the Game:
Goal: *Maintain a stable beanfish population in the Bay and a fishery that is stable enough to keep everyone in business.*

Rules:

- The watermen must make $6,000 each round to make a living. If a waterman makes under $6,000 for 3 rounds, he/she is out of business. Surplus from good rounds can carry a waterman through times of shortage. This means that if a waterman makes $6,500 in one year, $500 can be used to make up for a bad catch in another round.
- Recreational fishermen represent 25 people each. For each person to catch a fish, the recreational fishermen needs to catch at least 25 beans in a round.
- Make the most of the rules and regulations! Come up with creative solutions as you come across challenges in managing the fish stock!

Round 1.

- Commercial watermen may take 3 teaspoons of beanfish from the Bay. Fill in your chart.
- Recreational watermen may take 1 teaspoon of beanfish from the Bay. Fill in your chart.
- Once the harvested beanfish have been counted, put them in the 'extra' cup
- The fisheries scientist (with the graduated cylinder) now measures the remaining population of beanfish in the "Bay". Calculate how many fish will be added through reproduction this year:
  - For every 1ml of beanfish remaining add 1ml from the extras into the bay (reproduction doubles the number of beans)
- Fisheries scientist, watermen, and recreational fishermen provide recommendations to the lawmaker (check your individual role cards for ideas).
- The lawmaker decides which regulations (if any) harvesters must follow in the next round.
- The lawmaker draws a "Fish Factor" card and reads it to the group. If the instructions on the card conflict with the lawmaker's decision, the instructions on the card override the lawmaker's decision. Otherwise, both card instructions and laws apply for the next round.

Round 2 to Round 5…until you run out of time

Each group will repeat the steps in Round 1 with the new instructions from the Fish Factor card and any new regulations (if there are any) put in place by the lawmaker.

After the game, answer the following questions:

1. Summarize the results of the game. What trends did you see in the beanfish population over time (increase, decrease, stable, etc)?

2. Of the scenarios that happened (Fish Cards) during the game, which can we control? Look back at the "Bottle Model" and circle the factors that humans can control through various actions. Under each circled factor, provide an example of an action that humans could do to decrease the flow from the faucet.

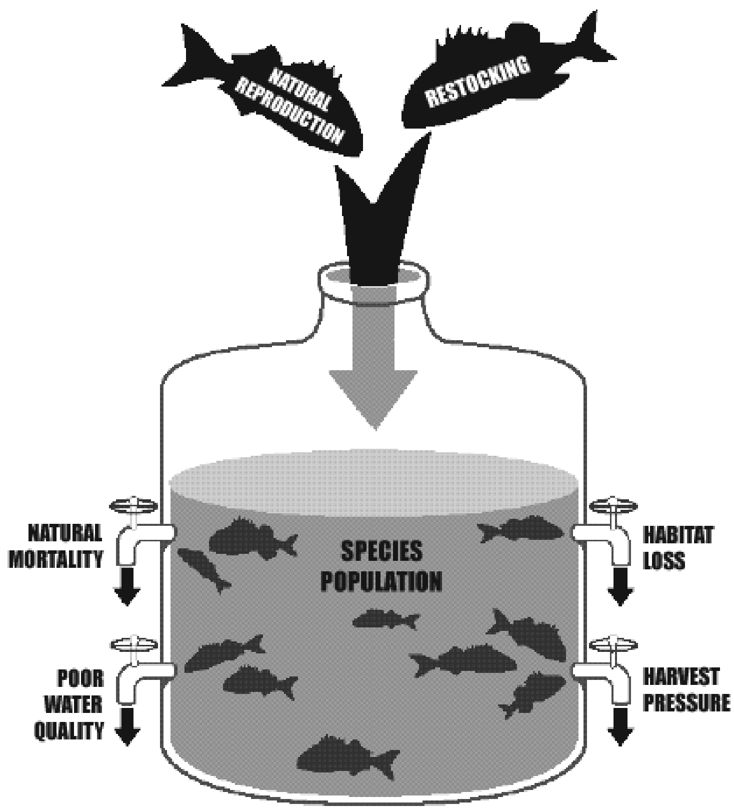
3. What were 3 events, actions, or decisions in the game that most influenced the health of the fishery?

4. Although this was only a game that modeled real-life, it gives you a good sense of the challenges, cooperation, and compromise involved in fisheries management. What other factors might influence populations and harvest besides human activity?

5. This game deals with a very real issue: the role of laws in fisheries management. Think about how regulations affected the watermen and recreational fishermen in your game. How did the regulations affect the fish population?

6. Write a persuasive statement to a classmate explaining whether or not you think we need laws, such as those you saw in the game, to manage fisheries. Use examples and evidence from the 'Bottle Model', the game, and any prior knowledge you might have to support your points.

The Bottle Model



A Population Growth Curve

- **Biotic potential** is the inherent reproductive capacity of a species (biological ability to produce offspring).
- Generally, biotic potential is much above actual replacement level.
  - There is a natural tendency for increase.

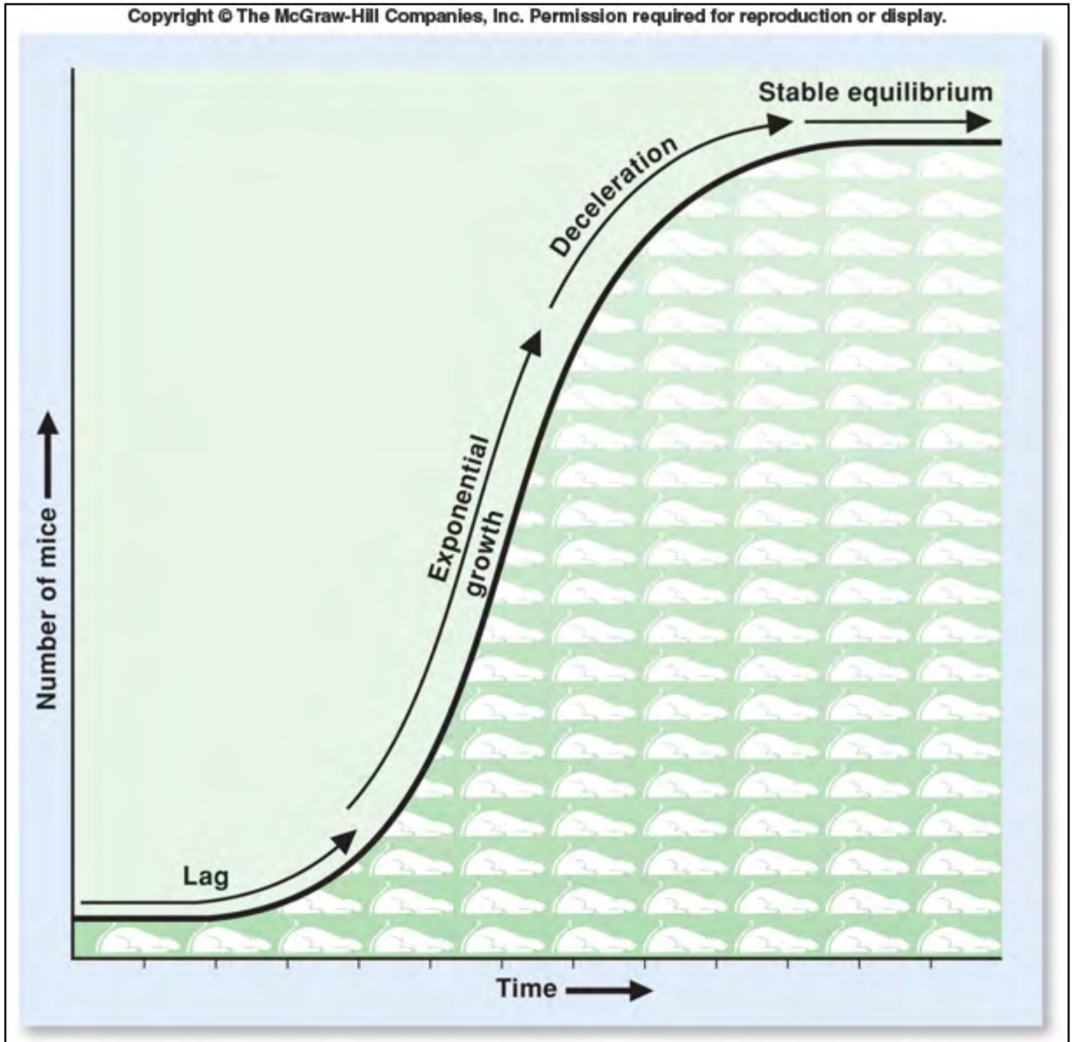
A Population Growth Curve

- Population growth follows a pattern consisting of a lag phase, an exponential growth phase, a deceleration phase, and a stable equilibrium phase.
  - **Lag Phase:** This is the first portion of the curve; slow population growth.

A Population Growth Curve

– **Exponential Growth Phase** (**Log Phase**): More organisms are reproducing, causing accelerated growth; this continues as long as birth rate exceeds death rate.
– **Deceleration Phase:** The population growth rate slows as the death rate and birthrate come to equal one another.
– **Stable Equilibrium Phase:** The death rate and birth rate become equal and the population stops growing.

A Population Growth Curve



A typical population growth curve

Factors That Limit Population Size

- Factors that prevent unlimited population growth are known as **limiting factors**.

- All of the different limiting factors that act on a population are collectively known as **environmental resistance**.

Factors That Limit Population Size

- **Extrinsic limiting factors** are those that come from outside the population.
  - Predators
  - Loss of food source
  - Lack of sunlight
  - Accidents of nature
- **Intrinsic limiting factors** are those factors that originate within the population
  - Behavioral changes amongst the population cause lower birthrates and higher death rates.

Factors That Limit Population Size

- **Density-dependent limiting factors** are those that become more effective as the density of the population increases.

- **Density-independent limiting factors** are population-controlling influences that are not related to the density of the population.

Categories of Limiting Factors

- For most populations, <u>limiting factors</u> recognized as components of environmental resistance can be placed into

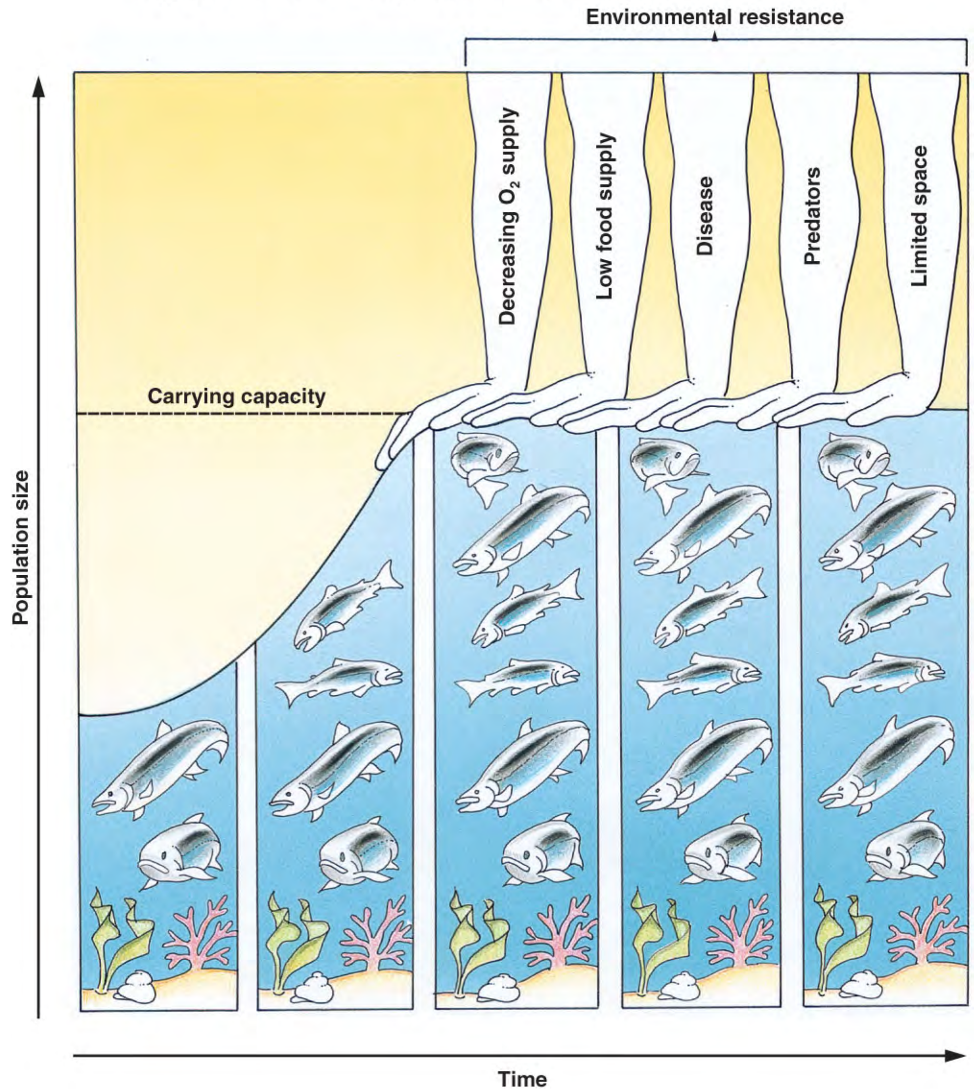
4 main categories:

- – Raw material availability
- – Energy availability
- – Accumulation of waste products
- – Interactions among organisms

Carrying Capacity

- **Carrying capacity** is the maximum sustainable population for an area.
- It is a flexible number; it can be influenced by environmental differences such as:
  - Successional changes
  - Climate variations
  - Disease epidemics
  - Forest fires, floods, or natural disasters
  - Nutrient levels in aquatic ecosystems

Carrying Capacity



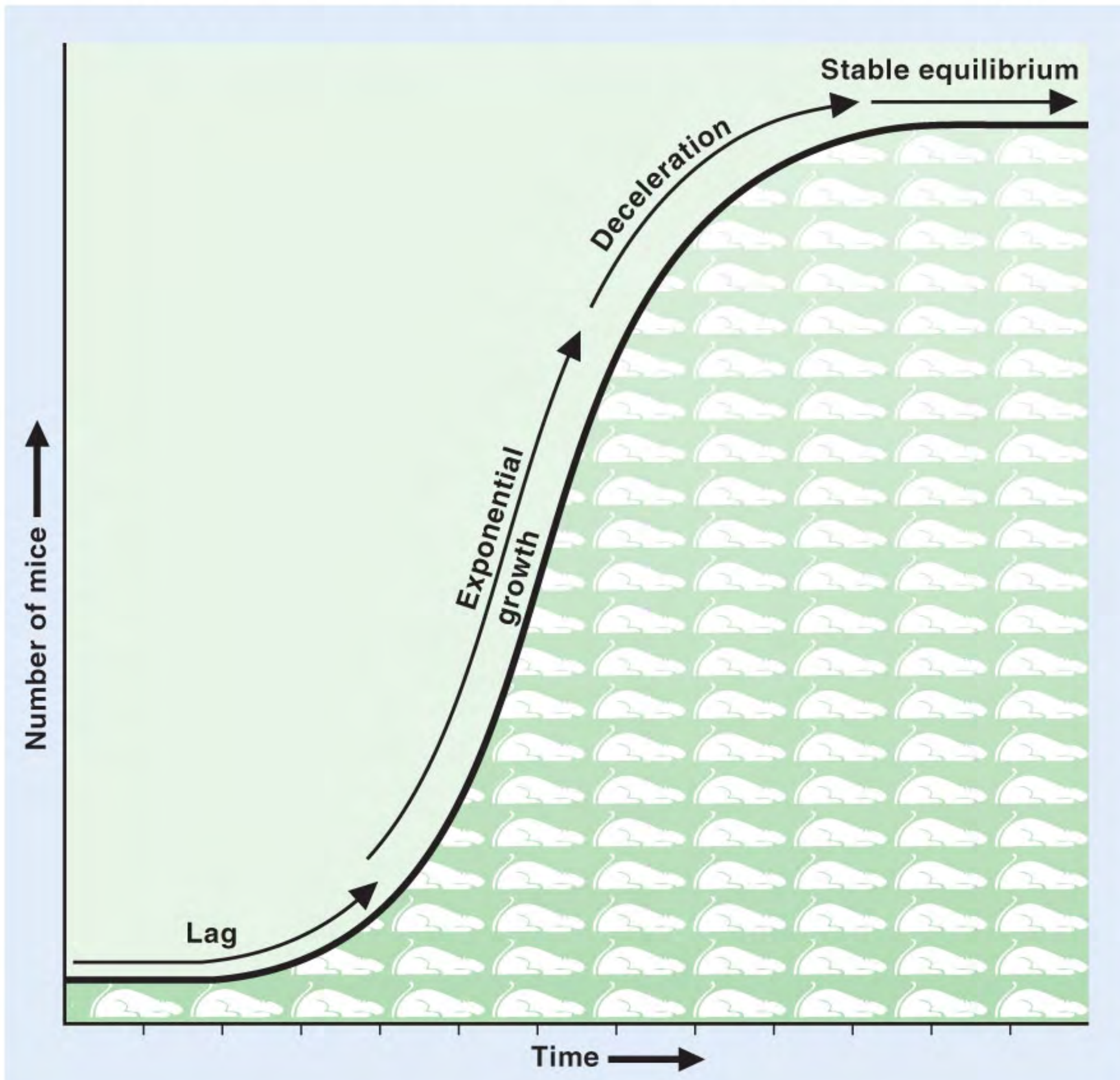
Reproductive Strategies and Population Fluctuations

- Species can be divided into two broad categories based on their reproductive strategies:
  - **K-strategists:** Organisms that typically reach a stable population as the population reaches the carrying capacity.
  - **r-strategists:** Typically, these are small organisms that have a short life, produce many offspring, exploit unstable environments, and do not reach a carrying capacity.

Reproductive Strategies and Population Fluctuations

- K-strategist characteristics include:
  - Usually occupy relatively stable environments
  - Large organisms
  - Long-lived
  - Produce few offspring
  - Provide substantial parental care
  - Reproductive strategy is to invest a great deal of energy in producing a few offspring that have a good chance of living to reproduce.
- K-strategists are controlled by density-dependent limiting factors.

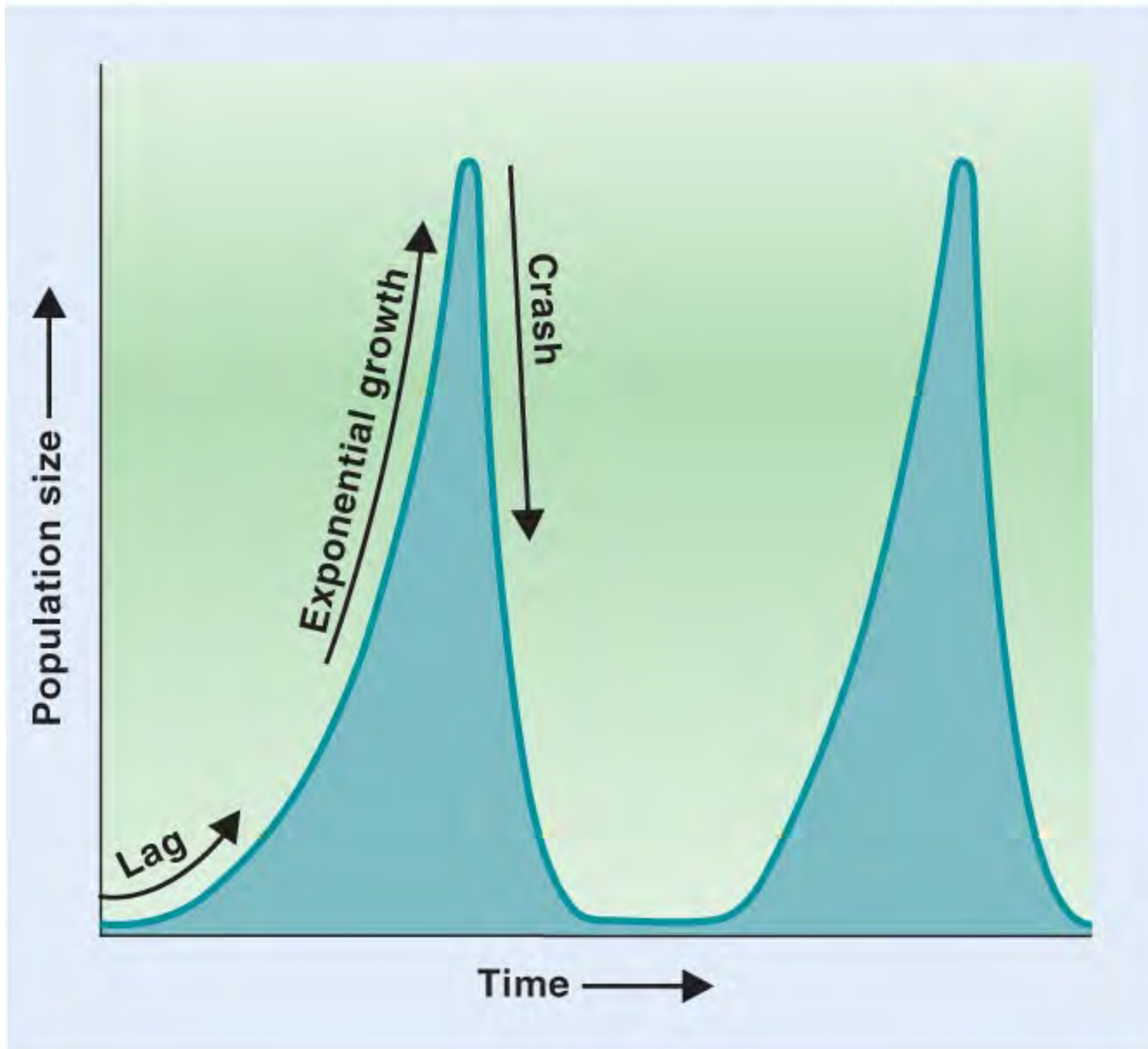
K-strategist



Reproductive Strategies and Population Fluctuations

- r-strategist characteristics include:
  - Small, short-lived organisms
  - Produce many offspring
  - Little if any parental care
  - Exploit unstable environments
  - Usually do not reach carrying capacity (boom-bust cycles)
  - Reproductive strategy is to produce large numbers of offspring to overcome high mortality.
- r-strategists are controlled by density-independent limiting factors.

r-strategist



Lawmaker

Introduction to your role:
Your job is to make the laws that determine how many beanfish the commercial and recreational fisherpeople can take out of the Bay each year. Your goal is to listen to everyone's point of view about how the fishery is doing and then make regulations that are fair and sensible. It is a tough job, but someone has to do it! Ultimately, you are striving to keep the fishing industry healthy throughout the *entire* game.

At the end of each round, you will get a recommendation from each interest group (fisheries scientists, watermen, and recreational fisherpeople). Although the recommendations may say completely different things, you need to use them to help decide which regulations to make.

What does the lawmaker do?
As the lawmaker, you can regulate fishing in a number of ways. You can make everyone take fewer beanfish, or allow everyone to take more. You can change the size of the equipment that watermen and/or recreational fisherpeople are allowed to use (they all have a set of spoons sizes you can choose from). You can also set different limits for recreational fisherpeople and watermen. As a last resort, you can set a moratorium for a round or more. A moratorium is a ban on all harvesting of the species and will allow the species to reproduce without being harvested. The lawmaker is also responsible for enforcing the regulations he or she sets, when necessary.

Remember:
As a lawmaker, you take responsibility for many people's happiness, and sometimes for their financial survival. Watermen make a living by catching and selling beanfish. They are not making a decent living if they make less than $6000 per round. They will go out of business permanently if they make less than this for a total of three rounds. This means that severe restrictions, or a moratorium might put them out of business. On the other hand, watermen depend on the existence of beanfish to catch, so overfishing might put them out of business in future rounds. Your goal is to find laws that will balance present and future needs.

Here are a few examples of regulations you can set:
- If the beanfish stock seems to be in wonderful shape, you can increase the amount everyone can catch or allow for an unlimited catch, where everyone can take as much as they want.
- If you are afraid that the beanfish stock is becoming too low, you can forbid the use of tablespoons to scoop up beanfish. This means that watermen and recreational fisherpeople will have to use their smaller spoons, which do not catch as many beanfish.

Round	Scientist's Suggestions	Commercial Watermen's Suggestions	Recreational Fishermen Suggestions	Final decision for the round	Fish Factor Card Summary
1					
2					

Recreational Fisherperson

Introduction to your role:

You do not make your living fishing, but it is still very important to you. You fish for fun, because you like to eat beanfish, or because you like to make a little extra money by selling beanfish on the side. Even though each of you only catches a small number of beanfish, there are so many of you that your harvest can be significant. For this reason, you must follow whatever laws are set by the lawmaker just as the commercial watermen do.

What do the Recreational Fisherpeople do?

Because there are actually many more recreational fisherpeople than watermen, you will represent 25 fisherpeople. This means that if you take a scoop of beans that has 25 beans in it, each recreational fisherperson has caught one bean. Not bad. However, if you only catch 10 beans, then only 10 out of 25, 2/5ths, or 40% of the recreational fisherpeople have caught a bean. Not so good! When your harvests get below one beanfish per person, recreational fisherpeople begin to get worried.

At the end of each round, you will try to influence the lawmaker through a verbal recommendation telling her/him how well fishing is going and what you think should be done. Should fisherpeople be allowed to catch more each round or use bigger and better fishing gear? Or are you worried that too much is being taken? Keep track of the number of fish that you are catching with the chart on the other side of this page.

Remember:

Just because fishing is a recreation to you doesn't mean that you don't care what regulations are set by the lawmaker. You want the freedom to continue your way of life.

Round	# of beanfish caught total	How many fish did each of the 25 fishermen catch?	How content are your 25 fishermen with their catch?	Fish Factor Card Summary
Example		HINT: (#fish caught ÷ 25)	2 fish per person = super happy! 1 fish per person = happy < 1 fish per person = not very happy	
1				
2				

Fisheries Scientist

Introduction to your role:
You are the person who studies the Bay's fish populations. You are an expert who provides hard facts to the lawmaker about how the beanfish population is doing. In this game, you are also the person who measures the fish left after each round and calculates how many get put back in to the pool through natural reproduction. This means that you are the only person who really knows how the beanfish are doing. Your goal in this game is to make sure that there are always enough beanfish left in the pool to replenish the stock after each round. In other words, you want to make sure that there will be a future for beanfishing in the Bay.

What does the Fisheries Scientist do?
To provide sound data to the lawmaker, you need to keep track of the amount of beanfish in the Bay before and after harvesting and beanfish reproduction. You will start the game by placing 200 ml of beanfish in the Bay. After each round of harvesting, you will measure the amount of fish left and calculate how much the beanfish population will reproduce that year. To do this, you will add one ml of beans to the Bay for every ml of beans left. For example: if there are 95ml of beanfish left in the Bay when harvest is finished, you will add 95ml more. This will bring the total amount of beanfish up to 190ml.

Based on what you know about the beanfish population after each round, you will need to make a verbal recommendation to the lawmaker, telling him/her what you think should be done to maintain a healthy beanfish stock.

Remember:
Since you are the only members of your playing group who actually measure the beanfish stock, you will need to explain to the others how the stock is doing. Most importantly, you need to convince the lawmaker to make regulations that will keep the stock healthy, and not bring it down to low levels.

- If you can see that the current regulations are allowing the beanfish stock to become seriously low, you can recommend that the lawmaker limit watermen to one scoop each per round or that the recreational fisherpeople use a smaller harvesting tool.
- If you think that the beanfish are doing particularly well, you can recommend that the lawmaker allow them to harvest more beanfish.

Round	Amount in the Bay after harvest (ml)	Final total after harvest and reproduction (double) (ml)	Fraction gained or lost from previous round	Fish Factor Card Summary
Example	50 ml	50ml x 2 = 100 ml	(final this round - final from previous round) ÷ final this round x 100%	
Example 2	60 ml	60ml x 2 = 120 ml	(120 - 100)÷120 x 100% = +16%	
1				
2				

Watermen/Commercial Fisherperson

Introduction to your role:

You make your living by catching beanfish from the Bay and selling them commercially. Your goal is to stay in business for the entire game while obeying the laws and regulations set by the lawmaker.

What does a Waterman do?

To stay in business, you need to catch enough beanfish to make $6,000 (your expenses) each round. For the first round, each bean is worth $100, meaning that you have to catch 60 beans in the first round. The worth of each bean may change throughout the game.

If you make more than $6,000 in any round, you can save your surplus in your savings account for tighter times. If you make less than this amount in any round, you must make up the difference with surplus from another time or count the round as a strike against you. If you have a total of three strikes against you during the game, you go out of business and become a recreational fisherperson.

At the end of each round, you will need to give a verbal recommendation to the lawmaker, telling her/him how your business is doing and what you think should be done to keep you in business. Should you be allowed to use bigger and better gear or take more scoops? Should you or recreational fisherpeople be taking less? Are you making enough money to make a living? Do you want to save money in case times get tight? To help you make these recommendations, you need to keep track of your harvests using the chart on the back of this page.

Remember:

If there are no fish, you will have nothing to catch and no way to remain in business. On the other hand, if regulations are too strict, you may go out of business anyway. You may work with other watermen and/or the recreational fisherpeople, or you may wish to be secretive about your business. It's your choice.

Round	Amount harvested (# of beanfish)	Price per beanfish this round	Amount earned	Savings account (total surplus)	Fish Factor Card Summary
Example	90	$100	$9,000	$9,000-$6,000=$3,000	
1					
2					

Commercial watermen have the option of buying bigger, more efficient equipment for $2000 that can be used until laws prohibit the use of such equipment. If you choose to make the purchase, subtract $2000 from your earnings this round or use any surplus you might have.

In coming rounds, use one spoon size bigger than you used this past round.

A disease from the Pacific Ocean is introduced into the bay through the release of ballast water from a large ship docked in Baltimore. The disease is devastating to the beanfish population.

Reduce your current beanfish population by 10%.

Students help restore a forest and wetland located between a large shopping mall and a local river. This vegetation helps to reduce the amount of pollution runoff from the mall into the river.

As a result, fewer beanfish die, leaving more to reproduce. Increase your population by 30%.

Suddenly, New Zealand starts shipping beanfish to your area, which are just as tasty as the beanfish the local commercial watermen catch. They are also cheaper!

This drives the market value of your beanfish down $20 per fish for one round.

The removal of a dam opens up prime beanfish spawning grounds and they have a very successful reproductive year. Add 30% more beanfish to the bay.

The General Assembly has called for a public vote on whether or not to reduce the amount of beanfish recreational fishermen are allowed to catch. Use a show of hands to determine whether or not recreational fishermen should use one size smaller scoop for harvest. Everyone may vote. This law will be put in place until another regulation changes it (at least 1 round).

If the commercial watermen caught less than a combined total of 150 beanfish this round, not enough fish are making it to market to meet the demand for tasty beanfish. Consumers are willing to pay more for a bit of this scarce fish and will now pay $110 per fish. This card now applies to every round.

Everyone move one seat to the left and take over the job and the data chart of the person whose seat you have just taken.

If commercial watermen caught more than a total of 210 beanfish this round, there is a surplus of beanfish at the markets. Seafood market owners are cutting their prices to get people to buy at their stores. Beanfish prices drop to $90 per fish. This card now applies to every round.

High school students have begun a project raising beanfish in the classroom! This week they released their fish into the bay in an effort to help restore the population.

As a result of their project, the beanfish population in the bay grows by 30%!

A dam has been constructed on a major river leading to the bay. The beanfish can no longer swim up river to spawning grounds. This migration path is crucial for successful reproduction and the obstructing dam has resulted in ½ the number of new fish (recruits) this year. Remove 25% of the fish in the Bay.		An aquarium owner accidentally released a number of non-native fish to the bay. These fish have successfully established a population in the bay and are now considered invasive. These invasive fish compete for food resources with the beanfish. Remove 10% of beanfish from the bay.
High rainfall this year has resulted in a lot of runoff from land and increased levels of nutrients to the bay. High nutrients fuel phytoplankton growth. When the phytoplankton bloom dies and sinks to the bottom, bacteria chew up the organic matter (decomposition) and cause a decrease in oxygen. Low oxygen zones in the bay results in a large 'fish kill' event. Remove 25% of beanfish from the bay.		Seagrass restoration activities by local agencies have been very successful in helping seagrass meadows grow. Seagrass is an important habitat for juvenile beanfish, where they seek refuge from predators and forage for food. The population of beanfish this year increased by 30%!
Unusually low temperatures this past winter has caused a decrease in crabs in the bay. Crabs are an important prey for the beanfish, without crabs they have little to eat. Therefore the decrease in crab populations causes a decrease in beanfish. Remove 25% of beanfish.		Unusually high temperatures this summer have increased the prevalence of particular bacteria that infects beanfish. The infection causes skin lesions and ultimately death. Remove 25% of beanfish in the bay.
An intense hurricane and its high rainfall wash a lot of sediment into the bay. The sediment buried seagrass meadows in the bay. Seagrass meadows are a crucial habitat for juvenile beanfish. Without seagrass there is no place for the beanfish to forage for food and hide from predators. Remove 25% of beanfish from the bay.		New, stricter regulations on the shark fishery in another region of the world have increased populations of migratory sharks in the bay. More sharks means more predation for the beanfish. High predation rates by sharks decreases the population of beanfish. Remove 10% of beanfish from the bay.
The gear commercial watermen use is not efficient in catching only the targeted species, the beanfish. The watermen have been having problems with catching non-targeted species or bycatch, such as sea turtles. Detangling the bycatch from their nets costs the watermen money (nets get torn, takes a lot of time to detangle the animals, and there are fines for catching bycatch). Each beanfish this round is only worth ½ as much as it was in the previous round. The price will return to normal after this round.		No changes this round!

A Day as a BATS Scientist

by Jami Ivory
Developed for
Partnership between Educators and Researchers for
Enhancing Classroom Teaching (GK-12 PERFECT)
Year 5, 2013-2014
Virginia Institute of Marine Science, College of William & Mary

Grade Levels: 7th

Time Required: 90min

Main Concept: Students will identify and count major zooplankton taxa using real data sets. They will graph counts over time and use physical and biological data from the same study site to determine drivers for trends in zooplankton populations.

Learning Objectives: Students will recognize major zooplankton taxa, and will count the zooplankton in each taxon. Students will produce a graph of the chaetognaths counted from all the samples combined. Finally students will determine drivers for chaetognath population trends by comparing their graph to graphed physical and biological data collected at the same study site.

VA Standards of Learning addressed:

LS.1: e) sources of experimental error are identified
h) data are organized, communicated through graphical representation, interpreted, and used to make predictions
j) current applications are used to reinforce life science concepts

LS.4: how organisms can be classified

LS.8: a) the relationships among producers, consumers, and decomposers in food webs

LS.10: b) factors that increase or decrease population size
c) eutrophication, climate changes, and catastrophic disturbances

LS.11 d) population disturbances and factors that threaten or enhance species survival

Materials: (all included)

- PowerPoint presentation of study site location with a little background about the study site and introduction to the zooplankton they will be identifying
- Counting tables sheet (1 table per pair)
- Zooplankton I.D. packet (1 per pair)
- Scans (1 per pair; 12 included; additional available upon request)

Management Notes:
It may be helpful to students if you allow them to draw on the scans so that they can more easily keep track of which organisms were counted. Each class will likely have different population over time graphs; as a result, a teacher will not be able to predict how nicely the chaetognaths will trend with the included biological and physical variables.

Background Information for Teacher:
The Bermuda Atlantic Time-series Study (BATS) has been collecting zooplankton in the upper 200m of the water column since 1994. Sampling has occurred on monthly and bimonthly intervals. A 200 µm plankton net is used to perform the zooplankton tows necessary to catch the zooplankton. Half of the netted zooplankton are preserved in formalin and archived. In addition to the zooplankton sampling, BATS also samples a variety of physical and biological variables.

A thesis project currently underway at the Virginia Institute of Marine Science aims to, for the first time, identify and count the major zooplankton sampled at BATS; identify seasonal, interannual, and decadal cycles; and determine what physical or biological processes drive the zooplankton population cycles. While historically such work would require microscopy, new technology, Zooscan, allows the samples to be scanned and images of the scans and individual zooplankton are saved to a computer. The images are then moved to identification folders and counted. The Zooscan allows for a researcher to take his/her work outside of the lab and also allows for the researcher to revisit a sample (by calling up the scan) without needing to prep the sample again like with microscopy work. Additionally this technique allows the scans to be shared in an educational setting to allow students to learn a variety of skills and concepts using real, very current research images.

Zooplankton are key components of the food web, making the phytoplankton energy available to higher trophic levels. They are a very diverse group with at least one taxonomic group to represent almost every phylum. The broad taxonomic groupings used in this activity are too general to be able to label a grouping as primary/secondary consumers or as herbivorous/omnivorous/carnivorous. The chaetognaths, however, are secondary consumers and veracious predators.

Vocabulary:
Chlorophyll – “standing crop”; proxy for biomass of phytoplankton
Productivity – rate of biomass production
Plankton – drifting organism in the water column (can be plant or animal)
Zooplankton – plankton animals, larva and/or mature
Phytoplankton – plankton plants
Abundance – quantity or amount of something
Diversity – degree of variation in live be it genetic, species, or ecosystem
SST – Sea Surface Temperature

Lesson Procedure:
1) PowerPoint (talking points provided in the notes area of the slides)

2) After introducing students to the animals they will need to identify and count in the scans, pass out the counting tables, zooplankton I.D. packet, and scans
3) Each pair of students should record the cruise number and date of the scan they are assigned
4) Have each pair count all of the individuals in their assigned scan for each taxa on the counting table sheet and record those counts on their counting table sheet
5) When finished each pair should record on the board their cruise number and the number of chaetognaths they counted
    *Chaetognaths were chosen because they can more easily be identified, reducing misidentification
6) Each student will use the class counts of chaetognaths to graph the chaetognath abundance over time (count on y-axis, cruise numbers on x-axis)
7) Discuss as a class any trends seen in the chaetognath population over time
8) Ask students what they think might cause these trends
9) Now, using the PowerPoint provided show the students the primary production graph, tell them what primary production is, and ask them if it looks like primary production trends well with the chaetognath population they graphed
10) Display the zooplankton dry weight graph, explain what zooplankton dry weight is, and ask if it looks like the dry weight is trending with the chaetognath population
11) Display the SST graph, explain what SST is, and ask if it looks like SST is trending with the chaetognath population
12) Display the SST graph with the 2011 cruises and, based on whether they thought the chaetognath population trended well with SST or not, have them predict what the chaetognath population would look like in 2011 and have them graph their prediction

Discussion Questions:

Now that you have worked with the Zooscan scans, what are some pros and cons you can think of to using this instrument for zooplankton identification and counting instead of microscopy?

Referring to your graph what chaetognath population trends do you see?

What do you think could cause this/these trends?

Does primary production trend well with your chaetognath population?

Would you expect the primary production to trend with the chaetognath population? Why/why not?

Does the zooplankton dry weight trend well with your chaetognath population?

Would you expect the dry weight to trend with the chaetognath population? Why/why not?

Does the SST trend well with your chaetognath population?

Would you expect the SST to trend with the chaetognath population? Why/why not?

Based on whether you think that the SST trends well with the chaetognath population or not, what do you think the 2011 chaetognath populations for cruises 269, 270, and 271 will look like?

Based on the data you have seen so far, do you think climate change will have an effect on the chaetognath population at BATS?

For homework research chaetognaths and using what you find from your research write a paragraph about chaetognaths' rule in food webs. How might climate change affect the open water food web at BATS?

Assessment:
A teacher can assess based on participation in class discussions and in the activity, discussion answers, the student's graphing skills, and/or the appropriate prediction for the chaetognath population in 2011.

Lesson Extension:
This lesson could be very inquiry based. Students could use the provided complete 2010, 2009, and 2008 scans found on a wiki link (email: jaivory@vims.edu to request access) to design their own question to investigate. Additional variables from BATS cruises can be used to test student designed hypotheses (link to BATS data → http://batsftp.bios.edu/BATS/). Additionally these scans can be used in other lessons. For example students could design a dichotomous key for zooplankton identification and test that key using the BATS zooplankton scans.

References:
Steinberg, D.K., C.A. Carlson, N.R. Bates, R.J. Johnson, A.F. Michaels, and A.F. Knap. 2001. Overview of the US JGOFS Bermuda Atlantic Time-series Study (BATS): A decade-scale look at ocean biology and biogeochemistry. Deep-Sea Research II 48: 1405-1447

http://bats.bios.edu/index.html

Smith L.D. and Johnson K.B. 2013. A guide to Marine Coastal Plankton and Marine Invertebrate Larvae Second Edition. Kendall Hunt Pub Co.

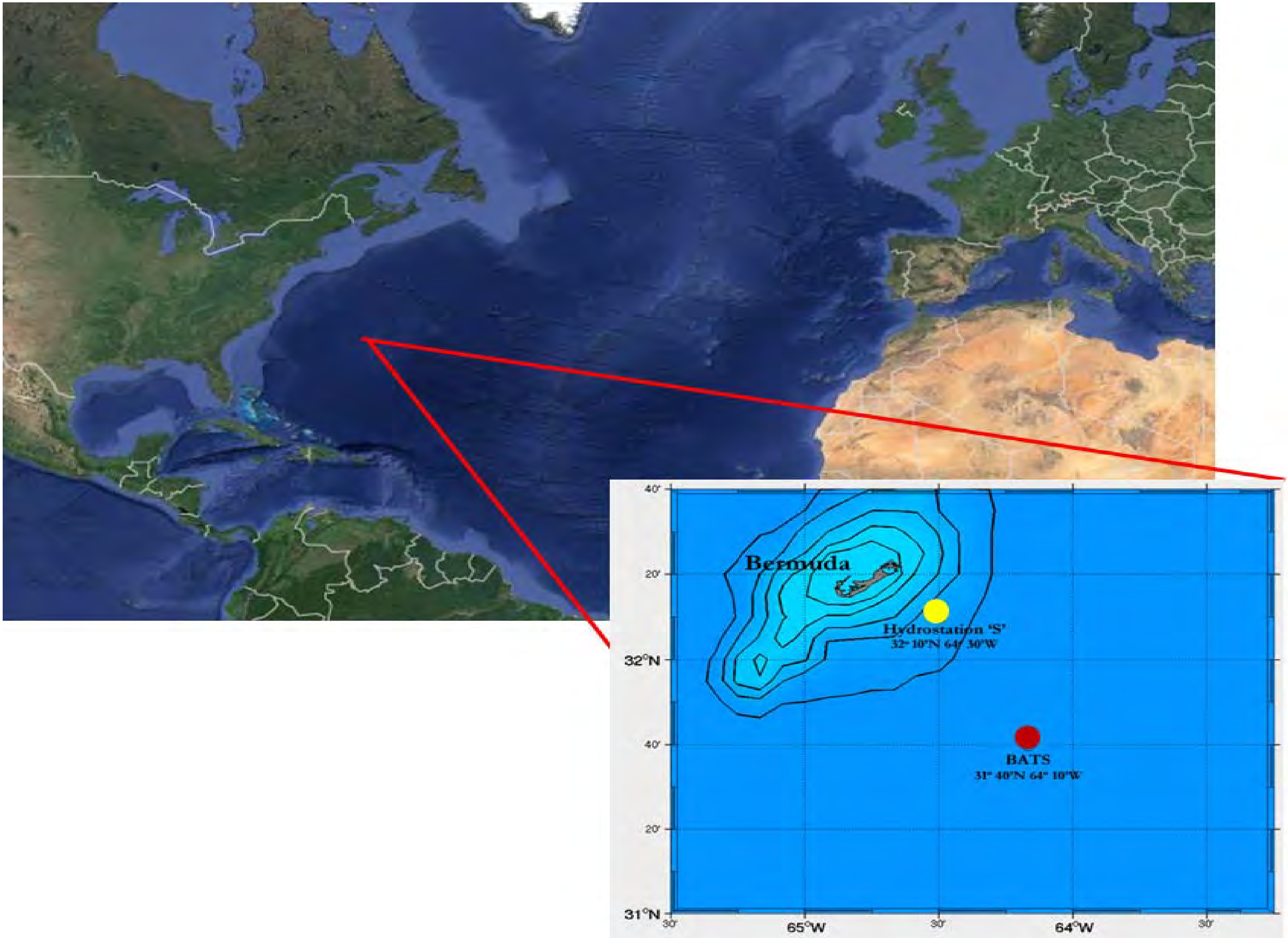
Nybakken J.W. 1982. Marine Biology Third Edition: Plankton and Plankton Communities Chapter. Harper & Row Publishers Inc.

This lesson plan is developed as part of a GK-12 project funded by the National Science Foundation under grant no. DGE-0840804 to the Virginia Institute of Marine Science, 2009-2014. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

A Day as a BATS (Bermuda Atlantic Time Series) Scientist

By Jami Ivory

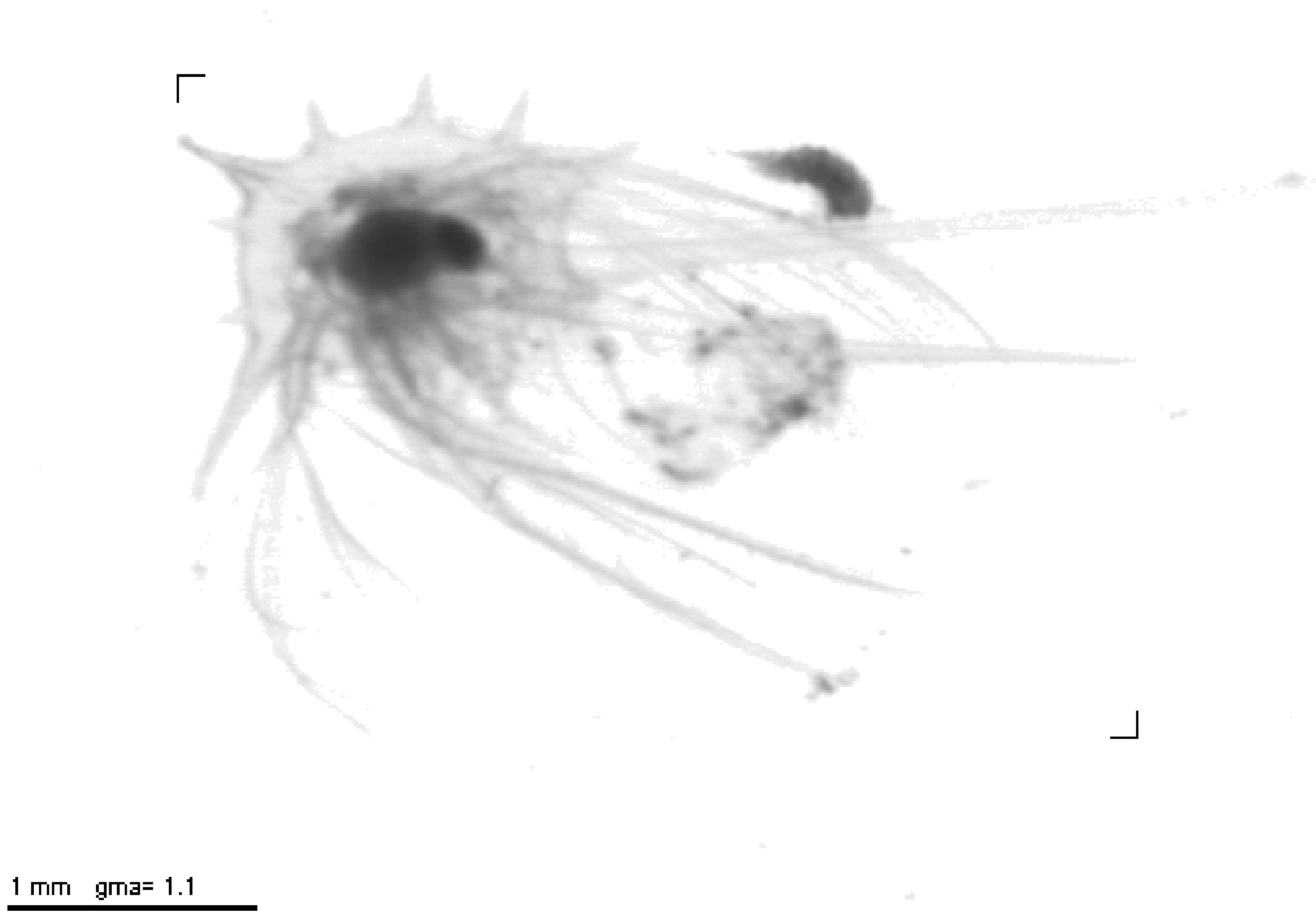
VIMS GK-12 Fellow 2013/14


Bermuda
Hydrostation 'S'
32° 10'N 64° 30'W
BATS
31° 40'N 64° 10'W
40'
20'
32°N
40'
20'
31°N
30'
65°W
30'
64°W
30'


R/V ATLANTIC EXPLORER
HSBC
Atlantic Explorer

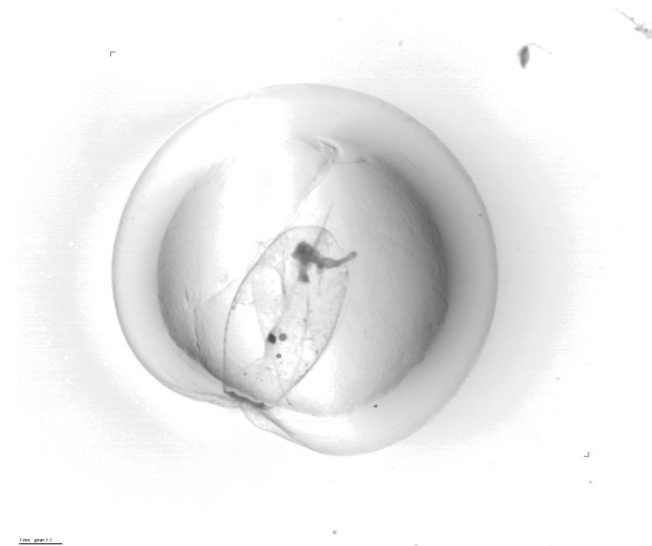
Amphipods

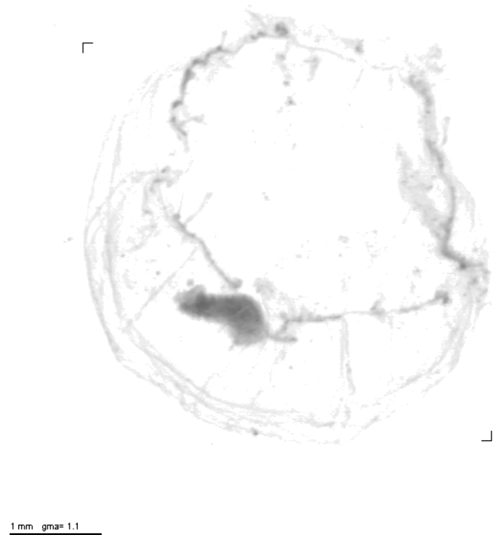
Barnacle nauplii

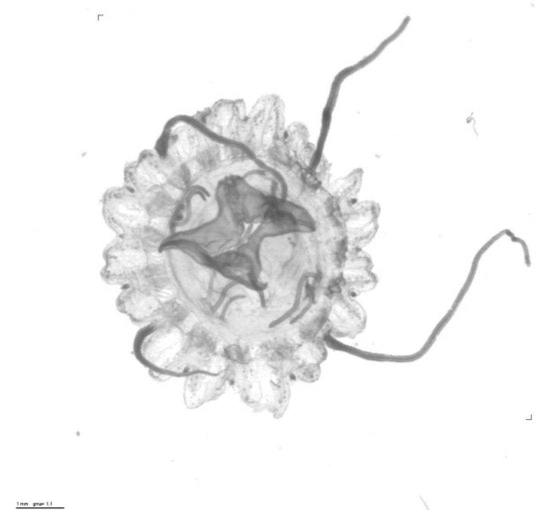


Chaetognatha

Jellyfish







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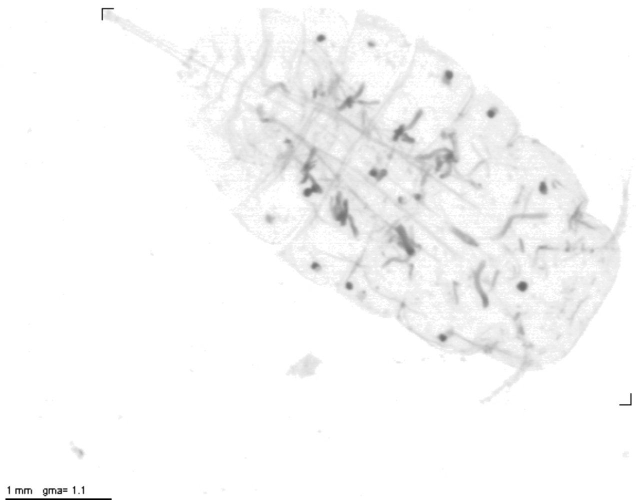

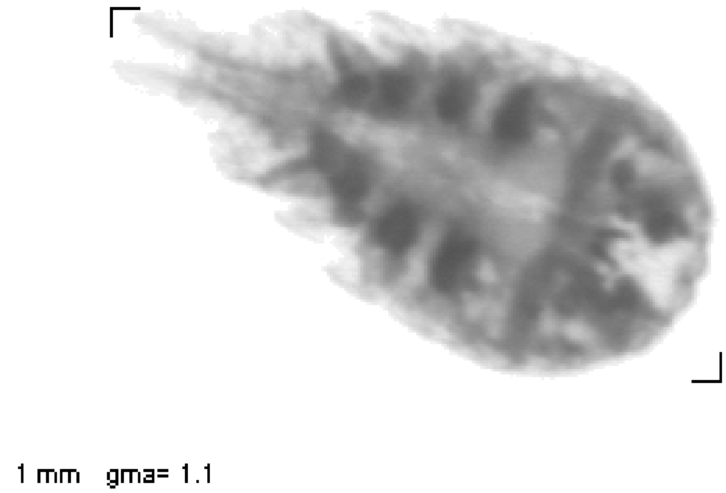

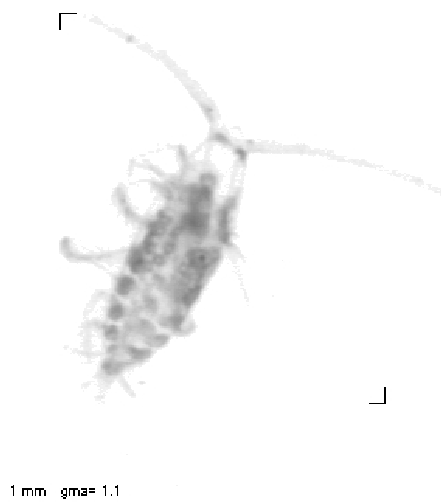

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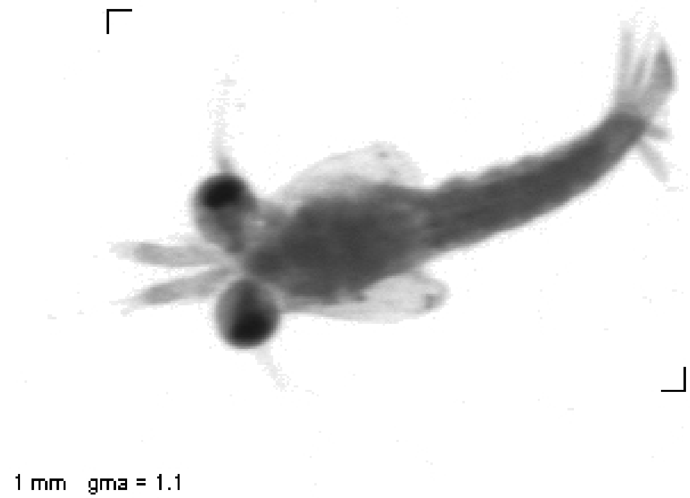
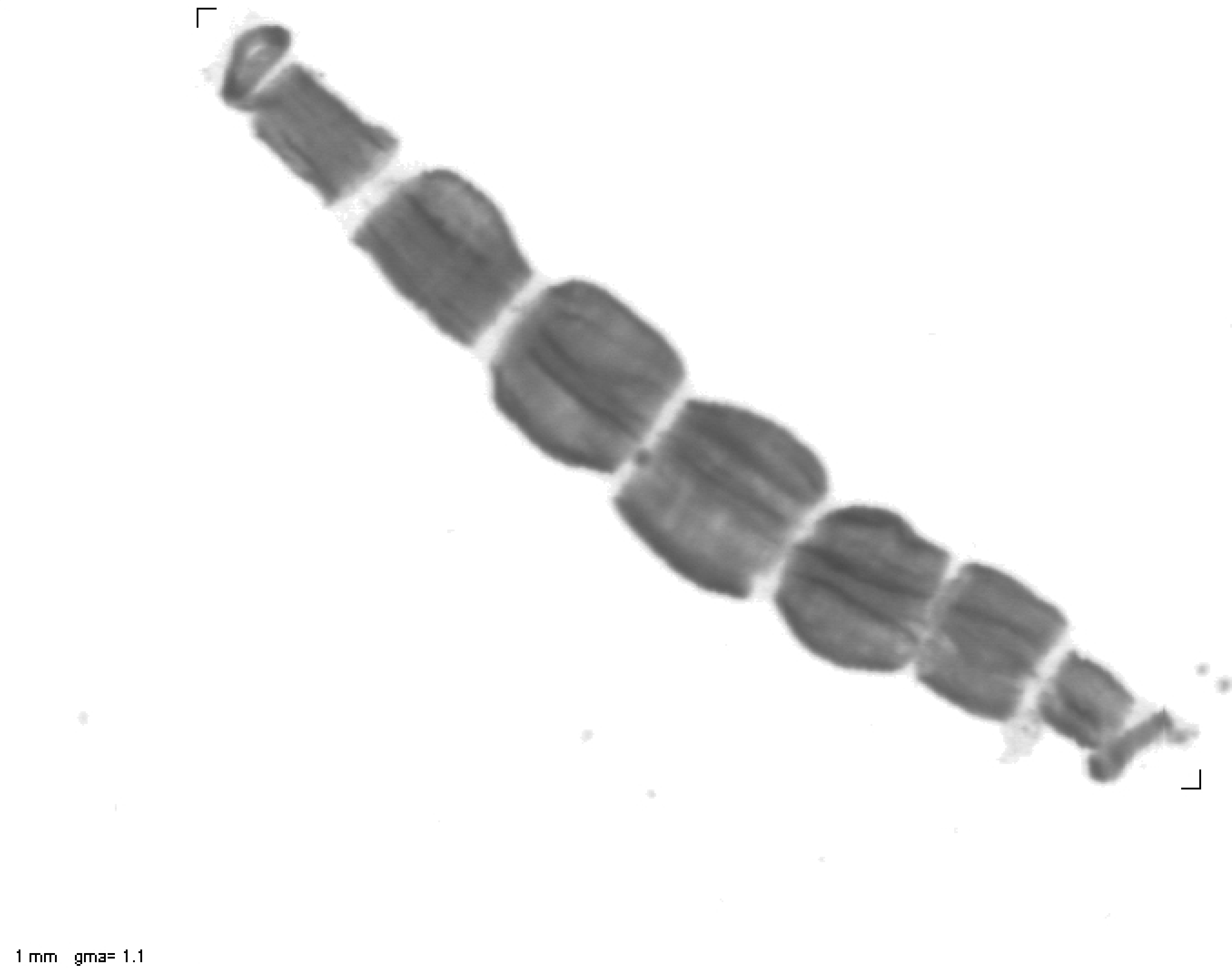
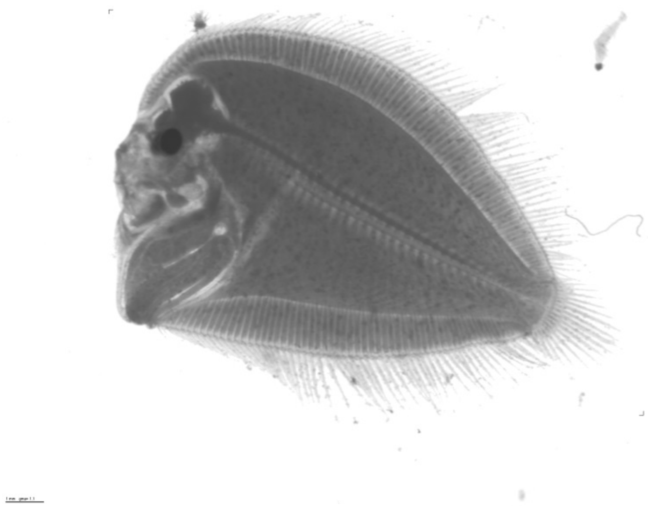


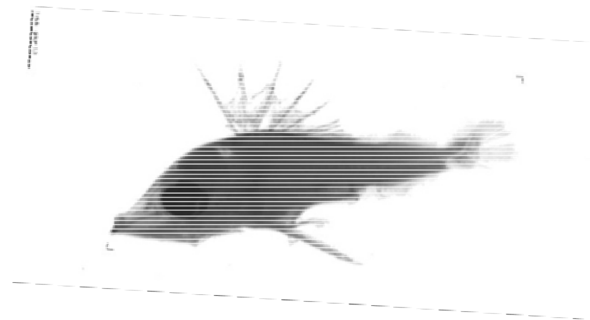
Doliolid

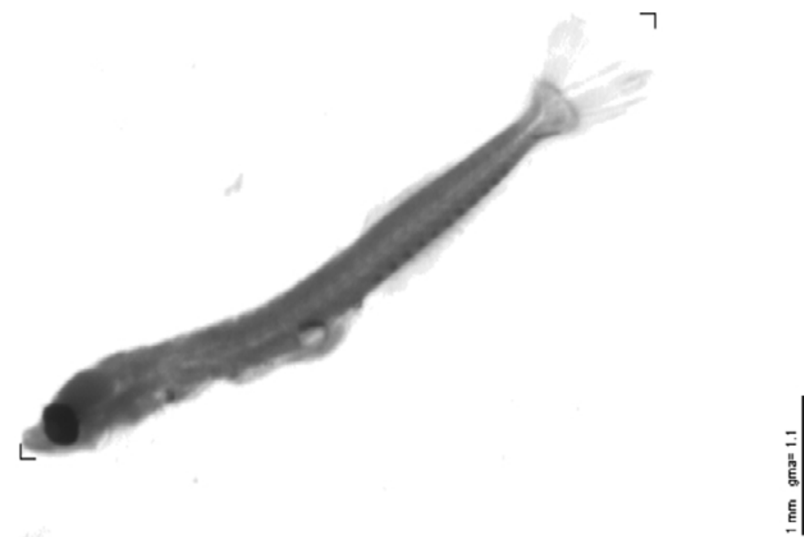


Lancelet

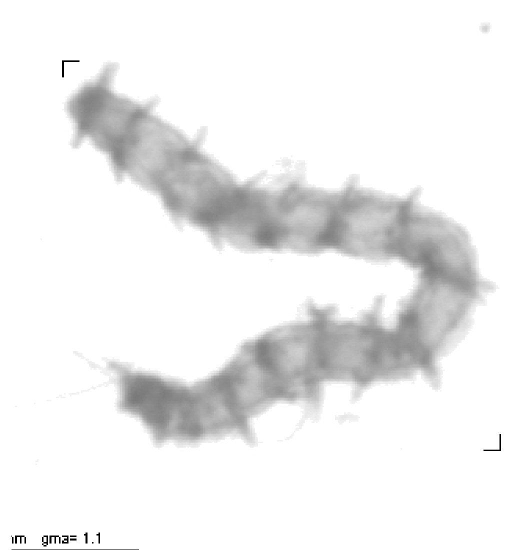
Fish larvae



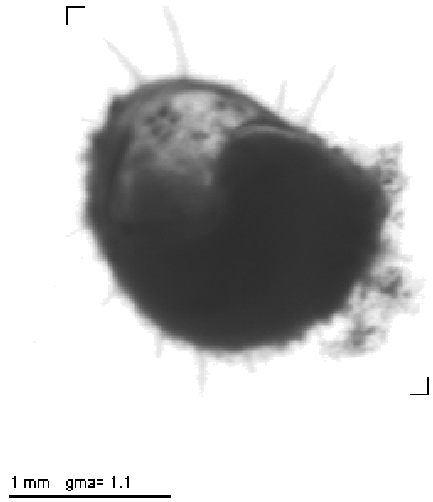


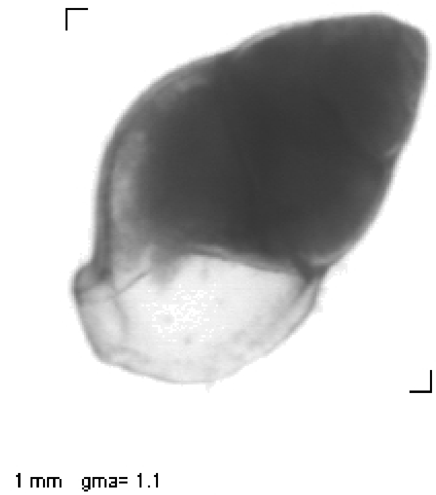


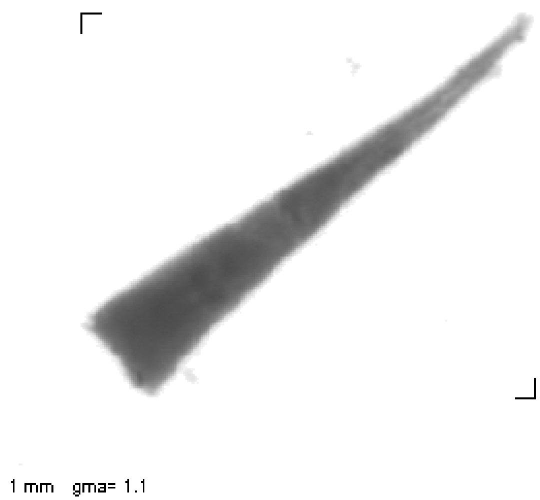
Polychaeta

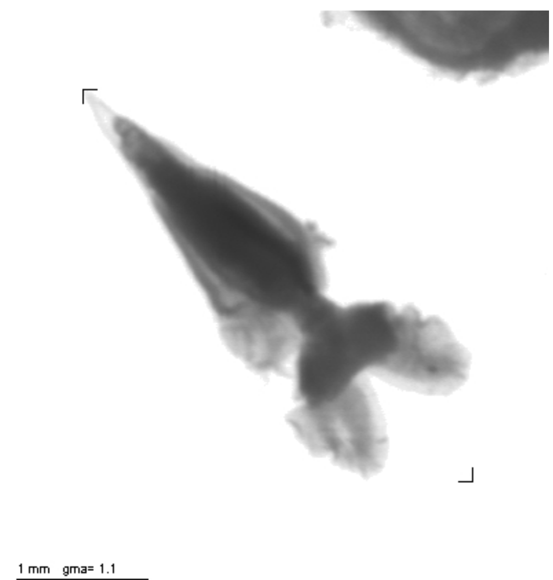


Pteropod (snail)



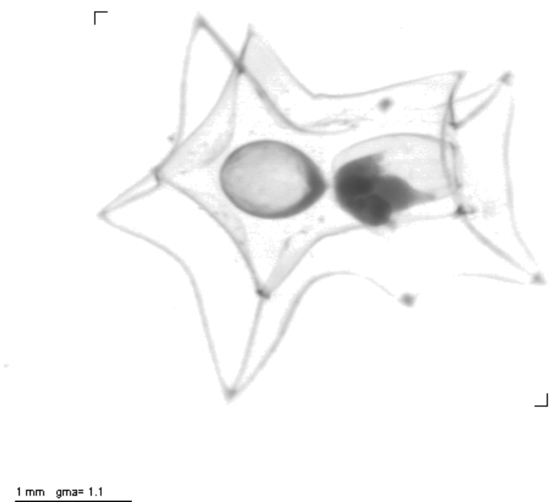


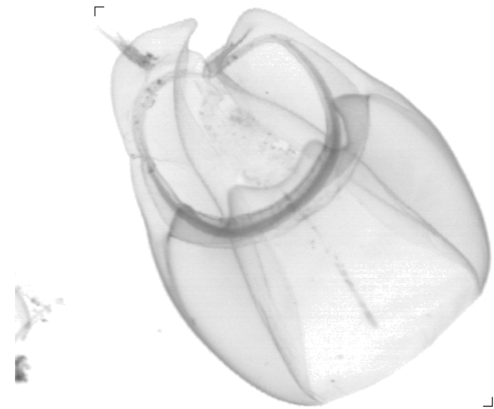


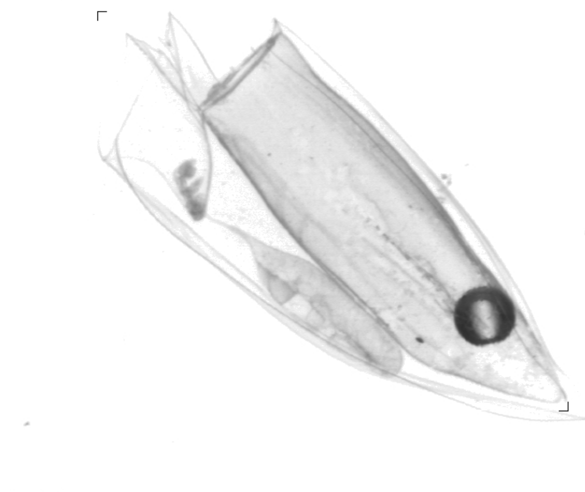


Salpa

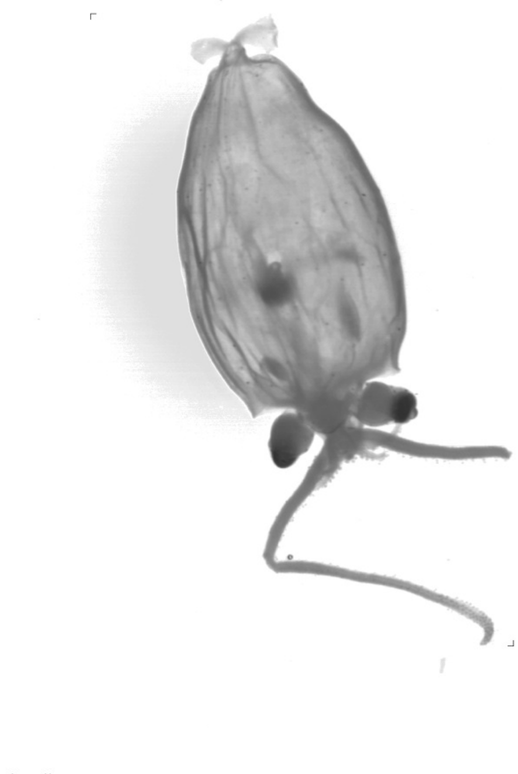
Siphonophora

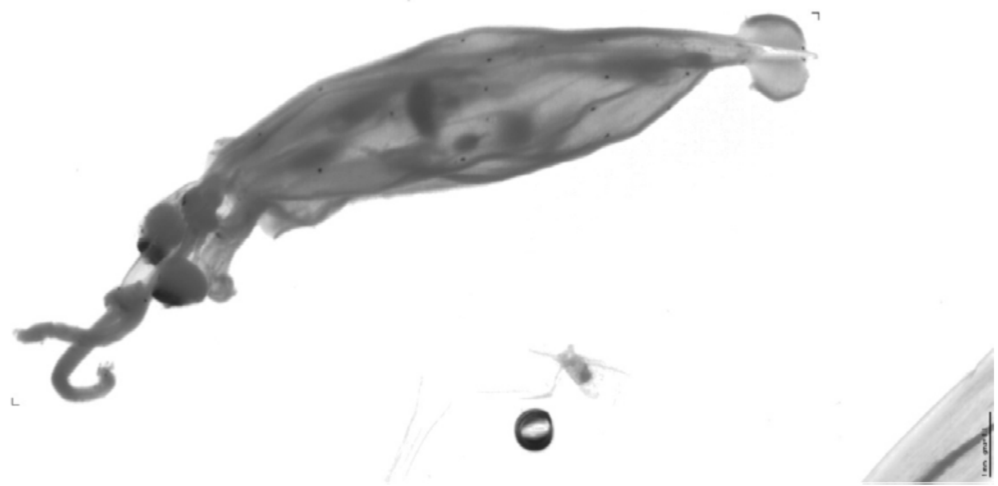




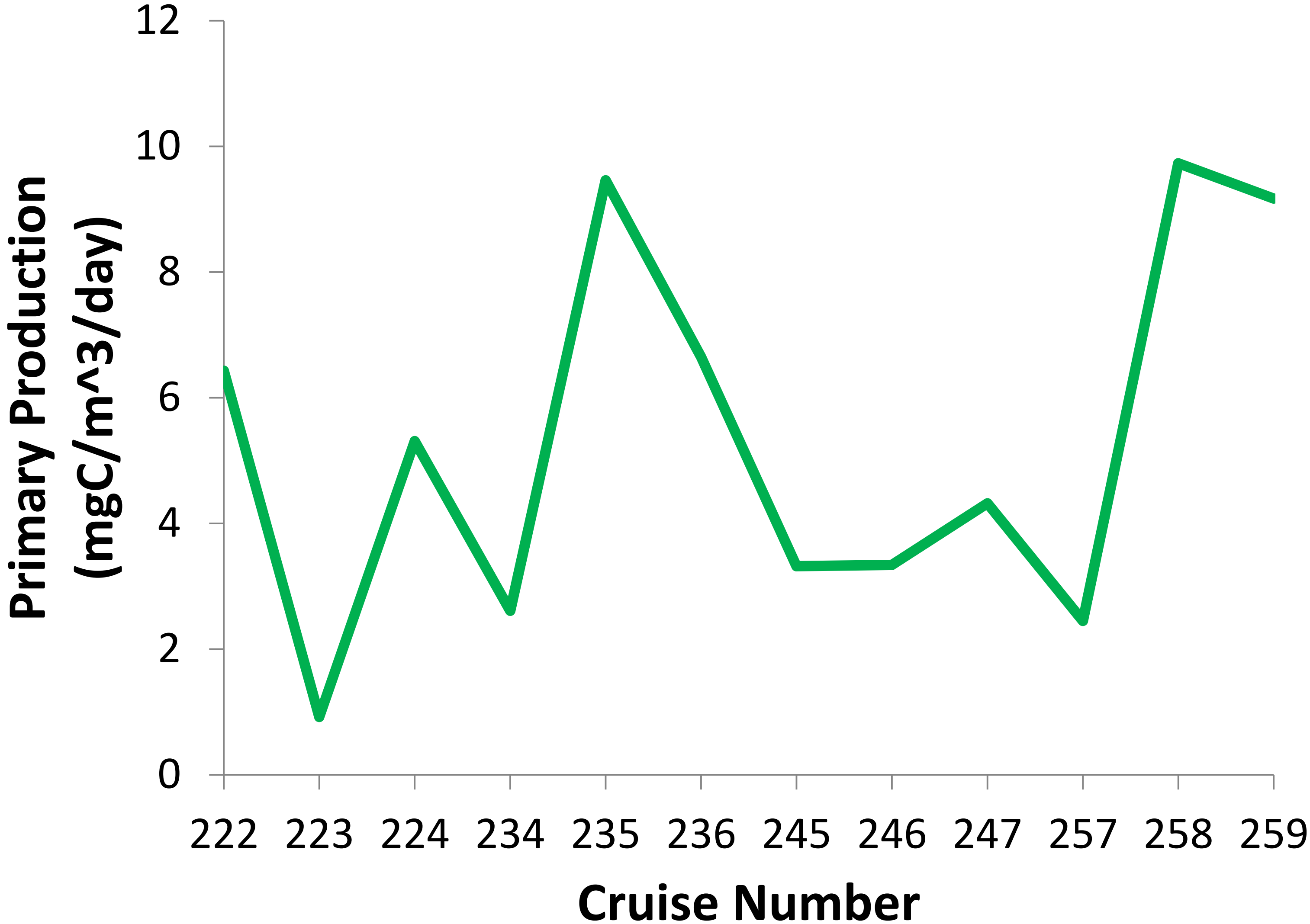


Squid

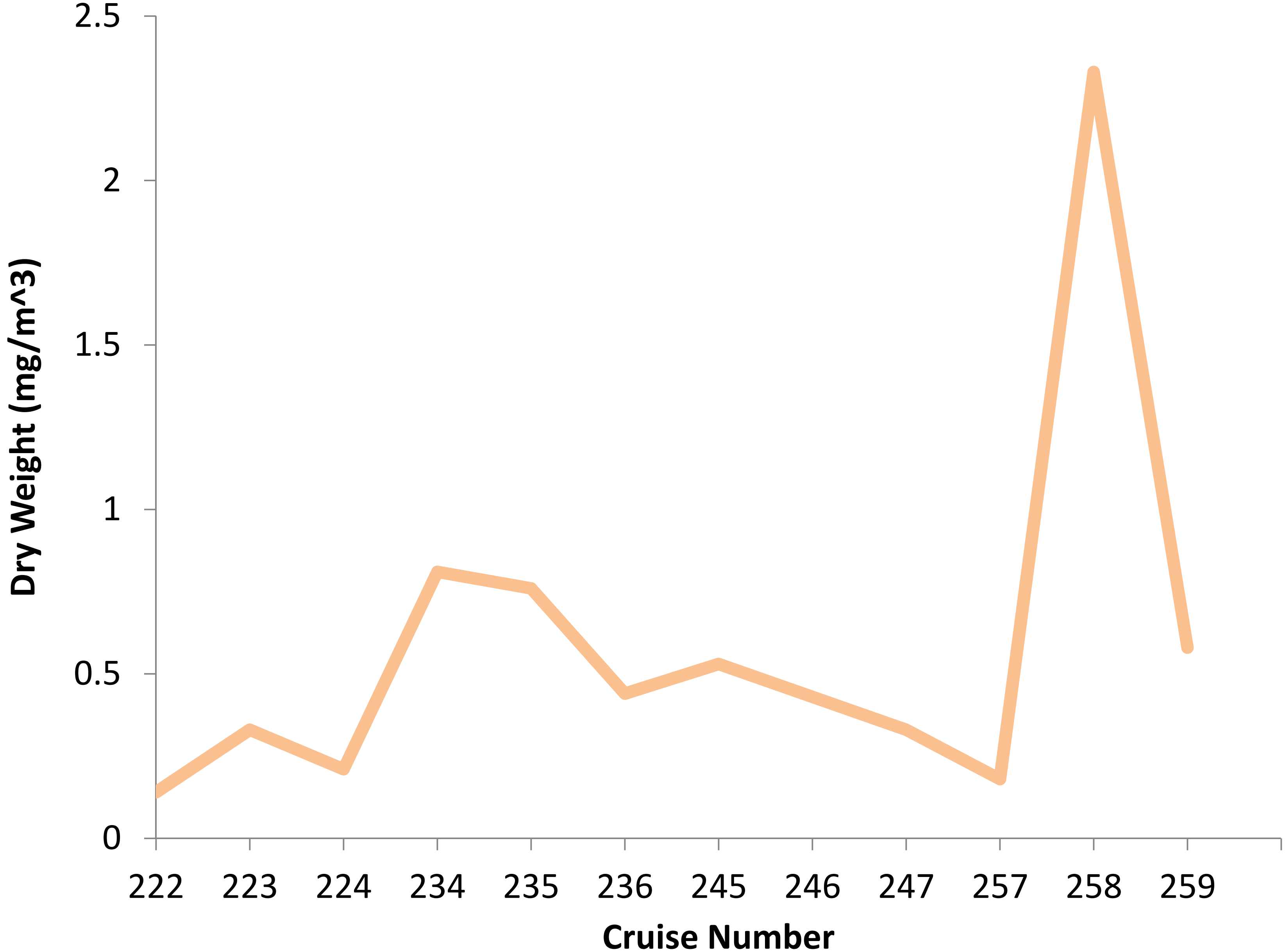




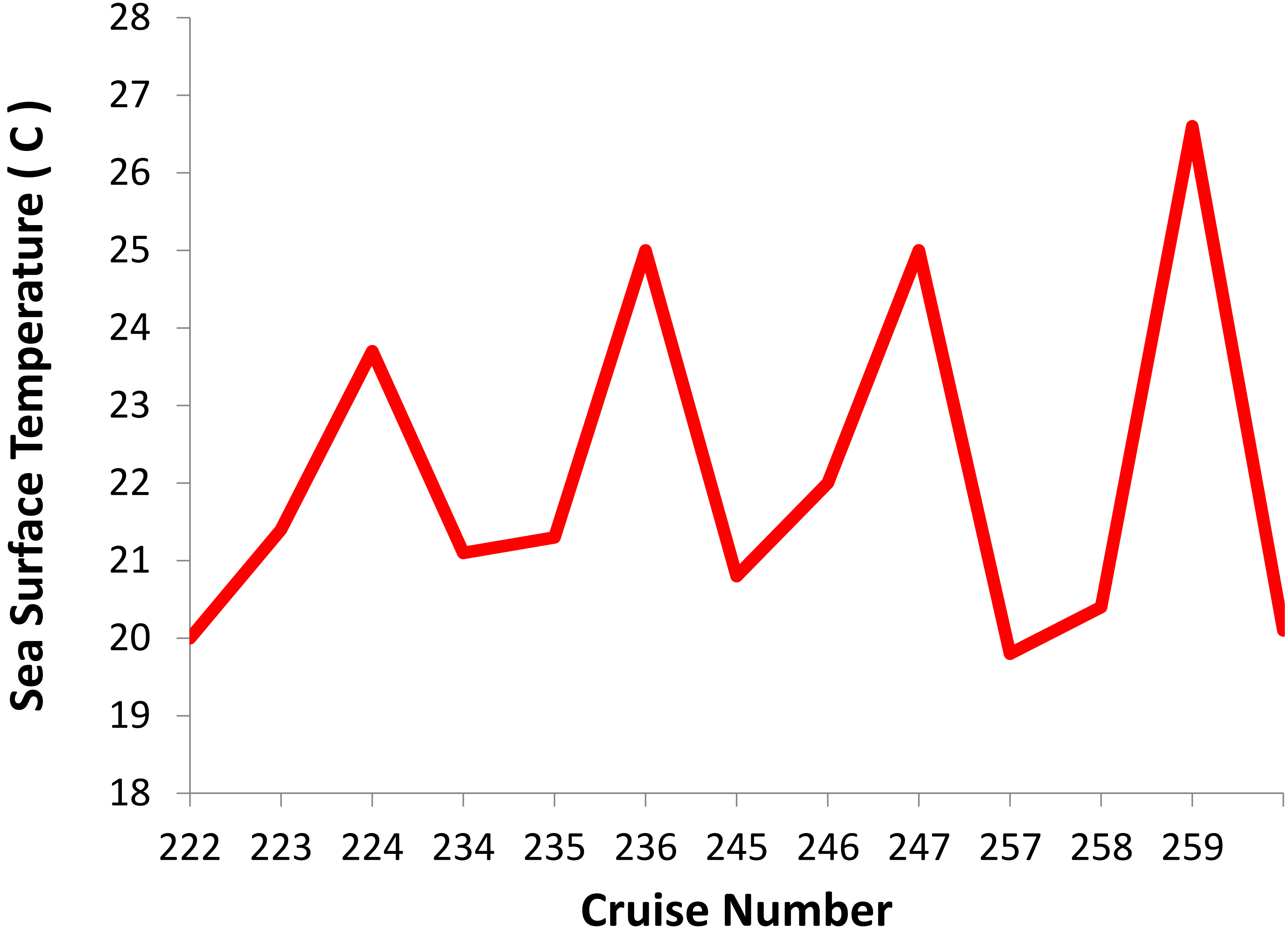
BATS Primary Production from 2007 to 2010

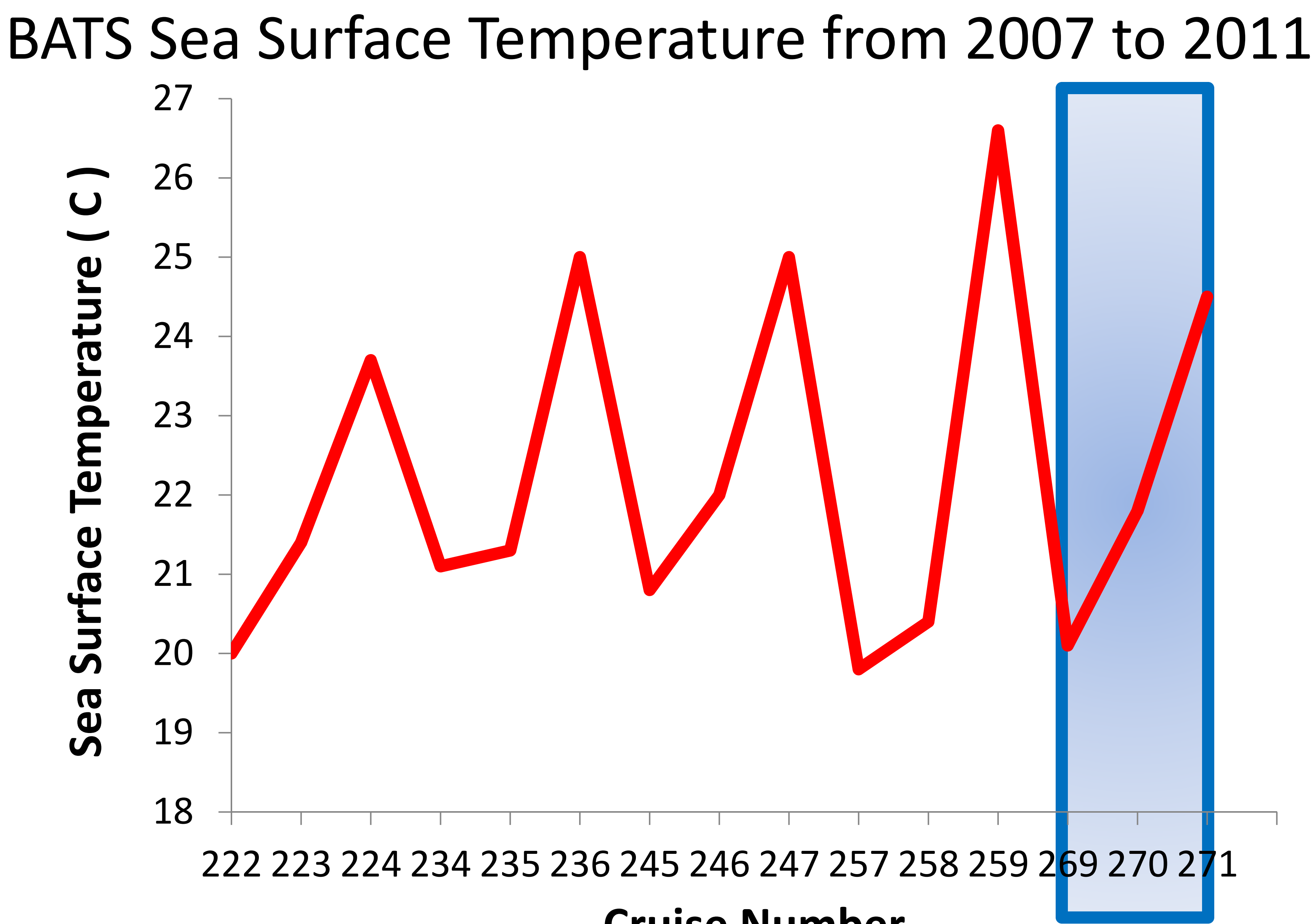


BATS Zooplankton Dry Weight from 2007 to 2010

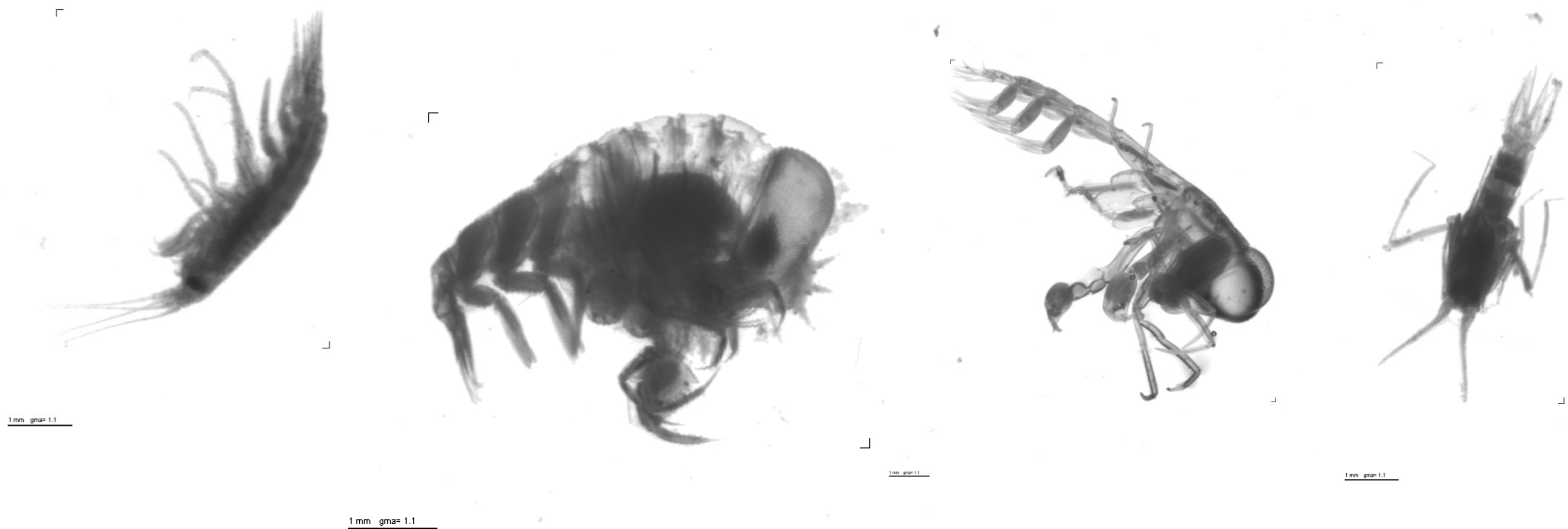


BATS Sea Surface Temperature from 2007 to 2010

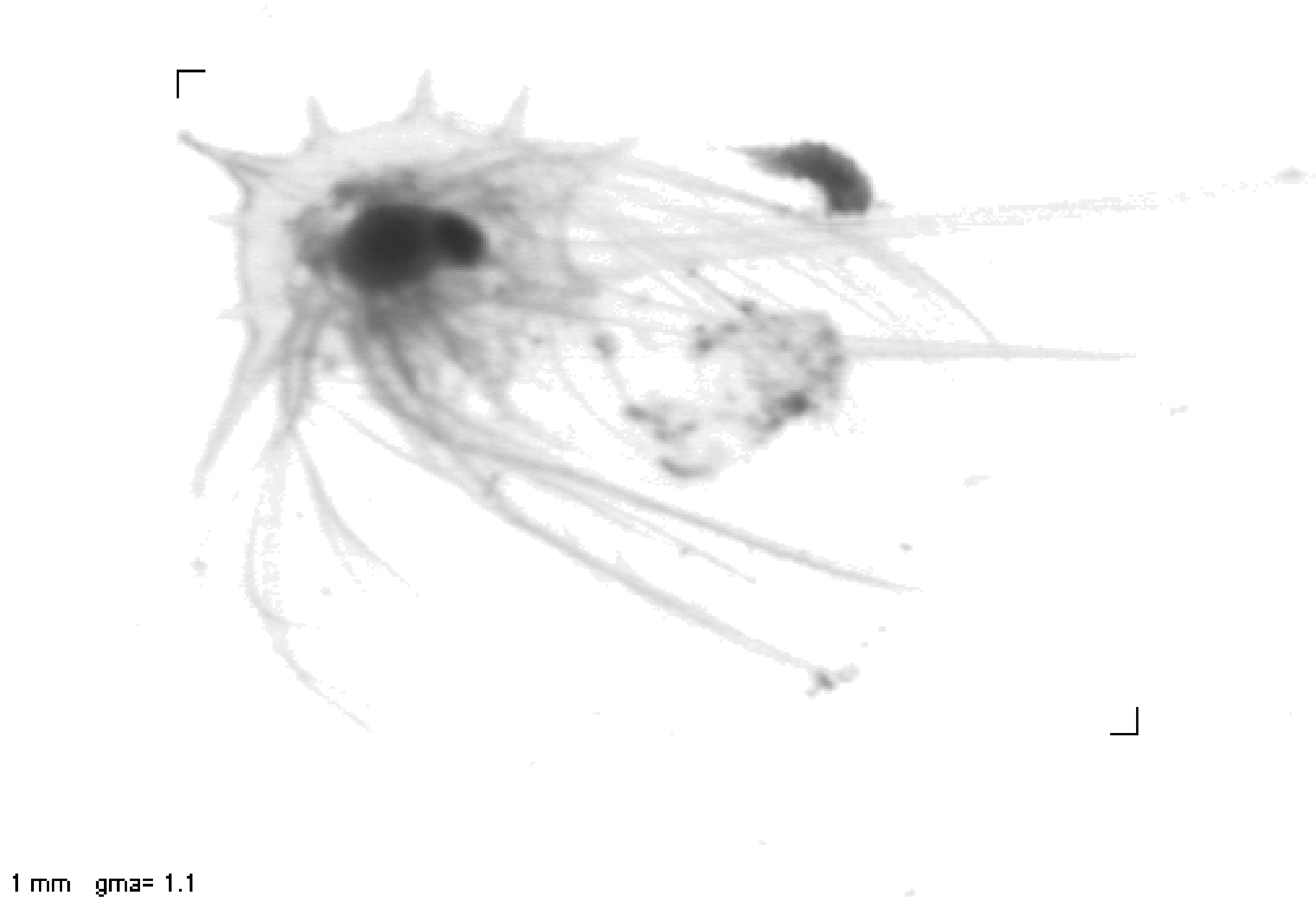



BATS Sea Surface Temperature from 2007 to 2011
Sea Surface Temperature (C)
27
26
25
24
23
22
21
20
19
18
222 223 224 234 235 236 245 246 247 257 258 259 269 270 271
Cruise Number

Amphipods

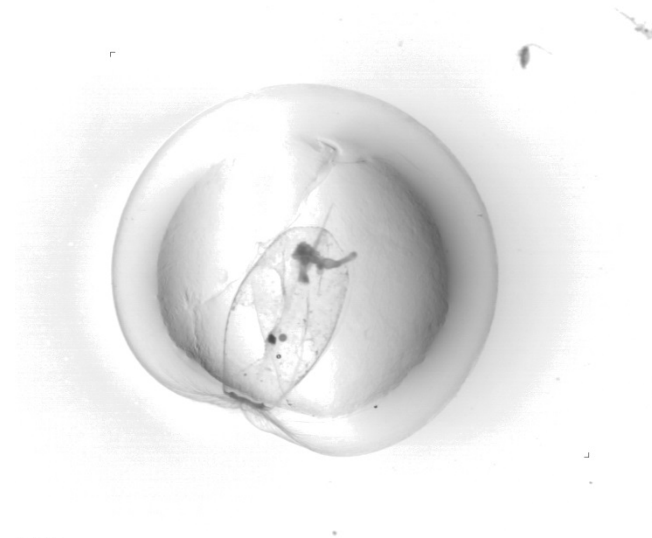


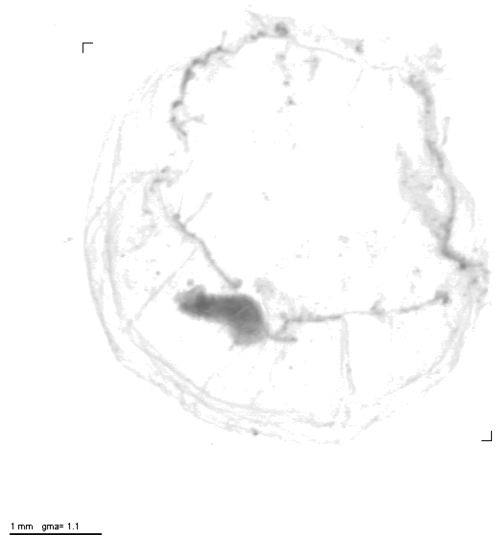
Barnacle nauplii

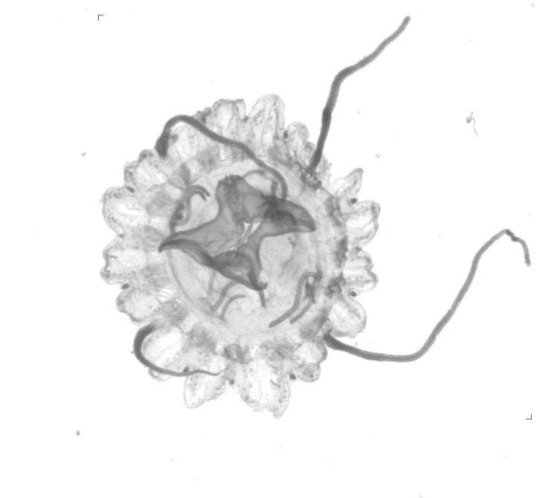


Chaetognatha

Jellyfish







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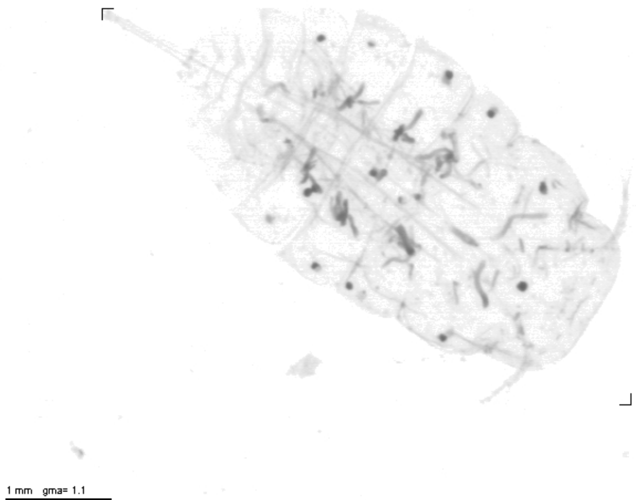
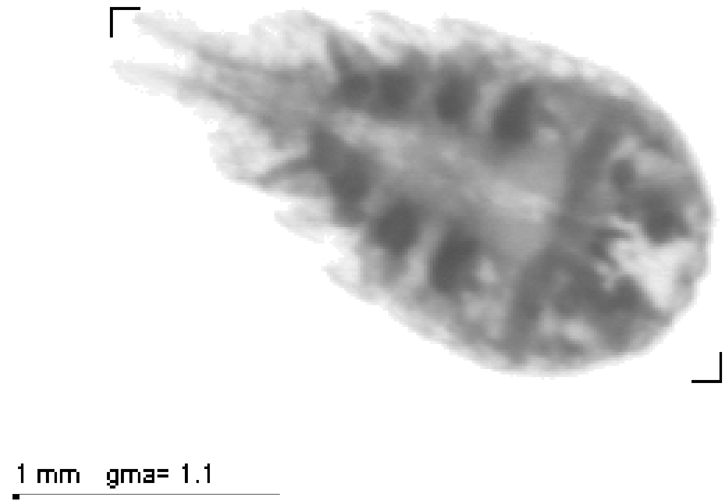
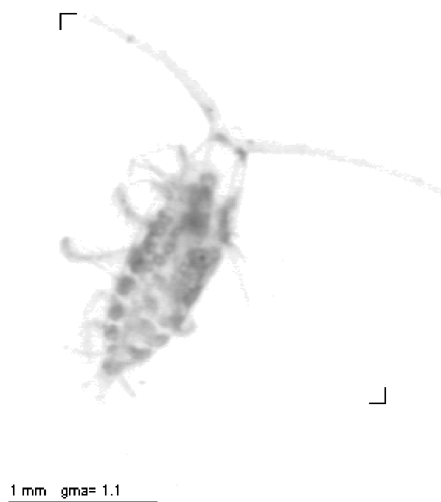
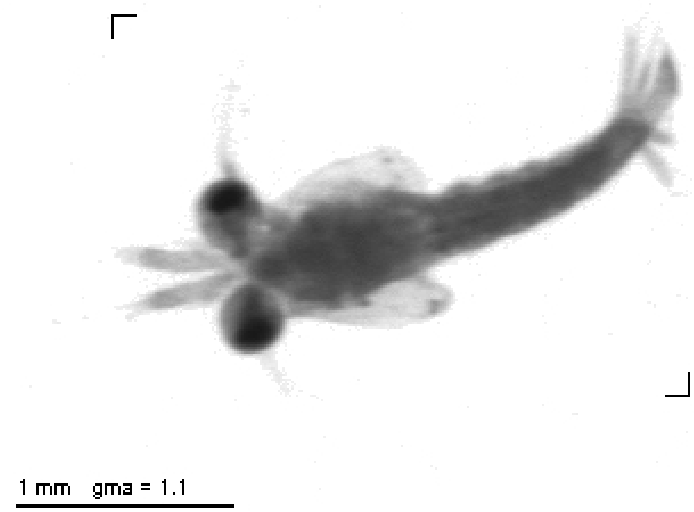






Decapod



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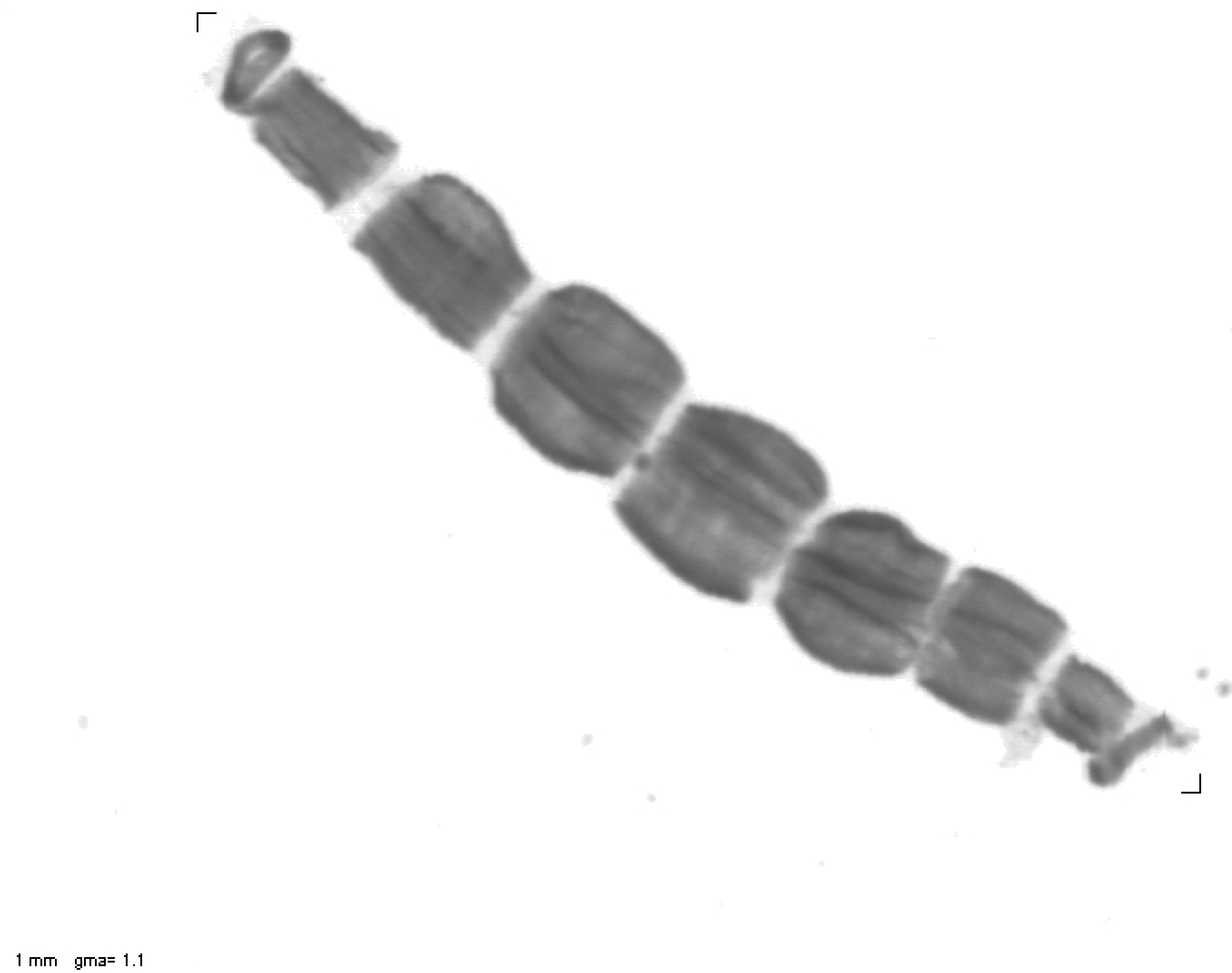
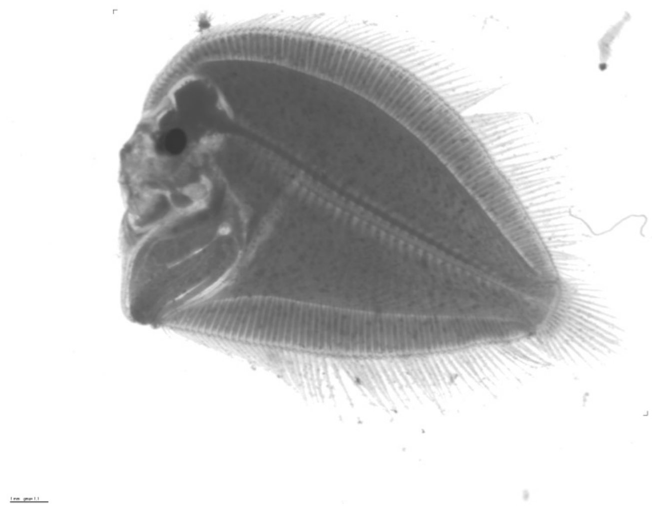
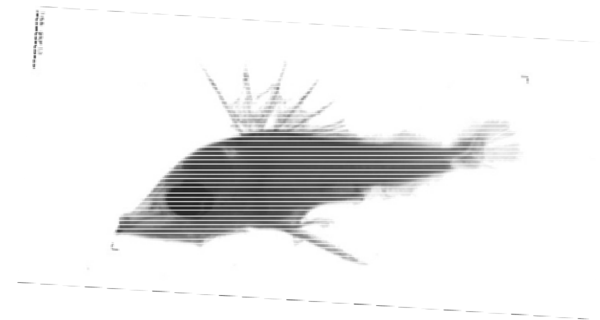
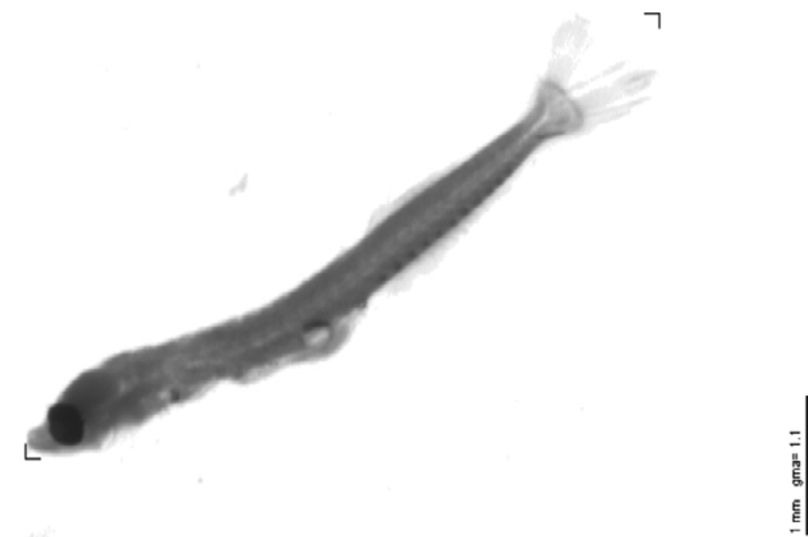


Lancelet

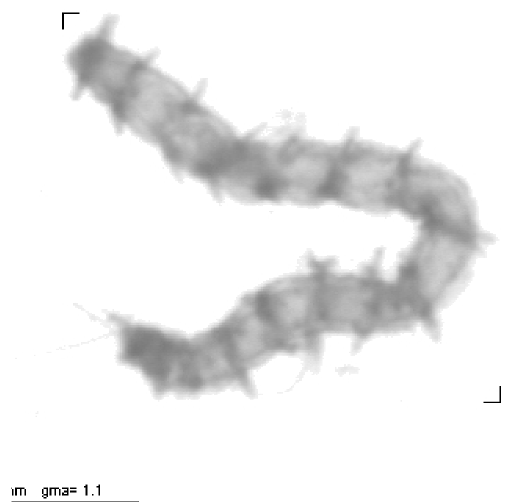
Fish larvae



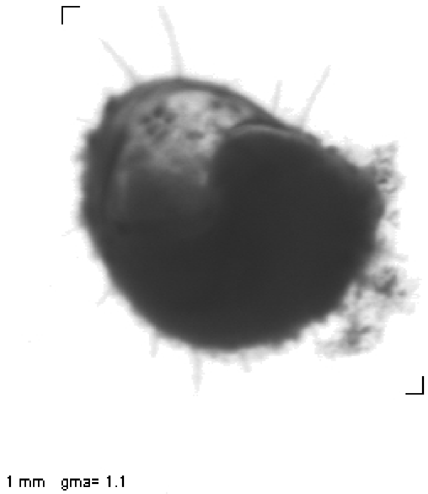


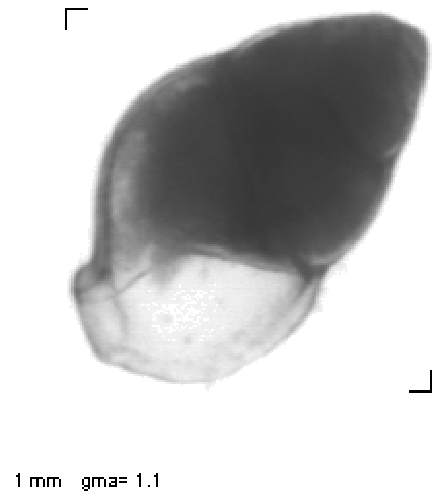


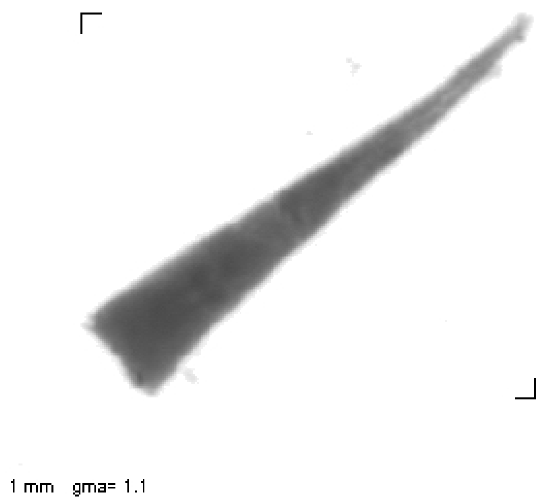
Polychaeta

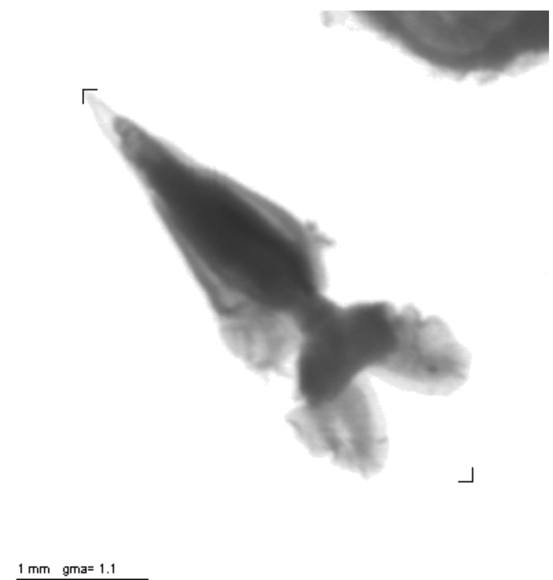


Pteropod (snail)



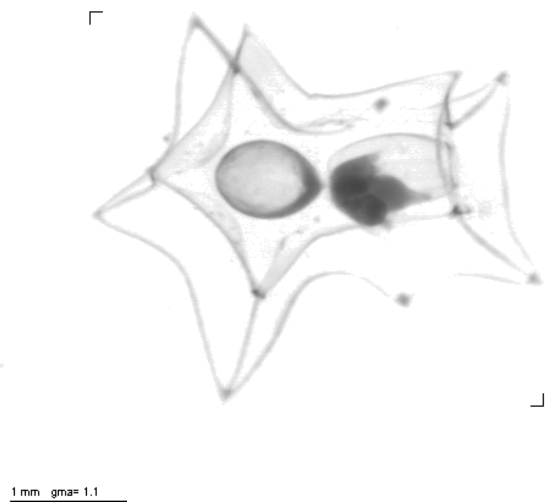


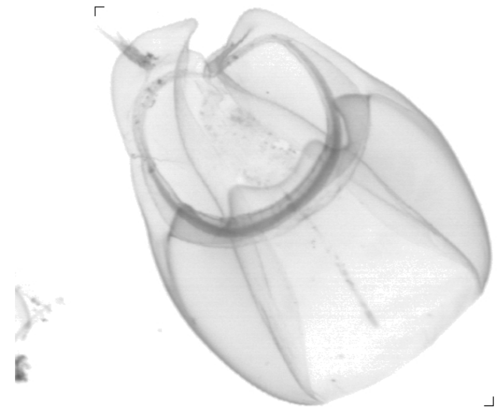


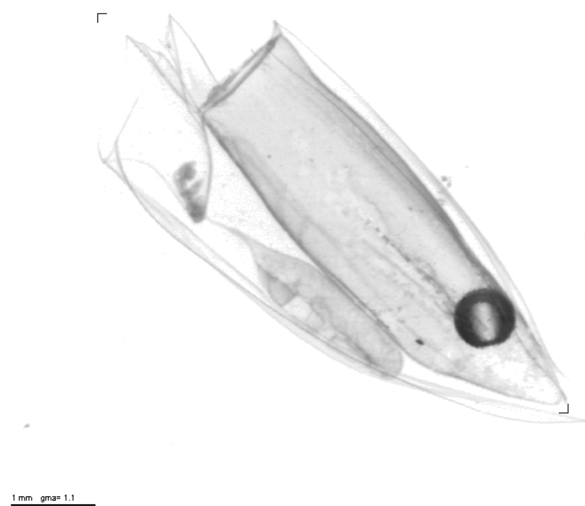


Salpa

Siphonophora







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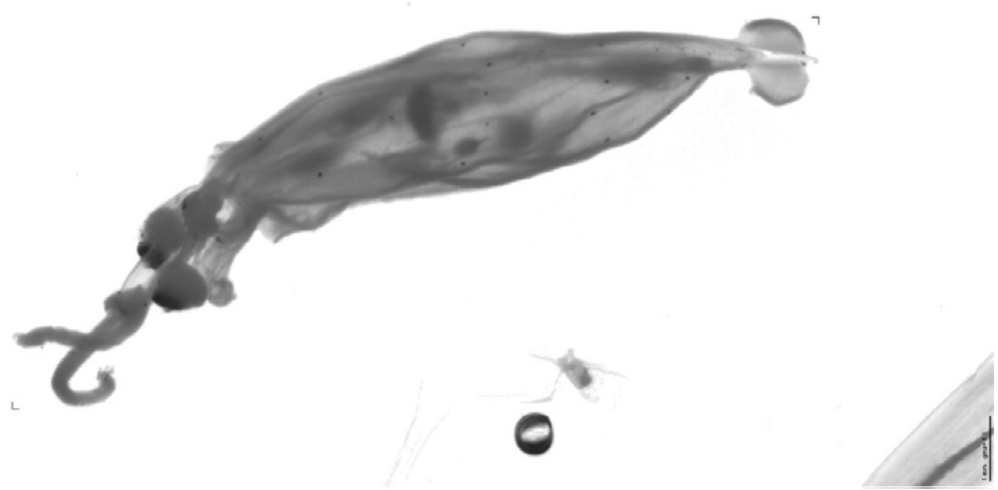

Cruise #

Identification	Count
amphipod	
barnacle nauplii	
chaetognatha	
jellyfish	
copepod	
decapod	
doliolid	
lancelet	
fish larvae	
polychaeta	
pteropod (snail)	
salpa	
squid	

Cruise #

Identification	Count
amphipod	
barnacle nauplii	
chaetognatha	
jellyfish	
copepod	
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doliolid	
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Cruise #

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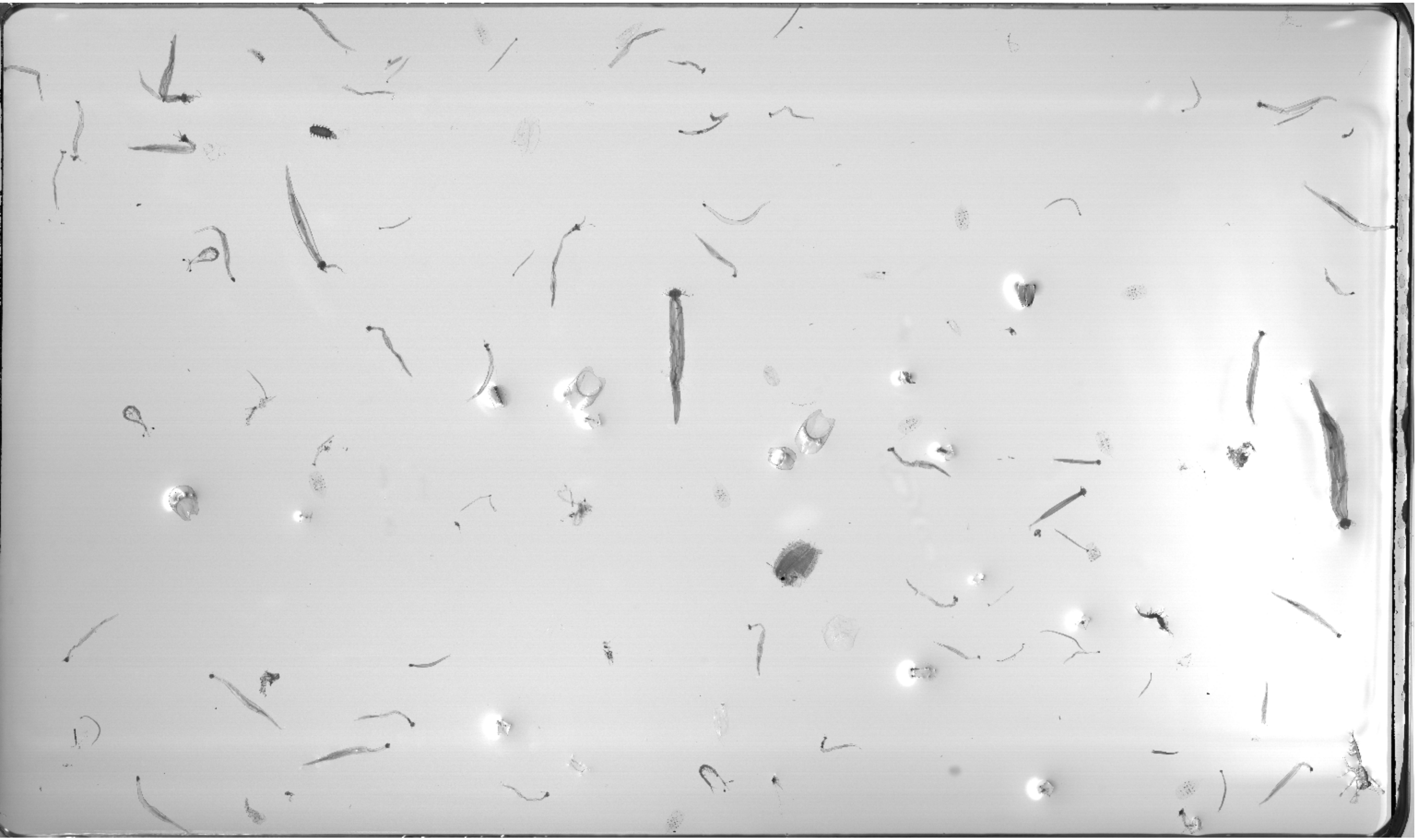
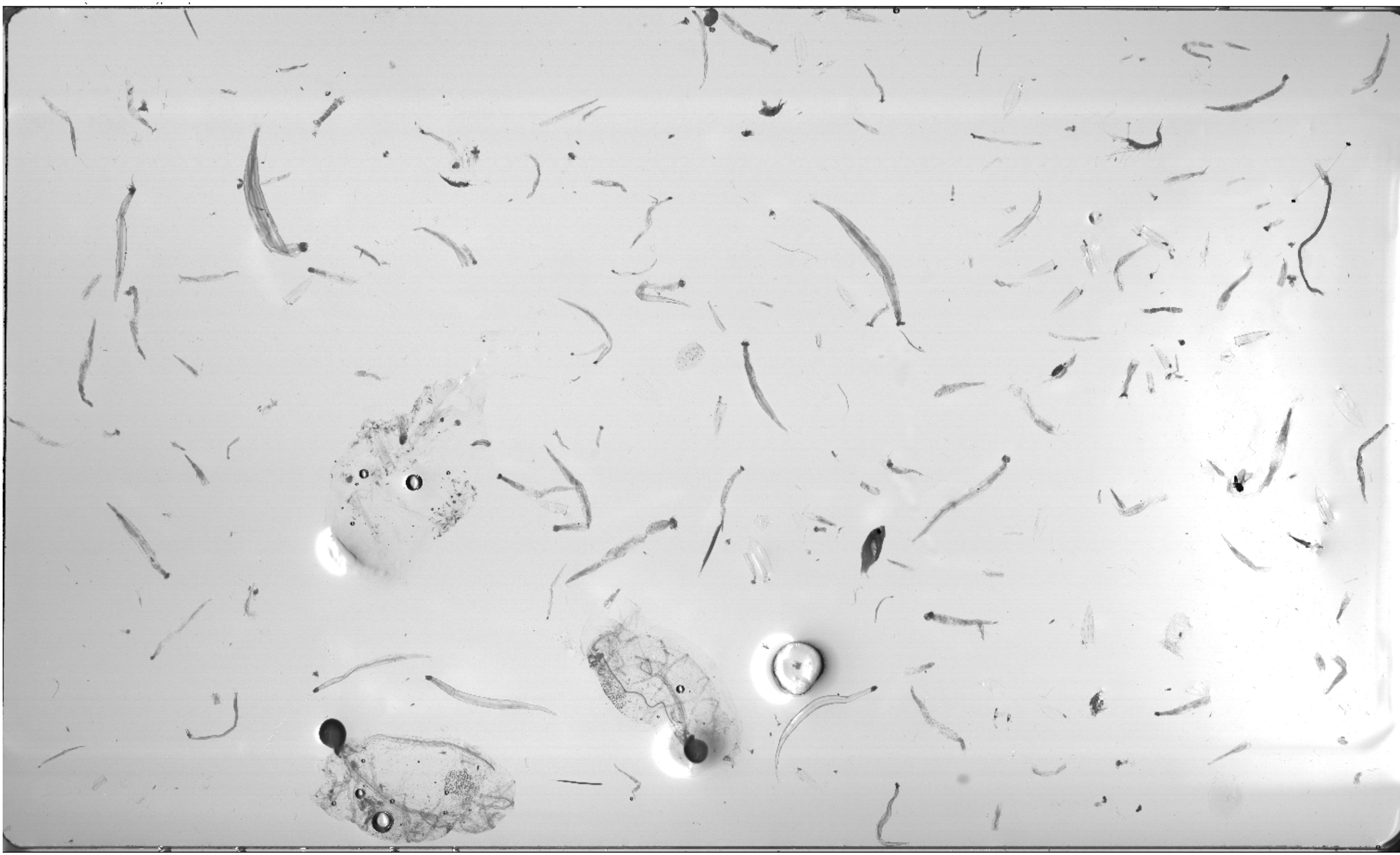
jellyfish	
copepod	
decapod	
doliolid	
lancelet	
fish larvae	
polychaeta	
pteropod (snail)	
salpa	
squid	

Cruise #222 **4/13/2007**



Cruise #223 **5/14/2007**

Cruise #224 6/18/2007



Cruise #234 **4/14/2008**

Cruise #235　　　**5/28/2008**

Cruise #236 **6/29/2008**

Cruise #245 **4/14/2009**

Cruise #246 5/14/2009

Cruise #247 6/9/2009

Cruise #257 **4/20/2010**

Cruise #258 5/12/2010

Cruise #259 6/21/2010

Sea Level Rise in Coastal Virginia

Developed by Samuel J. Lake

As part of the 2014 Virginia Sea Grant
Marine Advisory Program Summer Course
with support from the
Center for Coastal Resources Management and the
Virginia Institute of Marine Science, College of William & Mary

Grade Levels: Middle and High School

- Life Science
- Earth Science
- Environmental Science
- Marine Biology / Marine Science

Time Required: 2 days (total of 120 minutes)

Main Concept:

This activity is designed to introduce students to the global, regional, and local processes driving sea level rise (SLR) in coastal Virginia. An introductory presentation, demos, and video clips are used to reinforce the primary causes of SLR, which is followed by an interactive activity where students calculate the surface area of Virginia Beach that will be inundated under 3 SLR scenarios. Finally, students develop their own mitigation strategies, present them to the class, and learn what local and international groups are doing to overcome these issues.

Learning Objectives:

- Students will be able to utilize previously learned material (vocabulary, concepts, etc.) related to SLR: ocean heat content, glacial melting, isostatic glacial rebound, subsidence, groundwater removal, wetland decomposition, and comet impact craters.
- Students will connect current SLR projections to localities in Virginia and calculate how much land will be inundated in Virginia Beach.
- Student will develop their own mitigation strategies and present them to the class.

VA Standards of Learning addressed: (SOLs are at **www.doe.virginia.gov/testing/sol/standards_docs**)

Life Science

LS.6.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which

b) precise and approximate measurements are recorded;
c) scale models are used to estimate distance, volume, and quantity;
g) data are collected, recorded, analyzed, and reported using metric measurements and tools;
h) data are analyzed and communicated through graphical representation;
i) current applications are used to reinforce science concepts.

LS.6.3 The student will investigate and understand the role of solar energy in driving most natural processes within the atmosphere, the hydrosphere, and on Earth's surface. Key concepts include

a) Earth's energy budget;

LS.6.5 The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include

d) the ability of large bodies of water to store thermal energy and moderate climate;
f) the importance of protecting and maintaining water resources.

LS.6.7 The student will investigate and understand the natural processes and human interactions that affect watershed systems. Key concepts include

d) wetlands;
e) estuaries;
f) major conservation, health, and safety issues associated with watersheds;

LS.6.9 The student will investigate and understand public policy decisions relating to the environment. Key concepts include

d) the mitigation of land-use and environmental hazards through preventive measures; and
e) cost/benefit tradeoffs in conservation policies.

Earth Science

ES.1 The student will plan and conduct investigations in which

a) volume, area, mass, elapsed time, direction, temperature, pressure, distance, density, and changes in elevation/depth are calculated utilizing the most appropriate tools;
b) technologies, including computers, probeware, and geospatial technologies, are used to collect, analyze, and report data and to demonstrate concepts and simulate experimental conditions;
c) scales, diagrams, charts, graphs, tables, imagery, models, and profiles are constructed and interpreted;

Earth Science (cont.)

ES.2 The student will demonstrate an understanding of the nature of science and scientific reasoning and logic. Key concepts include

a) explains and predicts the interactions and dynamics of complex Earth systems;

ES.10 The student will investigate and understand that oceans are complex, interactive physical, chemical, and biological systems and are subject to long- and short-term variations. Key concepts include

a) physical and chemical changes related to tides, waves, currents, sea level and ice cap variations, upwelling, and salinity variations;
b) importance of environmental and geologic implications;
c) systems interactions;
e) economic and public policy issues concerning the oceans and the coastal zone including the Chesapeake Bay.

Background Information for Teacher:

Please see related reading material and PowerPoint notes for background information.

Vocabulary:

- Global Sea Level Rise: is an alteration to worldwide sea level heights, due to changes in the volume of water in the ocean or changes in the volume of an ocean basin.
- Local Sea Level Rise: is the height of the sea with respect to a land benchmark, averaged over a period of time (months to years) that is long enough to smooth out fluctuations caused by waves and tides.
- Ocean Heat Content: is the heat stored in the ocean. Changes in the ocean heat content play an important role in the sea level rise, because of thermal expansion.
- Thermal expansion: is a change in volume in response to a change in temperature, through heat transfer.
- Glacial Melting: the loss of ice on land due to natural and human induced causes.
- Isostatic Glacial Rebound: is the rise of land masses that were depressed by the weight of glaciers during the last glacial period, and the associated lowering of corresponding regions, through a process known as isostasy.
- Isostasy**:** refers to the state of gravitational equilibrium between the Earth's lithosphere and asthenosphere such that the tectonic plates "float" at an elevation which depends on their thickness and density.
- Subsidence: is the downward motion of the Earth's surface as it shifts relative to a reference point, such as sea level.
- Wetland Decomposition: the process of organic material (peat) breaking down through aerobic and anaerobic respiration. This process is faster under oxygen-rich (aerobic) conditions following wetland drainage for development, housing and agricultural purposes.
- Groundwater Related Subsidence: is the downward movement of land resulting from the extraction of water located in the spaces between soil particles.

Provided Materials:

- Sea Level Rise PowerPoint Presentation (and PDF)
- Sea Level Rise Worksheet (Word Document and PDF)
- Sea Level Rise Activity PowerPoint File (and PDF) – Maps of Virginia Beach
- Sea Level Rise Excel File – Tables, calculations, and accompanying graphs.
- *Scientific American* Article – 'What Does the U.S. Look Like after 3 Meters of Sea Level Rise?'
- *Related Reading Material*
    - Boon, J. D. 2012. Evidence of Sea Level Acceleration at U.S. and Canadian Tide Stations, Atlantic Coast, North America. *Journal of Coastal Research*
    - MD: Updating Maryland's Sea Level Rise Projections
    - USGS: Land Subsidence and Relative Sea-Level Rise in the Southern Chesapeake Bay Region
    - VIMS: Chesapeake Bay Land Subsidence and Sea Level Change: An Evaluation of Past and Present Trends and Future Outlook
    - VIMS: Planning for Sea Level Rise and Coastal Flooding
    - VIMS: Eastern Shore Seawater Laboratory
    - VIMS: Ernesto: Anatomy of a Storm Tide

Lesson Procedure:

Day 1

- Set-up: 20 minutes
- Introduction to SLR: 30 minutes with demos
- SLR Activity (Virginia Beach Maps): 30 minutes
- Follow up Discussion on SLR in Coastal Virginia: 10 minutes
- Group Discussions of Mitigation Plans: Time Permitting

Homework

- Read *Scientific American* article
- Finish Worksheet
- Prepare for Day 2

Day 2

- Set-up: 5 minutes
- Groups Diagram Mitigation Plans: 20 minutes
- Groups Present Mitigation Plans to Class: 30 minutes
- Presentation on Adaptation Strategies: 10 minutes
- Reflections/Closure (wrap up): 5 minutes
- Clean-up: 5 minutes

1. **Required Material & Supplies, A/V/Tech Support**
   - Computer and Projector
   - SLR PowerPoint
   - SLR Excel File
   - SLR Worksheets
   - *Scientific American* Article
   - SLR Activity (Virginia Beach Maps) - printed on legal size ‘heavy weight’ card stock

   - Ocean Heat Content Demo
     - 2 Empty clear 12 oz. plastic bottles
     - 2 Bowls (1 with ice, 1 with hot water)
     - 2 Balloons

   - Glacial Melting Demo
     - 2 clear containers open containers
     - Food coloring (preferably green and blue)
     - 2 Ziploc bags
     - Tap water
     - Dry erase marker

   - Groundwater Removal Demo
     - Clear squirt bottle
     - 1 cup of pre-washed fish tank gravel
     - 2 - 3 sponges (cut in small pieces)
     - Tap water
     - Dry erase marker

   - Compaction and Deterioration of Drained Wetlands Demo
     - A new and an old sponge (same type)

   - Settling of the Impact Crater
     - Aluminum cooking pan (with 2 – 3 inch high sides)
     - 1 bag of flour
     - 1 container of Kool-Aid
     - Large marble

   - SLR Activity (Virginia Beach Maps)
     - Map printed on legal size ‘heavy weight’ card stock
     - Scissors for students
     - Postage Scale
     - A bowl for each group to put their cut pieces into.

- Mitigation Plans
    - Large paper for posters
    - Markers, crayons, or colored pencils
    - Can also allow students to print out pictures.

2. **Setup**

Prior to Day 1

- SLR Activity (Virginia Beach Maps)
    - Printed maps in advance on legal size 'heavy weight' card stock
    - Maps need to be printed in color

- Groundwater Removal Demo
    - Fill clear squirt bottle with sponges and gravel (¾ full)
        - Add a lot of buoyant sponges to the container
    - Fill the squirt bottle with tap water
    - Test the mixture of gravel and sponge to make sure it replicates subsidence as you remove 'groundwater'.
    - Place a dry erase marker next to the demo

- Locate remaining supplies for demos and activities

- Print out worksheets and *Scientific American* articles

Day 1

- Layout supplies for SLR Activity and Groundwater Removal Demo detailed above.

- Ocean Heat Content Demo
    - Place balloons over top of empty plastic bottles
    - Fill 1 bowl with ice
    - Heat water to add to second bowl

- Glacial Melting Demo
    - Fill 2 clear containers half way with tap water
    - Fill two Ziploc bags with tap water. Add green dye to 'glacier' bag and blue dye to 'sea ice' bag.
    - Place water filled Ziplocs in containers to verify that the water won't spill over the top of the containers.
    - Leave the 'iceberg' Ziplock in its container. Remove the 'glacier' Ziplock and set it aside.
    - Place a blue and green dry erase marker next to the demo

- Compaction and Deterioration of Drained Wetlands Demo
  - Lay out the new and old sponge
  - Before using the new sponge get it wet and ring it out slightly.

- Settling of the Impact Crater
  - Add flour to the aluminum cooking pan (approximately 1 inch)
  - Lightly cover the surface of the flour with Kool-Aid
  - Place large marble next to demo

- SLR Activity (Virginia Beach Maps)
  - Separate printed map into groups sets (total of 3 pages for each group)
  - Place scissors, bowls, and recycling containers in 'convenient' locations
  - Plug in an zero postage scale

Day 2

- Mitigation Plans
  - Prepare large paper (or posters), markers, crayons, and/or colored pencils

3. **Procedure:**

Day 1

1st. Begin class by asking the student to define SLR (typically this answer will be something related to 'Global' Sea Level Rise). Ask them what factors contribute to 'Local' SLR and tell them that it is a combination of Global, Regional, and Local factors that the class will be examining with a series of demos that you will need their help with. Advance through the SLR PowerPoint while involving students in the demos and where appropriate include video clips.

- Ocean Heat Content Demo
  - Prior to presenting the slide have a student come up to place the balloon covered plastic bottles into the two bowls (1 ice and 1 warm water).
  - Have them hypothesize what they think will happen.
  - Continue presenting the slide and reinforce the material with the demo

- Glacial Melting Demo

  This demo is helpful to distinguish between melting sea ice and melting glaciers on land.
  - Have a student draw a 'sea level' line on both containers using the dry erase markers. *Note that the one with the 'sea ice' bag in the container is higher.*
  - Have the student carefully remove the blue 'sea ice bag' and poor it back into its container. *The water should be at the same line.*

    - Have the student then poor the green ‘glacier’ Ziploc into its container and blue dye to ‘iceberg’ bag. The water level should now be above the sea level line. *Reinforce that melting ice on land contributes to SLR, while the water in sea ice is already displacing the same volume of water.*

- Groundwater Removal Demo
    - Have a ‘trusted’ student mark the elevation of the soil inside the squirt bottle with a line using the dry erase marker.
    - Slowly and carefully have the student empty the bottle by pumping the ‘groundwater’ out of the bottle, making sure that they don’t wipe away the line. *As the water is removed the note the subsidence.*

- Compaction and Deterioration of Drained Wetlands Demo
    - Give one student a dry old sponge and a wet. *Discuss why we drain wetland and relate the water removal to more peat (or marsh soil) being exposed to air. Since bacteria respire faster when oxygen is present this material breaks down faster. Causing a similar ‘visual’ effect to what they are used to as a new sponge ages.*

- Settling of the Impact Crater
    - Have a trusted student stand above the aluminum cooking pan full of flour and drop the large marble (aka the comet).
    - The marble will displace the flour and Kool-Aid creating an impact creator. *You can use this as an opportunity to discuss the anatomy of a crater.*
    - After discussing the creator gently shake the tray to cause the flour to ‘settle’ back in around the marble (comet). *Note that this is the settling process that is still occurring today.*

2nd. Discuss the science behind the future sea level rise predictions and emphasize that future storm events will be in addition to these predictions. For instance a 6 or 7 foot rise in sea level could result in storm surges that are 10 feet higher than the present day sea level.

3rd. Have students do the Sea Level Rise Activity (Virginia Beach Maps)

- SLR Activity
    - Have student separate into their groups (3 students per group). The more groups (replication) the better.
    - Review the instructions on the slide, show them an example of the precision you expect, and answer any questions.
    - Distribute scissors, bowls, and place recycling containers in ‘convenient’ locations around the room.
    - Stress to each group individually that they should only be cutting out the colored (green, yellow, and red) areas in the SLR scenario maps.

- Cut out and weigh the ‘scale’ and enter the value into the Sea Level Rise Excel File – Enter Data Here tab – Weight of Scale (grams).
- Draw a table on the board to have the student record their information, which will be the information they need to include on their worksheet. Write the ‘scale’ weight on the board so the students can also calculate the area above sea level for all of the groups.
- As students finish cutting out their maps, first blank the scale with their bowl on it and then add their map pieces. Once all of the ‘current’ sea level groups have added their weights to the board the students will be able to calculate the ‘% of Current Area’ for all of the groups.
- Enter all of the information into the Sea Level Rise Excel File – Enter Data Here
- Once you have finished entering all of the groups’ data compare your calculations to the students.
- Finish by presenting the remaining graphs in the Excel Spreadsheet

4th. Finish presenting the remaining PowerPoint slides, giving students extra time to explore how sea level rise will effect coastal regions around the country using the NOAA Sea Level Rise Viewer.

5th. Review what students need to do for homework (reading the *Scientific American* article, finishing the worksheet and any related calculations, preparing for the following class)

6th. Emphasize that the student will be working in their groups during the next class to develop their mitigation plans, diagram them, and present them to the class. If time permits they can begin working on this now.

Day 2

1st. Begin class by reviewing material from the previous class and highlight how these processes are acting together to cause the rates of local sea level rise listed on the slide. Before moving on have the students calculate how much sea level rise will occur based on these rates by the time the graduate college (or come back for their 10 year high school reunion) ~ 10 years, and when they retire ~ 50 years. It may be useful to convert to imperial units.

- SLR Mitigation Strategy Proposals
    - Have the students get into their 3 person groups from the previous class and work together to develop a management plan for coastal Virginia that includes at least 4 strategies to combating sea level rise.
    - If possible provide an example poster so the students can see how much detail you want them to include.

- Begin by having the students diagram their plans on a sheet of paper using both pictures and text.
- Provide rulers, colored pencils and/or markers.
- Once they have finished their example plan have them raise their hand and get ‘official approval’ from you.
- Once they have developed a satisfactory diagram have them transfer their plans onto poster board
- If you would like to display to poster make sure that they make it large enough to clearly read from 6 feet away.
- Have students take turns presenting their mitigation strategies in front of the class. Presentations should take 2 – 3 minutes.

2nd. Finish presenting PowerPoint presentation.

Discussion Questions:

1. Compare local sea level rise in coastal Virginia to regions in North America that are experiencing an opposite trend (i.e. Alaska, Canada, etc.). Contrast differences in isostatic glacial rebound, topography, soil types, etc.

2. Using the NOAA Sea Level Rise website zoom into New York City and ask the student what types of infrastructure would be effected by sea level rise. Highlight shipping, tourism, subway systems, and also basic necessities like the sewer systems. See websites below for additional information.
   - www.nyc.gov/html/planyc2030/downloads/pdf/npcc_climate_risk_information_2013_report.pdf
   - www.globalchange.gov/what-we-do/assessment/coastal-resilience-resources

3. Lead students in a policy related discussion.
   - What areas do the students feel are ‘critical’ to protect? Do natural (undeveloped) lands, agricultural lands, residential areas or military installations take precedence over other areas? Remind them that the natural areas often act as critical buffers to protect the other areas.
   - Does Virginia or the federal government have a responsibility to property owners to help them rebuild in recurrent flooding locations? For how long and given the significant cost (the federal government spent more than $60 billion dollars following Hurricane Sandy) what would the students’ requirements be for distributing funds? Who would and would not qualify?
   - Should Virginia buy property in ‘at risk’ locations before these areas are inundated? Who would pay for this? Since tax payers will pay for buying these lands, should it be the responsibility of the federal government, state, county or city.

Assessment:

- Students are actively participating in group work
- Grade or review worksheets after class
- Grade groups based on group presentation
- Include material in future tests
- Responses during post discussion

Lesson Extension:

- Have students research or contact local political, environmental, and scientific organizations to find out what strategies are currently being implemented in coastal areas that the students care about. Potential groups related to coastal Virginia include:

  Academia and Scientific Community
  - Center for Coastal Resources Management:
    - http://ccrm.vims.edu/about_us/contact_us/index.html
  - Chesapeake Bay Foundation:
    - www.cbf.org/about-cbf/contact-us
  - Georgetown University Climate Center:
    - *www.georgetownclimate.org/virginia-case-study-stemming-the-tide-how-local-governments-can-manage-rising-flood-risks*
  - Lynnhaven River Now
    - www.lynnhavenrivernow.org/aboutus.aspx
  - Old Dominion University's Mitigation and Adaptation Research Institute
    - www.mari.odu.edu/
  - William and Mary
    - *http://law.wm.edu/academics/programs/jd/electives/clinics/vacoastal/index.php*
  - The University of Virginia
    - *www.virginia.edu/ien/sealevelrise/*
  - Virginia Institute of Marine Science
    - *www.vims.edu/bayinfo/tidewatch/index.php*
    - *www.chesapeakeadaptation.org/*
  - Virginia Polytechnic Institute
    - *http://vwrrc.vt.edu/projects.html*

  Non-Governmental Organizations
  - Chesapeake Climate Action Network
    - *www.chesapeakeclimate.org/index.php?option=com_k2&view=item&id=3736:virginia-safe-coast&Itemid=19*
  - Natural Resource Defense Council
    - *www.nrdc.org/water/readiness/water-readiness-report.asp*
    - *www.nrdc.org/water/thirstyforanswers.asp*
  - The Nature Conservancy
    - *www.virginia.edu/ien/sealevelrise/docs/VA%20Eastern%20Shore%20CC%20Adaptation%20Report%20Final.pdf*
  - Wetlands Watch
    - *www.wetlandswatch.org/WetlandScience/SeaLevelRise/Adaptation.aspx*

  State Legislature
  - The Coastal Resource Management Law of 2011 (Code of Virginia § 28.2-1100.9)
    - *http://leg1.state.va.us/cgi-bin/legp504.exe?111+sum+SB964*
  - The Recurrent Flooding
    - *www.ccrm.vims.edu/recurrent_flooding/Recurrent_Flooding_Study_web.pdf*
  - The Virginia Governor's Climate Change Commission (2008)
    - *www.sealevelrisevirginia.net/main_CCC_files/*
    - *http://wetlandswatch.org/Portals/3/WW%20documents/Adap_Strat_adopted_VCCC_062109.pdf*

Sea Level Rise in Coastal Virginia

Developed by Samuel J. Lake
As part of the 2014 Virginia Sea Grant
Marine Advisory Program Summer Course
with support from the
Center for Coastal Resources Management

VIMS | William & Mary
Virginia Institute of Marine Science
Marine Advisory Services

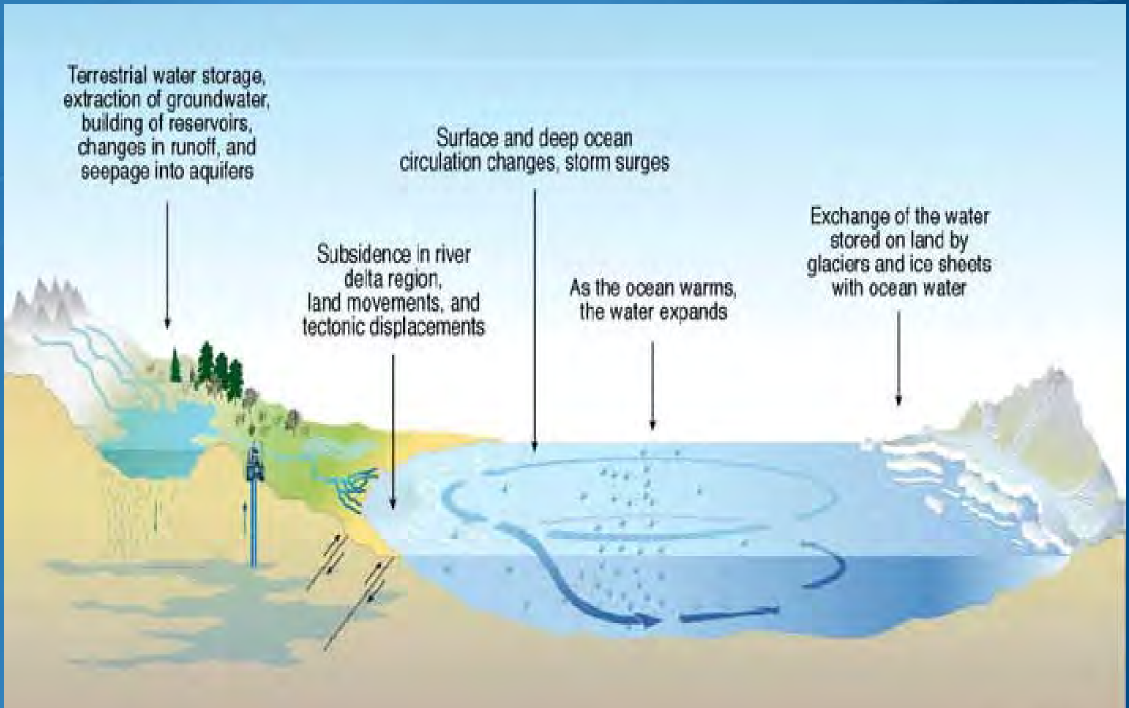
Sea Grant
Virginia

Center for Coastal Resources Management
Virginia Institute of Marine Science

What Causes Sea Level Rise?

Multiple processes acting at global, regional and local scales

- Global
  - Balloons and 2 bags of 'glacial' ice
- Regional
  - Seesaw
- Local
  - Two sponges, squirt bottle, and flour & a marble

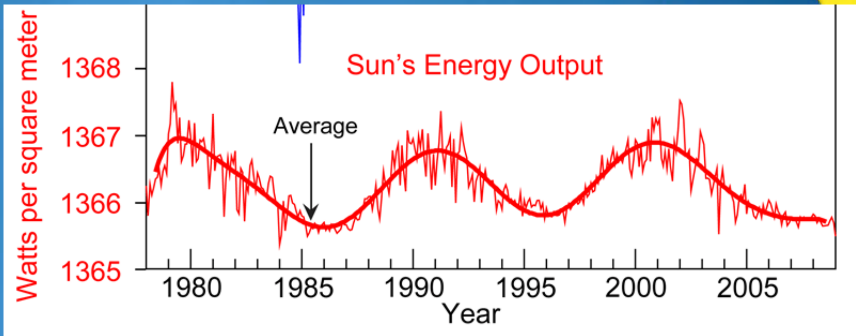


Causes of sea-level rise. Image credit: IPCC Climate Change 2001 Synthesis Report

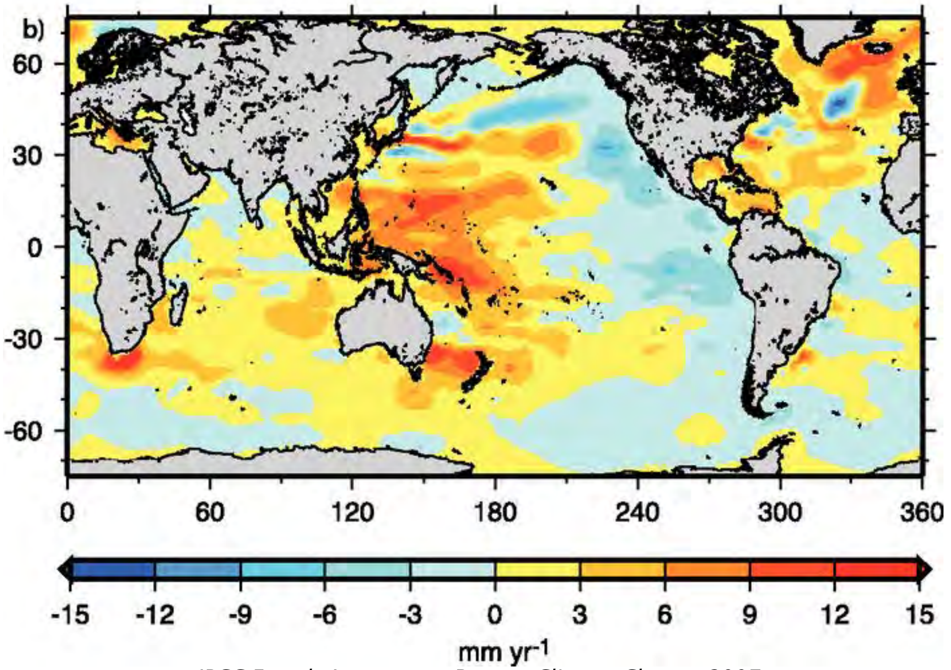
Global Processes

Balloon: Ocean Heat Content

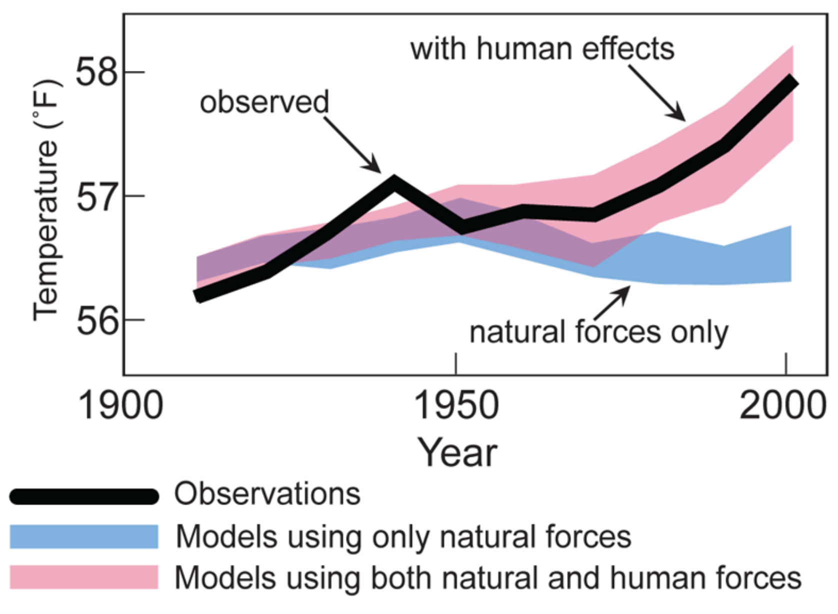
- As the ocean warms the distance between the water molecules will expand



www.ncdc.noaa.gov/indicators/



IPCC Fourth Assessment Report: Climate Change 2007

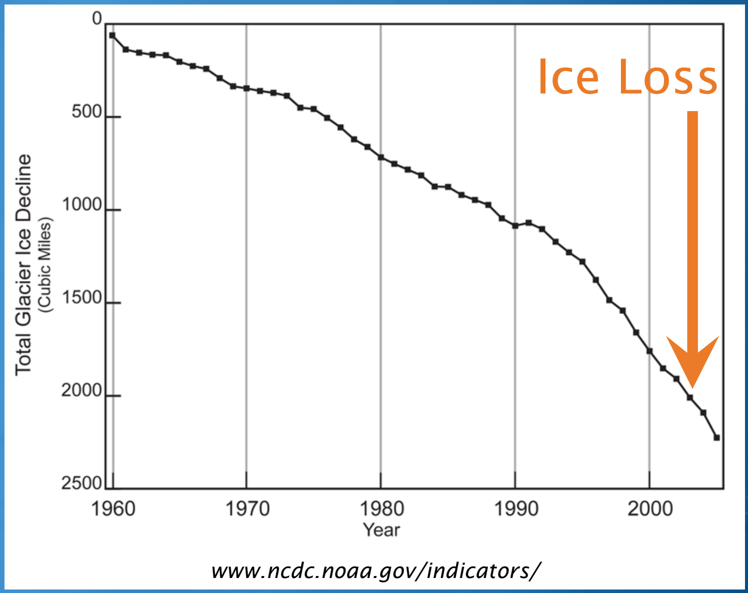


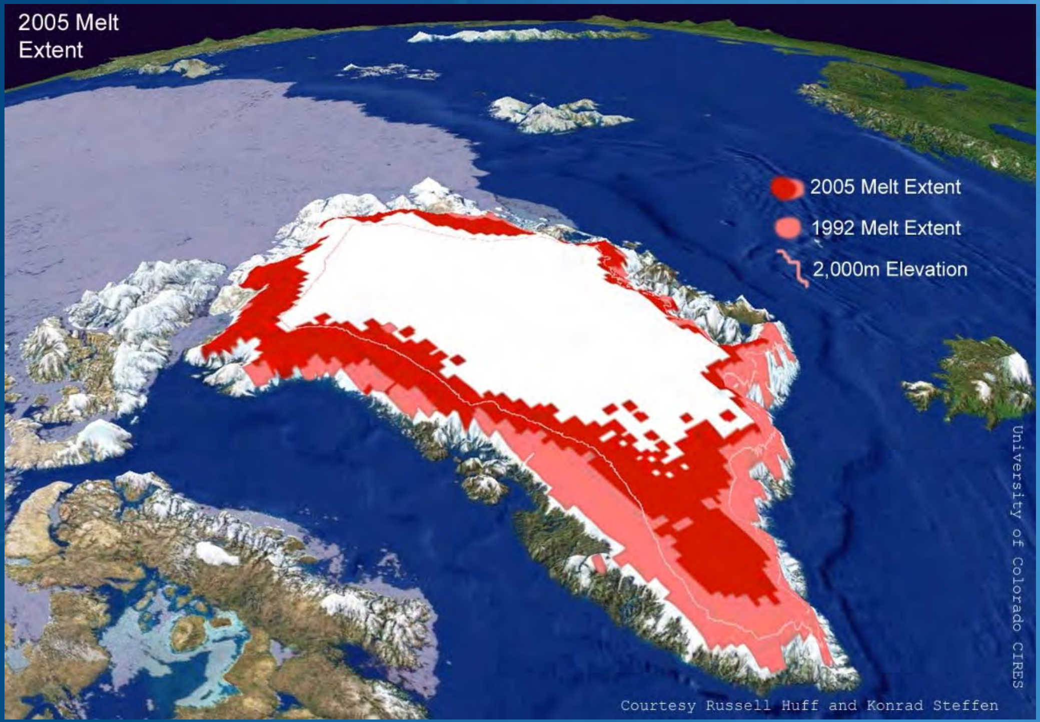
www.ncdc.noaa.gov/indicators/

Global Processes

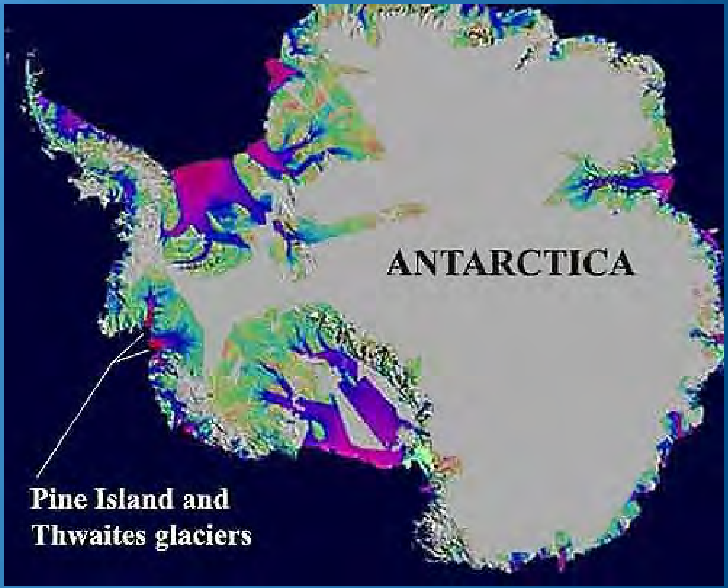
Two Bags of Ice: Glacial Melting

- As ice on land melts global sea level goes up





Greenland

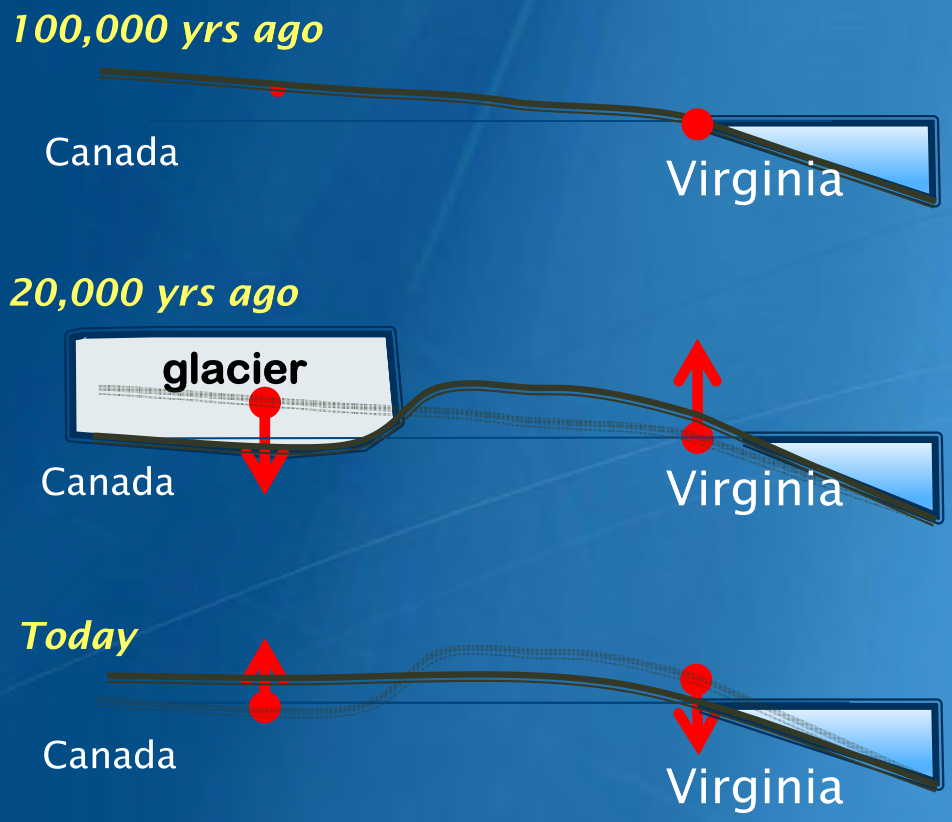


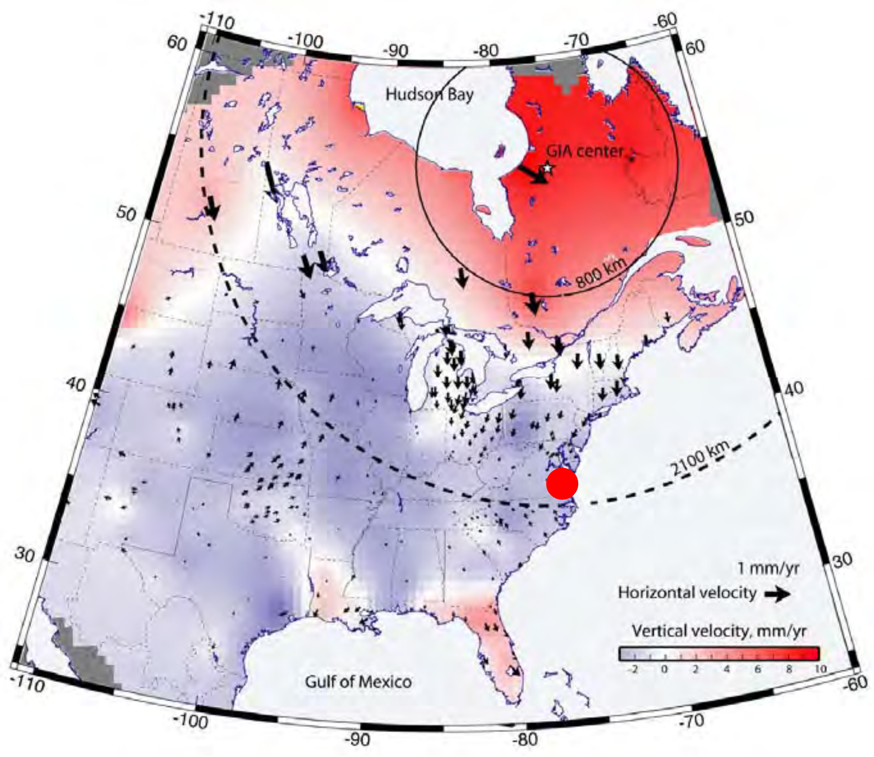
Antarctica

Regional Processes

Seesaw: Isostatic Glacial Rebound

- Will continue for the next ~ 10,000 years



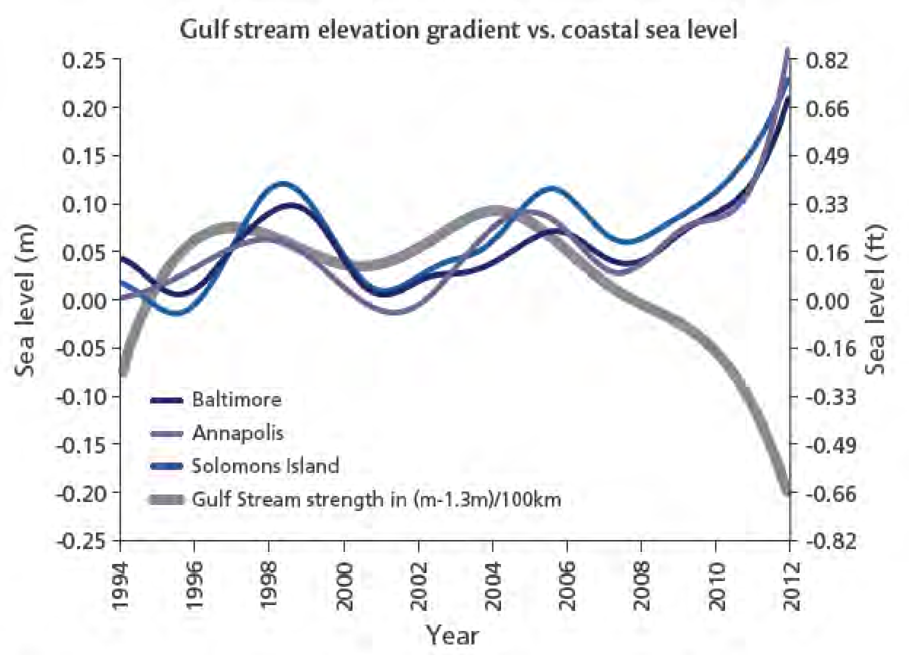


http://web.ics.purdue.edu

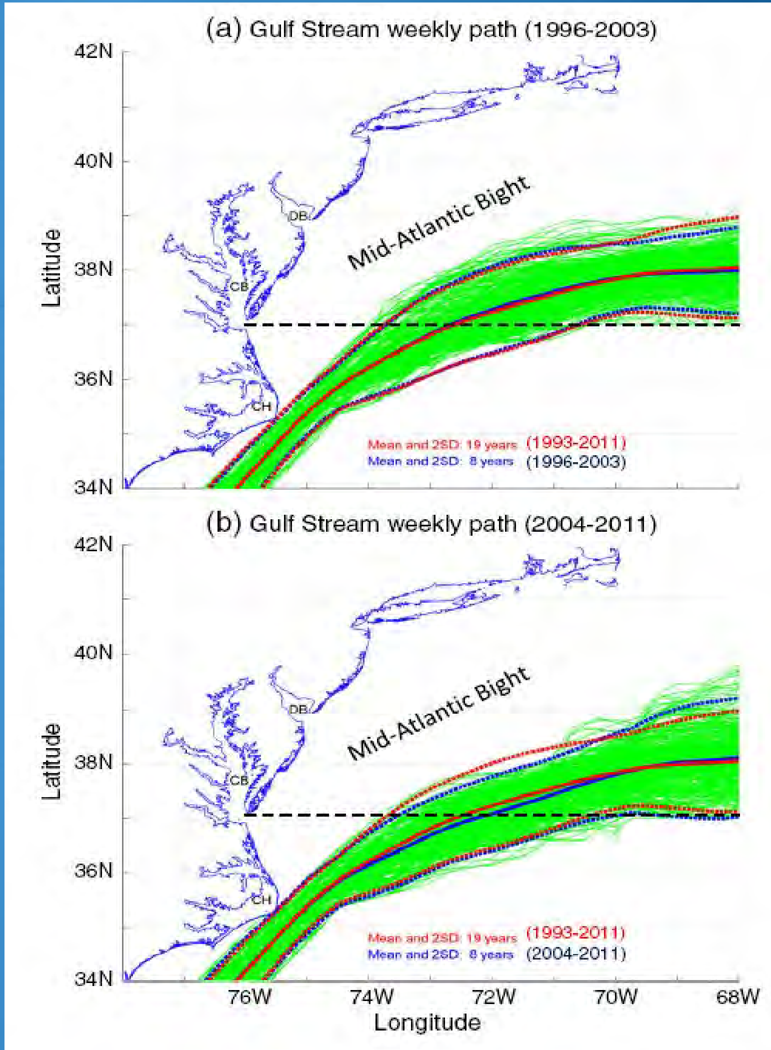
Regional Processes

Tub of Water: Regional changes in water levels

- As the Gulf Stream moves and changes speed it causes shift in sea level



Ezer et al. 2013, J. Geophys. Res. Oceans



Ezer et al. 2013, J. Geophys. Res. Oceans

Local Processes

Squirt Bottle: Subsidence

- Groundwater removal

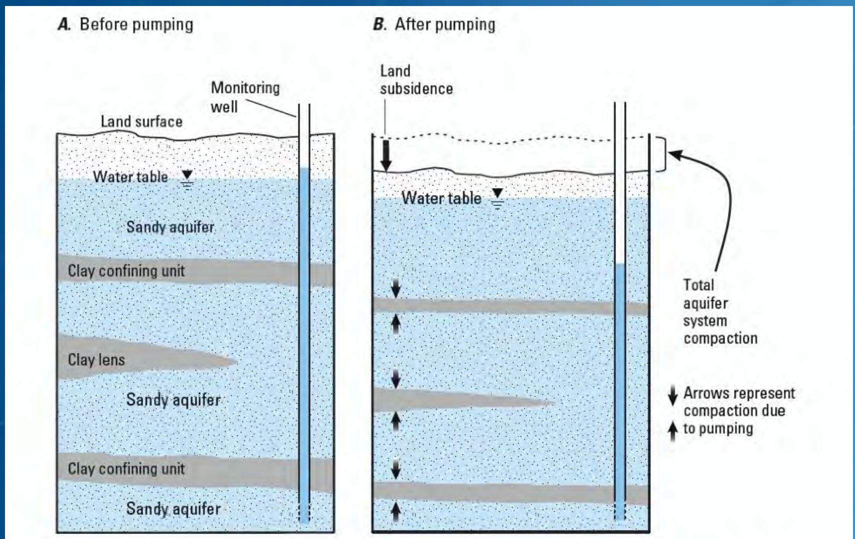


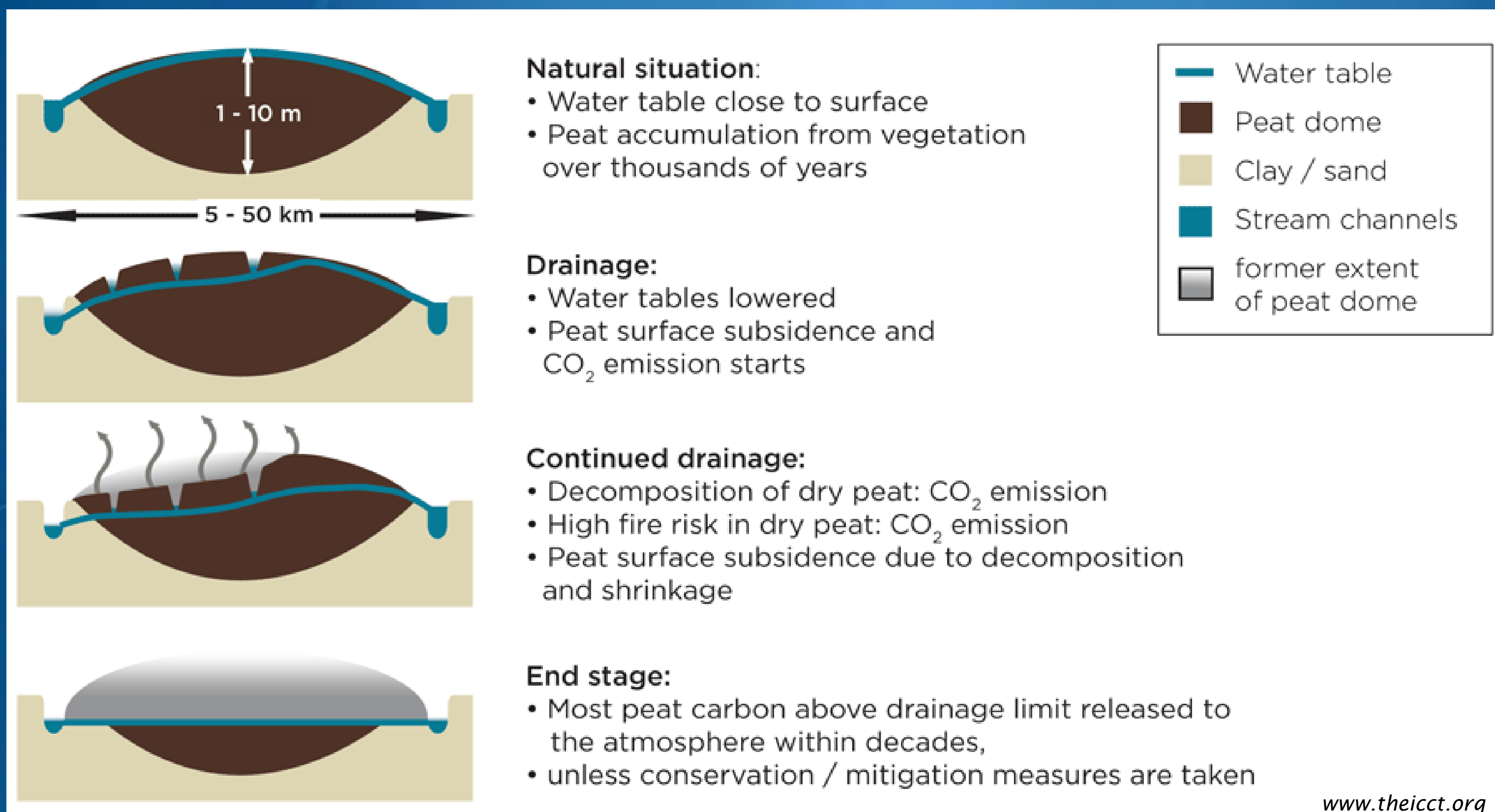
Figure 10. Aquifer-system compaction caused by groundwater withdrawals *A*, before and *B*, after pumping. Modified from Galloway and others (1999).

Wikimedia Commons 2014

Local Processes

Two Sponges: Subsidence

- Compaction and deterioration of drained wetland soils

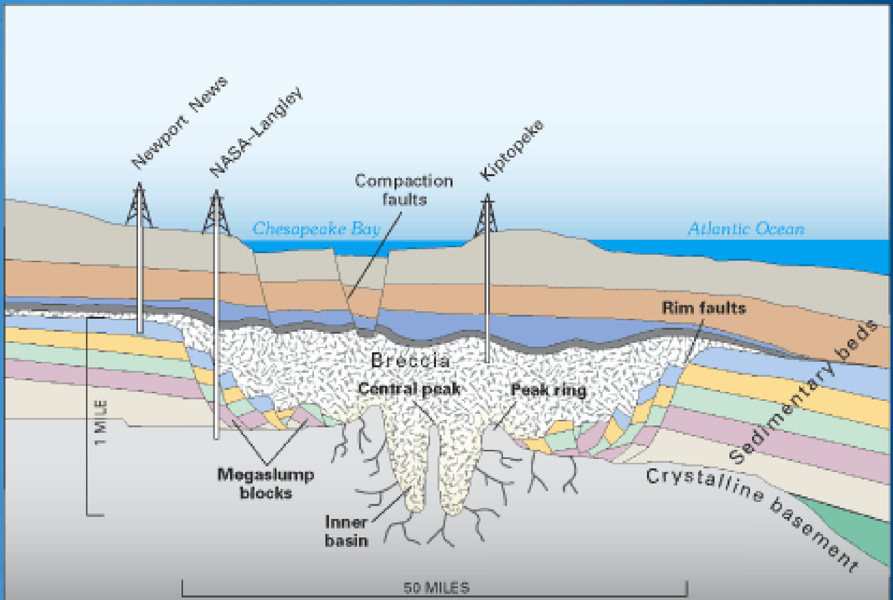


Local Processes

Flour and a Marble: Settling of the impact crater

- Bolide Comet ~35 mya

Middle Peninsula Planning District. The Washington Post



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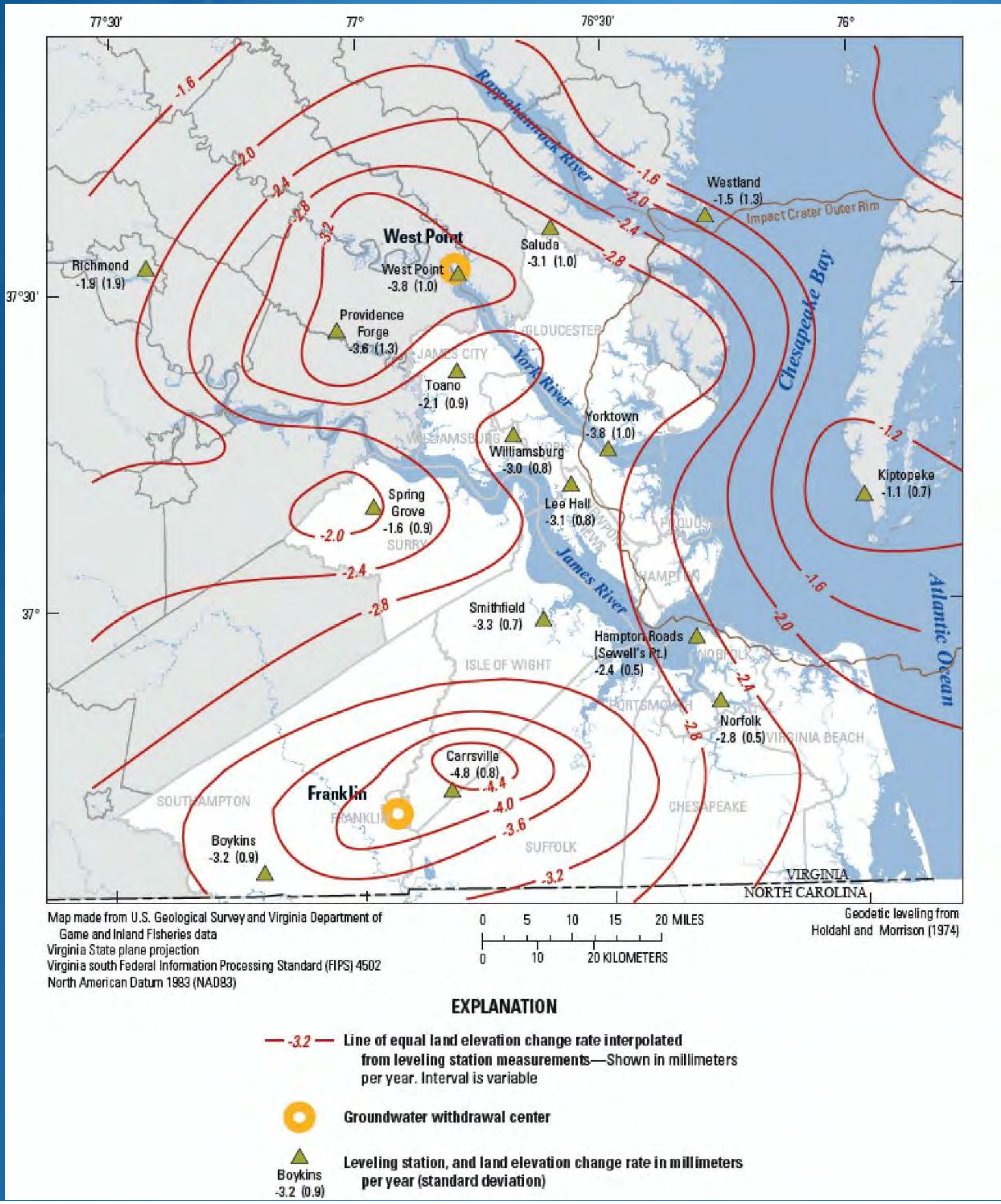
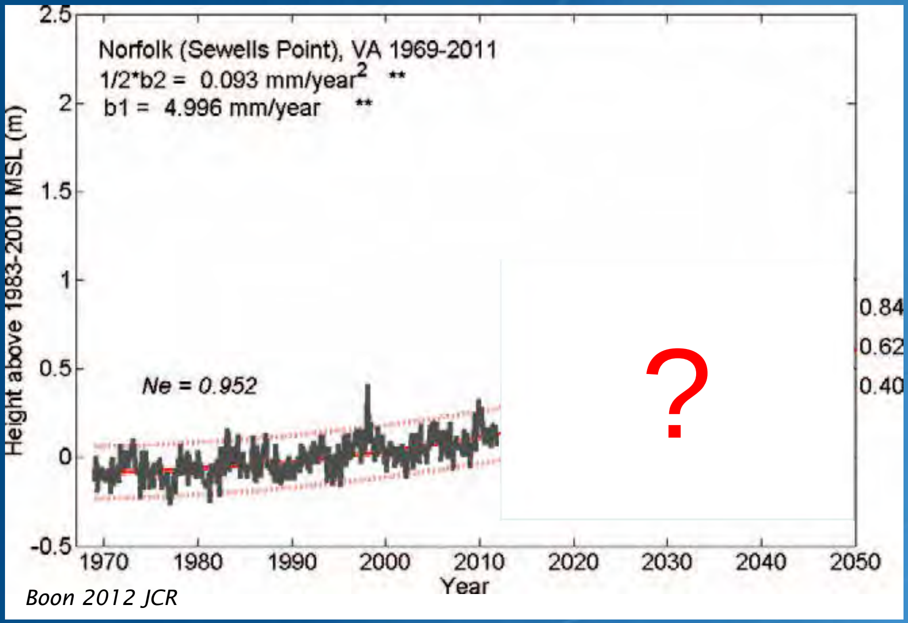
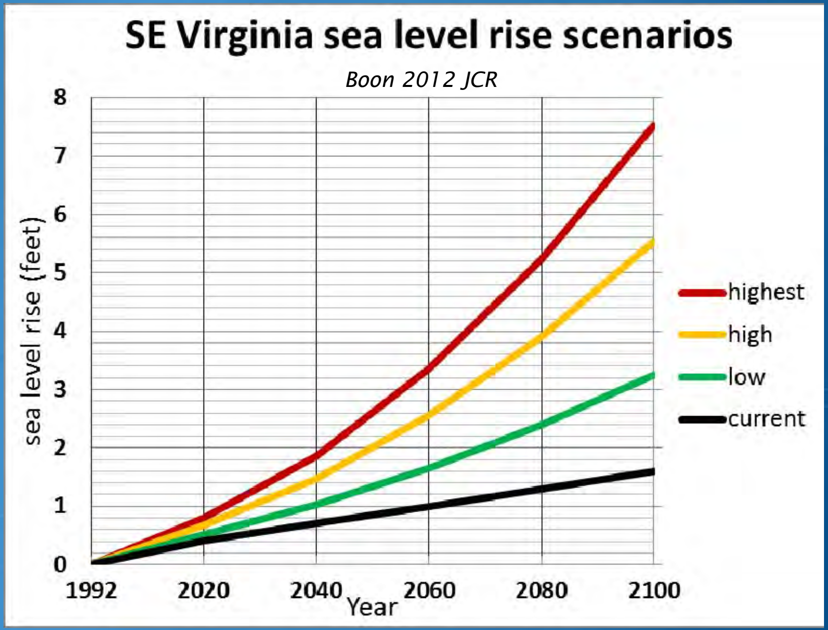
Local Processes



Past and Future Sea Level Rise





Virginia Beach Activity

Break into groups of 3 students. Each group will receive a map corresponding to a sea level rise scenario.

1. In 10 minutes or less cut out the colored area (red, orange, or green) and weigh only the colored pieces on the scale.

2. Record the total weight of the colored areas on your data sheet and enter it into the computer.

3. Complete the table on your worksheet by filling in all of the other groups information.

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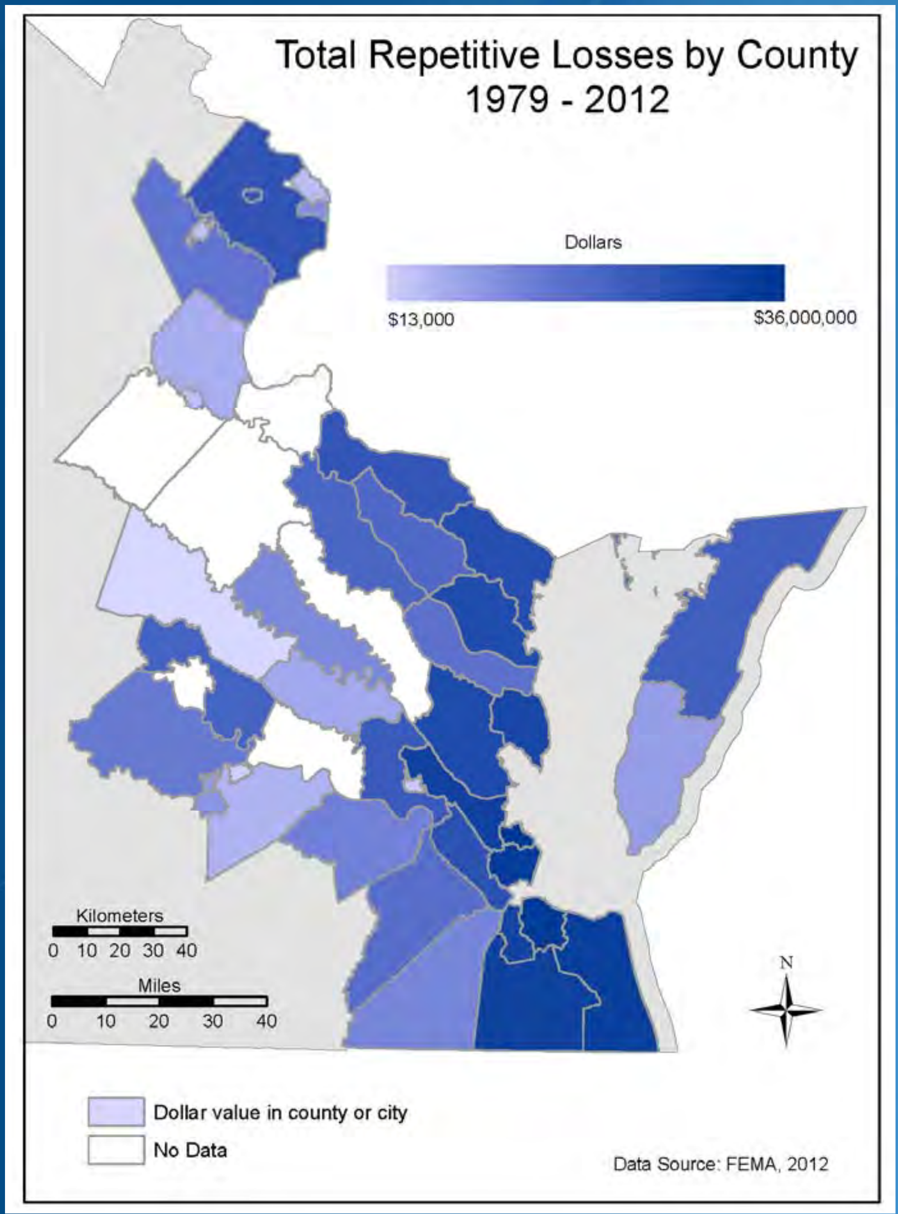
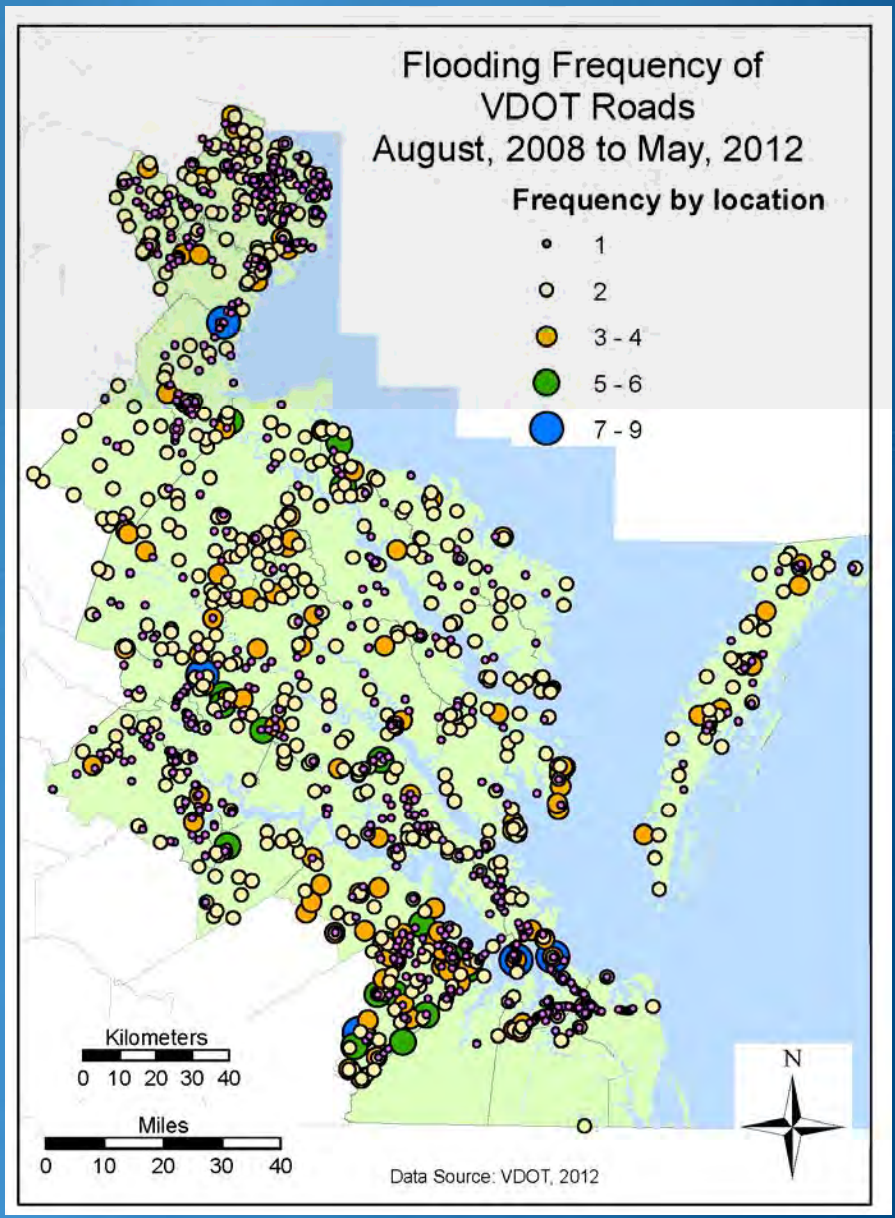
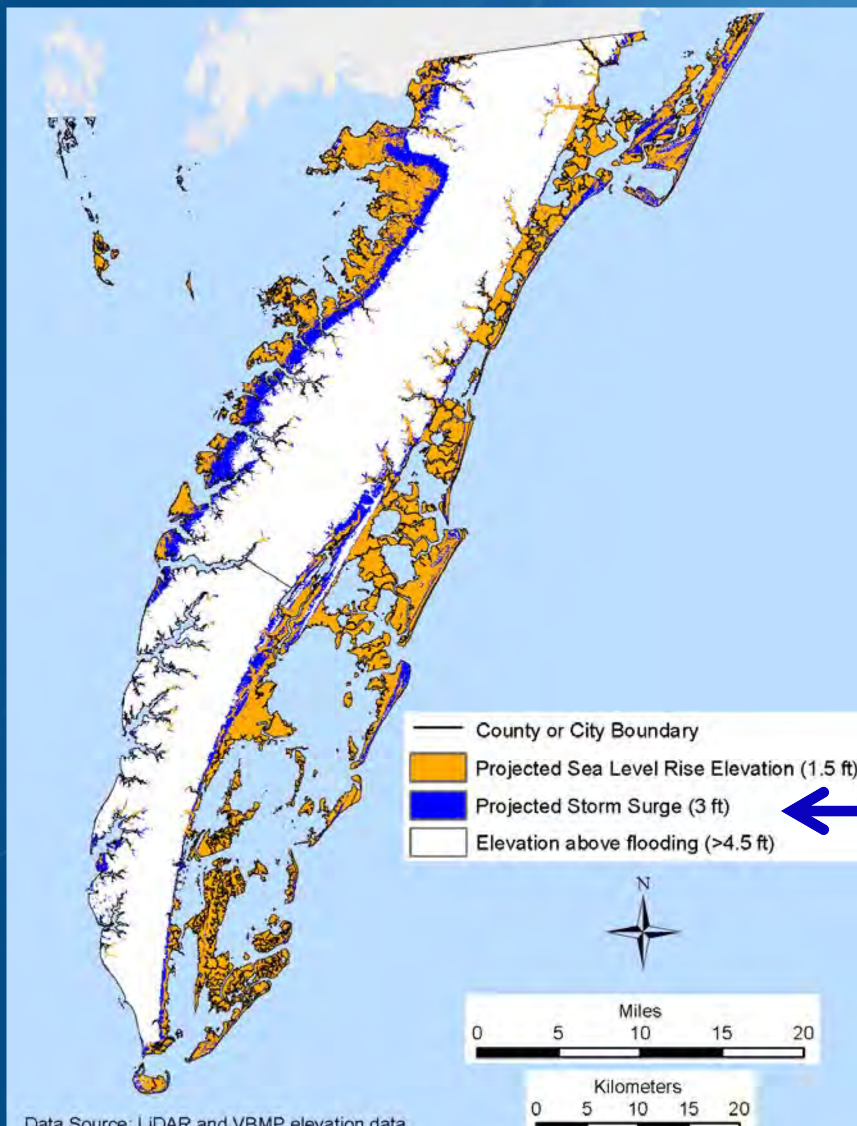
Recent Flooding in Virginia





Vulnerable Areas in Coastal Virginia

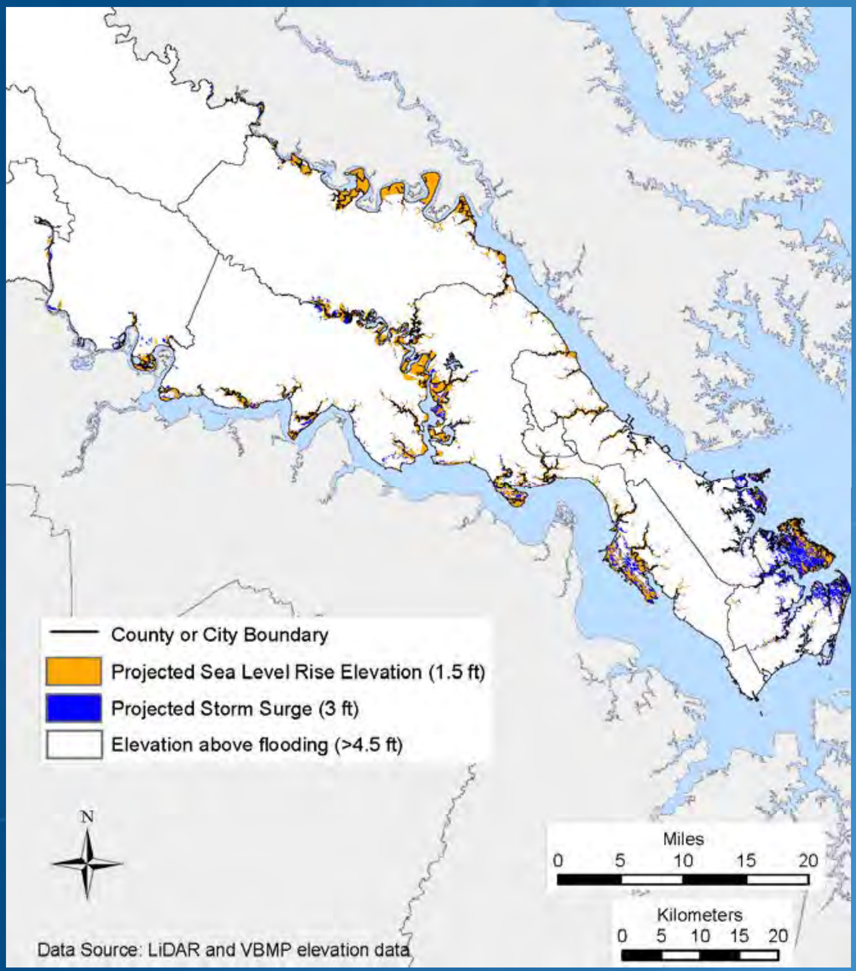


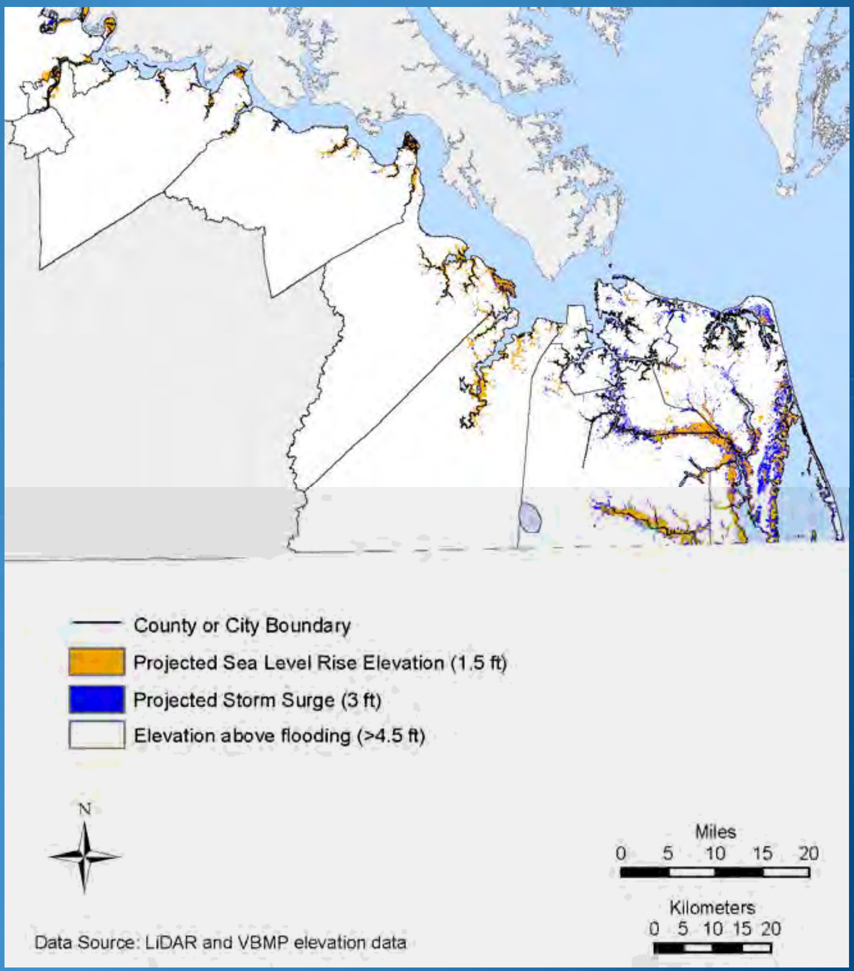
	Accomack	Northampton
Total area (acres)	289,612	132,032
Total area flooded	41%	46%
Flooded area that is developed	2	1
Road miles flooded	362	44

Expected sometime 2040-2060

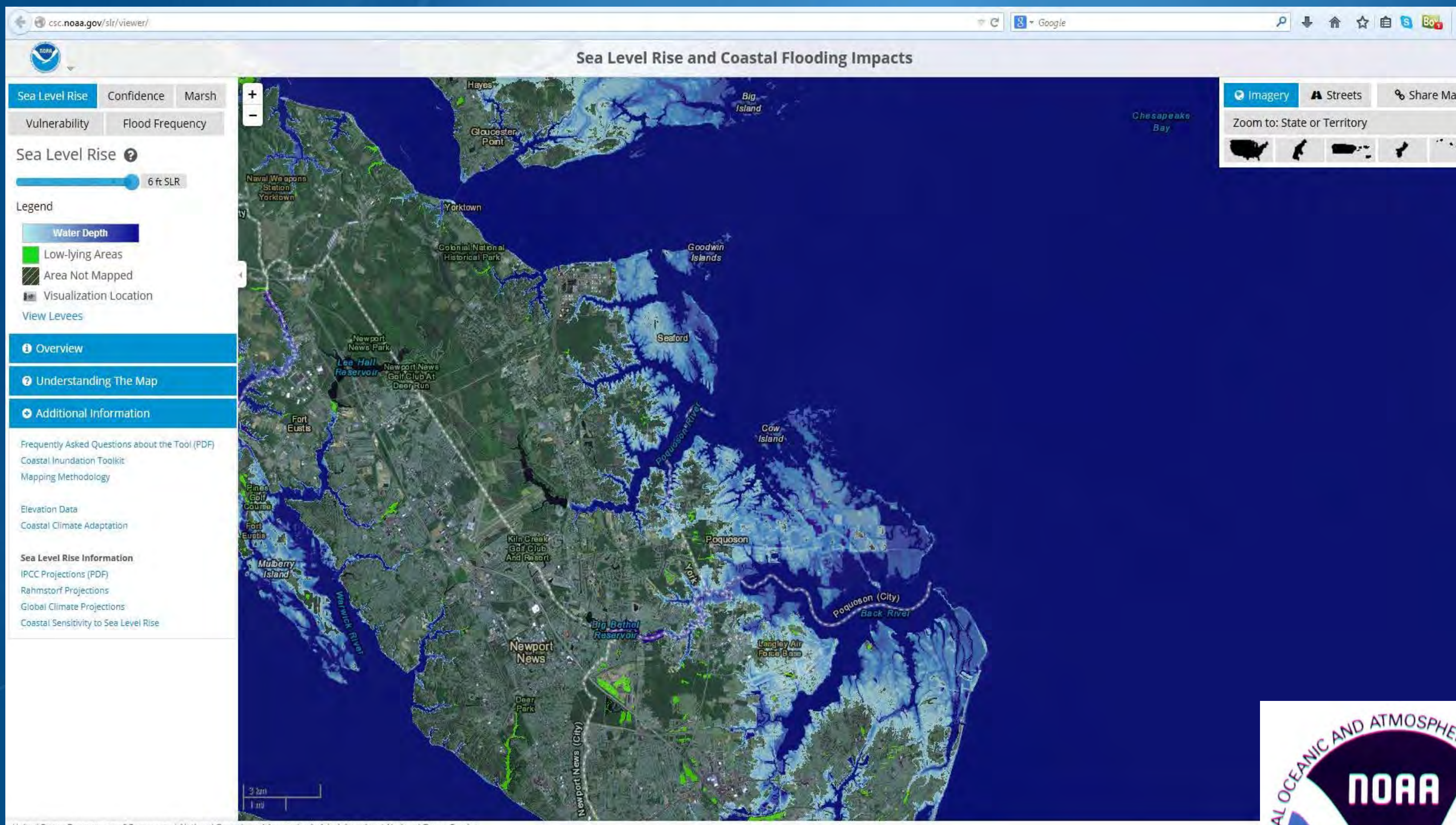
Typical size storm surge

Vulnerable Areas in Hampton Roads





Sea Level Rise in Your Backyard



http://csc.noaa.gov/slr/viewer/

Homework Assignment

1. Read the *Scientific American* article
   'What does the U.S. Look Like After
   3 Meters of Sea Level Rise?'

2. Complete your Coastal Sea Level Rise worksheet.

3. Brainstorm sea level rise mitigation plans for Hampton Roads.
   - Have at least 3 ideas to share with your group next class.
   - Think about how long your strategies would work and when it would be insufficient.
   - Who would and would <u>not</u> benefit.

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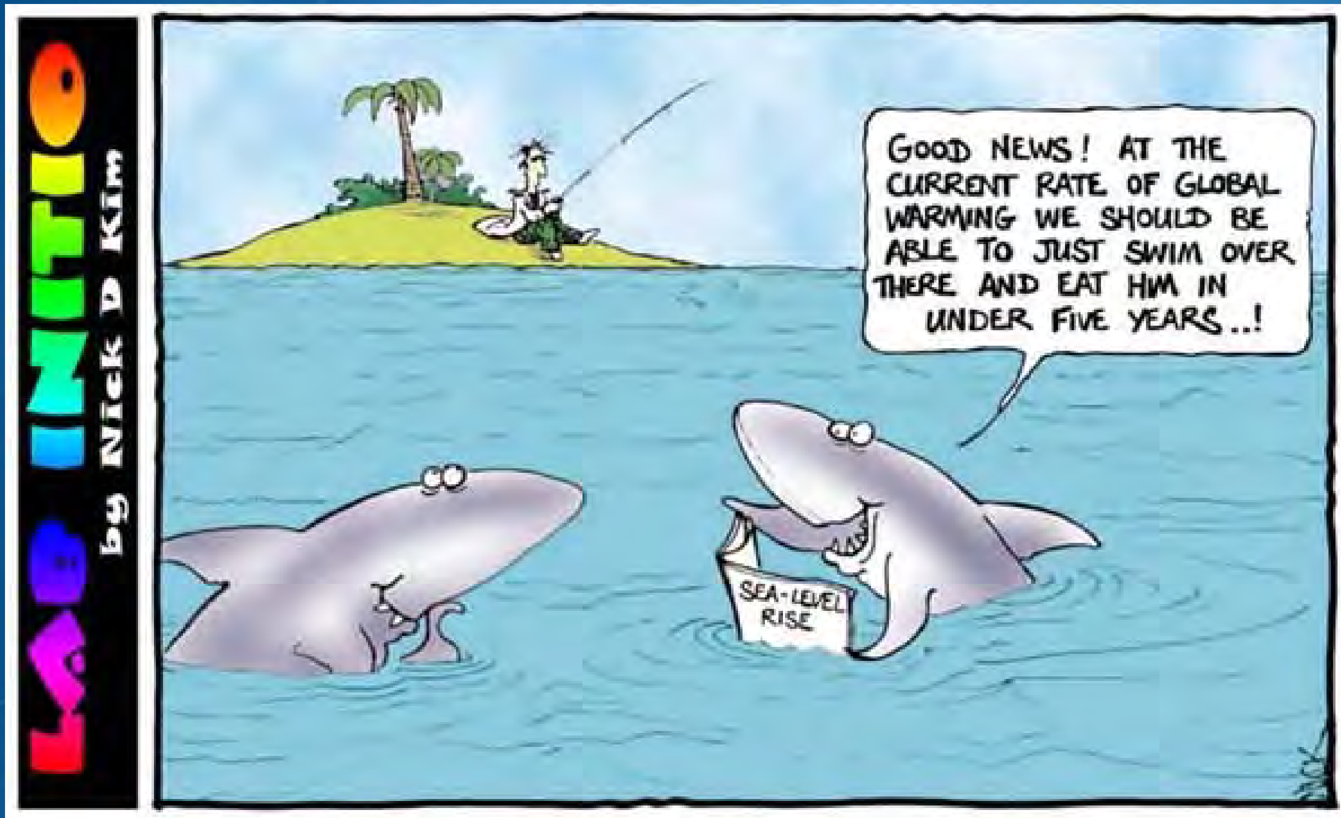

VIMS | WILLIAM & MARY
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Sea Level Rise in Coastal Virginia

Day 2

VIRGINIA INSTITUTE OF MARINE SCIENCE
MARINE ADVISORY SERVICES

Planning for Sea Level Rise

Global sea level rise *(2 - 4 mm per year)*

- Warming (expanding) ocean water
- Melting ice caps

Regional and Local Processes ***(1 – 3 mm per year)***

- Isostatic glacial rebound
- Groundwater withdraw
- Compaction and deterioration of wetlands
- Meteor crater sediment compaction

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Sea Level Rise
Mitigation Strategy Proposals

In your groups develop a management plan that includes at least 4 strategies to combating sea level rise in coastal Virginia.

1. Diagram your plan on a sheet of paper using pictures and text.

2. Once you have finished raise you hand and get 'official approval'.

3. Transfer you plan to poster board, making sure that it is large enough to clearly read from 6 feet away.

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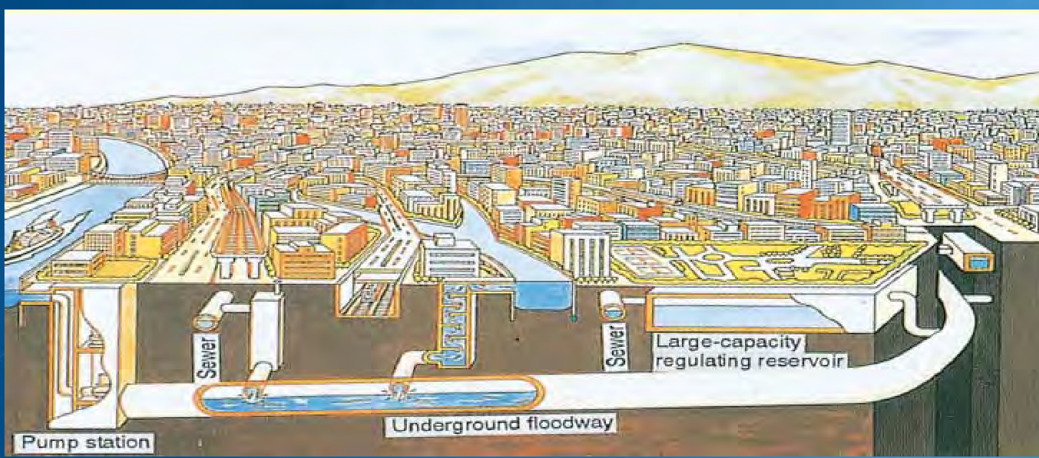
What are we doing?

VIRGINIA INSTITUTE OF MARINE SCIENCE

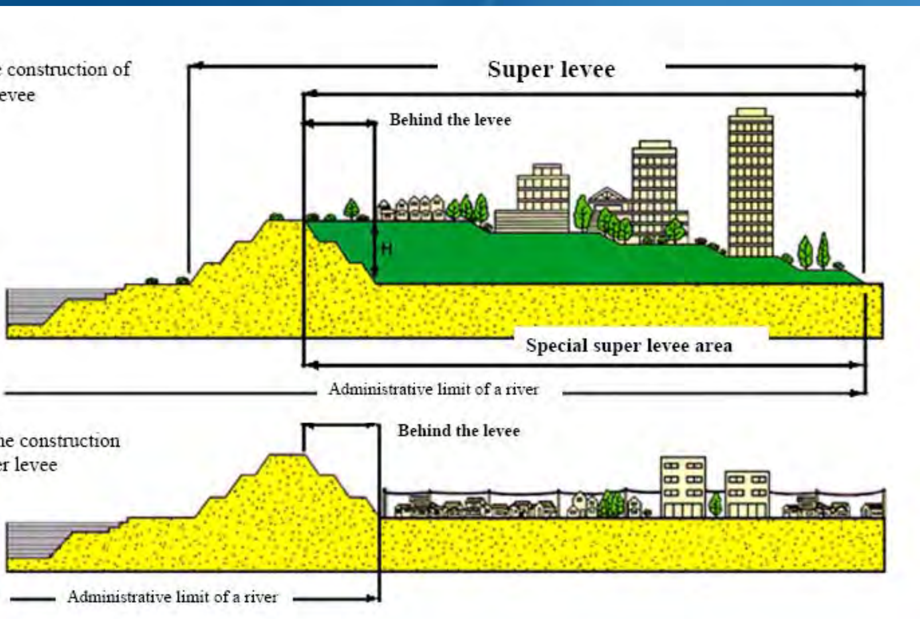
Adaptation Measures in Japan

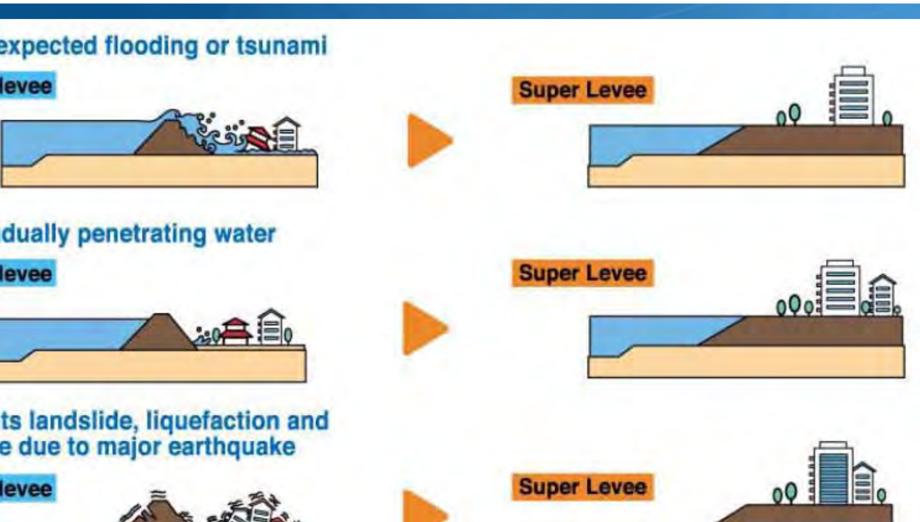
Stormwater storage facilities that are used as tennis courts in normal times (Tsurumi River Basin, Japan)



Ministry of Land, Infrastructure, Transport and Tourism www.mlit.go.jp

Adaptation Measures in Japan





daptation Measures in Bangladesh

Floating garden and house, Bangladesh style.
http://climateadapted.blogspot.com/2011/06/community-based-adaptation-in.html

daptation Measures in Netherlands

om for the River"

Lowering floodplains
Lowering/excavating part of the floodplain increases room for the river in high water situations.

Dyke relocation
Relocating a dyke inland widens the floodplain and increases room for the river.

Depoldering
The dyke on the riverside of a polder is lowered and relocated inland. This creates space for excess flows in extreme high water situations.

Deepening summer bed
Excavating/deepening the surface of the riverbed creates more room for the river.

Dyke reinforcement
Dykes are reinforced at given locations where river widening is not feasible.

Lowering groynes
Groynes stabilise the location of the river and ensure its correct depth. However, in a high water situation, groynes may obstruct the flow to the river. Lowering groynes speeds up the rate of flow.

Removing obstacles
If feasible, removing or modifying obstacles in the riverbed will increase the rate of flow.

Water storage
The Volkerak-Zoommeer provides temporary water storage in extreme situations where the storm surge barrier is closed and there are high river discharges to the sea.

High water channel
A high water channel is a dyke area branching off from the main river to discharge some of the water via a separate route.

daptation Measures in Netherlands

https://beeldbank.rws.nl, Rijkswaterstaat

http://www.spur.org/

Adaptation Measures in United Kingdom

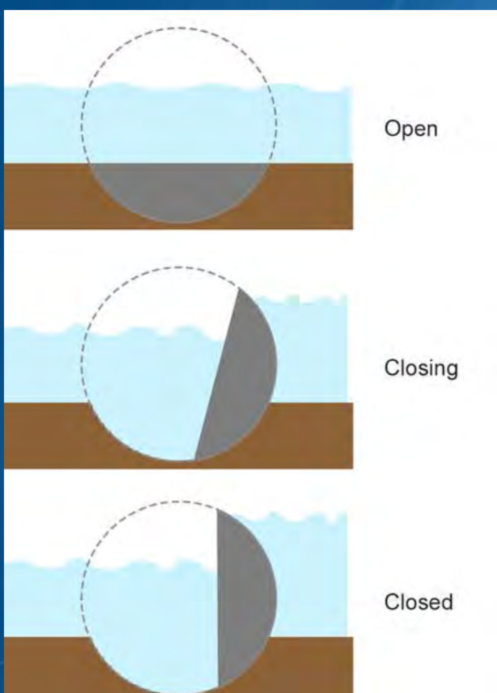
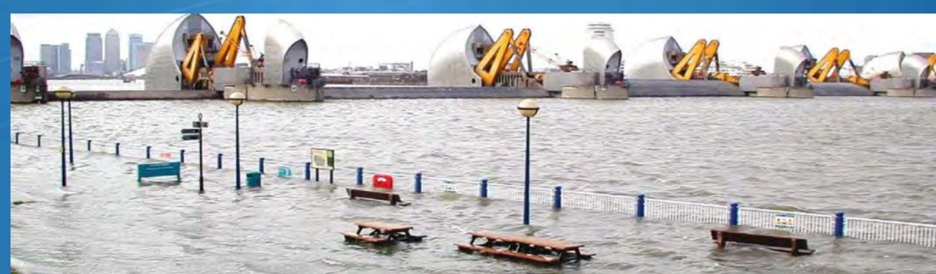


Photo by DAVID ILIFF. License: CC-BY-SA 3.0



http://www.environment-agency.gov.uk/homeandleisure/floods

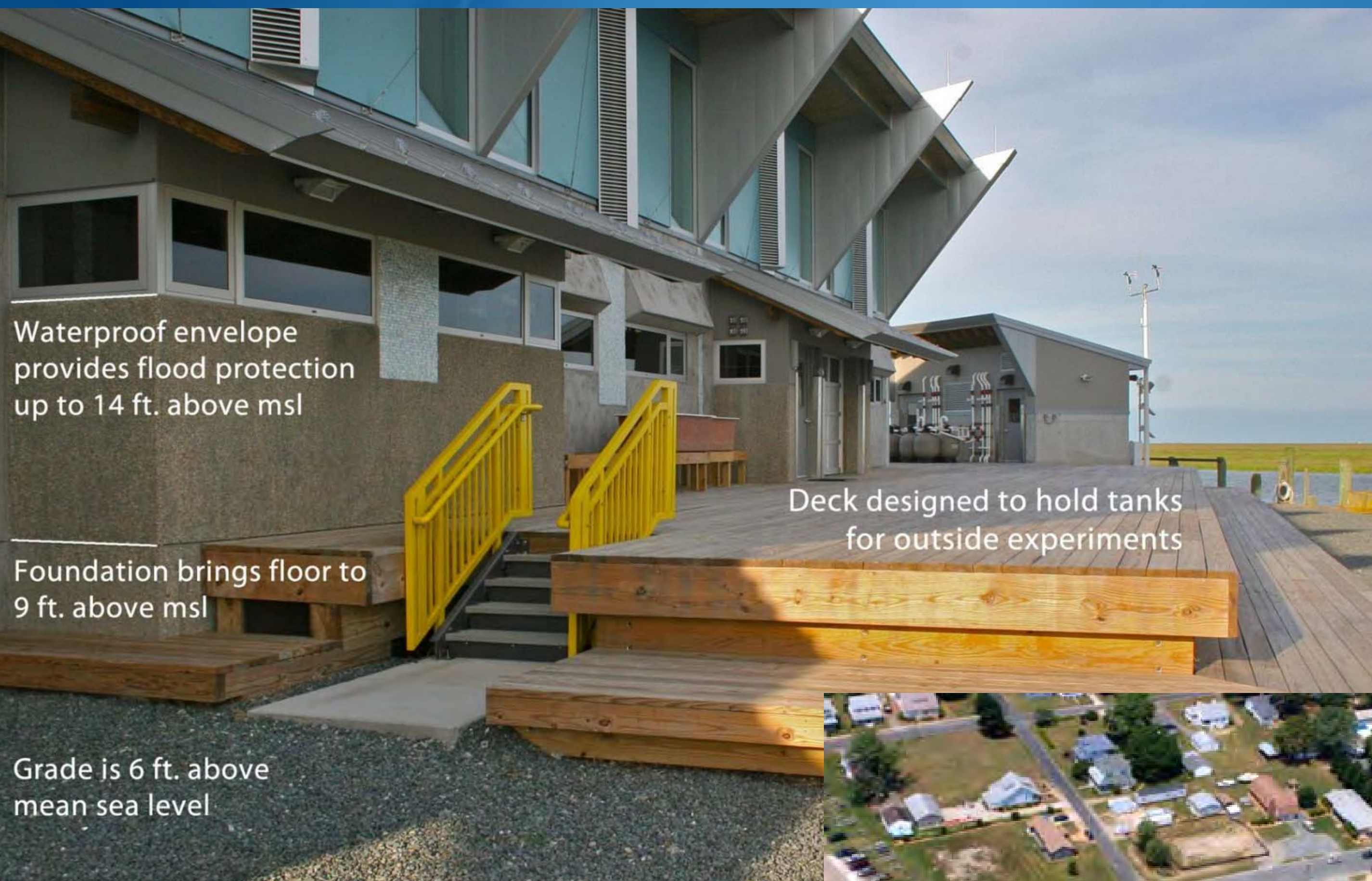
House Modifications

rfolk, VA, East Ocean View home before being
wered onto its new foundation, which will raise
e first floor about two feet above the flood plain.
e Virginian-Pilot

On the Mississippi, the easiest homemade solution, foam blocks under your home. The 4 guide posts keep the house in place as it rises, just like a floating dock. www.buoyantfoundation.org

at House, designed by Morphosis
cts and students from UCLA collects its
ater and generates its own electricity and is
e of floating as high as 12-feet on rising
vaters. www.makeitrightnola.org Pic by
aan

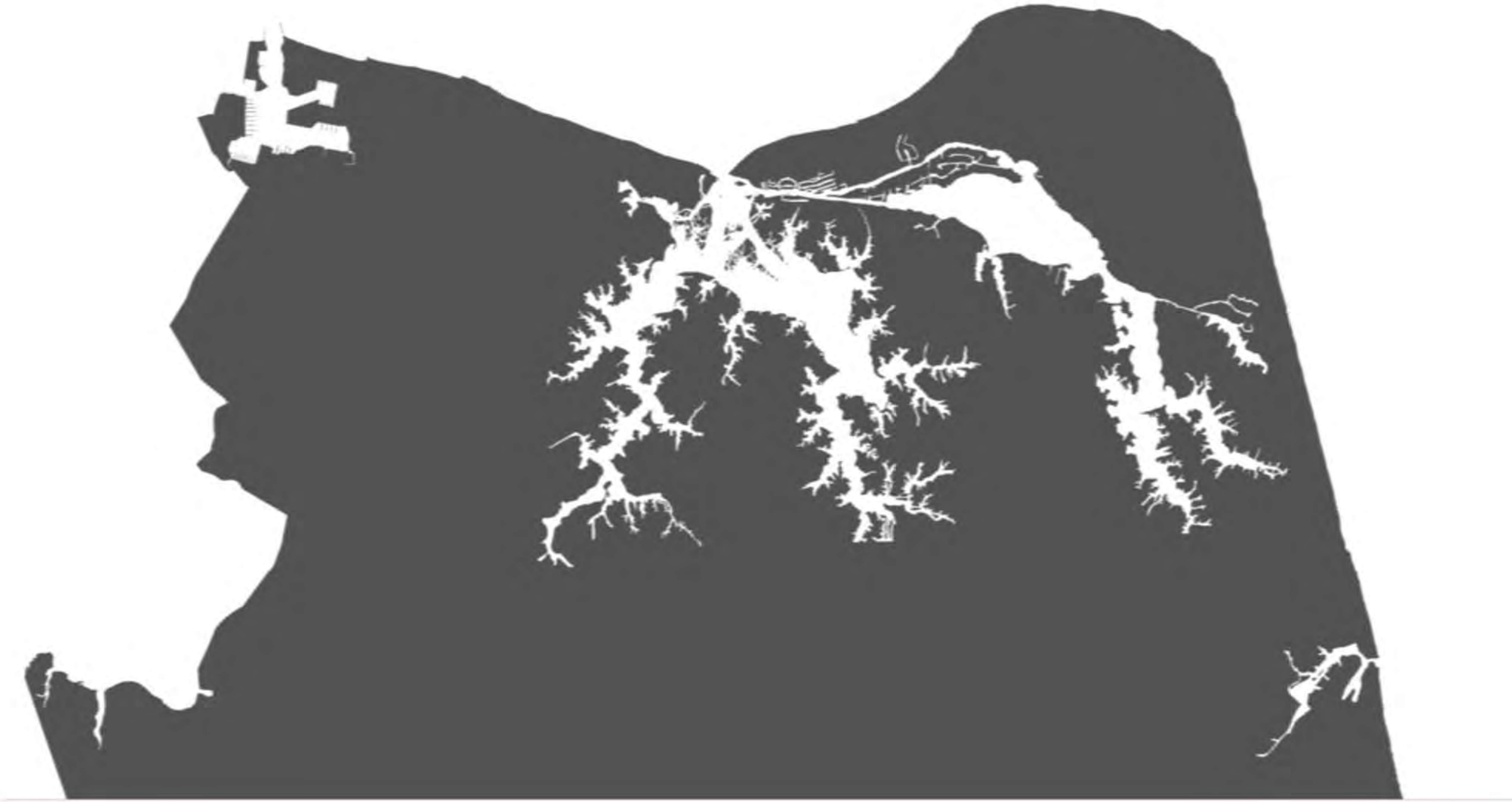
Adaptation Measures at VIMS



MS Eastern Shore Seawater Lab

MA Zone VE (Coastal High Hazard)

Current Sea Level



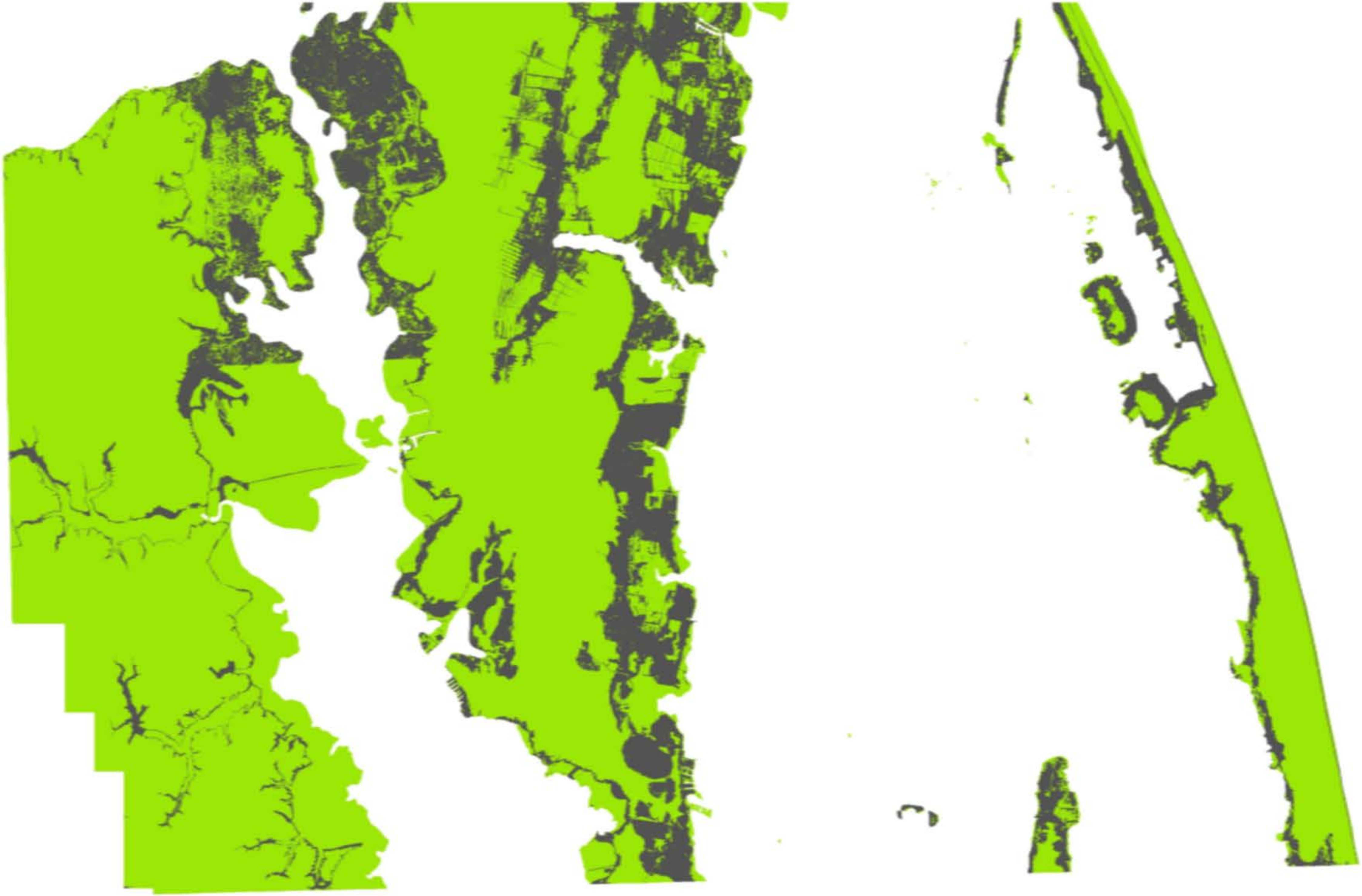
Current Sea Level

Current Sea Level

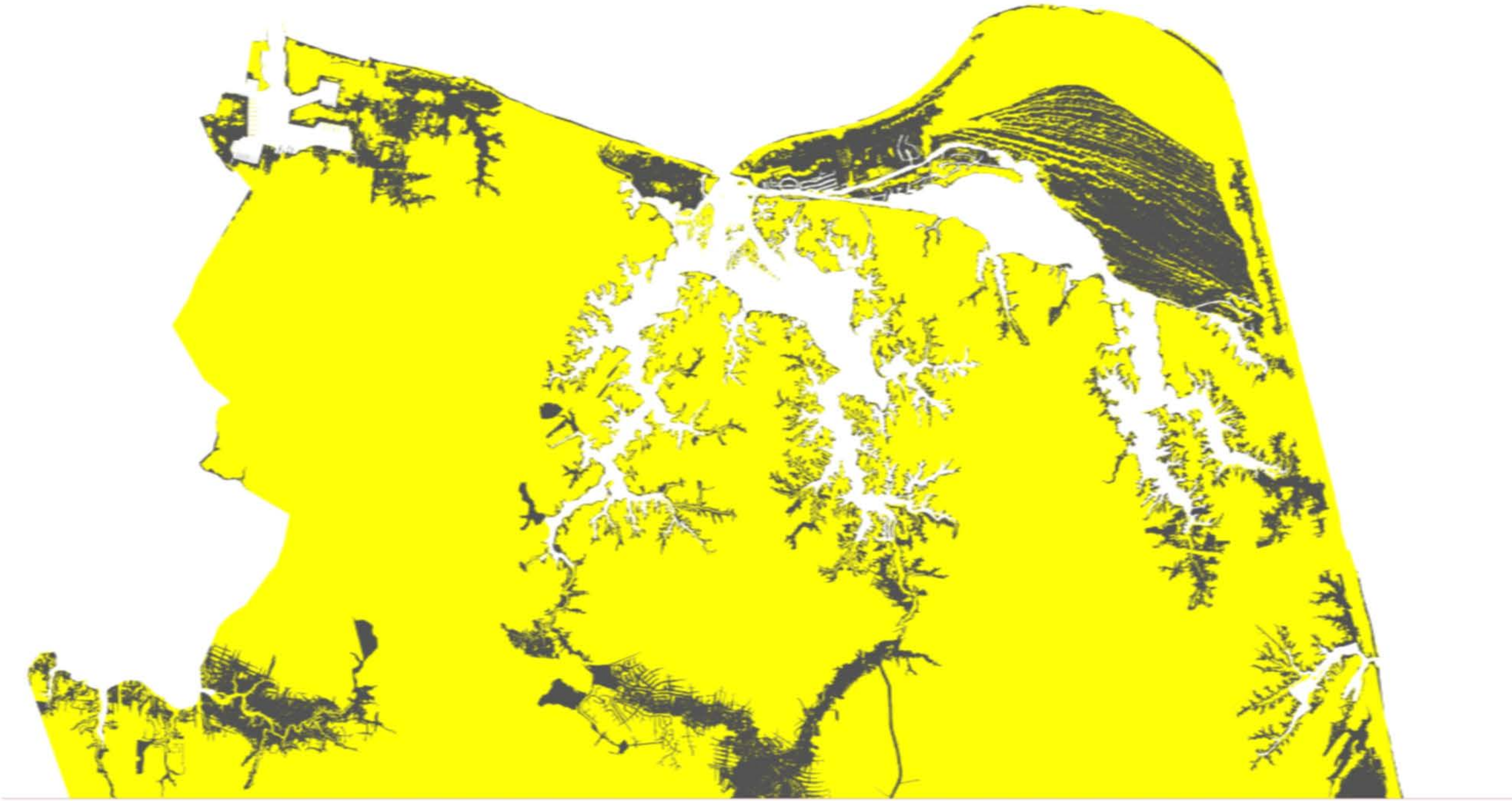
3 ft. Sea Level Rise

3 ft. Sea Level Rise

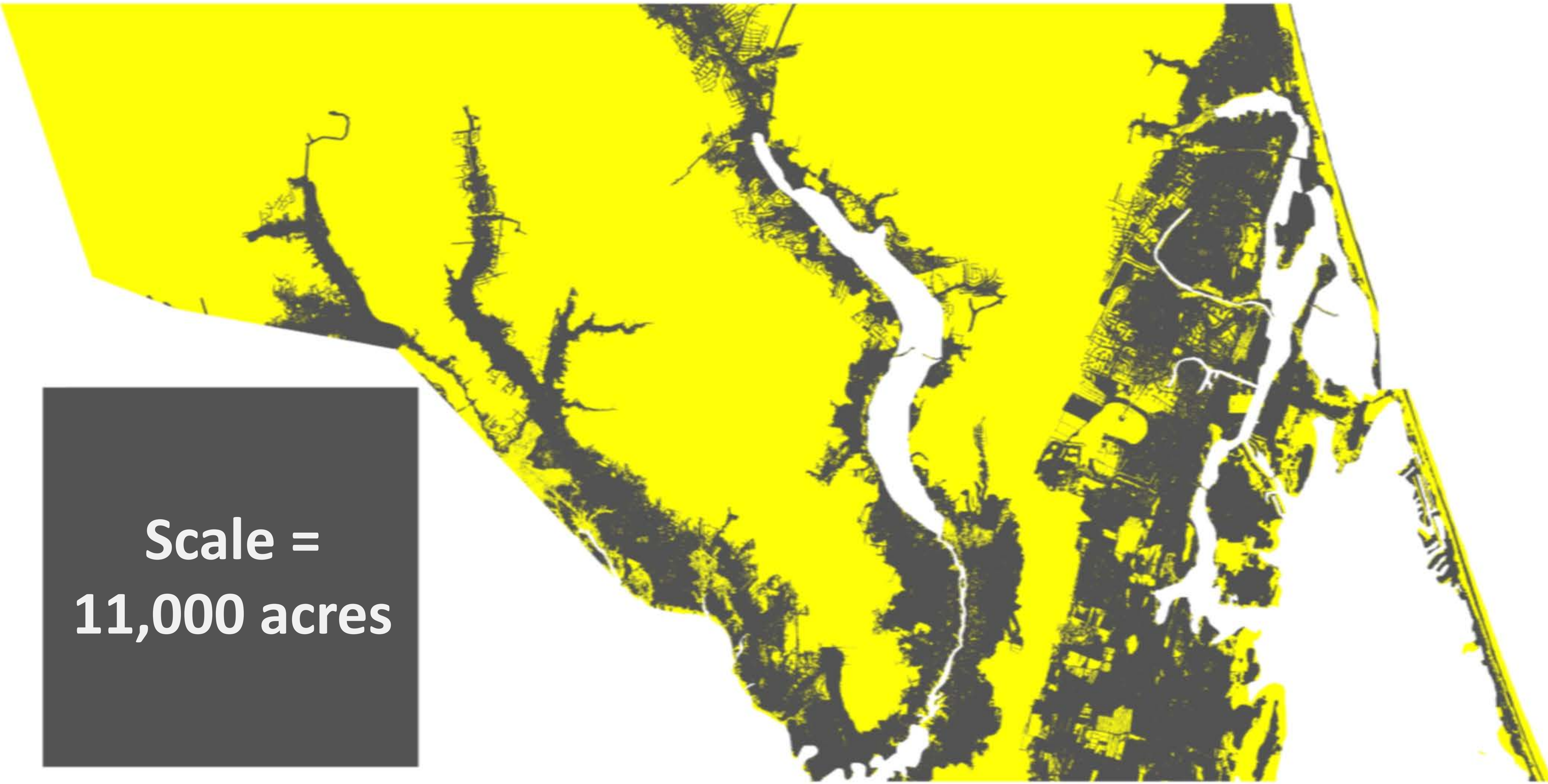
3 ft. Sea Level Rise



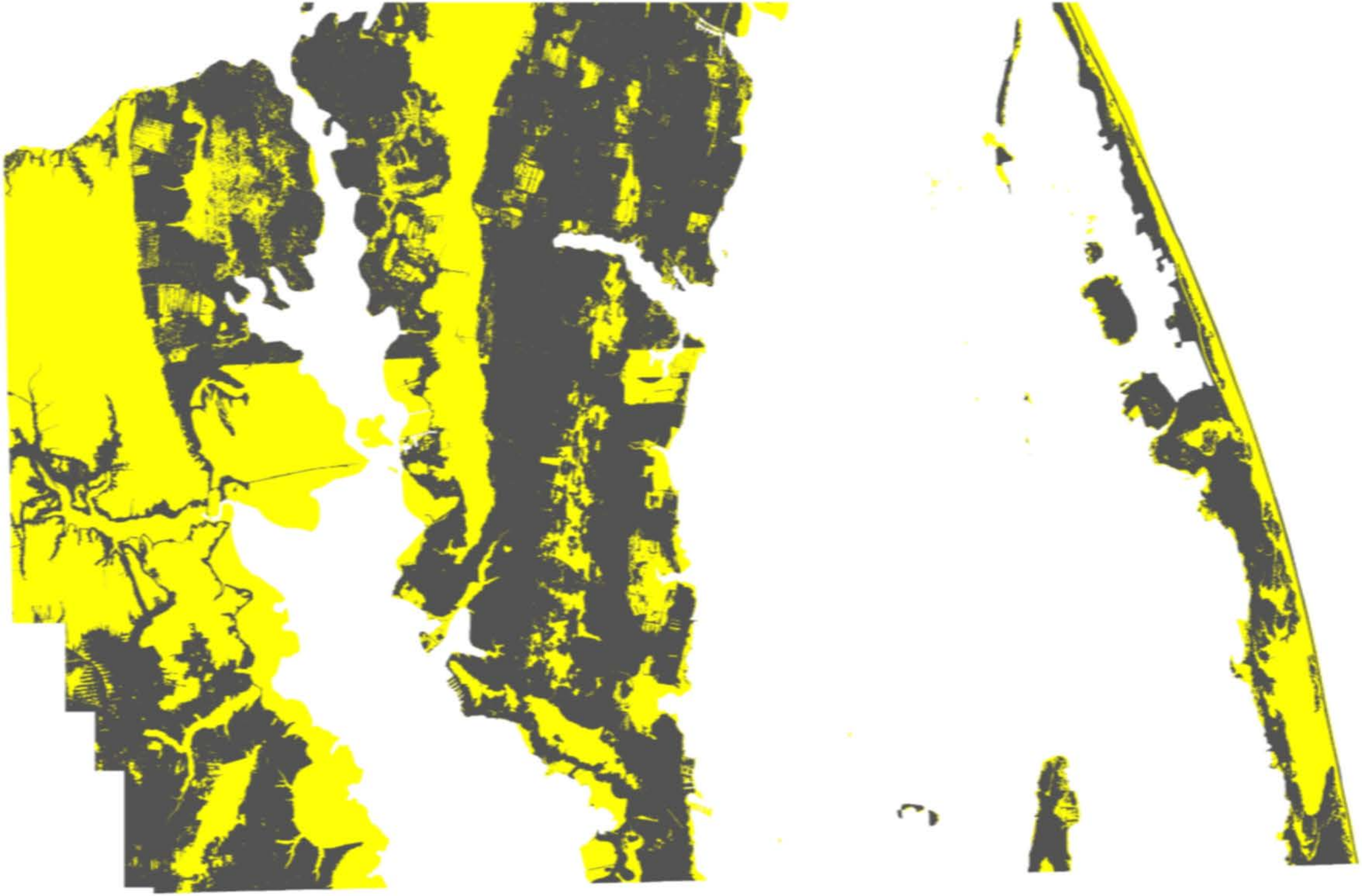
7 ft. Sea Level Rise



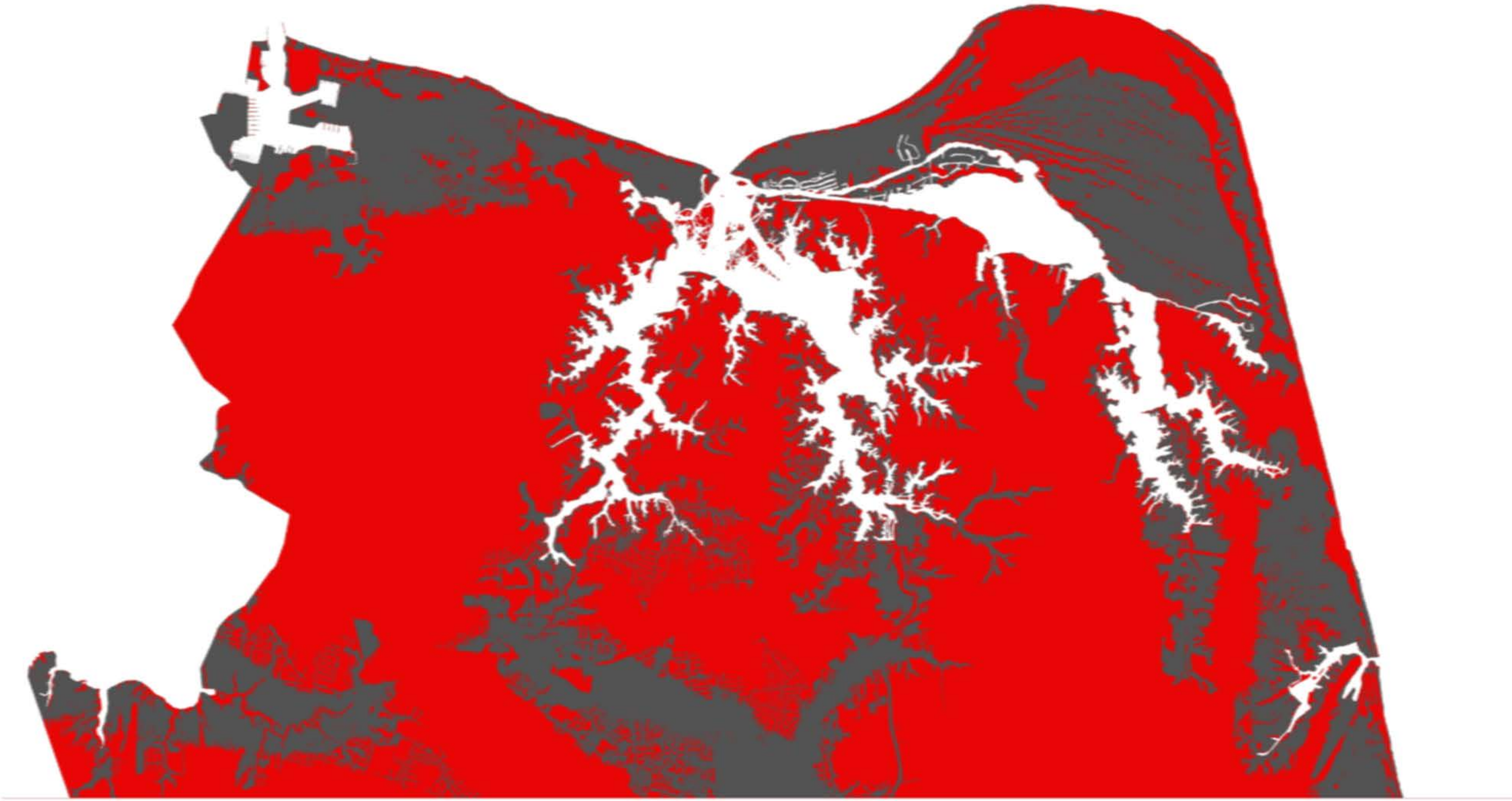
7 ft. Sea Level Rise



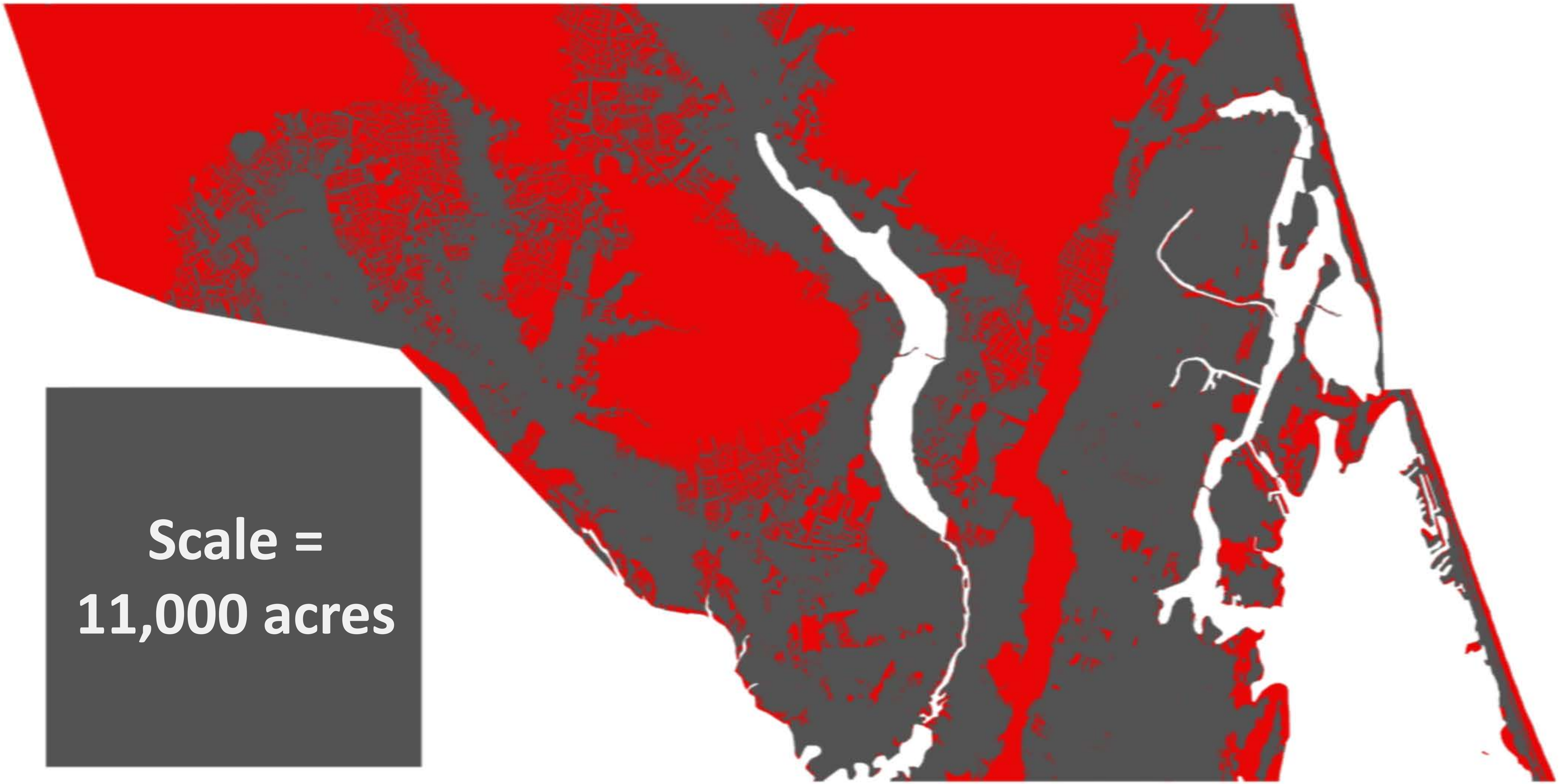
7 ft. Sea Level Rise



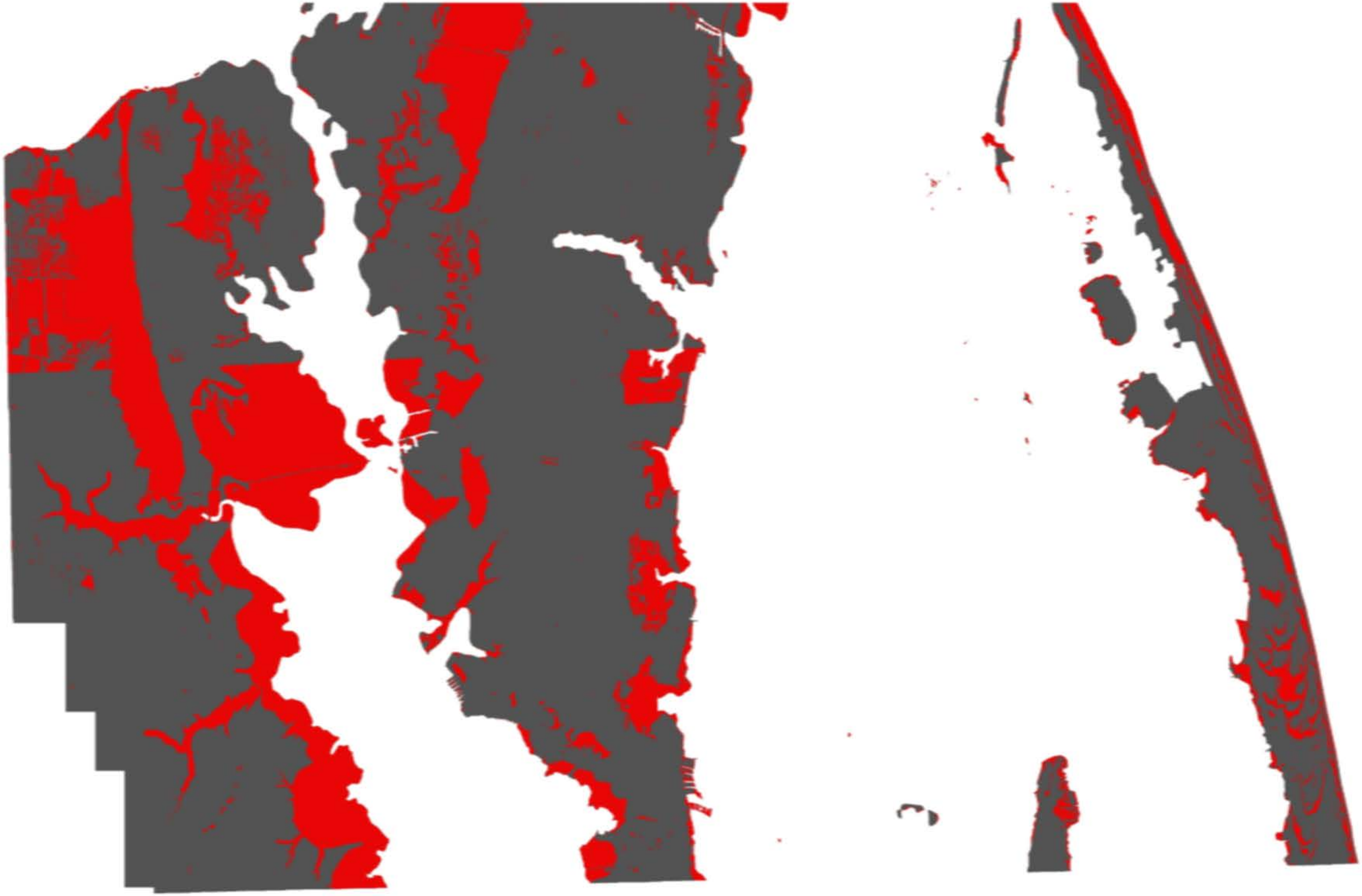
10 ft. Sea Level Rise



10 ft. Sea Level Rise



10 ft. Sea Level Rise



Name:______________________________ Date:_______________

Coastal Virginia Sea Level Rise Worksheet

1. List and define the processes that are acting together to cause sea level rise in coastal Virginia?

   Global:

   -
   -

   Regional:

   -

   Local:

   -
   -
   -

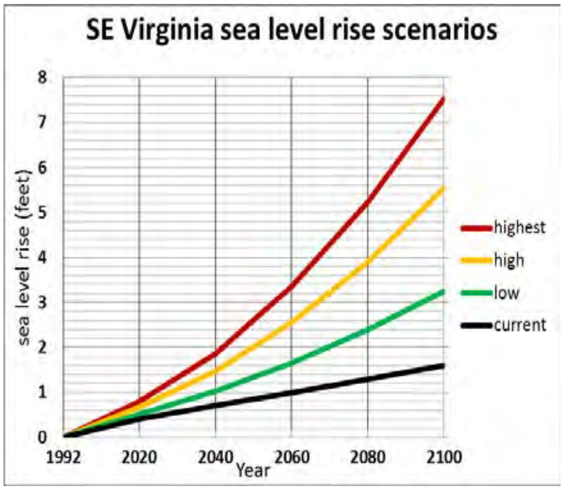
2. Fill in the table below with the class data

Group Name	Scenario (0, 3, 7, 10 ft.)	Weight (grams)	Total Area Above Sea Level (acres)	% of Current Area

Name:_______________________________ Date:________________

Read the 1 page *Scientific American* article before completing the worksheet.

3. Given the current threat of sea level rise on coastal Virginia, describe 3 strategies that you would recommend to the mayor of Virginia Beach to mitigate the impact on Hampton Roads over the next 50 years.

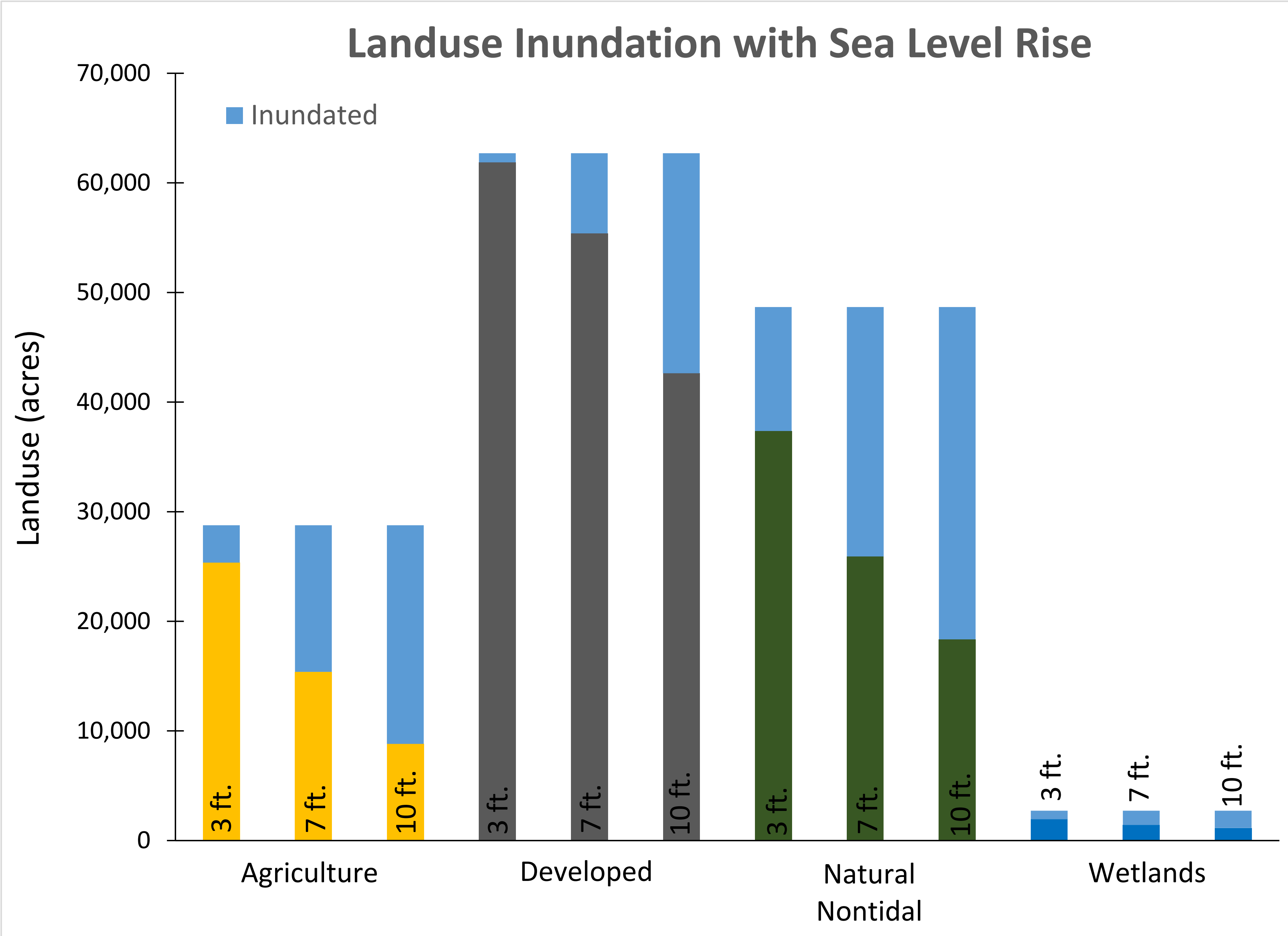


Boon 2012 JCR

-
-
-

4. Below draw and describe one of the 3 strategies you listed above that relates to residential communities, local industry, or military installations.

5. Will this strategy still work in the year 2100? Why or why not?



Landuse Inundation with Sea Level Rise
Inundated
Landuse (acres)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
3 ft.
7 ft.
10 ft.
Agriculture
Developed
Natural Nontidal
Wetlands

SCIENTIFIC AMERICAN™
Permanent Address: http://www.scientificamerican.com/article/what-does-the-u-s-look-like-after-3-meters-of-sea-level-rise/

What Does the U.S. Look Like after 3 Meters of Sea Level Rise?

New research indicates that climate change has triggered an unstoppable decay of the West Antarctic Ice Sheet, eventually leading to at least three meters of global sea level rise

May 14, 2014 |By Ben Strauss and Climate Central

By the metric of most people living on land less than 10 ft above the high tide line, New York City is most threatened in the long run, with a low-lying population count of more than 700,000.
Courtesy of Climate Central

New research indicates that climate change has already triggered an unstoppable decay of the West Antarctic Ice Sheet. The projected decay will lead to at least 4 feet of accelerating global sea level rise within the next two-plus centuries, and at least 10 feet of rise in the end.

What does the U.S. look like with an ocean that is 10 feet higher? The radically transformed map would lose 28,800 square miles of land, home today to 12.3 million people.

These figures come from Climate Central research published in 2012, analyzing and mapping every coastal city, county and state in the lower 48 states. (A next generation of research is currently under way.)

Cities with the Most Population on Affected Land

CITY	POPULATION
1. New York City	703,000
2. New Orleans	342,000
3. Miami	275,000
4. Hialeah, FL	224,000
5. Virginia Beach	195,000
6. Fort Lauderdale	160,000
7. Norfolk	157,000
8. Stockton, CA	142,000
9. Metairie, LA	138,000
10. Hollywood, FL	126,000

More than half of the area of 40 large cities (population over 50,000) is less than 10 feet above the high tide line, from Virginia Beach and Miami (the largest affected), down to Hoboken, N.J. (smallest). Twenty-seven of the cities are in Florida, where one-third of all current housing sits below the critical line — including 85 percent in Miami-Dade and Broward counties. Each of these counties is more threatened than any whole state outside of Florida – and each sits on bedrock filled with holes, rendering defense by seawalls or levees almost impossible.

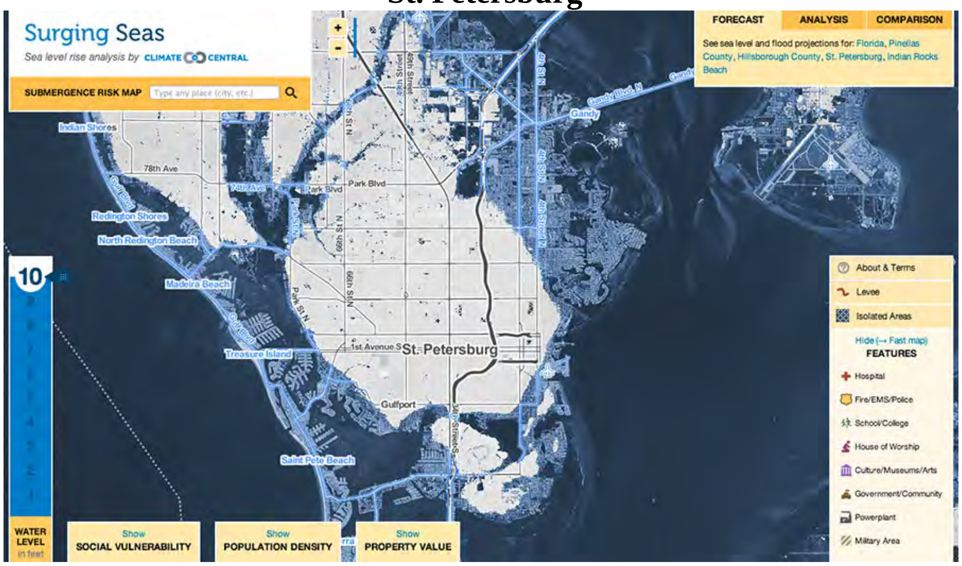
By the metric of most people living on land less than 10 ft above the high tide line, New York City is most threatened in the long run, with a low-lying population count of more than 700,000. Sixteen other cities, including New Orleans, La.; Norfolk, Va.; Stockton, Calif.; Boston, Mass.; St. Petersburg, Fla.; and Jacksonville, Fla.; are on the list of places with more than 100,000 people below the line. (Much of New Orleans is already below sea level, but is protected at today's level by levees.)

Climate Central's enhanced analysis paints a much more detailed pictured for completed states. For example, more than 32,000 miles of road and $950 billion of property currently sit on affected land in Florida. Threatened property in New York and New Jersey totals more than $300 billion. And New England states all face important risks.

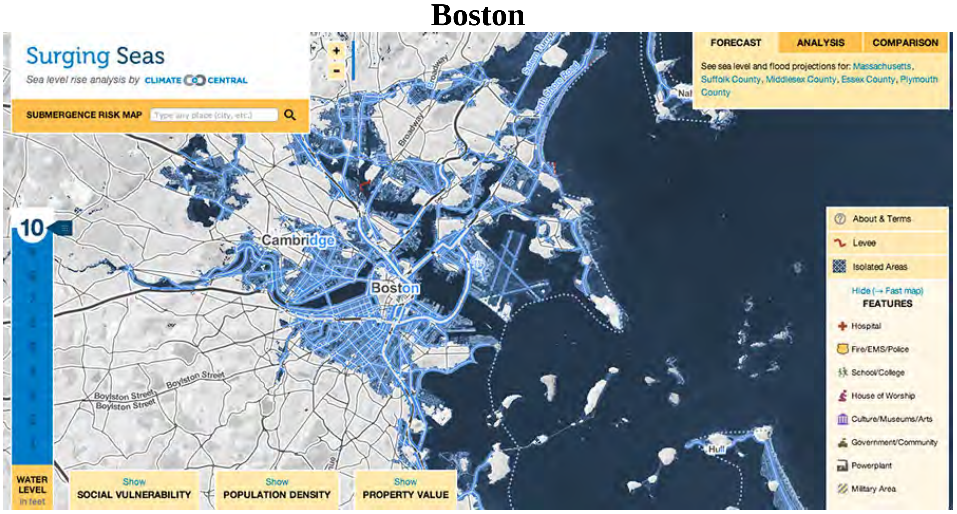
The predicted sea level rise will take a long time to unfold. The numbers listed here do not represent immediate or literal threats. Under any circumstances, coastal populations and economies will reshape themselves over time. But the new research on West Antarctic Ice Sheet decay — and the amount of humanity in the restless ocean's way — point to unrelenting centuries of defense, retreat, and reimagination of life along our coasts.

New York City

St. Petersburg



Boston



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Teacher Guidelines – Living in 3-D! (Habitat Preferences of Benthic/Littoral Fauna)

One or two 45-minute class periods (depending on depth of discussion and planning desired by the teacher, and the sophistication of the student experiments); 3-4 students per team. This is a fun lab for introducing the concept of habitat complexity and the three-dimensional structures that make estuaries and wetlands so attractive as nurseries and shelter. Students design their own brief experiments to test hypotheses about whether small fish (either local killifish or pet store goldfish) have an instinctive preference for habitats of greater 3-dimensional complexity. They really enjoy this lab because of the creativity and independence involved.

Materials:
Live local killifish or a species from a pet store (see below)
Central aquarium or bucket with aerators and dip nets
Large plastic basins
Toy building blocks (Lego's or a less expensive brand)
Thin dowel rods
Green ribbon
Tape
Modeling clay
Lead fishing weights (to weigh down buoyant objects like Legos and dowel rods)
Miscellaneous "nuts and bolts": clean stones, oyster or other seashells, glass beads, etc.
Tools: scissors and snips or small saws (for dowels)

Preparation and Execution:
Killifish ("mud minnows") live in the shallows of fresh, brackish, and saltwater, and are easy to catch with minnow traps (the best bait is dry dog food). They are tough, hardy fish that can tolerate a moderate change in salinity (e.g., when moved to tap water in your classroom). However, if they come from a saltier location, you will need to provide your students with water of a comparable salinity for use in their experiments. Killifish are also well adapted for low oxygen conditions, so it is not necessary for each team of students to aerate their own basin (unless they intend to keep the fish in the water for a longer than a few minutes). During class, keep the fish in a central location in a well aerated aquarium or bucket, with dip nets. Students can take fish as needed during each experimental trial and immediately return them afterwards. You may wish to have a second aquarium for "used" fish.

If your location or the season prevents you from catching killifish, you may instead use fish from a pet store. "Feeder" goldfish are cheap, and many pet stores will allow you to borrow fish for a day and then return them. They also do well in low oxygen water and do not require salt.

Provide materials in a central location, allowing students to choose the materials they want to construct their 3-dimensional structures. Alert students in advance that plastic building blocks and wood will float unless anchored down (hence the lead weights and modeling clay). Ribbon is good for modeling seagrass. Look for other good "nuts and bolts" in the crafts, hardware, toys, and pet sections of a department store.

Each team of students can design its own experiment. Many will have flaws, but that makes for good post-lab discussion. A common mistake is "pseudoreplication" in which students place 5 fish in a tank at a time and count the fraction that go to each structure, thinking that N = 5 (in reality, N=1; to replicate, they must use *more than one* group of 5). Another common flaw is to provide too many "choices" for the fish. The best experiments monitor the behavior of one fish at a time, giving it a simple either/or choice of two habitats. In science, simpler is often better!

An alternative approach is to lead a whole-class discussion in which students come to consensus on a single experimental design that all teams will employ. An advantage to this approach is that it increases sample size (replication), especially desirable if you want students to test results for statistical significance via Chi-square, t-test, or ANOVA.

Living in 3-D!!!

Lab Activity: Habitat Preferences of Local Killifish

Any fisherman can tell you that many kinds of fish prefer to congregate near 3-dimensional underwater structures: fallen trees along the shoreline, coral reefs, oyster bars, bridge pilings, sunken ships, even floating seaweed and drifting debris. They may do this for shelter from predators, to hunt and forage for food, or to meet potential mates. In the Chesapeake Bay and its family of rivers, such 3-D structures are a main attraction for many of the species that visit or reside in it. We can classify these structures in two groups: (1) **Littoral (shoreline) structures** like marsh grasses and fallen trees, and (2) **Benthic (seafloor) structures** like oyster bars and seagrass meadows. Unfortunately, over the past 300 years, human activity has destroyed much of this valuable habitat. How might this be affecting local populations of fish, crabs, and other animals? In this lab activity, you and your teammates will design an experiment to find out.

"The abundance of oysters is incredible. There are whole banks of them so that the ships must avoid them."

- Francis Louis Michel, 1701
upon visiting Virginia

In Chesapeake Bay and its rivers, there are four main kinds of complex 3-D habitat: oyster bars, seagrass meadows, marsh grasses, and fallen trees.

(1) **Oyster Reefs:** When Europeans were first exploring east coast bays and rivers during the 17th century, they found that oysters had created massive oyster reefs, tall underwater mounds and ridges that rose all the way from the seafloor to the water's surface. At low tide, in fact, their peaks were exposed to air! Oyster reefs were built by countless generations of oysters growing atop one another, as each new crop of baby oysters cemented themselves onto the larger shells of their elders. In the 1800's, however, these reefs became the easy target of fishermen, who rapidly harvested them down. They hauled millions of bushels of oyster shell out of the water, and this reduced the 3-D reefs to flat, 2-D "beds" or "bars" on the seafloor. ***For a fish or crab looking for a safe place to park, oyster bars and oyster reefs are two radically different habitats: one is like a parking lot, while the other is like a multi-level parking garage.***

(2) **Seagrass Meadows:** Back when Europeans were first colonizing Virginia, Captain John Smith wrote that Chesapeake Bay's water was so clear that he could see abundant fish swimming around near the bottom. Smith may have been exaggerating a bit, but there can be no doubt that the water back then was far less cloudy than it is now. What has "clouded" the water is an unnatural overgrowth of algae. This overgrowth is caused by fertilizer runoff from farms and lawns, as well as nitrogen compounds

that enter the Bay from sewage treatment facilities, septic tanks, and even the tailpipes of our cars. Some of these algae are microscopic and drift freely in the water column (phytoplankton), and this has darkened the water. Others grow like a slippery film on any solid surface, including the leaves of underwater seagrasses, thereby blocking sunlight. All this shading has decimated seagrass meadows (SAV: submerged aquatic vegetation), turning once dense thickets into sparse patches and naked seafloor. ***For a fish or crab looking for a place to hunker down and hide, this is like the difference between a lush forest and a barren desert.***

(3) **<u>Marshes</u>:** Marshes are a type of "wetland." Like seagrass meadows, a marsh is a big field of tall, dense grass. The difference is that seagrass meadows are totally submerged underwater, whereas marsh grasses live along shorelines, only partly submerged: the base of the plant is underwater, but the stems and leaf blades stick up into the air. Because marshes occupy broad, flat expanses of land at the water's edge, people used to fill them in with dirt in order to create farmland or waterfront property. This is no longer legal, but before the laws changed, hundreds of thousands of acres were destroyed. ***For small fish and crabs seeking protection from big waves and big predators, this was like being stuck outdoors during a hailstorm …or worse, a helicopter attack.***

(4) **<u>Fallen Trees</u>:** The shores of Chesapeake Bay and its rivers are lined not only by marshes, but also forests. Since the end of the last ice age, sea level around the world has slowly been rising as polar ice caps have melted and poured water into the ocean basins. As sea level rises, shorelines retreat backwards. Thus the Bay and its rivers slowly widen. As the shoreline retreats, trees tumble into the water, creating intricate tangles of twigs and branches where aquatic animals can take refuge. Eventually these dead trees decay and disappear, but as long as there are forests at the water's edge, and as long as sea level keeps rising, there will be a replenishing supply of new fallen trees. Unfortunately, property owners everywhere have been removing waterfront forests. Why? Because people who own waterfront property want a view! Trees block their view of the Bay or river, so they cut them down and haul away the wood. Also, they often build seawalls to stop shoreline erosion, and tow away whatever trees have already fallen into the water. ***For fish and crabs who want shade and shelter, this is like having a giant tornado sweep away your house …plus all the lumber and bricks for building a new one!***

Something that is **<u>two-dimensional</u>** is flat – like paintings, parking lots, and prairies. Something that is **<u>three-dimensional</u>** has depth and structure – like sculptures, parking decks, and playgrounds. Humans have destroyed 50-75% of the Chesapeake Bay's marshes and wetlands since colonial times. The darkening of the water by algae overgrowth has killed 15-30% of our seagrass meadows. The oyster population is a mere 2% of what it was during Captain John Smith's day; that's a habitat loss of 98%. And countless fallen trees have been hauled away, never to be replaced. In other words, many of the Bay's complex, 3-D structures have given way to simple, flat, 2-D seafloors of sand and soft mud.

Yet there are degrees of 3-dimensionality. Ecologists often speak of **habitat complexity**, by which they mean the amount of 3-dimensional "relief" found there. "Relief" is a term borrowed from art and architecture. A painting on canvas has zero relief. A collage, fresco, or engraving has "low relief," for some of the material rises slightly above (or sinks down into) the surface. A marble sculpture is "high relief," with a complex interweaving of solid stone and empty space. Consider, too, the fronts of city buildings. Some present a smooth, glassy face to the world. Others have ledges and crevices and decorative etchings. Still others bear grand columns, cascading stairways, great canopies, and elaborate carvings. These represent different amounts of 3-dimensional complexity.

In the wild, some habitats provide higher relief than others. A 3-D oyster reef, for instance, offers far more nooks and crannies than a 2-D bar. A hardwood forest is much more structurally intricate than an open savannah dotted with acacia trees. A patch of underwater grasses is more complex than a single pier piling.

Your Mission: **Design and conduct an experiment to investigate whether or not local killifish display an instinctive "preference" for habitats of higher 3-D complexity.**

Options & Advices

- You can create artificial habitats in a large plastic basin. You may use wooden dowel rods, modeling clay, ribbons, Legos, or any other "nuts and bolts" the teacher tosses your way.
- BUT WAIT! …BEFORE you start building habitats, first come up with a prediction – that is, a hypothesis – about how the fish will behave. Then take time to carefully think, PLAN, and design an experiment to test your hypothesis.
- You can model your habitats after real underwater structures: the stems of marsh grasses, the blades of seagrass, twigs and tree limbs, oyster bars vs. oyster reefs, etc. Alternatively, you can choose NOT to model your habitats after anything real at all, instead creating abstract structures with different degrees of 3-D complexity.
- In science, we usually want numerical data. We want numbers. So come up with a way to quantify the fish "preferences." In science, we also want to "replicate" our experimental trials. So you should conduct your experiment over and over again, each time with a new fish (or a new group of fish).
- **BE NICE TO THE FISH!!!!!!!!**

Afterwards, each team will share what they did with the rest of class.
Be ready to explain your hypothesis, experiment, results, and conclusions.

Field Data - VIMS Eastern Shore Lab, Wachapreague, VA: BEACH SEINE SURVEY

DATE: ______________________________ SITE: ______________________________

TIME: ______________________________ Data Recorder: ______________________________

Physical Description of Sampling Site:

ABIOTIC CONDITIONS

Gear to use	Parameter			
Thermometer	Air temperature (˚C):			
	Water temperature (˚C):			
Eyeball / Estimation	*Weather*			
	❑ Sunny	❑ Overcast	❑ Drizzle	❑ Snow
	❑ Partly Cloudy	❑ Fog/Haze	❑ Rain	
	Cloud cover (%):	Solar angle (°):		
	Wind speed (knots):	Wind direction (°):		
	Sea State			
	❑ Calm	❑ Ripple	❑ Waves	❑ White caps
	Wave height (cm):			
	Tidal Elevation			
	❑ High water	❑ Falling	❑ Low water	❑ Rising

BIOTIC SAMPLING

Species (common name)	Sizes (cm) and/or Tally	Total Count

Comments, observations, other wildlife, etc.:

Field Data - VIMS Eastern Shore Lab, Wachapreague, VA: BEACH TRANSECT

DATE: ______________________________ SITE: ______________________________

TIME: ______________________________ Data Recorder: ______________________________

Site #	Latitude (°N)	Longitude (°W)	Distance (m)	Cumulative Dist (m)	Elevation Change (cm)	Cumulative Elev Chg (cm)	Observations (vegetation, sand size/composition, etc.)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
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21							
22							
23							
24							
25							
26							
27							
28							
29							
30							

VIMS | William & Mary
Virginia Institute of Marine Science
Sea Grant Virginia

Field Data - VIMS Eastern Shore Lab, Wachapreague, VA: OYSTER DREDGE

SITE: ______________________________ Vessel: ______________________________

DATE: ______________________________ Captain: ______________________________

TIME: ______________________________ Crew: ______________________________

LAT/LONG: ______________________________ Data Recorder: ______________________________

Physical Description of Sampling Site:

ABIOTIC CONDITIONS

ATMOSPHERIC

Gear to use	Parameter			
Thermometer	Air temperature (˚C):			
Eyeball / Estimation	*Weather*			
	❑ Sunny	❑ Overcast	❑ Drizzle	❑ Snow
	❑ Partly Cloudy	❑ Fog/Haze	❑ Rain	
	Cloud cover (%):	Solar angle (°):		
	Wind speed (knots):	Wind direction (°):		

TIDES and SURFACE STATE

Gear to use	Parameter			
Eyeball / Estimation	*Sea State*			
	❑ Calm	❑ Ripple	❑ Waves	❑ White caps
	Wave height (cm):			
Tide Chart or Boat Captain (circle one)	*Tidal Elevation*			
	❑ High water	❑ Falling	❑ Low water	❑ Rising
	Tidal Current			
	❑ Flood	❑ Slack-before-ebb	❑ Ebb	❑ Slack-before-flood

WATER QUALITY

Gear to use	Parameter (surface only)	
Boat Depth Finder	Depth (m):	
Secchi Disk	Secchi depth (m):	
	Photic zone (Secchi x 2):	
Thermometer	Water Temp (°C):	
pH Test Kit	pH:	
D.O. Titration Kit	D.O. (mg/L or ppm):	
Salinity Titration Kit	Salinity (ppt):	

OVER >>

BIOTIC SAMPLING

OYSTER DREDGE **–** Tow Heading, Duration, and Velocity (or Distance): ____

OYSTERS (live)

Species	**Shell Height (cm; bill to heel) and Tally**	**Total Count**
Eastern oyster (*Crassostrea virginica*)		

FINFISH

Species (common name)	**Fork Length or Total Length (cm) and Tally** *For each species, record size of largest fish, smallest fish, and up to 3 others (random sub-sample). Tally the rest.*	**Total Count**

INVERTEBRATES

Species (common name)	**Sizes (cm) and Tally** *Blue crabs: Record carapace widths. Other invertebrates: Tally only.*	**Total Count**

PLANKTON TOW **–** Tow Heading, Duration, and Velocity (or Distance): ____

Representative Groups:

PUT A LABELLED SAMPLE IN COOLER!

Comments, additional organisms collected or observed (e.g., birds):

Field Data - VIMS Eastern Shore Lab: MUDFLAT SURVEY, East Wye (both boats)

DATE: ______________________________ SITE: ______________________________

TIME: ______________________________ Data Recorder: ______________________________

Physical Description of Sampling Site:

ABIOTIC CONDITIONS

ATMOSPHERIC

Gear to use	Parameter			
Thermometer	Air temperature (˚C):			
Anemometer	Wind speed (knots):			
GPS / Compass	Wind direction (°):			
Eyeball / Estimation	*Weather*			
	❑ Sunny	❑ Overcast	❑ Drizzle	❑ Snow
	❑ Partly Cloudy	❑ Fog/Haze	❑ Rain	
	Cloud cover (%):	Solar angle (°):		
Tide Chart or Boat Captain (circle one)	*Lunar Phase*			
	❑ New moon	❑ Waxing crescent	❑ First quarter	❑ Waxing gibbous
	❑ Full moon	❑ Waning gibbous	❑ Third quarter	❑ Waning crescent

TIDES and SURFACE STATE

Gear to use	Parameter			
Eyeball / Estimation	*Sea State*			
	❑ Calm	❑ Ripple	❑ Waves	❑ White caps
	Wave height (cm):			
Tide Chart or Boat Captain (circle one)	*Tidal Elevation*			
	❑ High water	❑ Falling	❑ Low water	❑ Rising
	Tidal Current			
	❑ Flood	❑ Slack-before-ebb	❑ Ebb	❑ Slack-before-flood

SEDIMENTS / GEOLOGY

Gear to use	Parameter			
Specify:	Color:			
❑ Ponar Grab	*Texture / Grain Size(s)*			
❑ Shovel	❑ Pebble	❑ Sand	❑ Silt	❑ Clay
❑ Other:	*Compaction*			
__________	❑ Hard	❑ Firm	❑ Soft	❑ Fluidized (soupy)
Additional field notes on sediment / local geology:				

OVER >>

WATER QUALITY ***Specify body of water (shoal, tide pool, gut, etc.):***

Gear to use	Parameter	
Thermometer	Water Temp (°C)	
pH Test Kit	pH	
D.O. Titration Kit	D.O. (mg/L or ppm)	
Salinity Titration Kit	Salinity (ppt)	
YSI probe	D.O. (mg/L or ppm)	
	D.O. (%)	
	Conductivity (mS)	
	Water Temp (°C)	
	Salinity (ppt)	
Refractometer	Salinity (ppt)	
Hydrometer	Salinity (ppt)	

BIOTIC SAMPLING

MUDFLAT SURVEY

Species (common name)	Observations / Data

Comments, observations, other wildlife (e.g., birds):

VIMS | William & Mary
Virginia Institute of Marine Science
Sea Grant Virginia

Field Data - VIMS Eastern Shore Lab, Wachapreague, VA: OTTER TRAWL

SITE: ______________________________ Vessel: ______________________________

DATE: ______________________________ Captain: ______________________________

TIME: ______________________________ Crew: ______________________________

LAT/LONG: ______________________________ Data Recorder: ______________________________

Physical Description of Sampling Site:

ABIOTIC CONDITIONS

ATMOSPHERIC

Gear to use	**Parameter**			
Thermometer	Air temperature (˚C):			
Anemometer	Wind speed (knots):			
GPS / Compass	Wind direction (°):			
Eyeball / Estimation	*Weather*			
	❑ Sunny	❑ Overcast	❑ Drizzle	❑ Snow
	❑ Partly Cloudy	❑ Fog/Haze	❑ Rain	
	Cloud cover (%):	Solar angle (°):		
Tide Chart or Boat Captain (circle one)	*Lunar Phase*			
	❑ New moon	❑ Waxing crescent	❑ First quarter	❑ Waxing gibbous
	❑ Full moon	❑ Waning gibbous	❑ Third quarter	❑ Waning crescent

TIDES and SURFACE STATE

Gear to use	**Parameter**			
Eyeball / Estimation	*Sea State*			
	❑ Calm	❑ Ripple	❑ Waves	❑ White caps
	Wave height (cm):			
Tide Chart or Boat Captain (circle one)	*Tidal Elevation*			
	❑ High water	❑ Falling	❑ Low water	❑ Rising
	Tidal Current			
	❑ Flood	❑ Slack-before-ebb	❑ Ebb	❑ Slack-before-flood
	Current direction (°):	(how measured?):		
	Flow rate (kt):	(how measured?):		
	Water depth (m):	(how measured?):		

SEDIMENTS / GEOLOGY

Gear to use	**Parameter**			
Specify:	Color:			
❑ Ponar Grab	*Texture / Grain Size(s)*			
❑ Shovel	❑ Pebble	❑ Sand	❑ Silt	❑ Clay
❑ Other:	*Compaction*			
__________	❑ Hard	❑ Firm	❑ Soft	❑ Fluidized (soupy)
Additional field notes on sediment / local geology:				

OVER >>

WATER QUALITY

Gear to use	Parameter	Surface	Benthic (bottom)
Boat Depth Finder	Depth (m)	~ 0.1 meters (10 cm)	
YSI probe	D.O. (mg/L or ppm)		
	D.O. (%)		
	Conductivity (mS)		
	Water Temp (°C)		
	Salinity (ppt)		
Refractometer	Salinity (ppt)		X
Hydrometer	Salinity (ppt)		X
Thermometer	Water Temp (°C)		X

BIOTIC SAMPLING

OTTER TRAWL – Tow Heading, Duration, and Velocity (or Distance): ______________________________________

FINFISH

Species (common name)	**Fork Length or Total Length (cm) and Tally** *For each species, record size of largest fish, smallest fish, and up to 3 others (random sub-sample). Tally the rest.*	**Total Count**

INVERTEBRATES

Species (common name)	**Sizes (cm) and Tally** *Blue crabs: Record carapace widths. Other invertebrates: Tally only.*	**Total Count**

Comments, additional organisms collected or observed (e.g., birds):

Ideas and Resources for Educators and Students

Aquatic Stewardship and *You*

By heading up programs, projects or experiences that teach about and inspire emotional connections to water, you can help create a citizenry that is genuinely interested and involved in the conservation of this vital natural resource. So dive in! Join other educators across the Commonwealth who are teaching people about our water resources.

Me teach about water? How?

Stay cool, teaching about water is easy and fun.
Here's how:

1. **Learn about water resources and water-based recreation:**
   Obtain teaching materials listed here.
   Attend workshops designed for educators.

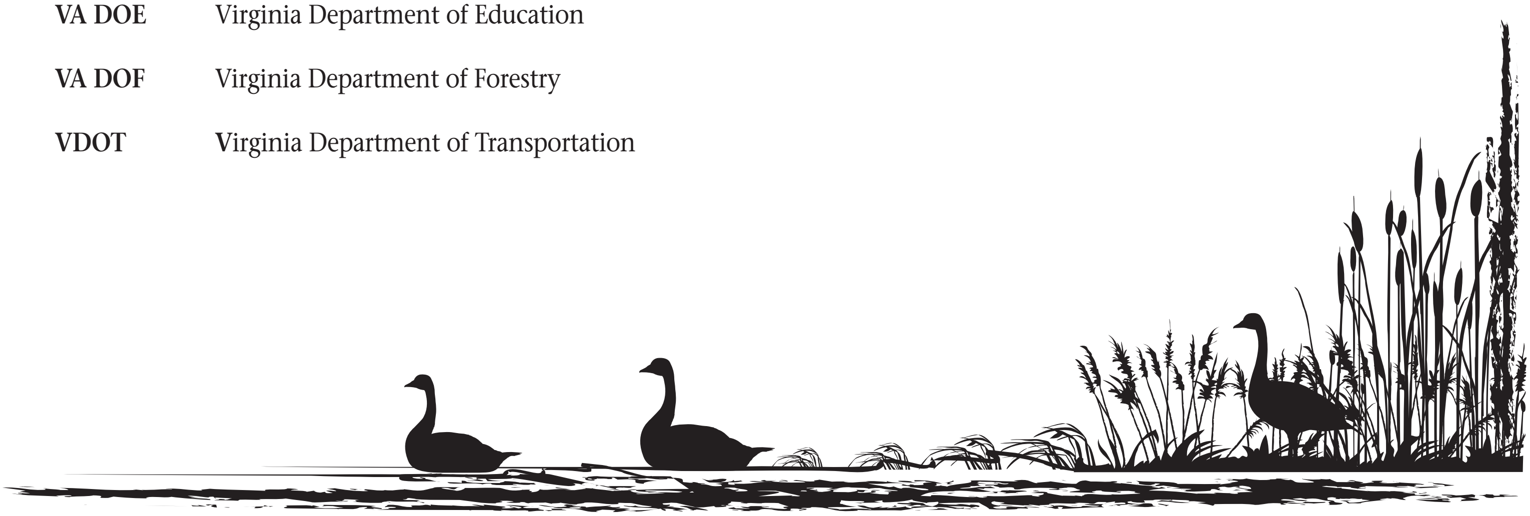
2. **Then teach a unit of study or conduct a water-based recreation activity.**
   Topics to consider include: the water cycle, water quality, ground water, fishing, rafting, canoeing, water supply, water conservation, boating safety, commerce, historical uses of rivers, riverine habitats and riparian zones, wetlands, aquatic plants and wildlife, waterfowl hunting, plastics in our waterways, or other current issues.
   Tips to make these activities "meaningful" can be found at www.chesapeakebay.net/education_mwee.aspx?menuitem=19534.

3. **Integrate a stewardship project that is related to what you are studying.**
   You'll find resources on how to monitor a stream, how to stencil storm drains, restore streamside areas, organize a "fish it out" litter project, build and install wood duck boxes, conduct a wildlife mapping project and more. There's something for everyone.

4. **And don't forget to register your effort with Stewardship Virginia.**
   All participants in your project will receive a certificate of recognition from the Governor. Visit www.dcr.virginia.gov/stewardship.

Guide to Agency Abbreviations Used in the Descriptions

VA DCR	Virginia Department of Conservation and Recreation
VA DEQ	Virginia Department of Environmental Quality
VA DGIF	Virginia Department of Game and Inland Fisheries
VA DOE	Virginia Department of Education
VA DOF	Virginia Department of Forestry
VDOT	Virginia Department of Transportation



Need a Helping Hand? Check Out This Stuff!

Instructional Resources: Workshops and Activity Guides

Angling Education Program

Educators can tip the scales when it comes to inspiring appreciation and stewardship for our fisheries and water resources by teaching people to fish. The VA DGIF Angling Education Program offers many resources to assist in accomplishing your goals of including fishing in your curriculum. The Tackle Loaner Program offers rods, reels and terminal tackle to use on loan, free of charge, for your fishing activities. The Materials Request Program provides educational materials such as posters, booklets, coloring books and the Basic Angling Education Series. The Basic Angling Education Series is a set of easy-to-use lesson plans that even the novice educator can use to teach about fish, aquatic habitats and sport fishing. Lessons cover a variety of topics on the how-to's of fishing while teaching environmental concepts. They can be supplemented with lessons from Project WILD or WET to form a total water education program. To access these programs, visit www.dgif.virginia.gov/education/fishing/ or contact the Angling Education Program at 804-367-6778.

Boating Basics Course

Boat Virginia is an eight-hour certification course that meets the boating safety education requirement for all boaters and personal watercraft operations in Virginia. This education requirement is being phased in over the next several years. The course is taught by trained instructors. It is suitable for high school age youth. For additional information, contact the Regional Boating Education Coordinator at VA DGIF in your region. Visit the website for more information including the phase-in schedule for compliance at www.dgif.virginia.gov/boating/education/.

Community Fishing Clinics Program

Getting people in our communities more involved with local water resources can begin with an interest in fishing. This program is designed to help civic and youth groups, clubs and other organizations sponsor short duration angling education events. Planning assistance, educational materials and equipment loan are a part of the package. For more information visit www.dgif.virginia.gov/education/fishing/.

Offer a Course in Canoeing

Canoeing down a waterway can be considered as a course in itself on environmental appreciation and sensitivity. So "go there," but teach canoeing first. It's a great way to start a water education program. The American Canoe Association offers courses in basic canoeing. For information on who to call in your area, contact their office in Fredericksburg at 540-907-4460 or visit www.americancanoe.org.

Virginia Agriculture in the Classroom Classes

Farmers are finding new ways to improve water quality. Targeted primarily at K-8 grades, this program covers history, geography, technological changes, economics, plant science, agricultural ecology and environmental issues. Teacher workshops and other resources are available, as well as material for all age levels. For more information, contact the Ag in the Classroom coordinator at the Virginia Farm Bureau at 804-290-1141 or visit www.agintheclass.org.

Aquatic Project WILD Activity Guide

This resource is a compilation of activities for educators that focus on aquatic wildlife, habitats, and human interactions. The lessons may be integrated into existing units of study, or a selection of activities can be used as the basis for a course of study. To obtain a guide, educators must attend a four-hour workshop sponsored by the VA DGIF. For more information contact Suzie Gilley, Project WILD Coordinator at VA DGIF at 804-367-0188 or Suzie.gilley@dgif.virginia.gov or visit the website at www.dgif.virginia.gov/education/project-wild/.

Project WET (Water Education for Teachers) Curriculum and Activity Guide

This guide is a collection of 91 innovative activities, for use with kindergartners through twelfth graders that focuses on teaching about water resources. Water as a natural resource is the major theme, but it also addresses water chemistry and physics, historical and cultural uses of water, quantity and quality issues, aquatic wildlife, ecosystems and management strategies. To obtain a Curriculum and Activity Guide, educators must attend a free six-hour workshop. For more information, contact the Virginia Office of Environmental Education at the VA DEQ by visiting the website at www.deq.virginia.gov/education/wet.html.

Healthy Water, Healthy People Activity Guide

Healthy Water, Healthy People (HWHP) is a new curriculum which includes an Educator's Guide and a Field Monitoring Guide. The Educator's Guide is a 200-page activity guide for educators of students in grades 6 through university level and is available from Project WET International for $24.95. The Monitoring Guide is a 100-page technical reference manual with companion text and is available for $14.95. These books are also available for free through a HWHP workshop offered periodically by the VA DEQ. For upcoming workshops, visit the Virginia Naturally Calendar of Events. (www.vanaturally.com)

Project Learning Tree® Program

Project Learning Tree® (PLT) is an environmental education program of the American Forest Foundation which provides activity guides for grades K-12, internet resources, GreenWorks! service learning grants, and a new GreenSchools! program. The PLT PreK-8 Environmental Education Activity Guide has been used by educators for over 30 years and has 96 activities that cover a broad array of environmental topics. Modules for secondary educators include Focus on Forests, Forest Ecology, Municipal Solid Waste, Risk, Places We Live, Biodiversity, and Forests of the World. PLT's Energy & Society Kit for grades K-8 is available for $39.95 at PLT's online store. All PLT materials are correlated to Virginia's Standards of Learning and are available through free workshops. Workshops are posted on the Virginia Naturally Calendar of Events. Visit www.plt.org and www.cnr.vt.edu/plt for more information. To request a workshop, contact Lisa Deaton, Virginia PLT State Coordinator at the VA DOF, at 804-328-3031 or lisa.deaton@dof.virginia.gov.

Project Underground

The purpose of Project Underground is to create and build awareness of and responsible attitudes toward karst and cave resources and their management needs. The project is an environmental education program designed to promote better understanding of caves and karstlands. It is a supplemental program for use by educators of kindergarten through high school age students. Participants in Project Underground activities will gain an understanding of how the underground environment is an important part of the total environment. For more information, visit www.dcr.virginia.gov/underground.shtml or contact Carol Zokaites at VA DCR at 540-394-2553 or Carol.Zokaites@dcr.virginia.gov to schedule a workshop.

Project WILD: Science and Civics Guide

Science and Civics: Sustaining Wildlife is designed to serve as a guide for involving students in environmental action projects aimed at benefiting the local wildlife found in a community. The guide's activities are designed to help high school students in making decisions affecting people, wildlife, and their shared habitat in the community. The structure of Science and Civics makes it a suitable curriculum guide for high school teachers providing a Meaningful Watershed Educational Experience for their students. The guide is available only through in-service workshops sponsored by the VA DGIF. For more information contact Suzie Gilley, Project WILD Coordinator at VA DGIF at 804-367-0188 or Suzie.gilley@dgif.virginia.gov, or visit www.dgif.virginia.gov/education/project-wild/.

Virginia Wild School Sites Workshop

A Virginia WILD School Sites Workshop is a six-hour, basic introduction workshop that covers some of the technical aspects of establishing wildlife habitat on school property. Virginia WILD School Sites is primarily intended for classroom teachers of grades K-12 who are just getting started with a schoolyard project. Because the most successful schoolyard projects are those which involve all grade levels and all subject areas, WILD School Sites workshops are intended for all of the faculty at one school. In those cases where there is a county-wide interest, workshops may be arranged for an entire district, with participants coming from more than one school. For more information, visit www.dgif.virginia.gov/habitat/wild-school-sites.asp or contact Wildlife Habitat Education Coordinator, Carol Heiser at 804-367-6989.

WOW (Wonders of Wetlands) Guide

Wetlands are valuable, diverse and interesting water environments to teach about. WOW (Wonders of Wetlands) is a collection of 40 lesson plans for use with K-12th graders that focuses on teaching about wetlands. An extensive section on restoration of wetlands highlights this guide. The 330-page guide is available for $21.95 from National Project WET through their on-line store at http://store.projectwet.org/ or by calling toll free 866-337-5486. For more information about Project WET International contact info@projectwet.org. For more information about upcoming WOW workshops, visit the Virginia Naturally Calendar of Events or contact the Virginia Office of Environmental Education at VA DEQ by visiting the website at www.deq.virginia.gov/education.

Stewardship Projects and Programs

Adopt-A-Highway

So, what do roadways and waterways have in common? ***Litter.*** Much of what is deposited on roadways ends up in our rivers and streams. So, clean up a highway and you'll be helping to keep our waterways clean. For information on how your club or group can adopt a highway, contact the VDOT at 1-800-PRIDE-VA or visit www.virginiadot.org/programs/prog-aah-default.asp.

Adopt-A-Stream

You need to get your hands a little dirty to truly learn about nature. Whether intentional or not, our waterways receive tons of litter each year. There are many ways that litter is hazardous. Swimmers can cut their feet on glass. Propellers get caught in old rope and fishing line and it can be deadly to marine animals. Sea turtles swallow plastic bags mistaking them for their favorite food, jellyfish. They slowly starve as their digestive systems are inactivated. Seagulls, ducks and other animals become entangled in discarded fishing line, and many fish die in old nets driting free with the tides. Some trash will sink and be covered up with sediment eventually. But plastics will not disintegrate and can float or remain suspended in the water. Thus a single piece of plastic litter might be a problem for hundreds of years. It's up to each of us to keep Virginia's rivers, streams, lakes and bays clean. This statewide program aims to reduce litter while advancing citizen stewardship and understanding of the Commonwealth's precious waterways. For more information visit the VA DCR website at www.dcr.virginia.gov/soil_&_water/adopt.shtml.

Become Active in Earth Force

Earth Force engages young people as active citizens who improve the environment and their communities now and in the future. Through Earth Force young people get hands-on, real-world opportunities to practice civic skills, acquire and understand environmental knowledge, and develop the skills and motivation to become life-long leaders in addressing environmental issues. Capital Region Earth Force provides hands-on training, resources and support to assist educators with implementing the GREEN program in their classrooms. Through our unique six-step process, students learn how to assess the health of a local watershed and use their findings to create lasting solutions to environmental problems. Visit their website at www.earthforce.org.

Contact Your Local Litter Program Managers

VA DEQ has a list of regional litter program managers throughout the state. Each litter program is different, and there are different opportunities to get involved in each locality. Are you interested in serving as a "Litter Ambassador" and helping staff booths at community events? Are you willing to work with a committee to address litter issues in your local area? Do you want to participate in a litter cleanup? Go to the VA DEQ website and look at the contacts page and contact your local litter program manager www.deq.virginia.gov/recycle/contactlist.html or call VA DEQ's Litter Coordinator at 804-698-4055.

Organize a Waterway Cleanup

Cleanups can help restore the natural beauty of an area and be an educational activity. You can jump on board and organize your own cleanup project or help out at events statewide during September and October during Virginia Waterways Cleanup and International Coastal Cleanup in Virginia. Their planning guide features data sheets to track and analyze the kind of litter and debris that is collected. Contact Katie Register at cleanva@longwood.edu or visit the Clean Virginia Waterways website at www.longwood.edu/cleanva/.

Plant a Buffer Strip

By planting trees and other native plants along streams and banks, you'll help keep the water clean. Vegetation takes up nutrients and helps prevent erosion by stabilizing the soil. Your local forestry office or soil and water conservation district will have publications that give more background on "riparian buffers." You can get your class or group started by planting trees. Visit their on-line resources at the VA DOF website, www.dof.virginia.gov/rfb/index.shtml or call 434-977-6555.

"Plant" an Oyster Garden

Students who have access to a pier in a tidal zone, can nurse seed oysters in a floating garden. Baby seed oysters are "planted" in "floats" in the fall. The floats are kept clean and oysters are protected from predators like blue crabs. The following summer, when they've reached approximately two inches in diameter, they're transplanted into designated sanctuary reefs. The cost to build the float and purchase the seed oysters is about $100.

For more information, visit the Virginia Coastal Zone Management Program for the Virginia Oyster Gardening Guide at www.deq.virginia.gov/coastal/gardening.html. Also visit the Virginia Marine Resources Commission website at http://web.vims.edu/abc/green/ogp.html?svr=www or contact the Chesapeake Bay Foundation at 804-780-1392, Chesapeake@cbf.org or visit www.cbf.org/virginiaoysters or contact the Oyster Reef Keepers of Virginia at 757-460-1200.

Save Our Streams Program

This adopt-a-stream program is intended to get you and your group into the water. This is a national water quality monitoring program for streams that involves the collection and analysis of aquatic insects. It is suitable for youth and adult audiences. Workshops are available for program leaders. Contact Virginia Save Our Streams, Izaak Walton League of America at 804-615-5036, email vasosoffice@vasos.org or visit www.vasos.org/.

Stencil Your Storm Drains

Rain water and snowmelt are diverted from city streets, sidewalks, parking lots, schoolyards, and subdivisions by storm drains which lead to local waterways. Water draining from these areas can carry significant amounts of fertilizers, motor oil, litter, pesticides, animal wastes, and other contaminants. By stenciling a message on the drains in your community such as "Dump No Waste…Drains to Stream," you can encourage people to prevent pollutants from entering their waterways. For more information visit the VA DCR Resource Guide on-line at www.dcr.virginia.gov/stewardship/svresourceguide.htm.

WildlifeMapping Project

This is an outreach project that allows school children, citizens, community groups and other organizations to collect data on the distribution of common wildlife species. The data will then be added to the state's biological database and used in the development of population distribution maps, which are a vital component for stewardship programming. For more information, contact Lou Verner, coordinator, at VA DGIF at 804-367-1779, lou.verner@dgif.virginia.gov or visit www.dgif.virginia.gov/wildlifemapping/.

More Resources and Ideas of Things to Do

Alliance for the Chesapeake Bay

The Alliance for the Chesapeake Bay is a regional nonprofit organization that builds and fosters partnerships to protect and to restore the Bay and its rivers. They teach and promote watershed protection and restoration, and offer a variety of information, publications, outreach and training. For more information visit www.acb-online.org/index.cfm or call the Virginia office at 804-775-0951 or submit your question to "Ask the Experts" online.

Bay Education and Watershed Training

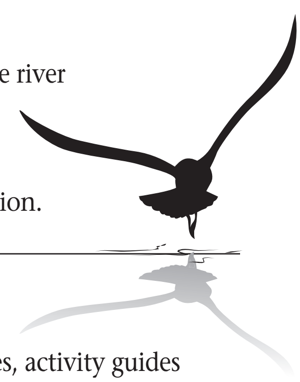
The National Oceanic and Atmospheric Administration (NOAA) Chesapeake Bay B-WET Program provides resources for hands-on watershed education to students and teachers to foster stewardship of the Chesapeake Bay. NOAA recognizes that environmentally literate citizens with the skills and knowledge to make well-informed environmental choices are the key to sustaining the Nation's ocean and coastal environments. A variety of NOAA resources are available, such as cooperative programs at Nauticus, the National Maritime Center (Norfolk, VA), the Cooperative Oxford Laboratory (Oxford, MD), the Smithsonian Environmental Research Center, and other future partner sites. These strategic partnerships are designed to increase knowledge and awareness of NOAA sciences and career opportunities. For more information visit NOAA online www.noaa.gov/.

Chesapeake Academic Resources for Teachers (ChART)

Chesapeake Academic Resources for Teachers (ChART) is a resource designed to help educators provide Meaningful Watershed Educational Experiences to their students. The ChART clearinghouse offers Bay-related lesson plans and activities, field studies and professional development opportunities for educators. Visit http://chart.chesapeakebay.net/.

Dan River Basin Association (DRBA)

Dan River Basin Association (DRBA) offers river and trail outings for fun and friendship. They create river accesses for boating, floating and fishing, and link people with places by promoting trails and greenways. They create opportunities for adults and school children to learn about the health of their local streams and to restore local trout fisheries. And DRBA actively works to protect the region's heritage, such as the Dan River's bateau navigation system. Visit www.danriver.org/ for more information.



Ocean and Bay Teaching Materials by VIMS

The Virginia Institute of Marine Science has a collection of more than 100 videos, software packages, activity guides and other resources for teaching about water and the environment awaiting you and your water education program. Bay Team Teachers can come to your school and conduct lessons for your students. Visit their website at www.vims.edu/ or call 804-684-7164.

Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools

This is the definitive instructional guide to conducting chemical tests for water quality parameters. It is also available from LaMotte at www.lamotte.com/pages/edu/3-1508.html.

Floating/Fishing Guides

Get the drift of what Virginia's rivers really have to offer by taking a class rafting trip, perhaps with a little fishing on the way down. VA DGIF has publications that will give you details on put-in and take-out points, float times, fishing information, and so forth for Virginia's rivers. Or, maybe you can organize a club or community float. For a copy of these brochures call VA DGIF at 804-367-1000 or visit www.dgif.virginia.gov/fishing/.

GLOBE (Global Learning and Observation to Benefit the Environment)

GLOBE (Global Learning and Observation to Benefit the Environment) is a worldwide hands-on, primary and secondary school-based science and education program. GLOBE's mission is to promote the teaching and learning of science, enhance environmental literacy and stewardship, and promote scientific discovery. Students and teachers participating in the GLOBE hydrology program should gain inquiry abilities and understanding of a number of concepts. These abilities include the use of a variety of specific instruments and techniques to take measurements and analyze the resulting data along with general approaches to inquiry. For more information about the GLOBE program and a list of Virginia GLOBE partners, training opportunities, and facilitators, go to: www.globe.gov.

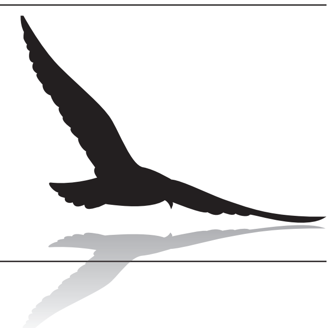
Lessons from the Bay

Available on-line, the purpose of Lessons from the Bay is to help Virginia school teachers of grades 3-6 incorporate into their classrooms a variety of activities and projects related to protecting and restoring the Chesapeake Bay watershed, in keeping with the state's commitment to the Chesapeake 2000 Agreement. Their website is found on the VA DOE website at www.doe.virginia.gov/VDOE/LFB/.

Living on Karst: A Reference Guide for Landowners in Limestone Regions

By keeping Virginia's rivers clean, you can help protect the Commonwealth's vital ground water supplies. This guide explains the connection between surface and ground water, as well as protection methods. It is available on-line at www.virginiacaves.org/lok/page1.htm or www.dcr.virginia.gov/natural_heritage/livingonkarst.shtml.

The James River in Richmond: Your Guide to Enjoying America's Best Urban Waterway



This book is an incredible source for unique and valuable historic, ecologic, recreational, and scenic information on the James River. It includes sections on fishing, paddling, floating, nature study, rock climbing, biking and much more. It is available at some libraries and at bookstores and on-line.

The Landowner's Guide to Managing Streams in the Eastern United States

Doctor up a steam by following the example renovation projects in this guide. The information is available on-line through Virginia Cooperative Extension at www.ext.vt.edu/pubs/forestry/420-141/420-141.html.

Trout in the Classroom Program

The Virginia Museum of Natural History (VMNH) offers Trout in the Classroom (TIC) programs. TIC is an environmental education program that connects water quality issues and conservation for all ages. TIC participants raise brown trout eggs, monitor the tank water quality, and engage in stream habitat studies. In the TIC program, students learn to care about their trout and the habitat in which trout live. As the program progresses, students see connections between the trout, water resources, the environment, and themselves. For more information on the TIC programs offered at VMNH, or other water related programs, call (276)-634-4185 or visit http://www.vmnh.net/.

Virginia Master Naturalist Program

The Virginia Master Naturalist Program is a statewide corps of volunteers providing education, outreach, and service dedicated to the beneficial management of natural resources and natural areas within their communities. Interested Virginians become Master Naturalists through training and volunteer service. As part of the basic training program, master naturalist are trained in such topics as in ecosystem dynamics, wetlands or aquatic ecology, and estuary and coastal ecology and management. Chapter members contribute to volunteer service projects in their communities related to water quality education, stewardship, and citizen science projects. For more information, go to: www.virginiamasternaturalist.org.

Virginia's Natural Resource Education Guide

This guide is available on-line and offers information, activities and resources for elementary teachers. Topics include agriculture, bay, forests, energy, open space, public policy, soils, pollution prevention and wildlife to name a few. To read or download the chapters visit www.vanaturally.com/guide/.

Water Resource Education Poster Series

Nine water resource topics are covered in this series of posters. The posters are illustrated in cartoon format and are available on-line and in pdf format (they are no longer available in print format). They are designed to be used individually or combined to form a wall mural. The reverse sides contain educational activities. Two versions are available, one for grades 3-5 and the other for grades 6-8. Topics include oceans, watersheds, hazardous waste, wetlands, water use, wastewater treatment, navigation, ground water and water quality. The posters and their activities could be used as the core of a water education program. To obtain the downloads, visit the U.S. Geological Survey website at http://www.water.usgs.gov/outreach/OutReach.html.

Wildlife Plantings, Boxes and Platforms

How-to plans for building osprey and goose platforms are included in this publication. These make great aquatic stewardship projects for clubs or classrooms. Contact Suzie Gilley, Project WILD Coordinator at VA DGIF at 804-367-0188 or Suzie.gilley@dgif.virginia.gov.

Places to Go and "Get Your Feet Wet"

4-H Camps and Conference Centers

Most 4-H camps offer outdoor skills programs for youth that often include fishing, canoeing and other water-related topics. Many are available to school groups. Or, become a 4-H leader and start an outdoor club or your own. Contact your local 4-H agent or Virginia Cooperative Extension Office for more information about these programs. Visit the Virginia Cooperative Extension website at www.ext.vt.edu/ and click "Local Extension Offices."

Camps

A number of private camps have professionally-trained environmental educators on staff and offer day-long or overnight nature programs. Consult the yellow pages directory, call the American Camping Association's Virginia office at 1-800-347-7523 or visit their website at www.acacamps.org/.

Chesapeake Bay Interpretive Buoy System (CBIBS)

Chesapeake Bay Interpretive Buoy System (CBIBS) is a newly installed trail guide and observing system being developed by the National Oceanic and Atmospheric Administration. CBIBS is a system of buoys placed along portions of the Captain John Smith Chesapeake National Historic Trail. These on-the-water platforms merge the modern technologies of cellular communications and internet-based information sharing. You can pull out your cell phone and dial up the interpretive buoy closest to your destination – it reports real-time weather and environmental information like wind speed, temperature, and wave height. For more information see the website at www.buoybay.org/site/public/.

Conservation Groups

Many groups, like the Virginia Native Plant Society, Trout Unlimited, and the Nature Conservancy, sponsor field trips for their members or organized groups. Many of these groups are Virginia Naturally Partners and you can search for their contact information at www.vanaturally.com/partners.html.

John Smith Trail

Captain John Smith's Trail is a 40-site water trail and auto tour for modern explorers. Each set of three travel maps features historic descriptions and information for the modern traveler, including where to hike, camp and launch your boat. Maps can be ordered and educator's resources are available on the website, www.virginia.org/johnsmithtrail/.

Local Parks & Recreation Departments

Many city and county parks and recreation departments offer outdoor skills programs. Refer your students. Consult your phone directory under the governmental listings section for your county or city agency (usually in the blue pages). Many localities supply a seasonal listing of activities.

"On the Water" Field Trips

You can make the Chesapeake Bay come alive for your students by scheduling a field trip with professionally-trained educators. From a canoe, workboat, or even a schooner, they'll fish, dredge oysters, observe land uses, or learn ways to test water quality. Visit the Chesapeake Bay Foundation website www.savethebay.cbf.org or call the Virginia office at 804-780-1392 to find out about scheduling a field trip. Funding assistance is available through Virginia Naturally Classroom Grants, see www.vanaturally.com/classroomgrants.html.

Wildlife Management Areas (WMAs)

The VA DGIF welcomes visitors to their Wildlife Management Areas (WMAs). These are tracts of land that are purchased and maintained for hunting and fishing. WMAs can offer great backdrops for a day of outdoor education. Virginia has 36 WMAs. For more information visit the website at http://www.dgif.virginia.gov/wmas/.

Virginia State Parks

Virginia has 35 state parks that abound with opportunities to get your self into the water. You can pan for gold at Lake Anna, watch eagles at Caledon, bike along the New River, learn about water-etched caves at Natural Tunnel, or enjoy a quiet canoe venture on one of their many lakes. Schedule a field trip. Most parks have trained naturalists and educators who can assist you in designing or conducting an educational activity. Some offer special education facilities and equipment for conducting nature study.

To find out what state park is nearest to you, call the VA DCR at 1-800-933-PARK, email at resvs@dcr.virginia.gov or visit their website at www.virginiastateparks.gov. They also offer "Your Backyard Classrooms" curriculum and teacher workshops which is a set of K-12 science and social studies activities tailored to the parks. There are three editions: Chesapeake, Mountain and Piedmont. Each contains activities directly related to the natural environment in the region. Visit the website for more information at www.dcr.virginia.gov/state_parks/ybc.shtml.

Virginia Soil and Water Conservation Districts (SWCD)

Virginia has 47 Soil and Water Conservation District (SWCD) offices throughout the state that offer educational outreach programs. Find your local office at www.dcr.virginia.gov/soil_&_water/swcds.shtml. Contact them to see what they offer.

Virginia State Forests

Virginia has 19 state forests that can provide opportunities for student research projects and other outdoor learning. State forests are managed to supply multiple benefits, including soil and watershed protection, wildlife habitat, recreation, and sustainable forest products. Visitors to state forests are asked to adopt a “leave no trace” ethic. Locations and information about state forests can be found at www.dof.virginia.gov/stforest/index.shtml.

DEQ VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Virginia Naturally
Linking Virginians to the Environment
www.VaNaturally.com

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

Wrap It Up!

Get Funding and Recognition

Chesapeake Bay Restoration Fund Grants

This grant program funds environmental education and action-oriented conservation and restoration projects within the Chesapeake Bay watershed. Applicants (state agencies, local government, public and private non-profits and institutions) should complete an application by calling Chesapeake Bay Restoration Fund at 804-786-3591or visit www.dcr.virginia.gov/soil_&_water/bayfund.shtml.

Environmental Stewardship Awards

These awards, sponsored by the Secretary of Natural Resources and the Virginia Petroleum Council, recognize innovative actions and effective stewardship initiatives that help enhance or protect Virginia's environment. Awards are presented in each of four categories: youth, adult, organization, and communication/education products or programs. For more information, visit www.deq.virginia.gov/info/vpcaward.html.

Stewardship Virginia

Stewardship Virginia is a statewide initiative held twice annually in April/May and in September/October to help citizens with projects that enhance and conserve Virginia's natural and cultural resources. For more information, visit the website at www.dcr.virginia.gov/stewardship/, call 1-877-42-WATER or email Bonnie.Phillips@dcr.virginia.gov.

Virginia Environmental Endowment Grants

Mini-grants of $1,000-$5,000 are offered on a competitive basis for community based projects that strengthen environmental education in schools and community programs. Projects must focus on water quality, land use, wetlands protection and/or the Chesapeake Bay and should promote stewardship through local action. Call 804-644-5000 or visit www.vee.org.

Virginia Naturally

Virginia Naturally provides citizens with "one-stop" shopping to programs and information to learn about Virginia's environment. At this gateway site, you'll find links to more than 800 organizations which provide environmental education programs and services in Virginia including volunteer and funding opportunities, teacher workshops and lesson plans, conferences, and community events to name a few. Visit Virginia Naturally at www.vanaturally.com.

Virginia Naturally School Recognition Program

The Virginia Naturally School Recognition Program is the official environmental education school recognition program for the state. This program recognizes the wonderful efforts of many Virginia schools to increase the environmental awareness and stewardship of our youngest citizens. To participate, visit www.dgif.virginia.gov/education/school-recognition/.

Watershed Roundtables

Active in each major river basin, these collaborative groups include agencies, local government, community groups, and help facilitate and promote many projects related to water quality. Find your watershed's roundtable at http://www.vawatersheds.org.

International Coastal Cleanup Data Card

Ocean Conservancy
Start a Sea Change

Thank you for participating in Ocean Conservancy's International Coastal Cleanup (ICC). The commitment you have made today is the first step to ensuring we can enjoy a cleaner ocean all year-round. The data you collect during the Cleanup is invaluable to Ocean Conservancy's effort to start a sea change every day; helping us educate public, business, and government officials about the scale and serious consequences of the global marine debris problem. Thank you. We could not do it without your help!

1. CLEANUP SITE INFORMATION

Category of Cleanup (choose one): ☐ Coastal ☐ Inland Waterway (River/Stream/Tributary/Lake)

Type of Cleanup (choose one): ☐ Beach/Shoreline ☐ Underwater ☐ Watercraft (powerboat, sailboat, kayak or canoe)

Location of Cleanup: Country ______________ State ______________

Province ______________ County/Zone/City Cleaned ______________

Cleanup Site Name (beach, park, etc.) ______________

Today's Date: Month: ________ Day ________ Year ________ Name of Coordinator ______________

Number of People Working on This Card ______________ Distance Cleaned ________ miles or ________ km.

Number of Trash Bags Filled ______________ Total Estimated Weight Collected ________ lbs. or ________ kgs.

Estimated Time Spent on Cleanup ______________

2. CONTACT INFORMATION (EACH INDIVIDUAL TEAM MEMBER)

1. Name ______________
   Email Address ______________
2. Name ______________
   Email Address ______________
3. Name ______________
   Email Address ______________
4. Name ______________
   Email Address ______________

3. ENTANGLED ANIMALS

List all entangled animals found during the Cleanup. Record the type of debris they were entangled in, for example: fishing line, fishing nets, balloon string/ribbon, crab/lobster/fish traps, plastic bags, rope, six-pack rings, wire and other items (please specify). In addition, please take photo of the entangled animal and send to Ocean Conservancy (contact information below).

Animal	Alive/Released or Dead	Entanglement Debris

4. WHAT WAS THE MOST PECULIAR ITEM YOU COLLECTED? ______________

The following national and international organizations endorse and/or support the International Coastal Cleanup
- NOAA-Marine Debris Program
- U.S. Environmental Protection Agency
- UNEP – United Nations Environment Programme
- IUCN-The World Conservation Union
- Intergovernmental Oceanographic Commission (IOC) of the United Nations' Educational, Scientific, and Cultural Organization (UNESCO)

Please return this card to your area coordinator or mail or email it to:

Ocean Conservancy
Attn: International Coastal Cleanup
1300 19TH Street, NW,8TH Floor
Washington, DC 20036

cleanup@oceanconservancy.org
www.oceanconservancy.org

OCEAN CONSERVANCY'S
International
Coastal
Cleanup®

ITEMS COLLECTED

Please pick up ALL debris that you find. Only record information for the items listed below.
Keep a count of your items using tick marks and enter the item totals in the box.

Example: [8] **Beverage Cans** ~~||||~~ |||

SHORELINE AND RECREATIONAL ACTIVITIES

Debris from fast food, beach-goers, sports/games, festivals, litter from streets/storm drains, etc.

- [ ] Bags (paper) ______
- [ ] Bags (plastic) ______
- [ ] Balloons ______
- [ ] Beverage Bottles (plastic) ______
- [ ] Beverage Bottles (glass) ______
- [ ] Beverage Cans ______
- [ ] Caps, Lids ______
- [ ] Clothing, Shoes ______
- [ ] Cups, Plates, Forks, Knives, Spoons ______
- [ ] Food Wrappers/Containers ______
- [ ] Pull Tabs ______
- [ ] 6-Pack Holders ______
- [ ] Shotgun Shells/Wadding ______
- [ ] Straws, Stirrers ______
- [ ] Toys ______

OCEAN/WATERWAY ACTIVITIES

Debris from recreational/commercial fishing and boat/vessel operations

- [ ] Bait Containers/Packaging ______
- [ ] Bleach/Cleaner Bottles ______
- [ ] Buoys/Floats ______
- [ ] Crab/Lobster/Fish Traps ______
- [ ] Crates ______
- [ ] Fishing Line ______
- [ ] Fishing Lures/Light Sticks ______
- [ ] Fishing Nets ______
- [ ] Light Bulbs/Tubes ______
- [ ] Oil/Lube Bottles ______
- [ ] Pallets ______
- [ ] Plastic Sheeting/Tarps ______
- [ ] Rope ______
- [ ] Strapping Bands ______

SMOKING-RELATED ACTIVITIES

- [ ] Cigarettes/Cigarette Filters ______
  ______
  ______
- [ ] Cigarette Lighters ______
- [ ] Cigar Tips ______
- [ ] Tobacco Packaging/Wrappers ______

DUMPING ACTIVITIES

- [ ] Appliances (refrigerators, washers, etc.) ______
- [ ] Batteries ______
- [ ] Building Materials ______
- [ ] Cars/Car Parts ______
- [ ] 55-Gal. Drums ______
- [ ] Tires ______

MEDICAL/PERSONAL HYGIENE

- [ ] Condoms ______
- [ ] Diapers ______
- [ ] Syringes ______
- [ ] Tampons/Tampon Applicators ______

DEBRIS ITEMS OF LOCAL CONCERN

Identify and count 3 other items found that concern you

- [ ] ______
- [ ] ______
- [ ] ______

Printed on recycled paper. 100% PCW.

Coastal Plant Zonation
Data Sheet

VA Sea Grant - VIMS

Date: __________________________ **Tide Height: _____________** **Recorder: __________________**

Location: ______________________________; Start Lat/Long:_______________________ **Quadrat size:________________**

Site #	**Distance from WL (m)**	**Plant Species Present**	**Plant Density by species**	**Range of Plant Size Base Dia. x Height (cm)**		**Observations/Comments**
				Smallest	**Largest**	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

Site #	**Distance from WL (m)**	**Plant Species Present**	**Plant Density by species**	**Range of Plant Size Base Dia. x Height (cm)** Smallest	Largest	**Observations/Comments**
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						

Site #	Distance from WL (m)	Plant Species Present	Plant Density by species	Range of Plant Size Base Dia. x Height (cm)		Observations/Comments
				Smallest	Largest	
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						

Chesapeake Bay Program
A Watershed Partnership

STEWARDSHIP AND MEANINGFUL WATERSHED EDUCATIONAL EXPERIENCES

The "Stewardship and Community Engagement" Commitment of the *Chesapeake 2000* agreement clearly focuses on connecting individuals and groups to the Bay through their shared sense of responsibility and action. The goal of this Commitment, included below, not only defines the role of the jurisdictions to *promote* and *assist*, but formally engages schools as integral partners *to undertake initiatives* in helping to meet the Agreement. This goal commits to:

> *Promote individual stewardship and assist individuals, community-based organizations, businesses, local governments and schools to undertake initiatives to achieve the goals and commitments of this agreement.*

Similarly, two objectives developed as part of this goal describe more specific outcomes to be achieved by the jurisdictions in promoting stewardship and assisting schools. These are:

> *Beginning with the class of 2005, provide a meaningful Bay or stream outdoor experience for every school student in the watershed before graduation from high school.*

> *Provide students and teachers alike with opportunities to directly participate in local restoration and protection projects, and to support stewardship efforts in schools and on school property.*

There is overwhelming consensus that knowledge and commitment build from first-hand experience, especially in the context of one's neighborhood and community. Carefully selected experiences driven by rigorous academic learning standards, engendering discovery and wonder, and nurturing a sense of community will further connect students with the watershed and help reinforce an ethic of responsible citizenship.

To this end, the Chesapeake Bay Program Education Workgroup seeks to define a common set of criteria to help the Bay watershed jurisdictions meet the intent of this Commitment of the *Chesapeake 2000 Agreement*. From these criteria, each jurisdiction will continue to craft and refine its own plan, tailored to its own population, geography, and fiscal and human resources.

Defining *a Meaningful* Bay or Stream Outdoor Experience

A *meaningful* Bay or stream outdoor experience should be defined by the following.

Experiences are investigative or project-oriented. Experiences include activities where questions, problems, and issues are investigated by the collection and analysis of data, both mathematical and qualitative. Electronic technology, such as computers, probeware, and GPS equipment, is a key component of these kinds of activities and should be integrated throughout the instructional process. The nature of these experiences is based on each jurisdiction's academic learning standards and should include the following kinds of activities.

- Investigative or experimental design activities where students or groups of students use equipment, take measurements, and make observations for the purpose of making interpretations and reaching conclusions.

- Project-oriented experiences, such as restoration, monitoring, and protection projects, that are problem solving in nature and involve many investigative skills.

- Social, economic, historical, and archaeological questions, problems, and issues that are directly related to Bay peoples and cultures. These experiences should involve fieldwork, data collection, and analysis and directly relate to the role of the Bay (or other bodies of water) to these peoples' lives.

Experiences such as tours, gallery visits, simulations, demonstrations, or "nature walks" may be instructionally useful, but alone do not constitute a *meaningful* experience as defined here.

Experiences are richly structured and based on high-quality instructional design. Experiences should consist of three general parts including a) a preparation phase; b) an outdoor action phase; and c) a reflection, analysis, and reporting phase. These "phases" do not necessarily need to occur in a linear fashion. These include the following.

- The *preparation phase* should focus on a question, problem, or issue and involve students in discussions about it. This should require background research and student or team assignments as well as management and safety preparation.

- The *action phase* should include one or more outdoor experiences sufficient to conduct the project, make the observations, or collect the data required. Students should be actively involved with the measurements, planning, or construction as safety guidelines permit.

- The *reflection phase* should refocus on the question, problem, or issue; analyze the conclusions reached; evaluate the results; and assess the activity and the student learning.

Experiences are an integral part of the instructional program. Experiences should not be considered ancillary, peripheral, or enrichment only, but clearly part of what is occurring concurrently in the classroom. The outdoor experiences should be part of the division curriculum and be aligned with the jurisdiction's learning standards. Experiences should make appropriate connections among subject areas and reflect an integrated approach to learning. Experiences should occur where and when they fit into the instructional sequence.

Experiences are part of a sustained activity. Though an outdoor experience itself may occur as one specific event, occurring in one day, the total duration leading up to and following the experience should involve a significant investment of instructional time. This may entail smaller amounts of outdoor time spread over an entire school year. Likewise, the actual outdoor experiences may not necessarily involve all students in a class at the same time. Rich learning experiences, especially those involving monitoring and restoration activities, may require time increments spread over weeks or even months. A sustained activity will generally involve regularly-scheduled school time and may involve extended day or weekend activity.

Experiences consider the watershed as a system. Experiences are not limited to water-based activities directly on the Bay, tidal rivers, streams, creeks, ponds, wetlands, or other bodies of water. As long as there is an intentional connection made to the water quality, the watershed, and the larger ecological system, outdoor experiences that meet the intent of the Commitment may include terrestrial activities in the local community (e.g., erosion control, buffer creation, groundwater protection, and pollution prevention).

Experiences involve external sharing and communication. Experiences should warrant and include further sharing of the results beyond the classroom. Results of the outdoor experiences should be the focus of school-based reporting, community reporting, publishing, contribution to a larger database of water quality and watershed information, or other authentic communication.

Experiences are enhanced by natural resources personnel. Utilizing the expertise of scientists and natural resources professionals can heighten the impact of outdoor experiences. This includes both their participation in the classroom and leadership on-site during outdoor activities. These personnel have technical knowledge and experience that can serve to complement the classroom teacher's strengths and augment the array of resources for the learning. Additionally, these professionals can serve as important role models for career choices and as natural resources stewards.

Experiences are for all students. As it is crucial for all citizens to have an understanding of and connection with their own watershed, an outdoor experience is for all students regardless of where they live. Much of the land area in the jurisdictions is outside of the Bay watershed; however, it is intended that students residing in those areas have similar opportunities within their own local setting or beyond.

It is also clear that these kinds of experiences must be extended to all students including students with disabilities, in alternative programs, and special populations. No child should be excluded from a *meaningful* watershed experience.

Meaningful Experiences across the K-12 Program

It is the intention that every student somewhere in the K-12 program will have a *meaningful* outdoor watershed experience before graduation from high school; however, it is the expectation that these kinds of activities will occur throughout formal schooling. Beginning with the primary grades, the jurisdictions' academic learning standards in the social and natural sciences call for inquiry, investigation, and active learning. These skills, concepts, and processes increase in complexity and abstraction, "spiraling" and building throughout the elementary, middle, and high school programs. Likewise, the experiences should reflect this progression.

Outdoor experiences should occur at each level, elementary, middle, and high school. These experiences should be defined by the local curriculum, be aligned with the jurisdiction's learning standards, and mirror the developmental level of students.

The following example "scope and sequence" describes experiences that should be appropriate for many students in the K-12 program.

> **K-5 experiences** should be predominantly local, school, or neighborhood-based, including activities reflecting students' background knowledge, shorter attention span, and physical capabilities. Experiences must clearly relate to academic learning standards across subject areas and reinforce basic concepts such as maps and models, habitat principles, and the concept of the water cycle and watersheds. Care must be taken with the introduction or discussion of complex issues.

6-8 experiences should focus on team and class projects and investigations. These experiences should reinforce research skills requiring the use and analysis of more authoritative print and electronic resources. Longer-term restoration, monitoring, or investigative projects should be conducted locally or on school grounds. Actual student experiences in or near water may be appropriate for many middle school students (following school safety guidelines carefully). Activities such as water-quality testing can be used to reinforce many science, mathematics, and technology skills developed in middle school.

9-12 experiences should reflect students' more abstract reasoning and detailed planning ability. Locally based activities continue to be important, but student watershed experiences beyond the immediate community will have considerable impact in meeting academic and stewardship goals. First-hand experiences in or near water should be part of the implemented curriculum, especially as these experiences relate to the Earth and biological sciences, concepts developed in civics and government, and attitudes reinforcing responsible citizenship.

Conclusion

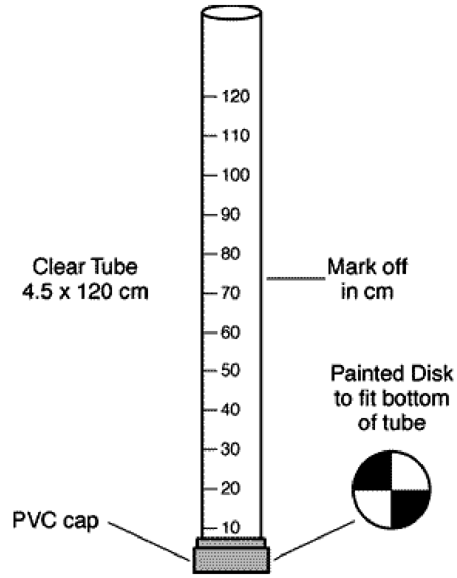
The preceding consensus criteria define a clear vision for bringing the Bay into every classroom and every child out into the watershed in a *meaningful* way. It will be the goal of every educator, teacher and administrator, to move toward incorporating those experiences that build academic success, reinforce responsible citizenship, and work toward the goals of the *Chesapeake 2000* agreement. With inspired leaders, committed parents, and supporting communities garnering the fiscal and human resources to help make this happen, young people will be significant contributors to healthy, bountiful, and enduring watersheds.

Making Your Own Transparency/Turbidity Tube

From http://www.in.gov/dnr/nrec/files/ed-Appendices.pdf (Page A-5) and
http://www.globe.org.uk/activities/toolkit/toolkit.doc
(>>Both sites includes lots of make-your-own equipment ideas!)
For instructions on how to correctly use the transparency tube see Chapter 4 Chemical Monitoring (of pdf).

Directions:

1. Put a PVC cap over one end of a clear tube (a florescent light bulb tube cover works great). Cap should fit tightly so water cannot leak out. A rubber stopper also works.
2. Cut a disk from wood or plastic the same size as the tube diameter.
3. Divide the disk into four quadrants. Paint the alternating quadrants black and white. Seal the disk by laminating or painting with varnish to make it waterproof.
4. Glue the disk in the bottom of the tube, painted side facing up (toward the open end of the tube).
5. Use a marker and meter stick to make a scale on the side of the tube, beginning at the disk with 0 cm. Or mark on a piece of tape and stick it to the outside of the tube.



From http://www.dnr.state.md.us/streams/volunteer/build_equip.html
Submitted by Ron Ohrel, Center for Marine Conservation

Materials:

- Clear plastic cover from fluorescent light tube
- Two plastic caps from fluorescent light tube cover
- Small piece of white plastic
- Silicone cement
- Meter stick

Building the Transparency Tube:

1. Remove the caps from the tube.
2. The caps should have oval-shaped holes near at the center of their closed ends. If the holes do not exist, cut a 1.5 cm x 2.5 cm hole in one of the caps.
3. Place the white plastic piece inside one of the caps (if only one cap has a hole, place the white piece inside the cap without a hole).
4. Cement the other cap snugly inside the first cap, so that the white plastic piece can be seen through the hole.
5. Slide the tube into the caps so that the black and white pattern made by the plastic and caps can be seen when looking down the tube.
6. Cement the tube to the caps.

Notes:

· Unless a valve is installed, the volunteer will have to incrementally pour water out of the tube until the black and white pattern can be distinguished.

· Use the meter stick to measure the water height where the user can no longer see the white plastic. Instead of using the meter stick each time a sample is measured, the volunteer can mark the tube at appropriate intervals (e.g., centimeters) using a permanent marker.
· The tube may be shortened to make it easier to carry. This can be accomplished by cutting the top off with scissors. However, the tube should not be shortened beyond the range of typical transparency readings (e.g., if tube readings are often found between 100-150 centimeters, make sure the tube is long enough to accommodate those readings).

Commercial Versions:
Forestry Suppliers Inc – 60cm $38.95 (item #77107); 120 cm $53.95 (item #77096)
http://www.forestry-suppliers.com/product_pages/View_Catalog_Page.asp?mi=5073

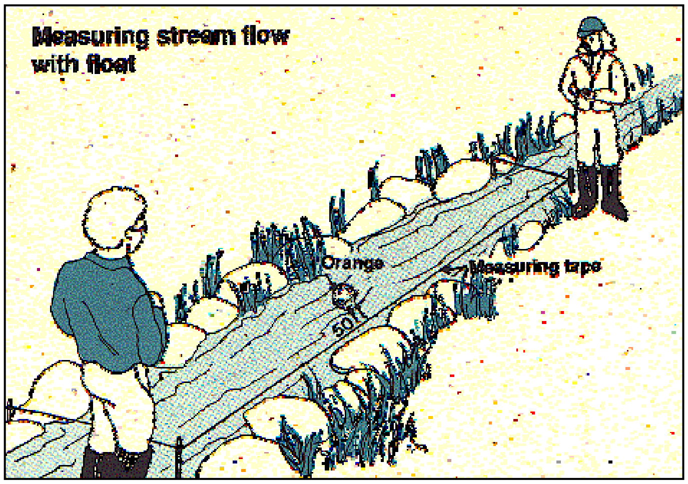
Wards Natural Science – 120 cm $99 (item #21 V 0920)
http://www.wardsci.com/product.asp_Q_pn_E_IG0014258_A_Secchi+Transparency+Tube

Additional Resources:
http://www.epa.gov/owow/monitoring/volunteer/newsletter/volmon16no1.pdf (transparency/turbidity tube info starts on pg 15)
http://www.cee.mtu.edu/sustainable_engineering/resources/technical/Turbidity-Myre_Shaw.pdf
http://southernbiological.com.au/Assets/pdf/Products/Kits&Equipment/SpecialLabAndFieldEquipment/ENV8_21_TurbdityTube.pdf

Measuring Stream Flow

Measuring Stream Flow with a Simple Float

From: http://www.ecy.wa.gov/PROGRAMS/WQ/plants/management/joysmanual/5float.html



If a flow meter is not available or a rough estimate is adequate, you can measure flow by using a float. The float can be any buoyant object, such as an orange or a partially filled plastic water bottle. It needs to be heavy enough so that about an inch of it is below the water line. (Don't use glass or any material that may cause problems if you can't retrieve the float after the measurement.)

Measure off at least 50 feet along the bank of a straight section of stream. If possible, string a rope across each end of the 50-foot length.

1. Estimate the cross-sectional area of the stream at one of these ends by using the total stream width and the average depth. (Calculate the average depth from depths measured at 1- to 2-foot intervals.)

   Total width (ft) x Average depth (ft) = area (ft^2)

2. Release the float at the upstream site. Using a stopwatch, record the time it takes to reach the downstream tape. (If the float moves too fast for an accurate measurement, measure off 75 or 100 feet instead of 50). Repeat the measurement two more times for a total of three measurements.

3. Calculate the velocity as distance traveled divided by the average amount of time it took the float to travel the distance. If the distance roped off is 50 feet and the orange took an average of 100 seconds to get there, the velocity is 0.5 ft/sec.

   $\frac{50 \text{ ft}}{100 \text{ sec}} = 0.5 \text{ ft/sec}$

4. Correct for the surface versus mid-depth velocity by multiplying the surface velocity by 0.85.

   0.5 x 0.85 = 0.43 ft/sec

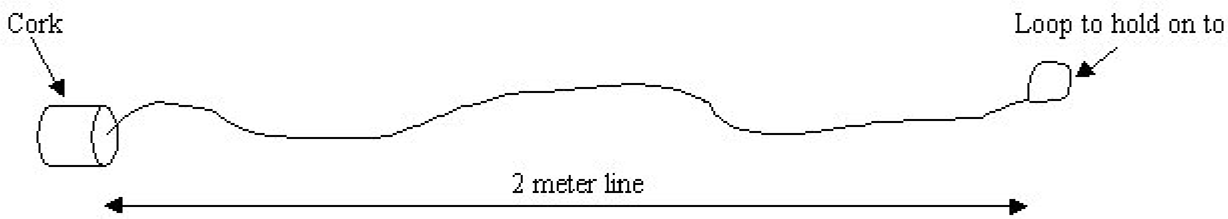
5. Calculate the discharge in cubic feet per second (cfs) by multiplying velocity (ft/sec) by the cross-sectional area (ft^2) of the stream.

   0.43 ft/sec x 10.73 ft^2 = 4.62 cfs

Measuring Stream Velocity

From: http://www.ag.iastate.edu/centers/wrg/mussels/appendix.html

Measuring stream velocity is important because it affects a variety of chemical, physical and biological characteristics of a stream. The objective is to calculate stream velocity by recording the amount of time (in seconds) it takes a floating object to travel a known distance. A simple way to do this is to attach a known length of line (2 meters is sufficient) to a cork (see diagram below) and record the time it takes the cork to float the distance of the full length of the line in the stream current.



Field instructions:

1. Hold the cork and attached line at the surface of the water. Position yourself so that you do not interfere with stream flow.
2. Release the cork (hold on to the other end of the line!) and start timing the float.
3. Stop timing when the cork has traveled the full distance of the attached line.
4. Record the time it takes the line to fully extend in the stream current.
5. Because velocity varies across the channel, repeat this process 5 times, sending the float down different paths at different location within the stream.
6. Calculate the average float time by dividing the sum of the timed values by the number of float trials.
7. The average surface velocity (m/sec) of the stream is simply the distance traveled (the length of the line) divided by the average float time of the 5 float trials.
8. Because stream velocity varies from surface to bottom, adjust this value to reflect the overall average velocity of the stream, by multiplying the average velocity by the correction factor 0.8 (Dunne and Leopold 1978).

Additional resources:

USGS information on why and how streamflow is measured
http://ga.water.usgs.gov/edu/measureflow.html

EPA information on why and how streamflow is measured
http://www.epa.gov/volunteer/stream/vms51.html

Another basic method, but contains tips and detailed information on why we should measure stream flow
http://watermonitoring.uwex.edu/wav/monitoring/flow.html

More advanced methods of measuring stream velocity and discharge:
http://snobear.colorado.edu/Markw/IntroHydro/05/lab09/lab09.htm
http://www.iupui.edu/~geogdept/g108/lab_7_exercise.htm
http://www.fao.org/docrep/field/003/AC061E/AC061E07.htm

Monitoring a Habitat

This activity was written by Jenny Brady and Laura Francis. For more information about this activity, please email laura.francis@noaa.gov

In this activity you will learn about ways that scientists monitor habitats in the marine environment of the Channel Islands National Marine Sanctuary and will be able to apply what they have learned to monitoring their own field study site.

Introductory Discussion:
Before beginning a monitoring project, or starting this lesson, you may want to discuss the following questions with your students.

- Why would you want to monitor a habitat?
- Where would you monitor?
- What would you measure?
- How often should you monitor the area? How often is realistic?
- What questions would you want answered through your project?

Background:
Long-term monitoring programs are often used to assess the ecological health of an area. Marine Sanctuary and Park managers and naturalists select and monitor a subset of species that is found in the area, because it would be impossible to count and track the presence of every species. The selected species represent a cross section of the ecological roles found in the area and a wide range of trophic (feeding) levels, from primary producers to herbivores, top-level carnivores to detritivores. Selected taxa are monitored regularly to learn more about population fluctuations and the impact of both natural and human-induced changes.

Monitoring programs are designed to detect changes spatially over time- changes in physical conditions, changes in distribution or abundance of organisms or changes caused by human actions or natural events. Physical factors such as temperature and salinity measured as baseline data can form the foundation of a monitoring program. So can the presence or absence of a species or age groups of a single species or entire groups of species. Habitats can be monitored to observe changes in structure, such as physical disturbance. In a monitoring project, observations are made or samples are taken- like "snapshots" of the habitat - on a regular basis, at various intervals depending on the type of information needed. Periodic reports of data compare snapshots against each other and against the baseline data. This information helps resource managers evaluate trends (systematic changes over time) or perturbations (sudden changes). Although the causes of the changes may not be apparent as a result of the monitoring, they alert managers and suggest ways of studying, in closer detail, the causes of change.

Scientists consider many factors when selecting a study site, including physical, geological and biological characteristics. Differences in temperature, substrate type, nutrient availability, degree of protection from winds or currents, depth or elevation, and many other factors can affect the diversity of species found in an area. Transition zones between biogeographic provinces are also interesting to survey because they display characteristics typical of both provinces. Around the northern Channel Islands, the Channel Island National Park Service, in cooperation with the Channel Islands National Marine Sanctuary and the California Department of Fish and Game, have established 16 permanent kelp forest monitoring sites and permanently affixed 100 meter transect lines to the seafloor at each site. These sites were selected because they represent different depths, locations (windward vs. leeward side of the islands), water temperature zones and areas with differing amounts of nutrients, currents, biodiversity and biogeographical provinces, and were accessible to monitor.

Survey Techniques
Many different sampling techniques can be used depending upon the species being monitored and their unique characteristics. Often a monitoring program will use several different techniques. Common monitoring techniques and step-by-step directions for you to conduct your own monitoring projects are described below. As you begin to design your own monitoring projects, you can explore techniques and applications from the Channel Islands Kelp Forest Monitoring Project to help you decide which survey method is best for your purposes.

- *Quadrat Survey*

Quadrat surveys are used to determine the abundance of sedentary or slow-moving organisms, such as different species of grasses herbaceous plants, or evidence of animal activity such as ant hills and spider webs. The size of the quadrat depends upon the species being sampled and their relative abundance. Common species may be sampled using smaller quadrats, while rarer, or clumped, organisms require a larger quadrat to be accurately sampled. For example, if you were sampling the types of shrubs found in a field, your quadrat would be larger than if you were sampling the types of grass or weeds in a field. If you live near a beach you may choose to sample organisms from the intertidal zone, such as barnacles, oysters, sea anemones and periwinkle snails.

During a quadrat study, a square area is marked off. All of the organisms being monitored within the survey area are identified and counted. The abundance of each species is determined by counting the individual organisms found within the study area. Larger organisms such as sea stars or sea urchins are counted individually, and the **density** of each species (number of individuals per square meter) is calculated. Smaller organisms, such as cup corals or algae, may be extremely difficult to count. **Percent cover** provides an alternative way to assess their abundance; as the name suggests, the amount of area that is "covered" by each species is determined as a percentage of the total area.

The size of the quadrat also varies, depending upon the organisms being sampled. Less common or clumped organisms require a larger study area to accurately sample their numbers. In the Channel Islands, a 1 meter^2 quadrat protocol is used to assess the abundance of common sedentary or slow moving species, including wavy turban snails, sea urchins, bat stars, sea cucumbers, giant kelp, sea palms and gobies (a territorial bottom dwelling fish). For the classroom below, ¼ meter square quadrats will be used.

Quadrat Classroom Activity Materials

- Approx 400 Multi-colored paper clips in 7 different colors

  Each color represents a different species. For example:
  Sea Urchins – Red Paper Clips – 165 paperclips
  Wavy Turban Snails – 100 – yellow paperclips
  Kellet's Whelk - 70 – pink paperclips
  Knobby Sea Star – 30- blue paperclips
  Keyhole Limpet – 20 – white paperclips
  Gorgonian Sea Fans – 10 – green paperclips
  Abalone – 5 – black paperclips

(Don't show the students the ratio of the animals until they have completed their counts)

- 10M transect tape
- Four ¼ meter square PVC quadrats
- Clipboard
- Pencil
- Data Sheet
- Chalk Board or Dry Erase Board with species names and ratio of paperclips (don't show this to students until the end).
- Kelp Forest Monitoring Video and or photos and shells of organisms listed above

Quadrat Classroom Demonstration Procedure:

1. Lay the transect tape along floor.
2. Randomly sprinkle paper clips along **one** side the transect line (within ¼ m or so of the line)
3. (NOTE: For the classroom demonstration we are just going to use one side of the transect line to simplify the procedure. When you go out into the field, you will conduct counts on both sides of the transect line).
4. Write the numbers 0-10 on a piece of paper, cut them out, turn them over and mix them up.
5. Choose four numbers from the pile and place a quadrat next to each number (with the bottom edge alongside the transect line).
6. Have students break up into groups and count the number and color of each paper clip that is found within their quadrat.
7. Tally the totals.
8. Show students photos or shells of the different organisms and give them some information about the natural history and abundance of these animals and have them guess which paperclip is represented by which species.
9. How do their quadrat totals relate to the total number of each species along the transect?
10. Discuss some of the limitations of quadrat sampling (if animals are very mobile they may move out of quadrats. If species are rare (such as the black abalone), they may not be found in quadrats even though they are found within the study area).

Field Survey Techniques:

Conducting a Quadrat Study

Materials:

Per group:

- 1 clipboard
- list of species to identify/look for
- 2 data sheets
- field guide if necessary
- 1 meter square quadrat, made from PVC pipe, or other material

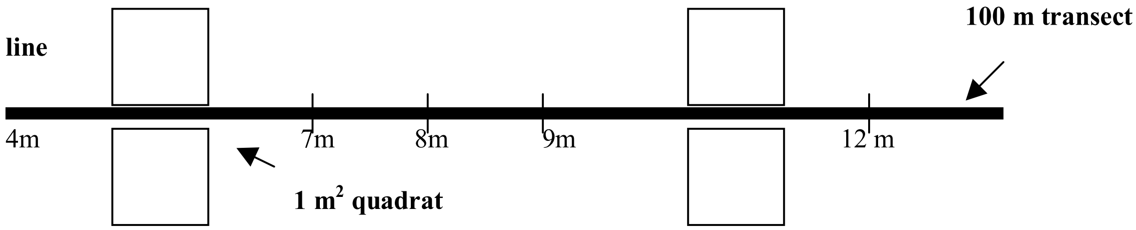
Per class:

100 meter transect tape 2 stakes

Method:

1 m^2 quadrat

Monitoring a Habitat



1. Select a study site.

2. Determine what species you will be sampling. Be sure you can identify each of these species.

3. Randomly pick a number between 1-8.

4. Run a 100 meter transect tape in a straight line through your study site. Place the tape so it accurately reflects the surrounding area.

5. Secure the tape down at both ends with stakes.

6. Beginning at your randomly selected number, place the 1-meter quadrat so that one edge lines up with the transect tape.

7. Record the names and abundance of all species found within the quadrat.

8. Flip the quadrat over to the opposite side of the transect tape and repeat the procedure. Record the species name and abundance codes in a new data table.

9. Continuing sampling at 10 meter intervals. You will have twenty separate 1-meter quadrat surveys when you are done surveying your study site.

10. Return to class and examine your data. Create an overall species list (a list of all species encountered during the survey project). Then, calculate the average density of each species.

$$\text{Average density of } \textit{species a} \text{ per quadrat} = \frac{\text{Total number of } \textit{species a} \text{ found in all plots}}{\text{(size of quadrat) (\# of plots sampled)}}$$

note: If you are using a 5-meter^2 quadrat, you will survey an area 1 meter wide, by 5 meters long. The 5 meter length of the transect line will run along the transect tape. You will start at the beginning of the tape. Each study site will be adjacent to each other.

Questions:

1. What is a quadrat study? What type of organisms can be studied using quadrats? Why do researchers and park managers use them?
2. Describe your study site; include physical and biological characteristics, the species sampled and quadrat size. Explain why you selected your study site, target species, and quadrat size.
3. Why did you sample so many quadrats instead of just one?
4. Determine a species list for study site. List all the species encountered in any of the surveys in alphabetical order.
5. Calculate the average density for each species.
6. Describe any changes in species density that you observe.

7. Are some species generally seen in smaller groups? If so, give examples. Are other species generally found in larger groups? If so, give examples. How might a large group size be an advantage? a disadvantage? Suggest reasons to explain the differences.

Conducting a Band Transect

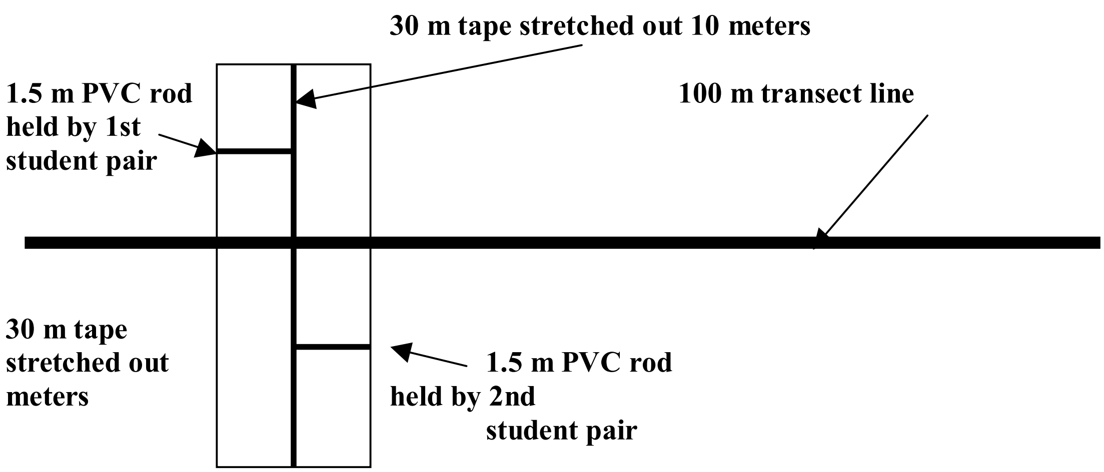
During a band transect, a larger rectangular area is sampled. In the Channel Islands kelp forests, divers conducting a band transect connect a transect tape to the 100 meter transect line and swim the tape out perpendicular to the transect line for 10 meters on both sides. All of the organisms found within a specified distance (1.5 meters) on either side of the second, shorter transect tape are counted and identified. Band transects are done at random intervals along the 100 meter transect line. Band transects are used to sample organisms that are less common, more mobile, are clumped, or may not be accurately sampled using a quadrat survey. In the Channel Islands, band transects extend for 3 x 10 meter area on each side of the transect line, covering a total of 60 meters^2. Band transects are commonly used to survey orange puff ball sponges, gorgonians, abalone, sunflower sea stars, rock scallops and California spiny lobsters.

In your own field study, band transects are used to determine the abundance and distribution of rare and clumped organisms that are not adequately sampled by quadrats. You might use them to sample trees or shrubs in a forested area, large cacti found in a desert, or sea stars along a rocky intertidal area.

Materials:

Per group:	2 clipboards	2 1.5-meter PVC rods
	2 30-meter tapes	2 data sheets
Per class:	100 meter transect tape	appropriate field guides
	2 stakes	

Method:



Band Transect Procedure: Together Team 1 (4 students) samples the entire area (60 m^2); one pair samples the top half, the other pair samples the bottom half. Their results are added together to create a single band transect data set.

1. Select a study site.
2. Determine what species you will be sampling. Be sure you can identify each of these species.
3. Randomly pick a number between 1-8.
4. Run a 100 meter transect tape in a straight line through your study site. Place the tape so it accurately reflects the surrounding area.
5. Secure the tape down at both ends with stakes.
6. Beginning at your randomly selected number, run a second transect line perpendicular to your original transect line. The second transect line should extend for 10 meters on both sides of your main transect line.
7. Begin on one side of the main transect line. Walk along the left side of the 10-meter transect, from the outer edge, towards your main 100-meter transect line. Actively search for your species. Count and record all species that you encounter.
8. When you reach the main 100-meter transect line, turn around and sample the opposite side of the secondary 10-meter transect line, walking back to the outer edge of the 10-meter transect tape. You have just sampled a 3 meter x 10 meter rectangular area, or 30 m^2.
9. Repeat steps 7 & 8 on the opposite side of the 100-meter transect line. Add your data from the opposite side to the data you just collected. The final size of each band transect is a rectangular area measuring 3 meter x 20 meter, or 60 m^2.
10. Pick up the 10-meter transect tape.
11. Move 8 meters down the main transect line and repeat the procedure.
12. When you have finished, you should have sampled twelve 60 m^2 rectangular areas.

Questions:

1. What is a band transect survey? What types of organisms can be studied using this method? Why do researchers and park managers use this method?
2. Describe your study site; include physical and biological characteristics, the species sampled and band transect size. Explain why you selected your study site and target species.
3. Why did you sample so many areas instead of just a single band transect?
4. Determine a species list for your study site. List all the species encountered in any of the surveys in alphabetical order.
5. Calculate the average density for each species.

$$\text{average density of } \textit{species a} \text{ per m}^2 = \frac{\text{total \# of organisms of } \textit{species a} \text{ in all transects}}{(\text{\# of transects}) \times (\text{size of transect in m}^2)}$$

6. Describe any changes in species density that you observe. Suggest reasons to explain the differences.

7. Are some species generally seen in smaller groups? If so, give examples. Are other species generally found in larger groups? If so, give examples. How might a large group size be an advantage? A disadvantage?

Conducting a Roving Survey

During a roving fish survey, SCUBA divers enter the water near the transect line and record all the fish species they see within 10 meters of either side of the 100 meter transect tape. Using an underwater slate, divers record the relative abundance of each species (S= single fish, F=Few 2-10 fishes, M=Many 11-100 fish, and A=Abundant more than 100 fish). Divers actively explore the area looking among the kelp fronds, under rocky ledges, along sandy bottoms, and at different levels within the water column in order to survey all of the fish species in the area.

The "Great Annual Fish Count" (GAFC) is an event coordinated by the Reef Environmental Education Foundation (REEF) that mobilizes and trains volunteer divers and snorkelers in roving fish survey techniques identify and document fish diversity and population trends in marine sanctuaries and coastal areas. This annual event takes place the month of July, and serves both to introduce and inspire recreational divers and snorkelers to: participate in REEF's year-round volunteer monitoring programs; raise awareness among both the diving community and public-at-large regarding marine habitats and trends in fish populations; and provide researchers, marine resource managers and policy makers with this useful information that would otherwise be unavailable. To learn more about REEF, visit www.reef.org. To find out about the GAFC, visit http://www.fishcount.org/

While some individuals may be fortunate enough to be SCUBA certified and participate in a local fish count event sponsored by the Great American Fish Count, REEF, or another non-profit organization, many of us probably will not have the opportunity, at least as middle or high school students. We can learn about the Roving Diver Fish Count technique and modify to meet our terrestrial needs. Birds are abundant, easily identified, and occupy a diverse range of ecological niches. Furthermore, they exist within a three dimensional space, using ground cover to tree tops. With care, we can get close enough to birds species to identify them by sight.

Materials:

- clip board
- field guides
- stop watch or timer
- data sheet (1 per group)
- 4 colored stakes

Procedure:

1. Select a study site. *Depending upon where your school is located and if it is rural or urban, your study site will vary; your study site may include a wooded area, an area adjacent to a creek, a nearby wetlands, a desert area, a rocky intertidal area, or the school ball field.*
2. Using field guides, learn to identify the common birds found in your area by sight and sound.
3. Mark off the boundaries of your study site, using colored stakes or other markers.
4. Quietly approach your study site.
5. Record the names of all species of birds you see in your study area. Actively search for as many bird species as possible--look on the ground, in tree branches or on top of buildings or telephone wires. Each person should keep their own species list; do not share data or point bird species out to your classmates. Next to each species mark an "X" in the appropriate abundance column.

   S = Single (1)
   F = Few (2-10)
   M = Many (11-100)
   A = Abundant (100+)

6. Continue to record the names of bird species that you encounter for 20 minutes. If you see a species that has already been listed, adjust your "X" in the abundance column to include the newer sightings. For instance, if you saw one sparrow when you began your survey, and two more sparrows ten minutes later, add an "X" in the "Few" column next to "Sparrow". .

7. Return to class and compile your data. Determine the % sightings for each species.

Questions:

1. What is a roving count survey? What types of organisms can be studied using this method? Why do researchers and park managers use this method?
2. Describe your study site; include physical and biological characteristics, the species sampled and quadrat size. Explain why you selected your study site and target species.
3. Surveys of this type can be very variable. The bird species seen and the abundance of each species will vary throughout the day simply due to chance. Even so, a great deal of information can be learned by studying trends in species distribution and abundance. What other factors might effect the number and types of bird species seen?
4. Determine a species list for study site. List all the bird species encountered in any of the surveys in alphabetical order.
5. Calculate the percent sighting for each species. List the species in order from the greatest to smallest percent sighting. Which species were seen the most often and were the most abundant? Which were the least?

$$\text{\% sighting for species a} = \frac{\text{\# of surveys species was seen in}}{\text{\# of surveys}}$$

6. Which bird species were most abundant? Did they occur in large flocks, in smaller groupings, or by themselves?

Data Table for Band Transect or Quadrat Study

Team Members: ______________________ ______________________

______________________ ______________________

Type of Survey: ______________________

Location of Survey: ______________________

Began at ____m on 100m Transect Line

Species	Number Counted	Ave. Density per meter ^{2}

Data Table for Roving Bird Count

Name: ______________________

Location of Survey:______________________ Date of Survey: ______________________

Time Survey Began: ______________________ Time Survey Ended: __________________

Name of Species	**Single (1)**	**Few (2-10)**	**Many (11-100)**	**Common (over 100)**	**% Sighting**

Making PVC Transect Stadia for Beach & Dune Profiling

<u>Materials & Supplies:</u>

Two 5-foot lengths of 3/4-inch PVC pipe (1" and 1 1/2 " PVC pipe can also be used) (<$2 each)

Two PVC adapters,3/4-inch **slip-on** adapter, without threads (<$1 each)

Two PVC 3/4-inch **slip-on** plug, without threads (<$1 each)

Two 3-inch or 4-inch PVC cap fitting or knock out plug (<$1 each) to provide a footing on the sand

2 1/8-inch diameter x 1/2-inch sheet metal screws

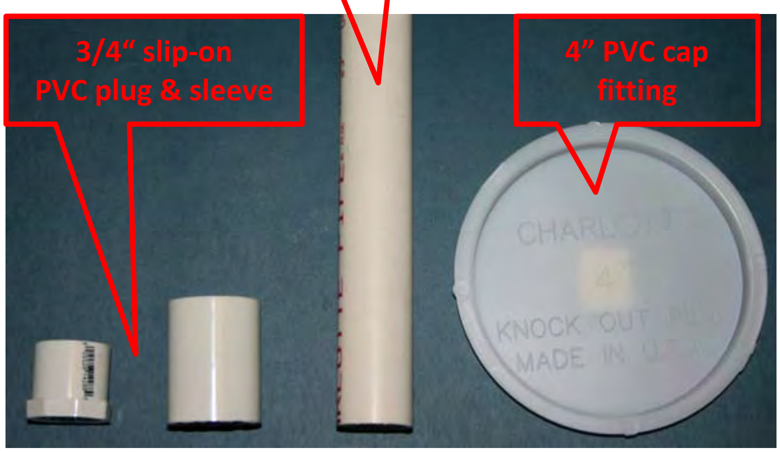
2 washers with 1/8-inch diameter hole

1 roll color vinyl tape or electrician's tape & a fine-tipped permanent marker

<u>Equipment needed:</u> hand drill, hammer, Phillips screwdriver

<u>Assembly Instructions</u>

1. With a 1/8" drill bit, drill holes in the center of the PVC adapters, PVC plugs & PVC cap fitting.
1. Insert one end of the 3/4-inch PVC pipe into the receptacle end of the PVC adapter.
2. Insert the PVC plug into the end of the adapter. Lightly hammer the plug into the adapter & pipe until fully seated. DO NOT use glue, these will fit snugly, but can be hammered apart if repairs need to be made.
3. Attach the PVC cap fitting to the pipe assembly using a washer & metal screw.
4. Use the top of the PVC adaptor as "zero" for the height measurements on the stadia, making marks & labeling every 2 cm with an indelible pen.
5. To make the 10 cm increments more visible, wrap colored vinyl tape at 0, 10, 20, 40cm, etc.



Meaningful Watershed Educational Experience

A Meaningful Watershed Educational Experience, or MWEE, enables students to participate in hands-on environmental learning about the Chesapeake Bay watershed. This experience will serve as the foundation for a rich, lifelong relationship between students and their Bay. Throughout the MWEE process, students develop a sense of environmental ethics and stewardship that are essential to the long-term sustainability of the Chesapeake Bay. In addition, studies have shown that hands-on environmental education increases the academic performance of students in a variety of subjects.

What Is a MWEE?

A MWEE integrates field work in the Chesapeake Bay watershed with multidisciplinary classroom activities and instruction. Students then share their discoveries with local schools and communities, both orally and in writing.

MWEEs Are Investigative or Project-Oriented.

Students investigate questions, problems, and issues related to the watershed. Activities include streambank or oyster restoration projects and planting underwater grasses; water quality monitoring; on-site studies of Bay plants and animals; or social studies that deepen a student's understanding of historical, cultural, or economic interests. Projects may also involve interaction with natural resource personnel.

MWEEs Are Integrated within the Instructional Program.

A MWEE is not a single field trip; rather, the experience reflects an integrated approach to learning. MWEEs align with jurisdictional learning standards and occur where and when they fit into the existing curriculum. They also are effective tools for teaching many subjects—including science, math, history, reading, and art.

MWEEs Involve Preparation, Action, and Reflection.

A MWEE is organized into three phases. First, students research and discuss a watershed issue or problem in preparation for the field component. Second, students take action by observing, measuring, or collecting data during their outdoor experience. Third, students return to the classroom, reflect upon and analyze their project, and reach conclusions.

MWEEs Reveal the Watershed as a System.

MWEEs have an intentional connection to the watershed as a whole. Experiences focus not only on the Bay, rivers, and streams, but also on terrestrial issues such as erosion control, buffer creation, groundwater protection, and pollution prevention.

Students and Teachers Sustain MWEEs throughout the School Year.

In-class preparation and reflection activities are vital to solidify the watershed concept. Thus, an outdoor experience, or extended outdoor project, should be expanded by classroom activities throughout the school year.

Did you know?

Recognizing the value of hands-on environmental education, the governors of the Chesapeake Bay states and the Mayor of Washington, D.C., signed a commitment in 2000 to provide a meaningful watershed experience for every student in the Chesapeake Bay watershed before graduation from high school.

www.chesapeakebay.net

1-800-YOUR-BAY

Eyes Are Opened, Environmental Ethics Are Formed

NOAA B-WET

Bay Watershed Education and Training Program

The NOAA Chesapeake Bay B-WET Program provides hands-on watershed education to students and teachers to foster stewardship of the Chesapeake Bay. B-WET supports the commitment of the Chesapeake Bay Program—a partnership for watershed restoration—to provide every student in the watershed with a meaningful bay or stream outdoor experience before graduation from high school. To accomplish this, B-WET focuses on enabling experiences for students and teachers.

MWEEs for Students

MWEEs support bringing the outdoors into the classroom through a strong complement of field and classroom experiences. This provides an opportunity to teach science, math, reading, social studies, and even art in an interesting and thought-provoking manner.

Professional Development for Teachers

By providing teachers with the knowledge and confidence to weave together classroom and field activities to meet existing learning standards, student engagement and achievement is increased.

How to Apply

The B-WET program provides competitive grants and technical support facilitating MWEEs for students and related professional development for teachers. Typical grants range from $50,000 to $150,000. Eligible organizations include:

- Schools and school systems
- Colleges and universities
- Nonprofit organizations
- State and local government agencies

More information on the application process and other programs is available at http://chesapeakebay.noaa.gov.

ChART Your Way to Bay Education

www.chesapeakebay.net/chart/

Chesapeake Academic Resources for Teachers (ChART) is a web site designed to help educators provide MWEEs to their students. It is conveniently divided into three searchable sections: teaching resources, professional development, and field studies. This makes finding information you need fast and easy.

Teaching Resources

Use ChART to search a host of great teaching resources including books, data, web sites, and much more.

Professional Development

Prepare yourself to teach your students about the Chesapeake Bay and its watershed. Browse a large database of professional development training that can help you find the right program for you.

Field Study Programs

Search our library of field study programs and find opportunities that enable your students to experience the Bay's watershed hands-on.

ChART content has been approved by state departments of education, and wherever possible aligns with standards of learning and/or academic standards.

STEWARDSHIP AND MEANINGFUL WATERSHED EDUCATIONAL EXPERIENCES

The "Stewardship and Community Engagement" Commitment of the *Chesapeake 2000* agreement clearly focuses on connecting individuals and groups to the Bay through their shared sense of responsibility and action. The goal of this Commitment, included below, not only defines the role of the jurisdictions to *promote* and *assist*, but formally engages schools as integral partners *to undertake initiatives* in helping to meet the Agreement. This goal commits to:

> *Promote individual stewardship and assist individuals, community-based organizations, businesses, local governments and schools to undertake initiatives to achieve the goals and commitments of this agreement.*

Similarly, two objectives developed as part of this goal describe more specific outcomes to be achieved by the jurisdictions in promoting stewardship and assisting schools. These are:

> *Beginning with the class of 2005, provide a meaningful Bay or stream outdoor experience for every school student in the watershed before graduation from high school.*
>
> *Provide students and teachers alike with opportunities to directly participate in local restoration and protection projects, and to support stewardship efforts in schools and on school property.*

There is overwhelming consensus that knowledge and commitment build from first-hand experience, especially in the context of one's neighborhood and community. Carefully selected experiences driven by rigorous academic learning standards, engendering discovery and wonder, and nurturing a sense of community will further connect students with the watershed and help reinforce an ethic of responsible citizenship.

To this end, the Chesapeake Bay Program Education Workgroup seeks to define a common set of criteria to help the Bay watershed jurisdictions meet the intent of this Commitment of the *Chesapeake 2000 Agreement.* From these criteria, each jurisdiction will continue to craft and refine its own plan, tailored to its own population, geography, and fiscal and human resources.

Defining *a Meaningful* Bay or Stream Outdoor Experience

A *meaningful* Bay or stream outdoor experience should be defined by the following.

Experiences are investigative or project-oriented. Experiences include activities where questions, problems, and issues are investigated by the collection and analysis of data, both mathematical and qualitative. Electronic technology, such as computers, probeware, and GPS equipment, is a key component of these kinds of activities and should be integrated throughout the instructional process. The nature of these experiences is based on each jurisdiction's academic learning standards and should include the following kinds of activities.

- Investigative or experimental design activities where students or groups of students use equipment, take measurements, and make observations for the purpose of making interpretations and reaching conclusions.

- Project-oriented experiences, such as restoration, monitoring, and protection projects, that are problem solving in nature and involve many investigative skills.

- Social, economic, historical, and archaeological questions, problems, and issues that are directly related to Bay peoples and cultures. These experiences should involve fieldwork, data collection, and analysis and directly relate to the role of the Bay (or other bodies of water) to these peoples' lives.

Experiences such as tours, gallery visits, simulations, demonstrations, or "nature walks" may be instructionally useful, but alone do not constitute a *meaningful* experience as defined here.

Experiences are richly structured and based on high-quality instructional design. Experiences should consist of three general parts including a) a preparation phase; b) an outdoor action phase; and c) a reflection, analysis, and reporting phase. These "phases" do not necessarily need to occur in a linear fashion. These include the following.

- The *preparation phase* should focus on a question, problem, or issue and involve students in discussions about it. This should require background research and student or team assignments as well as management and safety preparation.

- The *action phase* should include one or more outdoor experiences sufficient to conduct the project, make the observations, or collect the data required. Students should be actively involved with the measurements, planning, or construction as safety guidelines permit.

- The *reflection phase* should refocus on the question, problem, or issue; analyze the conclusions reached; evaluate the results; and assess the activity and the student learning.

Experiences are an integral part of the instructional program. Experiences should not be considered ancillary, peripheral, or enrichment only, but clearly part of what is occurring concurrently in the classroom. The outdoor experiences should be part of the division curriculum and be aligned with the jurisdiction's learning standards. Experiences should make appropriate connections among subject areas and reflect an integrated approach to learning. Experiences should occur where and when they fit into the instructional sequence.

Experiences are part of a sustained activity. Though an outdoor experience itself may occur as one specific event, occurring in one day, the total duration leading up to and following the experience should involve a significant investment of instructional time. This may entail smaller amounts of outdoor time spread over an entire school year. Likewise, the actual outdoor experiences may not necessarily involve all students in a class at the same time. Rich learning experiences, especially those involving monitoring and restoration activities, may require time increments spread over weeks or even months. A sustained activity will generally involve regularly-scheduled school time and may involve extended day or weekend activity.

Experiences consider the watershed as a system. Experiences are not limited to water-based activities directly on the Bay, tidal rivers, streams, creeks, ponds, wetlands, or other bodies of water. As long as there is an intentional connection made to the water quality, the watershed, and the larger ecological system, outdoor experiences that meet the intent of the Commitment may include terrestrial activities in the local community (e.g., erosion control, buffer creation, groundwater protection, and pollution prevention).

Experiences involve external sharing and communication. Experiences should warrant and include further sharing of the results beyond the classroom. Results of the outdoor experiences should be the focus of school-based reporting, community reporting, publishing, contribution to a larger database of water quality and watershed information, or other authentic communication.

Experiences are enhanced by natural resources personnel. Utilizing the expertise of scientists and natural resources professionals can heighten the impact of outdoor experiences. This includes both their participation in the classroom and leadership on-site during outdoor activities. These personnel have technical knowledge and experience that can serve to complement the classroom teacher's strengths and augment the array of resources for the learning. Additionally, these professionals can serve as important role models for career choices and as natural resources stewards.

Experiences are for all students. As it is crucial for all citizens to have an understanding of and connection with their own watershed, an outdoor experience is for all students regardless of where they live. Much of the land area in the jurisdictions is outside of the Bay watershed; however, it is intended that students residing in those areas have similar opportunities within their own local setting or beyond.

It is also clear that these kinds of experiences must be extended to all students including students with disabilities, in alternative programs, and special populations. No child should be excluded from a *meaningful* watershed experience.

Meaningful Experiences across the K-12 Program

It is the intention that every student somewhere in the K-12 program will have a *meaningful* outdoor watershed experience before graduation from high school; however, it is the expectation that these kinds of activities will occur throughout formal schooling. Beginning with the primary grades, the jurisdictions' academic learning standards in the social and natural sciences call for inquiry, investigation, and active learning. These skills, concepts, and processes increase in complexity and abstraction, "spiraling" and building throughout the elementary, middle, and high school programs. Likewise, the experiences should reflect this progression.

Outdoor experiences should occur at each level, elementary, middle, and high school. These experiences should be defined by the local curriculum, be aligned with the jurisdiction's learning standards, and mirror the developmental level of students.

The following example "scope and sequence" describes experiences that should be appropriate for many students in the K-12 program.

> **K-5 experiences** should be predominantly local, school, or neighborhood-based, including activities reflecting students' background knowledge, shorter attention span, and physical capabilities. Experiences must clearly relate to academic learning standards across subject areas and reinforce basic concepts such as maps and models, habitat principles, and the concept of the water cycle and watersheds. Care must be taken with the introduction or discussion of complex issues.

6-8 experiences should focus on team and class projects and investigations. These experiences should reinforce research skills requiring the use and analysis of more authoritative print and electronic resources. Longer-term restoration, monitoring, or investigative projects should be conducted locally or on school grounds. Actual student experiences in or near water may be appropriate for many middle school students (following school safety guidelines carefully). Activities such as water-quality testing can be used to reinforce many science, mathematics, and technology skills developed in middle school.

9-12 experiences should reflect students' more abstract reasoning and detailed planning ability. Locally based activities continue to be important, but student watershed experiences beyond the immediate community will have considerable impact in meeting academic and stewardship goals. First-hand experiences in or near water should be part of the implemented curriculum, especially as these experiences relate to the Earth and biological sciences, concepts developed in civics and government, and attitudes reinforcing responsible citizenship.

Conclusion

The preceding consensus criteria define a clear vision for bringing the Bay into every classroom and every child out into the watershed in a *meaningful* way. It will be the goal of every educator, teacher and administrator, to move toward incorporating those experiences that build academic success, reinforce responsible citizenship, and work toward the goals of the *Chesapeake 2000* agreement. With inspired leaders, committed parents, and supporting communities garnering the fiscal and human resources to help make this happen, young people will be significant contributors to healthy, bountiful, and enduring watersheds.

MWEE Resources

Project Ideas, Examples & How To Conduct Field Studies

NOAA Chesapeake Bay Office: /www.chesapeakebay.net
Classroom ideas: www.chesapeakebay.net/teachersschools
Bay Backpack: www.baybackpack.com/

- A Guide to Creating Meaningful Watershed Experiences: A guide for creating meaningful outdoor experiences from the Chesapeake Bay Foundation.
- Chesapeake Academic Resource for Teachers: ChART is a comprehensive resource for Bay-related lesson plans, educational activities and field study opportunities for students.
- Exploring the Chesapeake: Then and Now: Learn about the history of the Bay watershed and download lesson plan resources at this National Geographic site.

Bay Restoration project ideas: www.chesapeakebay.net/bayrestoration

Phytoplankton Monitoring Network –
www.ncddc.noaa.gov/interactivemaps/southeast-phytoplankton-monitoring-network
This NOAA-sponsored outreach program teaches students, teachers and the public about phytoplankton and harmful algal blooms. Volunteers sample sites along their coasts and submit observational data, educators can also access data from across the US.

The Globe Program - http://classic.globe.gov/projects
GLOBE projects provide student research experiences grounded in real science and using an inquiry-based, collaborative approach. The latest GLOBE projects, collectively called the Earth System Science Projects (ESSPs), have been funded by NSF and NASA.

Project-Based Learning - http://pbl-online.org/
A one-stop solution for Project Based Learning! You'll find all the resources you need to design and manage high quality projects for middle and high school students. Features a library of PBL project ideas.

LiMPETS (Long-term Monitoring Program and Experiential Training for Students)
-- http://limpetsmonitoring.org/
This hands-on program was developed to monitor the ocean and coastal ecosystems in CA, but the methods can apply anywhere! Teacher handbook on-line features lists of materials and supplies, illustrated instructions for conducting transects on rocky shores and beaches.

World Water Monitoring Day - www.worldwatermonitoringday.org/
This international outreach program builds public awareness and involvement by engaging students, teachers and citizens in basic monitoring of their local water bodies. Guidebook, classroom kits and lesson plans are available.

Healthy Water, Healthy People - http://projectwet.org/water-resources-education/water-quality-education/
Part of Project Wet (Worldwide Water Education) focusing on quality and conservation of water supplies. Testing kits, educator guides on critical topics and training in watershed water quality testing are offered.

VA Naturally/DEQ - www.deq.state.va.us/vanaturally/
Look for the school success stories page which includes some examples of past Classroom Grant winners.

Scuttlebutt - www2.vims.edu/bridge/search/scuttle.cfm
Ask other teachers for ideas, examples, tips._The Bridge and NMEA discussion list, is a forum for marine educators to talk informally about marine education ideas, issues, and questions. The Bridge staff monitors list activity and will assist in locating expertise to answer questions that teachers post to the list, as needed.

Teacher Guides/Curricula

Auldridge, T. (Project Director). 1987. River Times. Mathematics & Science Center, Richmond, VA

Bearman, J., S.H. Grant and Barbara Sayre. W.A.V.E. -Watershed Action for Virginia's Environment. Chesapeake Bay Foundation & VA Dept. of Education.

Edelstein, K., N. Trautmann, M. Krasny. 1998. Watershed Science for Educators. Cornell Cooperative Extension Publication, Cornell University.

Gilligan, M.R., T. Kozel & J.P. Richardsom. 1991. Environmental Science Laboratory. Halfmoon Publishing, Savannah.

Kresselheim, A.S., et al. 1995. WOW! – The Wonders of Wetlands. Environmental Concern and The Watercourse.

Lloyd, J.M. & K.M. Register. 2003. Virginia's Water Resources. Virginia Environmental Endowment, VA DEQ and VA DOE.

Wilson, I. (Project Director). 1990. Virginia's State Parks…Your Backyard Classrooms. Chesapeake Edition. VA Sea Grant Marine Advisory Program, VIMS.

Permits

State of Virginia Department of Inland Game & Fisheries: Collecting permits

www.dgif.virginia.gov/permits/guide.asp

This VA Department enforces the laws, regulations, and Agency guidelines governing the collection, holding, exhibiting, and release of wildlife by issuing permits and guidelines for these activities. The contact person for advice, questions is: Shirl Dressler, Program Support Technician, Wildlife Diversity Division , 4010 W Broad Street , Richmond, VA 23230. Phone: (804) 367-6913; FAX (804) 367-2427. E-mail: shirl.dressler@dgif.virginia.gov OR collectionpermits@dgif.virginia.gov.

Collection of Wildlife for Scientific and/or Educational Purposes

Virginia Scientific Collection, Research, Survey Permit/Salvage Permit/Threatened & Endangered Species Permit Applications and Permit(s) Report Form and Instructions: A permit is required for any activities involving the capture of nongame species. "Collection" includes all sampling activities that remove, even temporarily, any individuals from the natural environment. "Collection" also includes habitat disturbance such as turning over rocks/logs, putting down cover boards etc. as well as the capture and handling of species. "Salvage" includes all taking of species found dead. A permit is required for Scientific Collection and/or Salvage activities **ANYWHERE** in the Commonwealth of Virginia including federal lands.

The following items are REQUIRED to receive a Scientific Collection Permit:

- Fully completed permit application, including specific species and location information and you MUST have a specific project that the permit is addressing; blanket permits will not be issued. Applications must be submitted at least 30 days prior to the start of the project.
- The formal Project Proposal/Study Plan/Field Plan, must include specific information regarding the scientific affiliation or purpose of the project and include; collection methods to be used, data to be collected, specific species to be collected, the proposed and justified quantity to be collected/vouchered, and disposition methods.
- A resume/CV, or other documentation, providing project and species or taxon specific experience and qualifications for each person listed on the application. Students without experience should list appropriate course and must be accompanied by the Principal Permittee. (this applies only to the Collection and Threatened & Endangered Species applications)
- No hand written applications will be accepted.
- All applications and other documentation must be provided electronically to collectionpermits@dgif.virginia.gov.

Sampling Equipment – Selected Supply Companies

Acorn Naturalists: http://www.acornnaturalists.com 155 El Camino Real, Tustin, CA 92780
Science and environmental education supplies for teachers, outdoor educators, interpreters, homeschoolers, camp leader**s,** naturalists**,** nature centers.

Wildlife Supply Company: **www.wildco.com** 95 Botsford Place, Buffalo, NY 14216
Water, sediment and aquatic life sampling equipment, student kits. Plankton and benthic nets, sampling bottles, secchi disc, benthic grabs, sediment samplers, water chemistry kits & test meters, field equipment, student equipment, orienteering.

Forestry Suppliers, Inc.: **www.forestry-suppliers.com** 205 West Rankin Street, Jackson, MS 39201
Earth & environmental science natural resource kits, programs and equipment for K-12 science educators. Soil and aquatic testing, mapping, lab equipment, weather, field studies, science project supplies.

Project Wet Watershed Kit for Healthy Water, Healthy People :
http://store.projectwet.org/index.php/testing-kids/watershed-water-quality-testing-kit.html
Compact text kit includes test strips for five parameters. Includes Healthy Water Healthy People Educators Guide and Field Monitoring Guide. To order, call the Project WET Foundation at 406-585-2236 or toll free at 866-337-5486 or email at sales@projectwet.org

LaMotte Company: **www.lamotte.com** P.O. Box 329, Chestertown, MD 21620
Environmental science education products. Water test kits & chemicals. Hydrology and soil equipment. Environmental test kits and curricular packages: Shore, estuary, stream.

Rite-In-The-Rain: **www.riteintherain.com** J.L. Darling Corp. 2614 Pacific Hwy, E. Tacoma, WA 98424
Water resistant field notebooks, all-weather copy paper for field data sheets. Small supplies of notebooks also available at the VIMS Gift Shop.

Norva Plastics: **www.norvaplastics.com** 3911 Killman Ave., Norfolk, VA 23508
Custom-designed plexiglass viewing boxes, to your specifications.

Memphis Net & Twine: **www.memphisnet.net/category/fishing** P.O. Box 80331, Memphis, TN 38108
Fishing nets and netting.

Ward's Natural Science, Geology: **www.wardsci.com** P.O. Box 92912, Rochester, NY 14692
Earth science field equipment, meteorology equipment, environmental test kits, soil and water test kits & meters, safety equipment, mineral samples.

Hach Company: **www.hach.com** P.O. Box 389, Loveland, CO 80539
Water testing kits and chemicals, meters and probes, lab and field equipment, lab supplies and safety equipment

Parco Scientific Company: **www.parcoscientific.com** P.O. Box 851559, Westland, MI 48185
Laboratory and field equipment, including microscopes, refractometers, thermometers, lab glassware and safety equipment. Probewear and data loggers at www.pasco.com/products/probeware/Index.cfm

Vernier Software & Technology, LabQuest: **www.vernier.com/subjects.html**
13979 SW Millikan Way, Beaverton, OR 97005
Probeware sensors, data collection and graphing technology for lab and environmental field science.

Duluth Trading Company: **www.duluthtrading.com** P.O. Box 200, Belleville, WI 53508
Buckets and super seal bucket covers.

NRS: **www.nrsweb.com/shop/product_list.asp?deptid=951** 2009 S. Main St., Moscow, ID 83843
Safety equipment: Life jackets/PFDs (personal floatation devices), first aid kits, safety whistles.

Grants & Funding Sources

VA DOE - Learn & Serve Virginia Grants
www.doe.virginia.gov/instruction/high_school/science/learn_serve
The purpose of the LSV competitive grant is to integrate the Virginia Standards of Learning (SOL) in grades 6-12 with numerous existing environmental initiatives and partnerships in an effort to increase environmental, particularly watershed, stewardship. This includes water quality studies and watershed

restoration. Projects will build on the successes of current service-learning projects and follow the guidelines such as those outlined for a Meaningful Watershed Educational Experience (MWEE). Also see Learn and Serve America School-Based programs: www.learnandserve.gov/about/programs/school_based.asp

NOAA Office of Education B-WET Grants www.oesd.noaa.gov/grantprog.html

Environmental Literacy Grants Program - ELG supports informal and formal education projects, emphasizing partnerships that facilitate the integration of NOAA assets into education programs.

Bay-Watershed Education and Training (B-WET) Program - Environmental education program that promotes locally relevant, experiential learning in the K-12 environment. The delivery of B-WET occurs primarily through competitive funding that promotes Meaningful Watershed Educational Experiences (MWEEs).

NOAA Chesapeake Bay Office - Bay Backpack: www.baybackpack.com/index.cfm?page=app.funding

If you are looking for a way to finance field trips for your students or buy supplies to install an outdoor classroom on your school grounds, this site by the NOAA Chesapeake Bay Office offers a great list, plus tips for putting a proposal together.

VA Dept of Environmental Quality - VRUEC Classroom Grants

www.deq.state.va.us/vanaturally/classroomgrants.html

Sponsored by the Virginia Resource Use Education Council, the Department of Environmental Quality, the Department of Conservation and Recreation and the Virginia Environmental Endowment to provide teachers with small amounts of money for environmental education. Schools or school divisions can apply for a grant of $500, $750 or $1,000 for the purpose of conducting meaningful outdoor experiences with their students. Activities eligible for funding include: restoration, enhancement, protection and monitoring projects; investigative or experimental design activities that foster academic success, reinforce responsible citizenship, and give children tools they need to contribute to a healthy and enduring environment. Application deadline: Dec. 1.

Chesapeake Bay Restoration Fund http://dls.virginia.gov/cbrfac.htm

The Chesapeake Bay Restoration Fund Advisory Committee develops goals and guidelines for the use of the moneys collected from the sale of the special Chesapeake Bay license plates. Each year the Advisory Committee accepts proposals for Bay-related environmental education, public awareness and restoration projects. Grant awards are variable, depending on the project. Applications due Oct. 1. See list of successful proposals and projects.

Virginia Association of Science Teachers (VAST) – Project Grants

www.vast.org/index.cfm/go/content.dspcontent/Page_Name/Grants-and-Funding.html

VAST posts links for several funding opportunities, including the Virginia Environmental Endowment, School Grants, and others.

Dominion Energy - Dominion Educational Partnership Grants

www.dom.com/about/education/grants/index.jsp

Successful grant proposals should represent innovative and promising ideas, teach math and/or science skills, reach a significant number of students and demonstrate broad-based community support. Proposals must align with one of the following target areas: environmental education, energy. Includes: mini-grants (<$1000), larger (to $5000) and exceptional grants (to $10,000).

Target – Field Trip Grants www.Target.com

Target awards up to $800 to teachers for the purpose of taking students on enriching field trips. Registration opens Aug. 1. See 2009-10 fieldtrip grants for other schools that have received grants.

Mid-Atlantic Marine Education Association (MAMEA)
– Educational Project Grant www.mamea.org

Active MAMEA members may submit proposals for up to $1,000 in grant support for a classroom project in marine and aquatic education. Applications due September.

Reflection Phase of the

"Meaningful Watershed Educational Experience"

According to the definition of a "Meaningful Watershed Educational Experience," the reflection phase should refocus on the question, problem or issue; analyze the conclusions reached; evaluate the results; and assess the activity and student learning. The MWEE should be considered in its entirety, as opposed to focusing on the field investigation exclusively.

Reflective thinking is considered to be part of the critical thinking process, specifically the process of analyzing and making judgments about what has happened. Through reflective thinking, learners may assess what they know, what they need to know and how to bridge the gap. Potentially, reflection on the Meaningful Watershed Education Experience can occur at two levels, instructor and student.

Reflection by Instructors

Educators, including classroom teachers and natural resource personnel can reflect on the impact of the educational experience by analyzing specific components and responding to such questions as:

*Was material from previous (classroom) lessons incorporated into this experience?

*Was there sufficient probing of the students' knowledge and abilities?

*Were the students encouraged to listen and respond to remarks made by instructors and peers?

*Was the experience at the right level for the students? Were they challenged but not lost confused?

*Was there an appropriate amount of activity or work for the length of time allotted?

*Was there room for intellectual risk-taking and discovery?

*Were the students encouraged to rethink, reorganize or refine their ideas?

*Which component of this experience engaged the students' interest and attention to the highest degree?

*Were the learning objectives achieved? How do you know?

*Were there any unexpected outcomes?

*Is there anything you would change or eliminate?

*What was your role in this experience?

*Did you adequately prepare others for participation in this experience?

*What did you personally learn from this experience and how can you apply in to your teaching?

*How will you help students synthesize what they learned during the field experience and the rest of the unit of study?

(Questions adapted in part from Science Instruction Reflection, M. Allushuski, 2009)

Student Reflection

Reflective thinking in middle school students is recognized as being particularly valuable as it can support them in their transition between childhood and adulthood. It is considered an ideal time to develop thinking, learning and metacognitive strategies. Reflective thinking can provide middle school students with the skills to mentally process learning experiences, identify what they learned, modify their understanding of the topic based on new information and experiences and transfer their learning to other situations. The following strategies help students develop their ability to reflect on their own learning:

- Teachers model reflective thinking by explaining how they have learned from their own experiences
- Reflection activities are included in classroom study guides so that student know in advance this is a standard part of the learning process
- Questioning is used to prompt reflective thinking, specifically getting students to respond to why, how and what.....?
- Social learning through collaborative work with peers, teachers and experts
- Learning activities should be relevant to real-world situations
- Possible causes and solutions to problems are researched and discussed
- Results and findings are monitored and reevaluated throughout the entire unit

(Excerpted from Reflective Thinking, University of Hawaii)

Reflection activities with students may include more general interpretations of the experience as well as summarizing and presenting the field data that was generated. Debriefing exercises are a traditional component of outdoor adventure education. Challenge course participants who successfully move their team from one side of a high wall to another will often discuss how that experience relates to something else in their lives. Reflection can be integral to learning because it helps build self-awareness, strengthen personal and team growth and can improve performance in the future. Since students groups are typically diverse, reflection activities should mirror the differences in the group and accommodate a variety of learning styles. Reflection activities to consider include"

Rap and Rhyme: Give groups about 10-15 minutes to write a rap or rhyme about their experience. All group members should be incorporated into the production.

Sculpture: Each small group creates a sculpture around a work, phrase or other aspect of the experience using props. Other groups attempt to interpret the work. One quick option is to have the group members become "statues" or living sculpture.

Skits: Ask each small group to portray their experience through a skit. After each presentation, have the whole class provide responses, ideas and suggestions.

Group Poem Writing: Circulate a piece of paper around the class with the topic written across the top. Encourage each student to write a line in response to the previous one until everyone has contributed. Volunteers can read the entire work to the group and discuss it.

Imagining the Future: Ask students to imagine the site in the year 2020. Small groups reflect on the changes that have occurred.

Graffiti Museum: Glue a wide variety of photos taken on the day of the field work on sturdy paper and post throughout the classroom. Have students chose one that represents their impression of the experience and add a personalized caption. Teachers may need to give examples of what would or would not be appropriate.

Group Banners: Using large pieces of banner paper and markers, ask student groups to depict their experience using a combination of words and pictures. When completed ask each small group to share their banner with the class.

Data Analysis and Sharing

For science teachers and students, data analysis begins with the investigative question around which the field work revolves. The investigative question needs to be specific enough to be researched and answered with qualitative or quantitative observations or measurements taken at a certain places and times. Information is record systematically on a data collection sheet.

Results are organized into categories in tables, charts, graphs, maps or other written forms and appropriate calculations are made as needed. Students then analyze data to look for patterns and trends. A clear conclusive statement that answers the investigative question or states whether the hypothesis or prediction was correct is made. The data should be used to support the conclusion, description or model.

During group discussions, the data should be compared to that obtained during similar research projects or some type of standard result. Factors that may have affected the outcome of the investigation should be identified. Students may note how procedures may be improved. The group should discuss how the results relate to the essential question, list any new questions that emerge and make recommendations for future action.

(Summarized from Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Processes by the Association of Fish and Wildlife Agencies)

Virginia teachers and students have designed and participated in a creative assortment of reflection activities. Many school systems incorporate the use of student journals or science notebooks before, during and after the main field experience. Elementary students have made posters, compiled portfolios and assembled bulletin boards to share what they learned with the rest of the school. Older students have presented data using electronic graphing and mapping programs, and created PowerPoint presentations and photo journals. Research results have been shared with classmates, as well as school administrators and community decision makers. High school students have entered water quality data on-line through a variety of monitoring networks which include opportunities for additional communication through chats, blogs and other mechanisms.

Field Investigations:

Using Outdoor Environments to Foster Student Learning of Scientific Processes

ASSOCIATION of FISH & WILDLIFE AGENCIES

A Project of the Association of Fish and Wildlife Agencies' North American Conservation Education Strategy; Developed by the Pacific Education Institute

Funded by a Multistate Grant of the Sport Fish and Wildlife Restoration Program

December 2007

Field Investigations:

Using Outdoor Environments to Foster Student Learning of Scientific Processes

Developed By
Pacific Education Institute
Margaret Tudor, Ph.D.
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Co-Executive Directors

Developed for
Association of Fish and Wildlife Agencies'
North American Conservation Education Strategy

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December 2007

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Preface

This volume—*Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Processes*—was developed to help K-12 teachers introduce their students to the methodologies used for scientific field research and guide them through the process of conducting field studies. In particular, this volume demonstrates how to use descriptive and comparative methodologies for field studies.

Scientific inquiry is essential to the study of the natural world and the environmental issues that currently confront society. To identify the key methodologies employed by professional researchers for field science inquiry, the Pacific Education Institute (PEI) conducted a nationwide study. From the results of this study, PEI, a public-private consortium of natural resource and education agencies and organizations, developed the field investigation methodologies presented in this publication. These inquiry methodologies thus reflect the contemporary inquiry processes used by practicing field biologists in fish, wildlife habitat, forests and water related studies.

The Association of Fish and Wildlife Agencies (AFWA) engaged the Pacific Education Institute to provide the field investigation guidelines for teachers to help them implement meaningful science inquiry with their students. The guidelines fulfill expectations of the K-12 plan for the North American Conservation Strategy, funded by a Multistate Grant of the Sport Fish and Wildlife Restoration Program.

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Acknowledgements

Education should prepare both students and the public to understand the natural resources on which we all depend. It should also provide opportunities for students and other citizen scientists to investigate natural resource concerns and make meaningful contributions to our understanding of the natural environment. The guidelines for *Field Investigations* was developed to help facilitate this critical advance in education. For its creation and publication, we are especially indebted to those at the Washington State Department of Fish and Wildlife who recognized that an informed and engaged public is critical to the mission of natural resource agencies and who therefore championed this seminal education project: Dr. Jeff Koenings, Director of the Washington Department of Fish and Wildlife (WDFW), John Pierce, Chief Wildlife Scientist, Richard "Rocky" Beach, Wildlife Division, and Michael O'Malley, Watchable Wildlife Program.

Also special thanks to the Washington Forest Protection Association (WFPA) Executive Director Mark Doumit, and chair of the WFPA Environmental Education Committee Norm Schaaf, for their on-going support of the work of the Pacific Education Institute.

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Special thanks to all the teachers who have participated in workshops and shared their insights.

Table of Contents

Section 1
Field Investigations as Inquiry: A Conceptual Framework

> *". . .science is not a fixed body of knowledge but an evolving attempt by humans to create a coherent description of the physical universe." —White, 2003, p. 174*

What are field investigations?

Field investigations of the environment involve the systematic collection of data for the purposes of scientific understanding. They are designed to answer an investigative question through the collection of evidence and the communication of results; they contribute to scientific knowledge by describing natural systems, noting differences in habitats, and identifying environmental trends and issues.

Why conduct field investigations?

Field investigations help students become systems thinkers, learn the skills of scientific inquiry, and understand that science doesn't only happen in a laboratory or classroom. Outdoor experiences in natural settings increase students' problem solving abilities and motivation to learn in social studies, science, language arts, and math.

Systems Thinking

When planning and conducting field investigations, students and scientists grapple with the difficulties of working in a natural system and at the same time develop an understanding of its complexities and subsystems. Systems-thinking involves thinking about relationships, rather than about individual objects. A system can be defined in a number of ways:

- An assemblage of inter-related parts or conditions through which matter, energy, and information flow (Washington State EALR's).
- An organized group of related objects or components that form a whole (NRC).
- A collection of things and processes (and often people) that interact to perform some function. The scientific idea of a system implies detailed attention to inputs and outputs and interactions among the system components (AAAS).

Scientific Inquiry

State and national science education standards encourage instruction that focuses on problem-solving and inquiry—activities which characterize the pursuits of scientists. In field investigations, students pose a research question then plan and conduct an investigation to answer that question. Students use evidence to support explanations and build models, as well as to pose new questions about the environment. Students learn that the scientific method is not a simple linear process and, most importantly, experience the difficulty of answering essential questions such as:

What defines my environment?
What are all the parts and interrelationships in this ecosystem?
What is a healthy environment?

What is humans' relationship to the environment?
How has human behavior influenced our environment?
How can our community sustain our environment?
What is my role in the preservation and use of environmental resources?

Science Beyond the Laboratory or Classroom

Field investigations help students become informed citizen scientists who add knowledge to the community's understanding of an area in order to make issues of concern visible and share differing points of view about the preservation and use of community natural resources.

How are field investigations different from controlled laboratory experiments?

Classroom science often overemphasizes experimental investigation in which students actively manipulate variables and control conditions. In studying the natural world, it is difficult to actively manipulate variables and maintain "control" and "experimental" groups, so field investigation scientists look for descriptive, comparative, or correlative trends in naturally occurring events. Many field investigations begin with counts (gathering baseline data). Later, measurements are intentionally taken in different locations (e.g., urban and rural, or where some natural phenomenon has created different plot conditions), because scientists suspect they will find a difference. In contrast, in controlled experiments, scientists begin with a hypothesis about links between variables in a system. Variables of interest are identified, and a "fair test" is designed in which variables are actively manipulated, controlled, and measured in an effort to gather evidence to support or refute a causal relationship.

Are all field investigations the same?

No. For conceptual clarity, we have identified three types of field investigations—descriptive, comparative, and correlative.

Descriptive field investigations involve describing and/or quantifying parts of a natural system.	**Comparative field investigations,** involve collecting data on different populations/organisms, or under different conditions (e.g., times of year, locations), to make a comparison.	**Correlative field investigations** involve measuring or observing two variables and searching for a relationship.

Each type of field investigation is guided by different types of investigative questions. Descriptive studies can lead to comparative studies, which can lead to correlative studies. These three types of studies are often used in combination to study the natural world.

A Model for Field Investigation

Table 1 outlines the differences and similarities between the three types of field investigations and relates these to the essential features of inquiry. See Windschitl, M., Dvornich, K., Ryken, A. E., Tudor, M., & Koehler, G. (2007) *A comparative model of field investigations: Aligning school science inquiry with the practices of contemporary science,* School Science and Mathematics 1 (107), 367-390 for a complete description of the field investigation model.

<table>
<tr><th colspan="4">Three Types of Field Investigations</th></tr>
<tr><td>Essential Questions</td><td colspan="3">What defines my environment?
What is a healthy environment?
What is humans' relationship to the environment?
How can our community sustain our environment?
What is my role in the preservation and use of environmental resources?</td></tr>
<tr><th></th><th>Descriptive</th><th>Comparative</th><th>Correlative</th></tr>
<tr><td>Formulate Investigative Question</td><td>How many?
How frequently?
When happened?</td><td>Is there a difference between groups, conditions, times, or locations?
Make a prediction or hypothesis about differences.</td><td>Is there a relationship between two variables?
Make a hypothesis about the relationship.</td></tr>
<tr><td>Identify Setting within a System</td><td colspan="3">Identify geographic scale of investigation (e.g., riparian corridor or Cedar River Watershed)
Identify time frame of the investigation (e.g., season, hour, day, month, year)</td></tr>
<tr><td>Identify Variables of Interest</td><td>Choose measurable or observable variables</td><td>Choose a measured variable in at least two different (manipulated variable) locations, times, organisms, or populations</td><td>Choose two variables to be measured together and tested for a relationship</td></tr>
<tr><td rowspan="2">Collect and Organize Data</td><td colspan="3">Multiple measurements over time or location in order to improve system representation (model)
Individual measurement is repeated if necessary to improve data accuracy
Record and organize data into table(s) or other forms</td></tr>
<tr><td></td><td colspan="2">Describe how sampling, measurement, observations were consistent for the two or more locations, times or organisms (controlled variables) and was random and representative of the site.</td></tr>
</table>

<table>
<tr><th></th><th>Descriptive</th><th>Comparative</th><th>Correlative</th></tr>
<tr><td rowspan="2">Analyze Data</td><td colspan="3">Means, medians, ranges, percentages, estimations calculated when appropriate
Organize results in graphic and/or written forms and maps using statistics where appropriate</td></tr>
<tr><td colspan="2">Typical representations of the data to build descriptive and comparative models
• Charts
• Line Plots
• Bar Graphs
• Maps</td><td>Typical representations of the data to demonstrate correlations upon which models are developed
• Scatter plots
• r-values</td></tr>
<tr><td rowspan="2">Use Evidence to Support a Conclusion</td><td colspan="3">Answer the investigative question
Use data to support an explanation. What does the data mean?
Limit conclusion to the specific study site.
Compare data to standards.</td></tr>
<tr><td>Does the data summary answer the investigation question?</td><td colspan="2">Does the evidence support the prediction or hypothesis?</td></tr>
<tr><td>Discussion</td><td colspan="3">How does the data compare to other similar systems/models?
What factors might have impacted my research?
How do my findings inform the essential questions and/or understanding of the system?
What are my new questions? What other data do I need?
What action should be taken? Why?</td></tr>
</table>

Documenting the Field Investigation Process

Essential Question

Big picture questions that cannot be answered with one investigation.

Investigation Question

Researchable question that can be answered with qualitative or quantitative observations or measurements.

Hypothesis/Prediction

Predictions are not typically made for descriptive studies. For comparative studies, predict what will happen to the responding (measured) variable when one of the changes occurs. For correlative studies predict the relationship. Secondary students should also give a reason for their prediction.

Materials

List the materials needed to perform the investigation.

Procedure

- Logical steps to do the investigation; steps written clearly so someone else could follow procedure.
- What variables are under study? What is changed (manipulated)? What is measured (responding)?
- How, when, and/or where will observations/measurements be taken? How will samples or measurements be repeated?
- How is sampling/measurement method consistent (controlled variables) or systematic? Secondary students should describe how sampling is random and representative of the site.

Collecting, Organizing, and Analyzing Data

- Observe /Record Data—Data/observations/measurements are recorded systematically on a data collection sheet. Location, date, time of day and a description of study site (including weather) is recorded.
- Organize Results—Results are organized into categories in tables, charts, graphs, maps, and/or other written forms making appropriate calculations (e.g. total growth, distances, total number observed).
- Analyze Data to Look for Patterns and Trends—Populations are estimated; means, modes, medians, t-values and r-values are calculated; graphs, tables, or maps are analyzed for patterns; data are compared to standards.

Conclusion

- Provide a clear conclusive statement that answers the investigation question or states whether the hypothesis or prediction was correct. For descriptive investigations, provide a detailed description or model of results.
- Restrict conclusions to the time and place the investigation took place.
- Compare data to standards when appropriate.
- Use data to support the conclusion, description, or model.
- Use explanatory language to connect supporting data to the conclusion, description, or model.

Discussion

- Compare data to other similar systems models.
- Identify factors in the field that may have affected the outcomes of the investigation.
- Describe how the procedures might have been more systematic.
- Describe any other reasons/observations that could explain results.
- Discuss how results inform the essential question and/or system understanding.
- Provide new questions about the system or model.
- Recommend future actions and explain why.

Section 2
Preparing Students to Conduct Field Investigations

The three lessons presented in this section are designed to give you and your students structured experiences with field investigation. First, students learn about the kinds of questions that guide field investigations; then, students conduct a descriptive field investigation; and finally, students conduct a comparative field investigation of surface temperature at different locations on the school grounds. These experiences are designed to help students gain the skills necessary to conduct field investigations, such as posing an investigation question, collecting, organizing and analyzing data, and writing conclusions.

These experiences give students a framework and understanding of field investigations so they can later plan their own field investigations based on their own questions, as described in Section 3 and 4 of this guide.

Lessons in this section include:

What Questions Can I Investigate?

Descriptive Field Investigation: What Plants and Animals Use the Schoolyard Habitat?

Comparative Field Investigation: How Does Surface Temperature Vary With Location?

Section 2: Preparing Students to Conduct Field Investigations

Part 1: What Questions Can I Investigate?

Objectives

Students will:

1) distinguish between three different types of investigative questions, and

2) suggest questions that can be asked about the natural world.

Science Grade Level Expectation

Questioning: Understand how to ask a question about objects, organisms, and events in the environment.

Thinking Skills

Comparing/Contrasting, Classifying

Learning Experience

Students sort investigative questions into three categories (descriptive questions, comparative questions, and correlative questions).

Materials

- **Sets of Investigative Questions** (one set per three students). Copy questions onto card stock and cut into sentence strips; place in an envelope.
- **Handout.** Three types of field investigation questions.
- **Question on Board:** Given the categories descriptive, comparative, and correlative, how would you categorize the set of questions in your envelope?

Background

What defines my environment? What is a healthy environment? What is humans' relationship to the environment? How can our community sustain our environment? What is my role in the preservation and use of environmental resources? These essential questions about the relationships between humans and the environment cannot be answered with one field investigation.

Asking a testable question is central to scientific inquiry. The following lesson is geared to help students think about the ways questions are asked and the types of questions field investigators research. There are three types of field investigations—descriptive, comparative, and correlative.

Descriptive field investigations involve describing parts of a natural system. Scientists might try to answer descriptive questions such as, "Where do cougars go when their habitat gives way to a new housing development?" or "What areas do cougars select for den locations?"

In comparative field investigations, data is collected on different populations, or under different conditions (e.g., times of year, locations), to make a comparison. A researcher might ask a comparative question such as, "Is there a difference in lichen growth in areas of high pollution and areas of low pollution?"

Correlative field investigations involve measuring or observing two variables and searching for a pattern. These types of investigations are typically not explored until high school. Correlative questions focus on two variables to be measured together and tested for a relationship: “Do animal tracks increase with greater forest canopy cover?” “Does the salmon population go down when dissolved oxygen concentrations go down?”

There are many types of questions. In addition to the three types of investigative questions, students may ask **essential** questions, **why** questions and book/internet **research** questions.

Lesson

Focus

1. Review the essential questions. These big picture questions are why we conduct field investigations. What defines my environment? What is a healthy environment? What is humans' relationship to the environment? How can our community sustain our environment? What is my role in the preservation and use of environmental resources?
2. Distribute the handout and discuss the three types of field investigation questions. You might ask students questions to help them notice differences in the three types of questions.
   - What patterns do you notice in each type of question?
   - What words are important to look for when identifying each type of question?

Explore

3. Divide the class into teams of three. Hand each team an envelope set of investigative questions, and ask them to sort the questions into three categories—descriptive, comparative, and correlative.

Reflect

4. Give the teams time to think about each question and agree on the categories. You can facilitate this process by asking the questions below as you circulate the room.
   - Did you all agree to this category? Explain how you came to this decision.
   - Can each one of you come up with a justification as to why these questions fall into the categories they do?
   - Do you have an uncertainty pile…if so, why? What more do you need to know?
   - What questions do you have about your categories?
   - Can you write your own examples of each type of question?
5. After about 10 minutes, have the class share their categories by asking about a sample of the questions you handed out. With a chart at the front of the class, have students from various groups place a question in the category they selected and have them say why they chose that category.
6. Discuss why scientists need to think about the questions they pose before working in the field.

Assessment

As students categorize the questions ask them to justify how they classified each question, and ask them to identify the patterns they notice in each type of question (e.g., descriptive questions often begin with "how many," "when," or "where").

Some questions may fit more than one category; what is important is that students can justify their thinking for each category. For example, students may identify the question, "What is the air temperature at your school throughout the year?" as descriptive, because they would be documenting the temperature of a specific location. Other students may call it a comparative question, because they could use the collected temperature data to compare two different times of year.

Three Types of Field Investigation Questions

Descriptive Questions

Descriptive field investigations involve describing parts of a natural system. Descriptive questions focus on measurable or observable variables that can be represented spatially in maps or as written descriptions, estimations, averages, medians, or ranges.

- How many _____ are there in a given area?
- How frequently does _____ happen in a given period?
- What is the [temperature, speed, height, mass, density, force, distance, pH, dissolved oxygen, light density, depth, etc.] of ______?
- When does _____ happen during the year? (flowering, fruit, babies born)
- Where does_____ travel over time? (What is an animal's range?)

Comparative Questions

In comparative field investigations data is collected on different groups to make a comparison. Comparative questions focus on one measured variable in at least two different (manipulated variable) locations, times, organisms, or populations.

- Is there a difference in ______ between group (or condition) A and group B?
- Is there a difference in ______ between (or among) different locations?
- Is there a difference in ______ at different times?

Correlative Questions

Correlative field investigations involve measuring or observing two variables and searching for a pattern. Correlative questions focus on two variables to be measured and tested for a relationship.

- What is the relationship between variable #1 and variable #2?
- Does _____ go up when _____ goes down?
- How does _____ change as _____ changes?

Investigative Questions for Sorting

Copy these questions on to card stock and cut into sentence strips

Does more salal (type of plant) grow in riparian, forest, or field habitats?

Are more insects found in the schoolyard in September, October, or November?

Is wind speed greater near the building or out on the playground in March?

Where do you find the most pill bugs (isopods): under a log, under a pot, or under bushes?

Which habitat (in the forest, in a field, or by a stream) has the greatest percentage of sand in the soil?

Are soil temperatures the coolest at a depth of 5cm, 10cm, or 15cm?

In April, which twigs grow faster, those on maple trees or those on sweet gum trees?

Are traffic sounds louder in front of the school or behind the school?

How many Pileated Woodpeckers live in Schmitz Park?

How many deer live in Olympic National Park?

How many eggs does a salmon lay in the fall in Longfellow Creek?

How often do Swallowtail Butterflies lay eggs in a season in Eastern Washington?

What is the depth of McLane Creek at Delphi Road in September?

What is the air temperature at your school throughout the school year?

What kinds of plants grow in ___ Forest?

What types of birds use the school habitat during the school year?

When do robins in western Washington nest?

When do hemlock trees pollinate?

What is the range of black bears living in Snoqualmie Pass?

What is the number and range of cougars in the Cle Elum, Roslyn area?

Is there a difference in the size of the range of a screech owl or barred owl in Washington's lowland forests?

Are mature (greater than 30 cm diameter) conifer trees taller than mature deciduous trees in the Olympic Rain Forest?

Which location (under bushes, open grass, or on black top) has the highest temperature at 7:00 a.m. at Cedar River Middle School?

Are there more black bears per acre on Snoqualmie Pass or Olympic National Forest?

Are there more snowberry bushes near streams or away from streams in the Grasslands/Steppe in eastern Washington?

Are deer more active during the dawn or the dusk in____?

Do more ferns grow close to the water or away from the water?

Do tree species, tree density, tree diameter, or tree height differ between north and south facing slopes in ___?

Do temperatures differ between forested and non-forested streams in____?

Do birds sing more from 8:30-9:00 a.m. or from 3:00-3:30 p.m.?

How does Douglas-fir seed production time change as elevation changes in the North Cascade Mountains?

How does dissolved oxygen change as water temperature goes up in ___ stream?

How do mouse populations change as hawk populations increase in Puget Sound area?

How do heron populations change as eagle populations increase in the Puget Sound watershed?

As elevations increase, how does the number of Grand Fir trees per acre change in the South Cascades?

What is the relationship between number of days over 60 F in the spring and germination of _____ seeds (or time of flowering)?

What is the relationship between the amount of sunshine and red color in leaves in fall?

How does pH affect the number of salmon eggs hatching in a stream?

Section 2: Preparing Students to Conduct Field Investigations

Part 2: Descriptive Field Investigation
What Plants and Animals Use the Schoolyard Habitat?

Objectives

Students will:

1) observe an outdoor area,
2) represent their observations using pictures, numbers, words, labeled diagrams, and
3) pose descriptive and comparative questions based on their observations.

Science Grade Level Expectation

Characteristics of Living Matter: Observe and describe characteristics of living organisms.

Planning and Conducting Safe Investigations: Plan and conduct an observational investigation that collects information about characteristics or properties.

Thinking Skills

Observing, Finding Evidence

Learning Experience

Students will conduct a descriptive investigation by observing a particular outdoor area.

Materials

Per Class
Field Guides

Per Pair of Students
Hula Hoops
Yard or Meter sticks
Tape Measures
Colored Pencils
Paint Chips (to help name as many different forms of the "same" color, e.g., green)

Per Student
Clipboards
Ruler
Hand Lenses

Background

In descriptive field investigations researchers describe parts of a natural system. This lesson helps students learn how to conduct a descriptive field investigation of a specific site. Although it is not a long-term study focused on identification of organisms, students observe a large area and a small study area. Allowing students to make observations multiple times helps them notice detail and ask investigative questions based on their own observations of a habitat. By systematically collecting data over time at the same site, students can begin to see patterns.

Breaking a large area into parts can help students consider different aspects of a larger ecosystem. Students need multiple observation sessions outdoors in order to pose meaningful questions. Students could spend multiple sessions observing a large study area, first noting their overall observations, then focusing on looking up, looking down, and looking in the middle. Finally, students can select a much smaller study area for their focused observation.

Lesson

Focus

1. Write the investigative question on the board: "What plants and animals use the school yard habitat?" Discuss strategies for observing—using four of the five senses (sight, hearing, touch, smell) and recording observations (drawing, using numbers, labeled diagrams writing). Hold up an object (e.g., pinecone, leaf, twig, rock) and ask students to describe its physical properties and characteristics. To prompt student thinking you might model drawing and/or writing observations as you ask:
   - What does it look like? (e.g., size, shape, color)
   - What does it feel like? (e.g. texture, temperature)
   - What does it smell like?
   - What does it sound like?

Large Study Area

Explore

2. Divide the class into pairs before going outside. Students spend multiple lesson sessions journaling observations. Students can record measurements. They can use paint chips to name colors they observe in nature. Providing a wide range of green paint chips for example helps to expand students' color vocabulary beyond "green." Below are sentence starters that will help students generate questions about the system (Fulwiler, 2007).
   - I am curious about . . .
   - It surprised me that . . .
   - I wonder how this part effects another part of the system . . .
   - Questions I could investigate are . . .

   Day 1: Overall Observations. Students record general observations and questions.

   Day 2: Looking Up. Students look up (above eye level) and record observations and questions.

   Day 3: Looking Down. Students look down (to the ground) and record observations and questions.

   Day 4: Looking in the Middle. Students look at eye level and record observations and questions.

Reflect

3. After each observation session ask students to share their findings and questions.
4. Categorize the questions students pose (descriptive, comparative, correlative, essential, why, researchable).

Type of Question	Examples
Book/Internet Research	What is the name of this tree or shrub? How tall does this tree grow? Where does this tree grow?
Essential-Life Pondering, Always Wonder	How do trees alter climate?
Descriptive	What do twigs look like in winter? What plants live on this tree? What animals use this tree for their habitat? How does this tree produce seeds?
Comparative	Which type (species of tree) grows the fastest? Are deciduous or broadleaf evergreen leaves stronger?
Correlative	How is tree fall leaf color related to the number of sunny days in fall? How is hot weather related to disease in pine trees?
Why Questions	Why are there deciduous and evergreen trees?

Special Study Area

Explore

5. Divide the class into pairs and give each pair a hula hoop and yard stick.
6. Students select a study area and place the yard stick in the middle of the hula hoop to create a transect line and two observation quadrats. Model this set up in the classroom before going outside; show students how to record locations of plants and animals by noting the nearest inch on the yard stick (e.g. there are three acorns, one at 4 inches, one at 15 inches and one at 22 inches).
7. Students record observations using written words/phrases, drawings, labeled diagrams, and numbers to describe the area within the hula hoop, to contrast the two observation quadrats, or to note items along the transect line.
8. Students use field guides to identify plants and animals.

Reflect

9. Students discuss the relationship they have noticed between the large study area and smaller special study area. Ask students, what similarities and differences did you notice?
10. Students formulate two descriptive questions and two comparative questions about the larger study site based upon their observations.
11. Ask students to reflect on the investigative question by writing or discussing, "What plants and animals use the school yard habitat?"

Assessment

Review students' observations for a range of representational forms including numbers, words, labeled diagrams, and drawings. Descriptions might include size, shape, color texture, or smell. As you review student work you can look for

--drawings fill the notebook page

--small objects/organisms are enlarged

--drawings are detailed

--parts of an organism/object are labeled

--color is added as appropriate

--drawings have captions or titles and note the date and place recorded

In addition, in discussion with students as they observe, you can assess their insights and what they reflect about the quality of the observations.

5th grade students at Arlington Elementary School in Tacoma, Washington recorded counts of the animals in Oak Tree Park and then generated questions based on their observations:

What is the most occurring plant at Oak Tree Park?

What are the life styles of the birds at Oak Tree Park?

What is the lifecycle of each species?

What are the eatable plants?

What mammals (not birds) do we see at Oak Tree Park in the spring?

How big is Oak Tree Park?

How many different kinds of trees are there?

What the most common tree?

What part of the forest do most birds live in during the spring time?

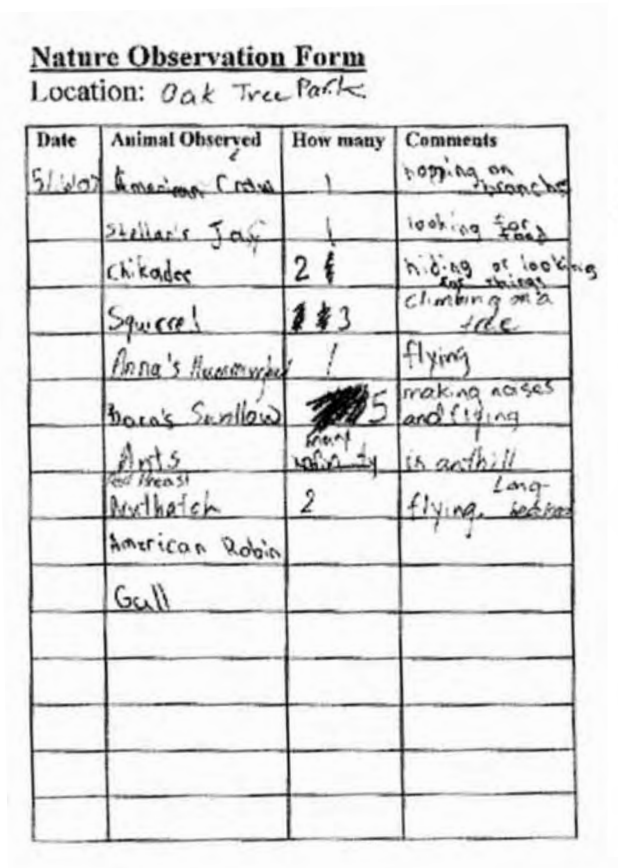
Why is Oak Tree Park a good habitat for plants and animals?

What kind of bird is not commonly seen in Oak Tree Park?

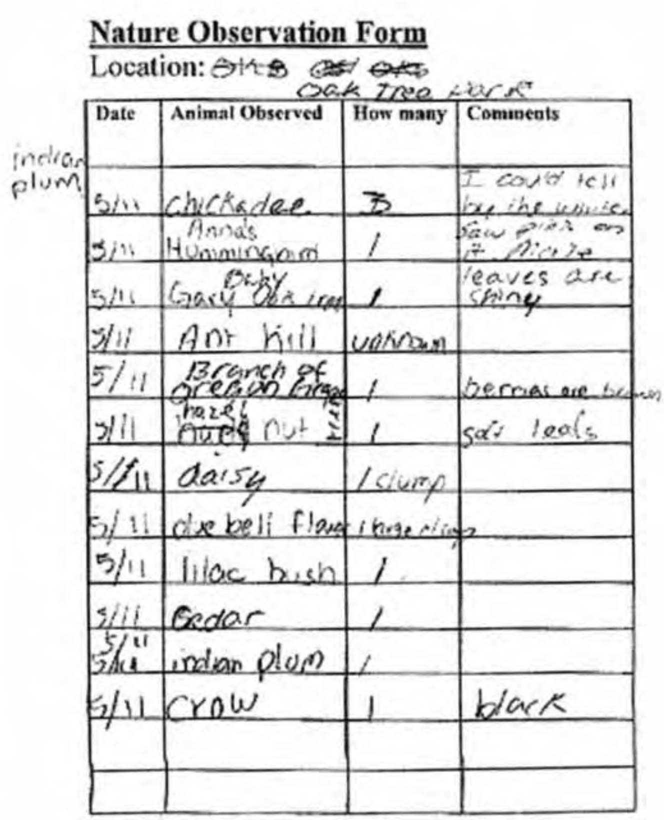
Is there water at the park during spring?

How many different animals live in the forest?

What is the most common plant you see at Oak Tree Park?
How many different types of birds are in Oak Tree Park?
How many different types of ants are there in Oak Tree Park?
What is the least common bird you see at Oak Tree Park?
How many total square miles is Oak Tree Park?
What kind of bird do we see in Oak Tree Park?
How many different species of plants are in Oa


Nature Observation Form
Location: Oak Tree Park

Date	Animal Observed	How many	Comments
5/ Wo	American Crow	1	hopping on branches
	Steller's Jay	1	looking for food
	Chikadee	2	hiding or looking for things
	Squirrel	3	climbing on a tree
	Anna's Hummingbird	1	flying
	Barn's Swallow	5	making noises and flying
	Ants	many infinity	in anthill
	Red Breast Nuthatch	2	flying. Long-beaked
	American Robin		
	Gall		


Nature Observation Form
Location: ~~Oak~~ ~~Oak~~ ~~Oak~~ Oak Tree Park

indian plum

Date	Animal Observed	How many	Comments
5/11	chickadee	3	I could tell by the white
5/11	Anna's Hummingbird	1	saw pink on it. Pink
5/11	Baby Gary Oak tree	1	leaves are shiny
5/11	Ant hill	unknown	
5/11	Branch of oregon grape	1	berries are brown
5/11	hazel nut	1	sat leafs
5/11	daisy	1 clump	
5/11	blue bell flower	1 huge clump	
5/11	lilac bush	1	
5/11	Cedar	1	
5/11	indian plum	1	
5/11	crow	1	black

Educator Insights

Below are insights shared by pre-service teachers who conducted the special study area investigation. The insights are accompanied by comments about their observations.

"We measured the circumference of this tree and discovered the circumference is equal to our height. We were really surprised; it looks so different in a circle."

Quantitative observations were used; numbers describe the physical characteristics of a tree and demonstrate understanding of comparative measurement by comparing human height to tree circumference.

"We've seen the effects of time in our space; things fly in and out of our space and the amount of shade in our space has decreased."

This observation demonstrated awareness that places are not static, but instead are constantly changing by citing two pieces of evidence ("things fly in and out" and amount of shade) to support a claim that time effects what is observed.

"What is this—pollen or a seed? What is this tree that is dropping berries on us?"

By posing questions, pre-service teachers demonstrated a desire to identify the objects they observed. By making detailed observations they could later conduct research to identify the object.

"Look at all the different green colors on this fern. We can't just call them all green."

This careful observation demonstrated attention to nuanced color differences, rather than just labeling an entire plant as green. They recognized a need for a larger color vocabulary to make accurate descriptions.

The next page shows how a pre-service teacher recorded descriptive and comparative questions in her lab book after observing a special study area.

Section 2: Preparing Students to Conduct Field Investigations

Part 3: Comparative Field Investigation
How Does Surface Temperature Vary With Location?

Objectives

Students will:

1) measure surface temperature,
2) write a detailed procedure,
3) analyze trends in the data, and
4) write a conclusion.

Science Grade Level Expectation

Planning and Conducting Safe Investigations: Understand how to plan and conduct scientific investigations.

Explaining: Constructing a scientific explanation using evidence.

Thinking Skills

Observing, Finding Evidence, Inferring

Learning Experience

Students will conduct a comparative field investigation by measuring the surface temperature at three different locations on the school campus.

Materials

Thermometers

Stopwatches

Background

Now that students have sorted investigative questions and conducted a descriptive field investigation of the school yard habitat, they are prepared to conduct a comparative field investigation by measuring one particular environmental parameter—temperature. See Fontaine, J. J., Stier, S. C., Maggio, M. L., and Decker, K. L. (2007). Schoolyard microclimate. The Science Teacher, 38-42, for additional background information about temperature.

In comparative field investigations, data is collected on different groups, or under different conditions, to make a comparison. In this investigation, students gather temperature data to answer the comparative question, "Which location—on the open grass, under the bushes, or on the black top—has the highest surface temperature?"

This investigation involves collecting and organizing multiple trials of temperature data in a data table, analyzing the data by calculating average temperatures, graphing the averages, and writing a conclusion about the average surface temperature at different locations. Having each group repeat multiple measurements at each location helps students understand the importance of multiple trials in scientific studies. A sample data sheet is provided. Students can record data in a science notebook, tape the sample data sheet into a notebook, or simply use the data sheet to record observations.
Conducting comparative field investigations involves identifying the manipulated, responding, and controlled variables.

Manipulated (Changed) Variable: The factor of a system being investigated that is deliberately changed to determine that factor's relationship to the responding variable (OSPI, 2005, p. 53)*. In this investigation, the location is the manipulated variable.

Responding Variable: The factor of a system being investigated that changes in response to the manipulated variable and is measured (OSPI, 2005, p. 54)*. In this investigation, the temperature is the responding variable. It is important that students actually record multiple measurements at one location so they experience repeating trials.

Controlled Variables: The conditions that are kept the same in a scientific investigation (OSPI, 2005, p. 52). In this investigation, the thermometers, laying the thermometer flat on the ground, wail time, and light exposure are all kept the same.

* OSPI Office of Superintendent of Public Instruction, Washington State. (2005) *Science K-10 grade level expectations: A new level in specificity.* Washington State's Essential Academic Learning Requirements. OSPI Document Number 04-0051.

Lesson 1: Planning and Conducting a Comparative Field Investigation

Focus

1. Review the investigation question, “Which location—on the open grass, under the bushes, or on the black top—has the highest surface temperature?”
2. Tell students that good investigation questions describe what we will manipulate (changed variable). Have students underline the manipulated variable in the question (location).
3. Good comparative questions also describe what to measure (responding variable). Have students double underline the responding variable in the question (temperature).
4. As students become more proficient at writing procedures they can write procedures before actually conducting an investigation. We have found it is helpful for students new to the procedure writing process to conduct a trial measurement before writing the procedure.
5. Take students outside. Students leave a thermometer flat on the ground for a determined number of minutes, shading the thermometer from direct sunlight, and record the temperature one time at one location (on the open grass, on the black top, and under the bush). Now that students have experienced the measurement process, they are ready to write a complete procedure.

    Teacher Tip: Marking locations with numbered flags or tape ahead of time helps groups quickly find a sampling site.

6. Students return to the classroom and write a prediction, along with their reasons, under the question in their notebooks.
7. Students write the materials needed for the investigation.
8. Ask students, “When we go outside and take the surface temperature, what do we all need to do the same each time (controlled variables)?” List controlled variables on the board and summarize procedure.
9. Review the importance of recording the date, time, and weather, and for describing the study site.
10. Review the importance of multiple trials and explain that every team will go to all three locations and take three trials at each location. High school students should select sampling sites that are representative of the site (see map for an example).
11. Have students create a data table below their predictions. A sample data sheet is included at the end of this lesson. Be sure the data table includes.
    - Clear title for the table
    - Locations (manipulated variable) to the left side
    - Temperature (responding variable) labeled across the top with appropriate units
    - Multiple trials labeled
    - A place for averages

Explore

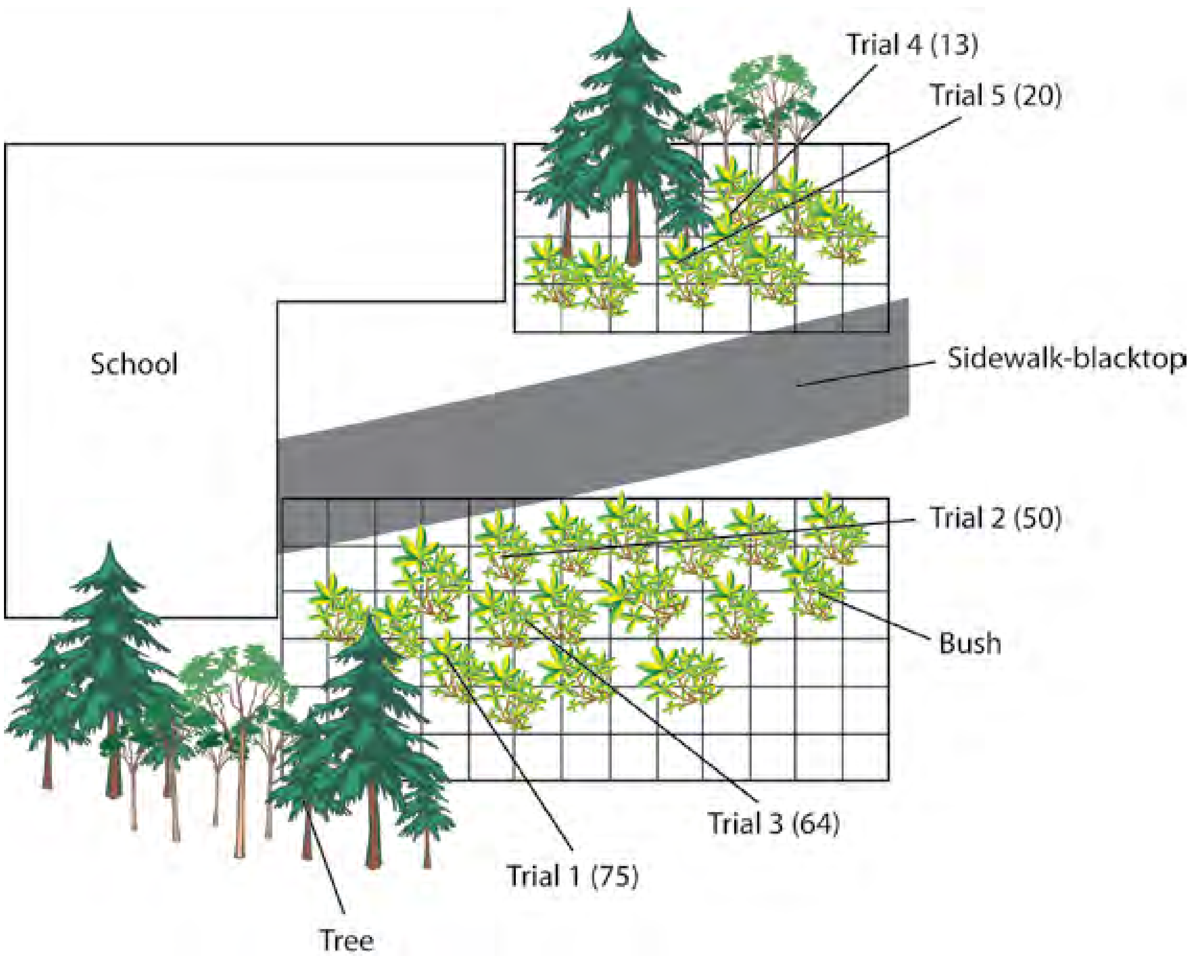
12. Secondary students choose random sample sites to take and record surface temperature (see map).
13. Students go outside to conduct the comparative investigation
    - Record date, time, and place where investigation takes place (study site).
    - Describe the weather and site of the investigation.
    - Leave thermometer flat on the ground the determined number of minutes, shading the thermometer from direct sunlight, and record the temperature four times at each of the three locations (on the open grass, on the black top, and under the bush).

Reflect

14. Students calculate the average surface temperature for each location.
15. Share and discuss similarities and differences in the data that each group collected.

Map of Random Site Selection

Elementary students can select any site on the schoolyard to take temperature measurements. Secondary students should use a selection procedure that ensures that sample sites are selected randomly.



One way to provide for random sampling is to obtain or create a map of the school grounds and then place an acetate grid over the map. Then, either using random numbers or every so many squares, take the surface temperature at those sample spots as the trials for the investigation. The example is given for taking the surface temperature under five bushes using ten random numbers. The first five sample spots that occur under bushes on the grid will be used as the five trials. The numbers generated were: 13, 20, 32, 34, 50, 64, 71, 75, 82, 97. Spots 13, 20, 50, 64, 75 were used because in those locations bushes are present.

Assessment

Review students' written procedures for the four important attributes of a procedure: 1) prediction, 2) materials, 3) variables identified, and 4) logical steps in which trials are repeated. See Appendix B for a weighted rubric.

Prediction/Hypothesis	Student states which location (manipulated variable)—under bushes, on the grass, or on the black top—will have the highest/lowest temperature (responding variable). Secondary students should also give a reason for their prediction.
Materials	Student lists all materials needed to conduct the investigation. For this investigation: · Thermometer · Stop Watches · Paper or other material to shade the thermometers
Controlled Variable (kept the same)	Student states at least one way that measuring variables and/or sampling are kept the same. · Temperature taken on top of ground each time · Wait the same # of minutes each time before reading temperature · Thermometer laid flat on the ground · Thermometer shaded from direct sun
Manipulated Variable (changed)	Student states what is changed. Secondary students should also state how the sites were chosen randomly at each location. For this investigation: · Location is implied or stated as the variable that is changed/ manipulated in the investigation
Responding Variable (measured)	Student states what is measured. For this investigation: · The temperature is implied or stated as the variable that is measured
Logical Steps with Trials Repeated	The steps of the procedure are detailed enough to repeat the procedure effectively. Student indicates that data will be recorded or creates a data table that includes date, time, and weather conditions. Student notes that data will be measured more than once at each location.

Sample Procedure

1. Record date, time, and area where investigation takes place (study site).

2. Describe weather (cloudy, sunny) and site of investigation.

3. Leave thermometer outside for five minutes to make sure first readings are accurate.

4. Place thermometer flat on the ground in first location (black top), shade from direct sunlight and wait two minutes.

5. Record the temperature in °C without picking up the thermometer (temperature can be recorded in Celsius or Fahrenheit depending on your thermometers).

6. Repeat the temperature measurement in this location two* more times.

7. Move to the second location (on the open grass) and take three* temperature measurements and record.

8. Move to the third location (under the bush) and take three* temperature measurements and record.

Key

Underlined	Manipulated (changed) Variable
Double underlined	Responding (measured) Variable
Circled	Controlled (kept the same) Variables
*	Multiple trials

Sample Data Sheet
How Does Surface Temperature Vary With Location?

Comparative Question: Which location—on the open grass, under the bushes, or on the back top—has the highest surface (on top of the ground) temperature °C?

Prediction/Hypothesis: ____

____

Date: ____________________ Time: ____________________

Study site (location): ____

Study site Description: ____

____

____

Weather: ____

Location vs. Surface Temperature °C

Location	Surface Temperature °C			
	Trial 1	Trial 2	Trial 3	Average Temperature
Open Grass				
Under Bushes				
Black Top				

Lesson 2: Analyzing Data and Writing a Conclusion

Focus

1. Review the procedure

Explore

2. Students complete data analysis by calculating averages for each location
3. Students display data in graphic form
4. Students write a conclusion

Reflect

6. Students write or participate in a discussion that considers the following questions:
   - How could the procedures be improved?
   - What other factors may have influenced the data?
   - Is any data inconsistent? Explain why.
   - What are the pros and cons of the different graphs?
   - How might this information be important?
   - How does this information add to my understanding of the school yard ecosystem?
   - How might this information inform actions or decisions?
   - What are my new questions?

Assessment

Review students' charts and graphs to see if they include: 1) accurate averages, 2) an appropriate graph for the data, 3) title, 4) correct units. In addition, students should reflect on the pros and cons of different graphical displays.

Review students' written conclusions for the five important elements of a conclusion: 1) limits conclusion to study place, date and time, 2) includes a conclusive statement, 3) gives lowest supporting data, 4) gives highest supporting data, 5) uses explanatory language. See the example conclusion that follows. Sample data is given below.

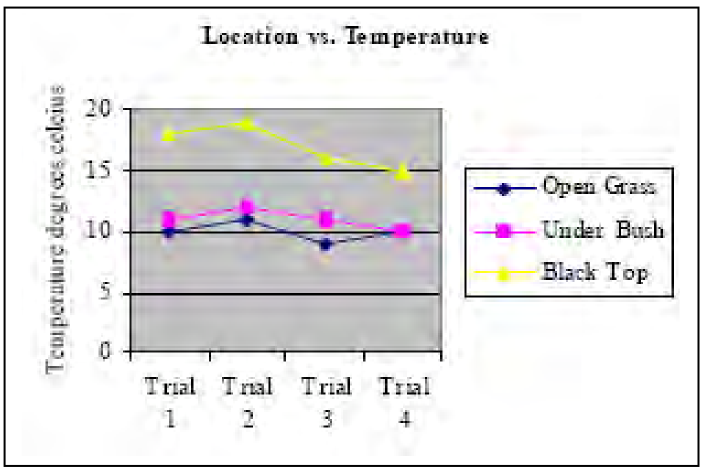
Sample Data:

March 18, 2005, 2:30 pm
Dearborn Park Elementary, Seattle, Washington
Sunny afternoon

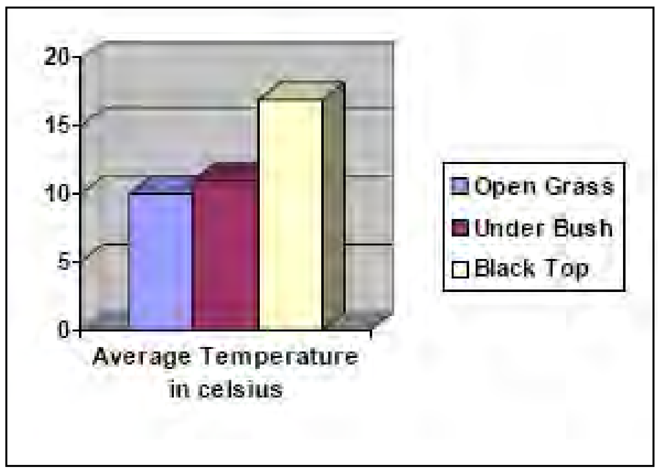
Location vs. Surface Temperature °C					
Location	**Surface Temperature °C**				
	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Average**
On the open Grass	10	11	9	10	10
Under Bushes	11	12	11	10	11
On the Black Top	18	19	16	15	17

Data Analysis

Students can analyze temperature data by calculating the average surface temperature in each location and then graphing the data. Graphs help students see the comparisons of average surface temperatures visually. Seeing data displayed in more than one way and discussing the pros and cons of each, helps students understand that scientists make choices about how to best present collected data.



This graph displays all the data points and provides an opportunity to consider how averages are calculated from a set of points.



This graph displays only a summary of the average surface temperatures.

A numberline helps student see median and mode when comparing only two locations

Grass			X									
		X	X	X								
Blacktop	8	9	10	11	12	13	14	15	16	17	18	19
								X	X		X	X

Sample Conclusion

Which location—on the open grass, under the bushes, or on the black top—has the highest surface temperature?

At Dearborn Park Elementary on March 18, 2005 at 2:30 pm on the black top had the highest average surface temperature, 17°C. Under the bushes had the lowest average surface temperature of 10°C. Our prediction that the black top would have the highest temperature was correct. The black top had the highest average surface temperature of any of the three locations.

Important Attributes of a Conclusion

See Appendix B for a weighted rubric.

Limits conclusion to place, date, and time of study

Gives location, date, and time where field study took place.

Dearborn Park Elementary, March 18, 2005 at 2:30 pm

A Conclusive Statement

Clearly describes which location has the highest temperature or describes that there was no differences among the temperatures.

the black top had the highest average surface temperature

Lowest Supporting Data

Gives location and temperature for location with the lowest degrees °C. (Not applicable if the average temperatures are the same).

Under the bushes had the lowest average surface temperature of 10 °C

Highest Supporting Data

Gives location and temperature for location with the highest degrees °C. (Not applicable of the average temperatures are the same).

On the black top had the highest average surface temperature of 17 °C

Explanatory Language

An explanation of how the given data supports the conclusion is stated or implied-comparative explanation using words like highest, lowest.

black top had the highest average surface temperature of 17 °C

Temperature Investigation
Scoring Your Conclusion

Attributes of a conclusion to a field investigation	Value Points
Limits conclusion to place, date, and time of study Gives location, date, and time where field study took place	1
A conclusive statement clearly describes which location has the highest temperature OR describes that there are no differences in temperatures at the three locations.	1
Lowest supporting data Gives location and temperature for location with the lowest degrees °C OR gives °C if all average temperatures are the same (5th grade students may use range or trial data to support; 8th and 10th must use average data)	1
Highest supporting data: Gives location and temperature for location with the highest degrees °C if temperatures are different (5th grade students may use range or trial data to support; 8th and 10th must use average data)	1
Explanatory Language is used to connect or compare the supporting data to a correct conclusion. An explanation of how the given data supports the conclusion is stated or implied-comparative explanation using words like highest, lowest would get this point.	1
Total	5

Sample Conclusion Sheet

How Does Surface Temperature Vary with Location?

Which location on the black top, on the grass, or under a bush has the highest temperature on the school campus?

- Give data to support your answer
- Explain how the data supports your answer

Discussion:

- What factors might have impacted my research?
- What are my new questions?

3rd grade students at Loyal Heights Elementary in Seattle, WA investigated the soil temperature on the north side and south side of the school yard. They recorded temperature data and wrote conclusions about which side of the school yard would be the best place to plant. Note that although both students conclude that the south side of the school yard is the best for planting because the soil temperatures are warmer, only one of the students includes the actual data points.

Soil Temperature Investigation

Soil Temperature Investigation Procedure:

1. Go to the first location north Side in the schoolyard and write the name in the first box under the heading: location.
2. Record the date, your school name, and study site description.
3. Describe the weather.
4. Insert the soil thermometer into the soil to the 5cm mark.
5. Wait 1 minute.
6. When the teacher says OK, take the temperature and record in the Trial 1 box.
7. Take the temperature of the soil at 2 more sample sites in the first location as instructed by your teacher, and record as Trials 2 and 3.
8. Go to the second location ______________ and write the name in the 2nd box under the heading: location, and follow steps 4 through 7.

Date 5/1/07

School Loyal Hight Elem

Study site description Some shade Some Sun a tree SS no tree

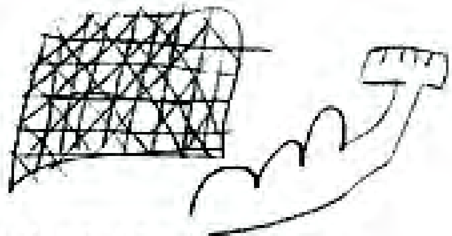
Weather Sunny partly cloudy, low 50s

Location vs. Soil temperature °F at 5 cm				
	Soil Temperature °F at 5 cm			
Location	Trial 1 °F	Trial 2 °F	Trial 3 °F	Middle Number °F
N.S.	52	69	62	62
S.S.	69	73	73	73

9

5/2/07

I think the south side would be the Best Place Because the Soil is warmor. And more people atend to the soil. Also the middle number was 69,73,73 on the South side. The middle number was 52,62,62,. Look at the numbers the South side is warmar.



Soil Temperature Investigation

Soil Temperature Investigation Procedure:

1. Go to the first location North side in the schoolyard and write the name in the first box under the heading: location.
2. Record the date, your school name, and study site description.
3. Describe the weather.
4. Insert the soil thermometer into the soil to the 5cm mark.
5. Wait 1 minute.
6. When the teacher says OK, take the temperature and record in the Trial 1 box.
7. Take the temperature of the soil at 2 more sample sites in the first location as instructed by your teacher, and record as Trials 2 and 3.
8. Go to the second location South side and write the name in the 2nd box under the heading: location, and follow steps 4 through 7.

Date 5-1-07

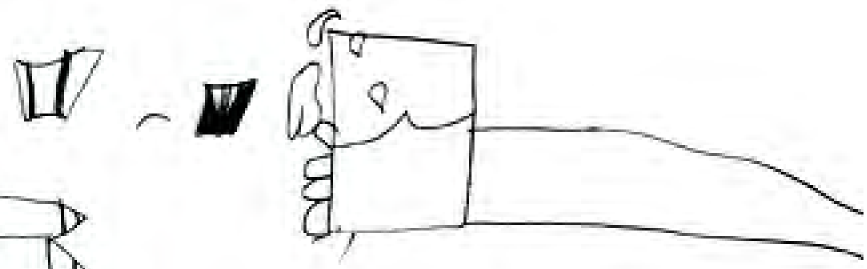
School loyal Heights

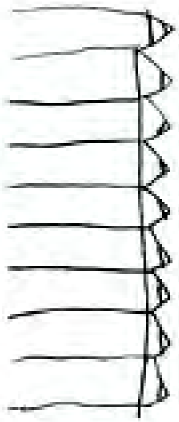
Study site description [illegible]

Weather Sun Clod low 50s

55 - no nce

Location vs. Soil temperature °F at 5 cm				
	Soil Temperature °F at 5 cm			
Location	Trial 1 °F	Trial 2 °F	Trial 3 °F	Middle Number °F
North	66°F	67°F	66°F	66°F
South	73°F	71°F	70°F	71°F





I think you should Plant
seeds in th south side of
the school. you
could plant them earlyer
than in the north side
because the south side
has less shade and
more people churn it up
so it is more used to
diffren't climate's in diffrent
seson's

Below are three conclusions written by high school students who conducted the surface temperature field investigation. In the first two, the students give both the highest and lowest temperature and make a conclusive statement. In addition, each student tries to explain what environmental factor might be causing the temperature differences—surface color and absorption of sunlight. The third student makes a conclusive statement, but does not support that conclusion by giving the highest and lowest temperature; instead, she states the difference in temperature between the environments. It is interesting to note that because the question asked "how," students go beyond giving data to try to explain the temperature differences. We have found "how" questions to be problematic; asking what is the effect? focuses students on the data they collected rather than tying to explain the phenomenon.

Question: How do different locations (on the open grass, under trees, or on the black top) affect the surface temperature of the ground on the school campus? when the thermometer was placed on the open grass, the temp. did not get that high and ended up being the lowest temp. on the grid. Because it was placed on the open grass the sunlight did not heat up the thermometer due to the sunlight soaking into the field. The first trial for "on the open grass" was 10°C, the second got hotter & was 10.6°C, the third at 9.9°C and the last even cooler with an 8.9°C, leaving it with an average of 9.7°C. Under the trees was an average of 10.7°C and on the black to extremely hot at an average of 17°C. The black top made it even hotter because the number one color that soaks up the most sun is black. The different locations get/soak up different amounts of sun making the thermometer hot.

Question: How do different locations (on the open grass, under trees, or on the black top) affect the surface temperature of the ground on the school campus? The hypothesis is, Under trees will have the lowest temperature because it's shaded all day. The hypothesis was wrong because the average temperature for under the trees was 10.7°C, when the temperature for in the grass was 9.7°C. Both lower than the 17.0°C the black top's temperature. I'm confident the different locations affected the surface temperature of the ground because some areas attrack more sun than others. The data supports my conclusion because the color black seems to attrack more sun light than an open field. Which is why the black top had the highest temperature. The reason the trees had a higher temperature than the field is because the trees are able to collect more sunlight for photosynthesis than grass.

Question: How do different locations (on the open grass, under trees, or on the black top) affect the surface temperature of the ground on the school campus? The temperature was the highest on the black top because there is nowhere for the heat to go but sit on the top. The grass and under the tree was about the same they had a difference of one 1°C when the black top was atleast 6°C hotter. The shade from the trees did not help at all because it was 1°C hotter than the open grass

Section 3: Building Field Investigations from Student Questions

The four lessons presented in this section show how to create a field investigation from student generated questions. Students begin with a descriptive investigation of schoolyard trees and shrubs, and then conduct a comparative field investigation of twig growth. First, students go outside and journal about whatever they find interesting in the schoolyard or park. Second, students observe, draw, and label the parts of a deciduous tree/shrub to answer a descriptive question about that tree. Third, students' observe, draw and label twigs in winter to answer a descriptive question about twigs. Finally, students plan and conduct a comparative investigation about twigs.

Lessons in this section include:

Descriptive Field Investigation: Schoolyard Habitat

What Plants and Animals Use the Schoolyard Habitat?

Descriptive Field Investigation: Trees/Shrubs

What Does This Tree/Shrub Look Like?

What are the Physical Properties/Characteristics of this Tree/Shrub?

Descriptive Field Investigation: Twigs

What do Twigs Look Like Each Month?

What are the Physical Properties/Characteristics of Twigs on this Tree in Winter?

Comparative Field Investigation: Twigs

Is There More Twig Growth on the North or South Side of the Tree/Shrub?

Do Buds on ______________Type of Tree/Shrub or ___________Type Tree/Shrub Burst Earliest in Spring?

Objectives

Students will:

1) observe their local environment,
2) draw and label the parts of a tree,
3) draw and label the parts of a twig, and
4) plan and conduct a comparative investigation on twigs.

Science Grade Level Expectation

Analyze how the parts of a system go together and how these parts depend on each other.

Describe the life function of a part of a living system.

Planning and Conducting Safe Investigations: Understand how to plan and conduct scientific investigations.

Constructing a scientific explanation using evidence.

Thinking Skills

Observing, Classifying, Inferring, Finding Evidence

Learning Experience

Students will observe, diagram and label a tree and then a twig, ask questions about deciduous twigs, and plan and conduct a comparative investigation about twigs.

Materials

Journals
Rulers
Compass
String

Background

The more time students have in the natural environment to observe, the greater their ability to ask questions. Outdoor journaling or year long observations are helpful in increasing the effectiveness of these lessons: Good questioning comes from good observation. For students to become inquirers and ask questions about the world around them, they must have multiple opportunities to observe their environment and learn to trust their own observations. Building investigations from students' questions typically involves observing a large system and then gradually narrowing the student's focus to one part of their environment by asking a researchable investigation question.

Each year we observe deciduous trees as their leaves turn color in autumn and fall to the ground, and new leaves burst forth again in the spring. During the growing season of spring and summer, twigs grow on trees from their tips and produce buds that have the beginnings of new leaves, stems, and sometimes flowers tightly contained in a water proof casing. By observing deciduous trees in winter, last year's growth can be measured from the twig tip to the last ring on the twig called a bud scale scar.

Section 3: Building Field Investigations from Student Questions

Part 1: Descriptive Field Investigation
What Plants and Animals Use the Schoolyard Habitat?

Lesson

Focus

1. Review the thinking skill of observation. Also review the use of descriptive words: Every sentence needs adjectives and adverbs. Hold up an object (e.g., leaf, pinecone, twig) and ask student to make observations. Record observations as students share.

Explore

2. Students go outside and journal about whatever they find interesting in the schoolyard or park. Below are some sentence starters for observations. (For helpful observation prompts, see Fulwiler, 2007.)
   - I see…
   - I hear…
   - I smell…
   - I touch…
   - This environment makes me feel…
   - It reminds me of…because…

Reflect

3. Students write down any questions that come to mind.
   - As I sit here I wonder…
   - I was surprised that…
   - I wonder what would happen if…

Assessment

4. Review student observations. Do they include:
   - Sentences or sentence fragments rather than just lists of words?
   - Multiple adjectives and adverbs to describe color, shape, size, texture, smell, edges, and arrangement?
   - Questions and wonderings that are linked to recorded observations?
   - Labeled drawings that are clear and large enough to show detail?

Section 3: Building Field Investigations from Student Questions

Part 2: Descriptive Field Investigation: Trees/Shrubs
What Does This Tree/Shrub Look Like?
What are the Physical Properties/Characteristics of this Tree/Shrub?

Lesson

Focus

1. Students write what they already know about trees/shrubs and draw and label a tree/shrub from memory (See Project Learning Tree Lesson 61, The Closer You Look).

Explore

2. Ask the question: What are the parts of the ___________ tree? Or, What are the physical properties/characteristics of the ______________tree? (See *Project Learning Tree Lesson 21, Adopt a Tree*)
3. Students record the date, time, place, air temperature, and weather.
4. Students go outside and draw and label the parts of a deciduous tree in late winter. Measuring the tree and its parts helps students make drawings to scale.
5. Students write down questions they have about the tree

Examples of Descriptive Questions about Trees and Shrubs

- When does this tree lose its leaves?
- How long does it take for the tree to lose all of its leaves?
- When do the leaves turn color in the fall?
- What color do the leaves turn in the fall?
- Do all the leaves turn the same color?
- Is each leaf a single color in the fall?
- What colored pigments are in leaves?
- How old is this tree?
- What plants live on this tree?
- What are the physical characteristics of this tree? (e.g., height, crown spread, shape of tree, shape of leaves, size of leaves)
- What animals use this tree for their habitat?
- What do twigs look like after the leaves have fallen off?
- What do twigs look like each month?
- When do twig buds burst?
- Which buds become flowers and which buds become leaves?

Reflect

6. Students reflect (in writing or in discussion) on the parts of the tree by comparing their memory-tree to the actual tree.

7. Students reflect (in writing or in discussion) on the function of the parts of a tree and how they are interconnected.

8. Students share and categorize questions by type (e.g. descriptive, comparative, correlative, essential, why, researchable) see p. 16.

Assessment

When assessing tree drawings and journal descriptions, look for:

- Words describing details of color, shape, size, branch angle, texture, smell
- Sentences or sentence fragments instead of lists of words
- Detailed drawings that fill the notebook page
- Labels indicating the parts of the tree (branches, twigs, roots, trunk…)
- Appropriate use of color
- Captions or titles that identify drawings and note the date and place recorded

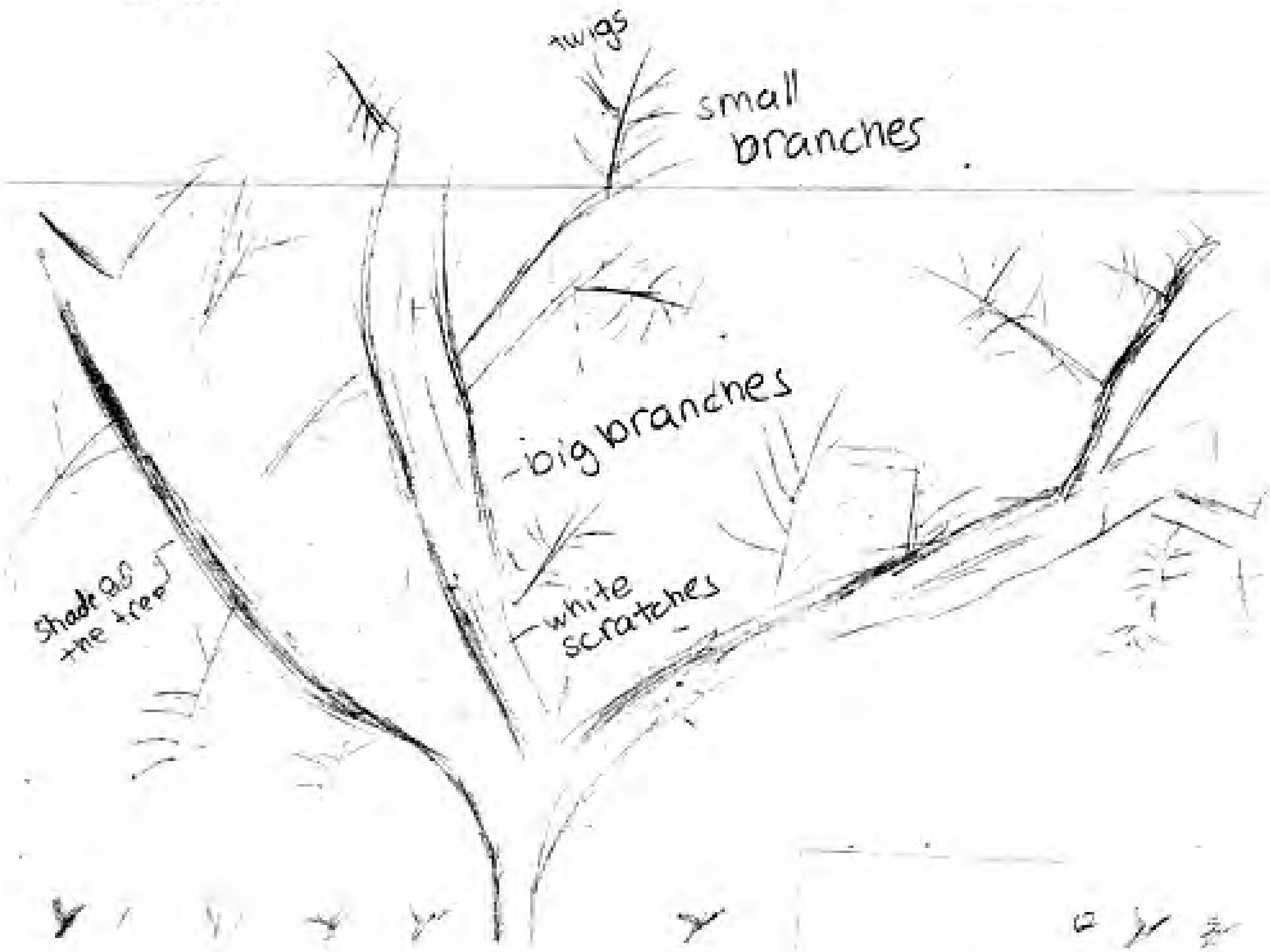
4th grade students at Sunny Hills Elementary in Issaquah, Washington drew trees and recorded their observations. The first student uses detailed observational evidence to support her answers to the questions (e.g., "The tree doesn't have leaves yet, but I can see there's little indents where they are going to be."). The second student uses technical vocabulary (e.g. bud, algae, scar, tentacles) and has realistic detail in her drawing.

Trees as Habitats

Examine a tree-Draw and Label the parts of the tree

1. • **What do you find on the tree's trunk?**
2. • **What do you see in the tree's branches?**
3. • **What do you see on the tree's leaves?**
4. • **What evidence do you see or hear that indicates animals use the tree?**
5. • **What evidence do you see that other plants are using the tree as a habitat?**
6. • **How might the tree be affected by the plants and animals that live on it?**
7. • **Do any of the plants and animals you observed seem to benefit the tree? In what ways?**

Draw and label one observation that indicates other plants and/or animals use the tree



1. knots on the tree, sharp flat cuts where a branch was cut off, different colors - brown with white marks

2. I see lots of and lots little branches on one big branch 3 big branches and one branch on each of them and then lots of small branches on those, the smallest branches have little round indents on them

3. The tree doesn't have leaves yet, but I can see ~~there's~~ little indents where they are going to be.

4. I see little white scratches all over the tree that a bird might of picked at it.

5. No ~~plants~~ are using the tree but there's a lot of little plants on the ground surrounding it.

6. The tree's bark may be affected by maybe a bird that is scraping off the bark.

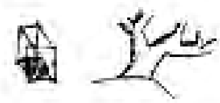
7. The plants at the bottom of the tree may give it more food or water

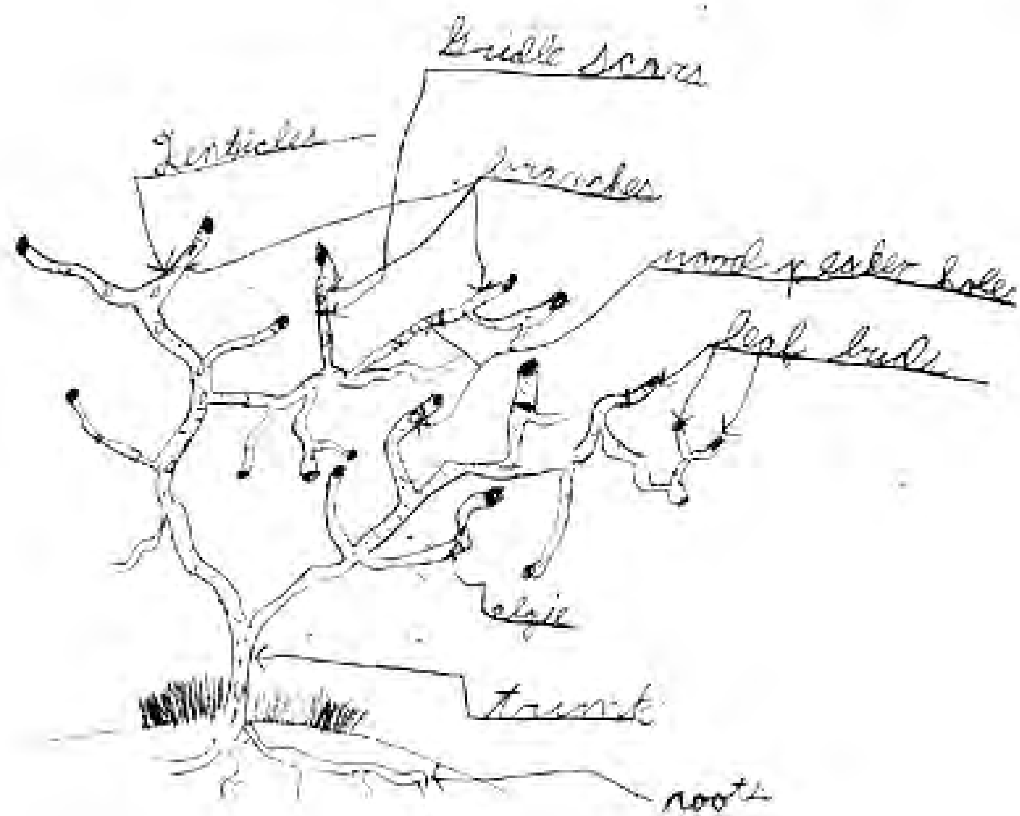
Trees as Habitats

Examine a tree-Draw and Label the parts of the tree

- What do you find on the tree's trunk?
- What do you see in the tree's branches?
- What do you see on the tree's leaves?
- What evidence do you see or hear that indicates animals use the tree?
- What evidence do you see that other plants are using the tree as a habitat?
- How might the tree be affected by the plants and animals that live on it?
- Do any of the plants and animals you observed seem to benefit the tree? In what ways?

Draw and label one observation that indicates other plants and/or animals use the tree





Q1. On the tree's trunk I found twigs, moss, and cut off twigs

Q2. On the tree's branches I found moss, leaf buds, and wood pecker holes,

Q3. The tree does not have leaves yet but it has leaf buds.

Q4. I can see that animals use the tree because their are woodpecker hols and scratches.

Q5. I can tell that plants live on the tree because the tree has moss, and algie on it.

Q6. The tree may be effected by the algie.

Q7. The plants and animals may benifit the tree by giving the tree food, shelter, and water.

Section 3: Building Field Investigations from Student Questions

Part 3: Descriptive Field Investigation: Twigs

What do Twigs Look Like Each Month?

What are the Physical Properties/Characteristics of Twigs on This Tree in Winter?

Lesson

Focus

1. From questions generated by students (see examples in Part 2), choose one question that has to do with twigs on the tree. Discuss what happens in spring in terms of weather and sunlight. Ask, "Where do new leaves come from?" (See Project Learning Tree Lesson 65, Bursting Buds)

Explore

2. Ask the descriptive investigation question:

   What do twigs on ___________tree look like in winter? OR, What are the physical properties/ characteristics of twigs on __________tree in winter?
3. Students record date, time, place, air temperature, and weather.
4. Students observe, draw, and label a twig from the tree. They label the twig-tree system.
5. Students look up a labeled twig diagram in a book and label more parts of their twig diagram (see example below).
6. Measuring from the twig tip to the first bud scale scar, students record last year's growth.
7. Students write questions they have about the winter twigs on trees using the following observation prompts.
   - I wonder…about tree growth or twig growth
   - I have questions about…
   - I wonder what would happen if. . . .
   - A comparative question I could investigate is…

Reflect

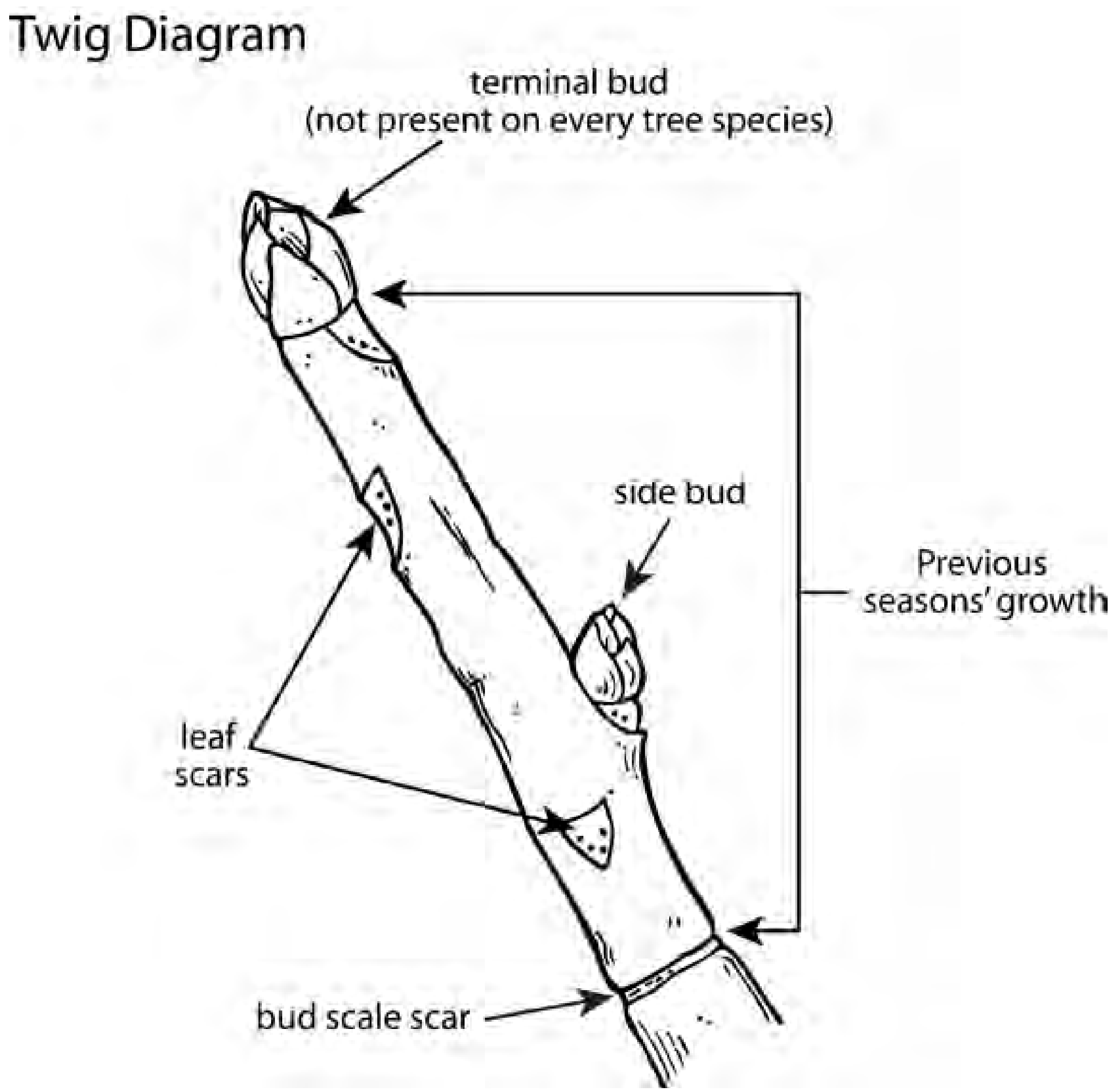
8 Students share and categorize questions by type.
   - Book/internet Research
   - Essential-Life Pondering, Always Wonder
   - Descriptive
   - Comparative
   - Correlative
   - Why questions?

9. Discuss bud development by asking some of the following questions:
   - When do buds form on trees?
   - What do buds become on trees and shrubs?
   - What did the leaf scars originally connect to?
   - What were the dots in the leaf scars connected to?

Assessment

When assessing the journal descriptions and drawings, look for:

- Words describing details of color, shape of twig and bud, size, leaf scars, bud placement, bud scale scars, texture
- Sentences or sentence fragments instead of lists of words
- Detailed drawings that fill the notebook page (details include shape of twig and buds, leaf scars, bud placement, and bud scale scars)
- Labels indicating the parts of the twig (leaf scar, bud, bud scale scars)
- Appropriate use of color
- Captions or titles that identify drawings and note the date and place recorded



Section 3: Building Field Investigations from Student Questions

Part 4: Comparative Field Investigation:

Is There More Twig Growth on the North or South Side of the Twig/Shrub?

Focus

1. Have students look at the comparative questions the class has come up with. Have students decide which questions they have the materials and access to conduct. For example, comparing upper twigs on a tall tree with lower twigs may not be feasible due to lack of a ladder.

Comparative Questions

- Which type of tree will have the largest leaves?
- Which type of tree has the largest buds in March?
- Which type of tree has the most twig growth?
- Are buds larger on the south or north side of the tree?
- Are leaves larger on the south or north side of the tree?
- Is last year's twig growth greater in maple trees on the north or south side of the building?
- Did taller maple trees (over a certain height) or shorter maple trees have more twig growth last year?
- Which year (last year or 2 years ago) had the greatest twig growth on the tree?
- **Was there more twig growth on the north or south side of __________tree/shrub last year?**
- **Do buds on ____________type of tree/shrub or _______________ type of tree/shrub burst earliest in spring?**

Explore

2. Students choose a comparative question to investigate.
3. Students gather the materials needed for the investigation.
4. Students write a procedure of the investigation and create a data sheet including a data table. For the two questions above in bold we have created example data sheets.
5. Students conduct the investigation.
6. Students analyze data and create charts and graphs.

Reflect

7. Students write a conclusion for their data.
8. Student participate in or write a discussion about their data.

Example Investigation Plan and Data Sheet

Comparative Investigation Question:

Is there more twig growth on the north or south side of our____________tree/shrub?

Prediction: ____

Materials: Compass, ruler, string, scissors or marker

Procedure:

1. Record date, time, and location of tree/shrub.
2. Describe study site.
3. Determine the north and south sides of the tree/shrub.
4. Choose four twigs (each twig is a new trial) at random on the north side of the tree/shrub.
5. Measure the last season's growth with the string on each of the 4 twigs and either cut or mark the string. (Growth is measured from the tip to the bud scale scar.)
6. Measure the string with a ruler to determine centimeters of growth and record as trials 1 through 4.
7. Repeat steps 3-6 for the south side of the tree/shrub.

Side of Tree/Shrub vs. Twig Growth

Side of Tree/Shrub	Twig Growth (cm)				
	Trial 1 (Twig 1)	Trial 2 (Twig 2)	Trial 3 (Twig 3)	Trial 4 (Twig 4)	Average Growth
North Side					
South Side					

Sample Data:

Issaquah Valley Elementary, Issaquah, Washington
March 29, 2007, 2:00 p.m.
Cool, sunny day

Side of Spindle Bush vs. Twig Growth

Side of Tree/Shrub	Twig Growth (cm)				
	Twig 1	Twig 2	Twig 3	Twig 4	Average Growth
North Side	30	32	28	30	30
South Side	21	24	23	20	22

Example Investigation Plan and Data Sheet

Comparative Investigation Question: Do buds on _____________type of tree/shrub or __________ type tree/shrub burst earliest in spring?

Prediction:____

Materials: Calendar

Procedure:

1. Start recording observations in late winter.
2. Record the date, time, place, and types of the trees/shrubs.
3. Observe the number of buds that have burst on type 1 tree/shrub and record under the correct date.
4. Observe the number of buds that have burst on type 2 tree/shrub under the correct date.
5. Repeat with one other tree/shrub of each type at the same time and record the number of buds burst on trial 2 and 3 charts.
6. Repeat steps 2 through 4 daily until the buds have burst on both types of trees/shrubs.

Date____________________ Time___________________ Place_______________

Description of Study Site:

Location of Study Site:

Data Sheet

Type of Tree/Shrub vs. Number of Buds' Bursting				
Type of Tree/Shrub				
Date				
Number of Buds on Plant 1				
Number of Buds on Plant 2				
Type of Tree/Shrub				
Date				
Number of Buds on Plant 1				
Number of Buds On Plant 2				

Section 4

Using Data Collected Over Time to Identify Patterns and Relationships

Water Quality and Macroinvertebrate Study
http://www.bgsd.k12.wa.us/hml/macros
http://nwnature.net/macros

Contributed by Peter Ritson, Ph.D., Science Programs, Washington State University and Michael Clapp, CAM Junior High

Students at CAM Junior High in Battle Ground, Washington, have participated in the Watershed Monitoring Network in Clark County since the fall of 2001. Their field investigations involve collecting physical, chemical, and biological data for the East Fork of the Lewis River at Lewisville Park. Of particular interest to the students and their teacher has been the study of benthic macroinvertebrates found in the stream. Benthic macroinvertebrates are organisms without backbones that inhabit the substrate at the bottom of the stream. Typically, these include the larval forms of many insects that mature and take flight, such as dragonflies, mayflies, and stoneflies. There are other aquatic macroinvertebrates, as well, that spend their entire lives underwater, such as different types of worms, snails and mussels. For classrooms in Washington State, physical conditions and chemical properties data can be stored and shared by posting the results to the state-wide NatureMapping – Water Module online database (http://www.fish.washington.edu/naturemapping/water/index.html).

This section describes one teacher's efforts to integrate an understanding of ecological principles through the combined assessment of a stream's physical characteristics, chemical conditions, and aquatic macroinvertebrate populations. While strongly influenced and supported by the testing protocols established by the Watershed Monitoring Network in Clark County, Washington, the teacher also incorporates a unique blend of background materials, testing protocols, and classroom activities to prepare and facilitate the class (corporate) and student (individual/small group) investigations. In addition, a number of original resources have been developed to assist the students in the collection of data, the identification of aquatic organisms, and the analysis of student-generated data.

Students collecting macroinvertebrates

Students sorting macroinvertebrates

What research questions guide the field investigation?

What are the environmental conditions of the East Fork of the Lewis River at Lewisville Park?
Is the river ecologically healthy?

Descriptive Questions	Comparative Questions
What are the physical characteristics of the stream? What is the surrounding land use? What are the chemical conditions of the stream (dissolved oxygen, pH, …)? How many different types (taxa) of macroinvertebrates are present? What portion of the macroinvertebrates collected are sensitive, moderately sensitive, or tolerant to pollution? What are the percentages for the different macroinvertebrate feeding groups (scrapers, shredders, collectors, predators)?	How does the macroinvertebrate population change over time (seasonally and annually)? How do our chemical tests and biological samples compare to the state standards, the Pollution Tolerence Index (PTI) and Oregon Water Enhancement Board (OWEB) (macroinvertebrate) protocols, and the River Continuum model?

Correlative Question

How does the macroinvertebrate analysis compare to the physical conditions and chemical test standards for the site?

What is the field investigation design?

The students visit their study site three times a year—once at the end of September, again during November, and a final trip in March. The field excursions involve two classes of 30 students that each have about one hour to conduct various chemical tests (dissolved oxygen, pH, …), make observations of the site conditions (weather, land use, …), take measurements (or estimates) of stream characteristics (depth, width, temperature, …), and collect samples of macroinvertebrates. The class is divided into pre-assigned groups to complete the various tasks and a staff member or a volunteer with the Water Resources Education Center assists each team of students. These responsibilities are rotated each trip so students have a chance to be involved in all of the tasks throughout the year. The last half of each field experience is devoted to sorting, identifying and recording the macroinvertebrates collected at the site. Sub-samples are created of the macroinvertebrates and the students work in pairs to examine the number and types of organisms found. At the end of the experience, all data sheets are collected as students board the bus. Results of the water quality tests are shared and macroinvertebrate counts are tallied during the next classroom session. Subsequent classroom sessions are devoted to analyzing and discussing the results of the data.

How is data collected and organized?

Summaries of our water quality tests and macroinvertebrate counts are shown below:

Location: E. Fork of the Lewis R. at Lewisville Park
Date: November 2005 - September 2007
Sample #/ID: CAM Jr. High - 7th gr. Science

	Functional Feeding Group (FFG***)	Nov 2005	Mar 2006	Sep 2006	Nov 2006	Mar 2007	Sep 2007
Mayflies (*Ephemeroptera*)							
ameletid minnow mayfly*	collector-gatherer	2	3	2	4	77	2
small minnow mayfly	collector-gatherer	50	98	27	23	58	48
flatheaded mayfly	scraper	185	277	92	74	78	205
spiny crawler mayfly	collector-gatherer	13	22	23	16	73	23
pronggilled mayfly	collector-gatherer	1	1	6	20	21	8
Stoneflies (*Plecoptera*)							
golden stonefly	predator	5	7	12	10	21	16
yellow stonefly	predator	20	11	16	10	8	6
little green stonefly*	predator	7	15	1	9	5	1
little brown stonefly*	shredder	2	5	2	5	6	0
slender winter stonefly*	shredder	0	0	1	4	1	1
giant stonefly*	shredder	1	0	1	0	0	0
rolled-winged stonefly	shredder	0	1	1	0	0	0
Caddisflies (*Tricoptera*)							
northern case-maker caddisfly	shredder	2	32	21	29	79	10
saddle case-maker caddisfly*	scraper	3	2	2	5	0	2
net-spinner caddisfly	collector-filterer	9	5	48	5	3	21
free-living caddisfly*	predator	1	1	8	1	3	0
finger-net caddisfly*	collector-filterer	1	0	5	3	3	3
lepidostomatid/humpless	shredder	4	0	1	27	2	2
Dobsonfly and Alderfly (*Megaloptera*)							
dobsonfly/hellgrammite*	predator	0	0	0	0	0	0
alderfly*	predator	0	0	0	0	0	0
Dragonflies & Damselflies (*Odonata*)							
dragonfly*	predator	0	0	0	2	0	0
damselfly*	predator	0	0	0	0	0	0

True Bugs (*Hemiptera*)								
	water boatman	collector-gatherer**	0	0	0	1	0	0
	water strider	predator**	0	0	0	2	1	2
Water Beetles (*Coleoptera*)								
	riffle beetle - larva	collector-gatherer	2	1	16	4	3	15
	riffle beetle - adult	collector-gatherer	1	0	22	7	1	29
	predaceous beetle*	predator	0	1	1	0	1	0
	water penny*	scraper	0	0	0	0	0	0
True Flies (*Diptera*)								
	midge	collector/predator	8	162	43	6	63	41
	black fly	collector-filterer	2	5	9	6	13	22
	crane fly	shredder/predator	0	4	5	4	2	7
Other Aquatic Macroinvertebrates								
	flatworm (*Platyhelminthes*)	predator/collector	1	0	7	3	5	12
	aquatic earthworm (*Annelida*)	collector-gatherer	35	13	54	31	13	78
	gilled snail (*Mollusca*) - right-side opening	scraper	1	0	3	2	1	1
	pouch snail (*Mollusca*) - left-side opening*	scraper	0	0	0	0	0	0
	snail (other - coiled shell, …)	scraper	0	0	0	0	0	0
	clam/mussel (*Mollusca*)	collector-filterer	0	0	0	0	0	0
	water mite (*Arachnida*)	predator/scavenger	13	13	42	22	26	67
	scud (*Crustacea*)*	collector-gatherer	1	0	0	0	0	0
	aquatic sowbug (*Crustacea*)*	collector-gatherer	0	0	0	0	0	0
	crayfish (*Crustacea*)	collector-gatherer	0	0	2	14	4	1
		Total Macros	370	679	473	349	571	623
*show macroinvertebrate to teacher								
**FFG from: Freshwater Invertebrates (Voshell/McDonald & Woodward)								
***FFG from: Macroinvertebrates of the Pacific Northwest (Jeff Adams/Xerces Society)								

Water Quality Tests

Date **Time**	**Nov. 18, 2005** **11:15 AM**	**Mar. 21, 2006** **11:15 AM**	**Sep. 28, 2006** **11:30 Am**	**Nov. 16, 2006** **11:30 AM**	**Mar. 27, 2007** **11:30 AM**	**Sep. 25, 2007** **11:00 AM**
Air Temperature	7° C	10° C	21° C	11° C	5° C	15° C
Rainfall (2 days prior)	None	Light	None	Heavy	Moderate	None
Water Temperature	7.6° C	8° C	12° C	9° C	4° C	8.5° C
	Optimal Levels Hatching salmonids: ~ 9° C; Salmonid: < 12.8° C; Non-salmonid: <17.8° C For a stream or river to be rated Class AA*, temperatures should not exceed 16 degrees centigrade Temperatures which exceed 21° C are not acceptable					
DO (mg/L) Dissolved Oxygen	10	10	9	9	9.8	10
	Optimal Levels for Salmonids: Optimal (Class AA*) >9.5 mg/L; Acceptable 7-8 mg/L; Poor 3.5-6 mg/L A DO level > 11 mg/L needed for spawning salmonids A DO level < 5 mg/L is stressful to most vertebrates and causes mortality to some invertebrates					
PH **(acid - base)**	7.4	7.5	7.8	7.3	7.5	8.0
	Optimal Levels pH values between 7.0 and 8.0 are optimal for supporting a diverse aquatic ecosystem A pH range between 6.5 and 8.5 is generally suitable (meets Class AA*)					
Phosphate	NA	NA	NA	NA	0	0.1
Turbidity (NTU)	<5	<5	<5	<5	<5	<5
	Turbidity Levels Class AA* = <5 NTU; Class B* = <10 NTU					
Stream Flow (cfs)	~630	~770	~47	~1850	~1600	~38
Fecal Coliform (colonies/100 mL)	NA	NA	NA	NA	60	53
	Fecal Coliform (Bacteria) Levels Class AA* = <50 [drinking water = <1; swimming/full contact = <200; boating/partial contact = <1000]					
PTI	20	16	26	29	26	26
	PTI (Pollution Tolerance Index) Scale using macroinvertebrates Poor = <11; Fair = 11 - 16; Good = 17 – 22; Excellent = >22					
OWEB	26	22	30	28	28	26
	OWEB (Oregon Watershed Enhancement Board) Scale using macroinvertebrates Severe Impairment = <17; Moderate Impairment = 17 - 22; No Impairment = >22					

* Water Quality Standards for Surface Waters of Washington, June 1998 (http://depts.washington.edu/natmap/water/index.html)

An important part of the study has been the collection of macroinvertebrate data. This requires students to sort, identify, and count a number of distinct groups (called "taxa") of organisms. Sufficient time must be given to train students in recognizing distinctive morphologic features. By magnifying and photographing, we were better able to compare our organisms with descriptions and illustrations found in various guides. This also provides a meaningful opportunity to discuss other important biological concepts with the students, such as invertebrate anatomy, adaptations, and classification. Below are two examples of macroinvertebrates. Can you see any distinctive characteristics?

Figure 1

Figure 2

Make some observations. What is similar and what is different between the two?

Both have six legs (insects). They have antennae, legs are jointed. #1 has two tails while #2 has three. #1 has hairy (gills) armpits while #2 doesn't. Here is what a field guide would tell you: Figure 1 is a stonefly: thorax divided into three parts; all have two tails; no gills along abdomen. Figure 2 is a mayfly: two segments to thorax; may have two or three tails; gills along abdomen.

The level of classification students can achieve influences the type of analysis possible. Simply looking at the presence or absence of certain "Orders" of macroinvertebrates will enable the use of the Pollution Tolerance Index (PTI). Taking identification to the next level—identifying the respective "Families" of the insects—makes it possible to use other indices, such as OWEB (Oregon Water Enhancement Board) Level II and an examination of functional feeding groups (FFG). Looking at FFGs also permits an enriching discussion of energy roles in the aquatic environment and comparison of student data to the River Continuum model for understanding stream ecology.

As part of the process of using these protocols, students are also asked to make predictions about the water quality of their stream site, organize and quantify the field data, and evaluate the results based on existing standards or models.

Much of the preliminary instruction and post-trip analysis described above is teacher directed. That is, the students are assigned specific lessons, some background informational reading, and a series of analysis worksheets. The data set developed, however, is very rich and provides many opportunities for discussion, including student-generated observations and questions.

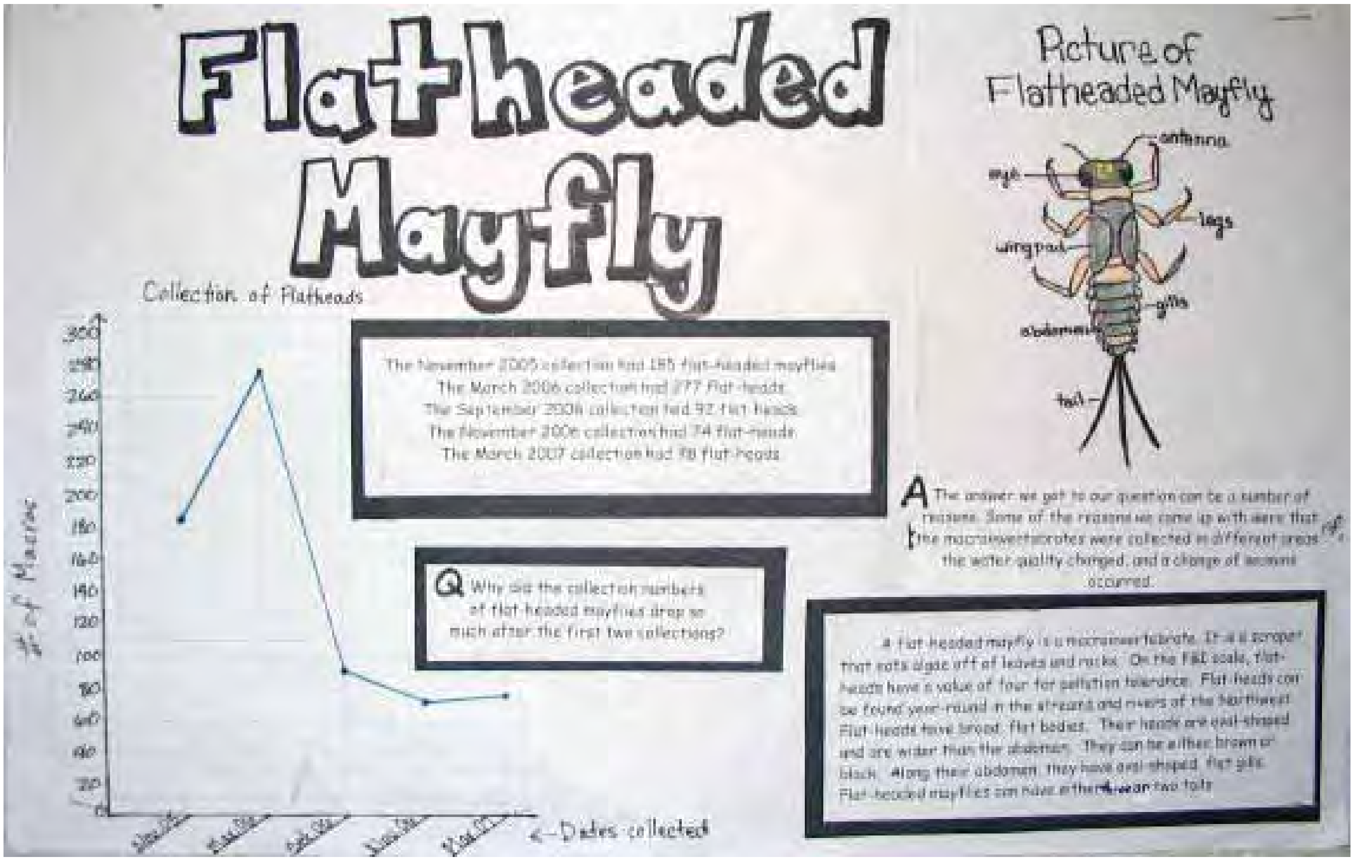
The activity presented below is an example of how students transition from following collection protocols to leading a scientific investigation. They pursue their own, self-selected analysis of the data and communicate their findings in the form of a poster and classroom presentation. In this poster project, students are in charge of exploring, identifying, and describing patterns or trends they identify in the data using graphical and quantitative tools, and preparing a summary analysis of their selected information.

Learning how to pose questions based on observations is an important data analysis skill. Look at the data table of macroinvertebrate counts and ask either a descriptive or comparative question about variations in macroinvertebrates, and then make a graph to answer your question.

Now, let us look at what students do. In preparing their projects, students are asked to:

1. Provide a title and pose a testable question.
2. Use applicable information from the data sets.
3. Create a table, chart or graph relevant to their topic.
4. Provide a written summary of the changes or comparisons observed in the data.
5. Present a reasonable explanation for the results.
6. Provide some background information about their topic and include an illustration.

A sample project created by a 7th grade student is shown below:



This student decided to examine temporal trends in the population of specific mayfly genera. Although not explicitly stated, she considers the comparative question, how does mayfly population vary by month? She has given several possible explanations of the population decrease, including collection area, water quality, and changing seasons. Note the importance of visiting the field site and participation in the data collection in building her explanation, as she notes the field conditions, “the macroinvertebrates were collected in different areas.” She remembered that we had to move the collection site off the main channel because the main part of the river was flowing too fast.

Field investigations involving water quality monitoring and benthic macroinvertebrates provide a dynamic and engaging context for developing science concepts and processes with students. The collection and recording of data over time also creates a rich data set that can be used by students to identify patterns (seasonal variations in temperature), changes (from year-to-year in macroinvertebrate populations), and even correlations (seasons and percentages of feeding groups) in water quality parameters and populations of aquatic organisms. Since students have been involved in the process of collecting, analyzing, and adding information to the data set, they have ownership and insight into how the information was generated and some potential reasons for the changes and correlations they might identify.

What advice do you have for a teacher who would like to design and organize a long-term field investigation?

- Keep it simple at the start of a project; build as you go.
- Seek help from local organizations or partner with another teacher.
- Find appropriate resources to support your project and assist your students.
- If you can't find good resources, modify existing ones or try make your own.
- Take lots of pictures.
- Save the results for future groups to build on and compare.
- Share the results with others: Science is about learning and sharing.
- Be prepared to make changes as you go.
- Don't be afraid to make mistakes. Even with thoughtful planning, there's a lot of trial and error in science.
- Doing science takes time; preparing to teach science takes even more time.

Section 5
Case Examples of Field Investigation in Washington Schools

In Washington State, students, teachers, and wildlife biologists collaborate to conduct field investigations. Below are profiles of two field investigation projects: A collaboration between elementary students and farmers to study short-horned lizard behavior, and a district-wide initiative to study cougar/human interactions. By systematically collecting data over time, students and scientists build knowledge about the environment and understand environmental systems. These projects require a long-term commitment from both classroom teachers and natural resource agency biologists.

Cases in this section include:

- **Elementary Students: Adopt-a-Farmer Project: Short-horned Lizard (Horny Toad)**
- **Middle and High School Students: Project CAT: Cougars and Teaching**

Adopt-a-Farmer Project: Short-horned Lizard (Horny Toad)

http://depts.washington.edu/natmap/projects/waterville/index.html
Contributed by Diane Petersen, Teacher, Waterville Elementary and Karen Dvornich, Fish and Wildlife Cooperative Research Unit, University of Washington

Students at Waterville Elementary School in Waterville, WA and local area farmers have worked together since 1999 to investigate short-horned lizard biology.

What research questions guide the field investigation?

How do horny toads and farmers exist together in the farm fields?	
Descriptive Questions	**Comparative Questions**
What do horny toads eat? What do they do during the winter? What is the movement/range of the horny toad?	Is the farm field a source or a sink? What are most horny toads close to, road, farm fields, homes, or stream?

What is the field investigation design?

There are two levels to our investigative design. Farmers collect data and students track the movement of horny toads using radio collars.

Farmers Collect Data

We realized the students couldn't collect observational data themselves, since most of the sightings occur during the summer. Thus, we invited local farmers to partner with us. We listed all the farmers we knew and composed a letter asking them to be "adopted."

We designed a data collection sheet based on the questions we had. We identified the habitats common to the area and translated them from ecologist language to language familiar to the farmers. We included the habitat list with the data collection sheets. We also sized the data collection form so that it was easy for farmers to use. During the summer months, the farmers record their observations. At the beginning of each new school year, farmers come into the classroom with their forms and partner with students to share data.

Habitats of Waterville

(Revised 11/5/06)

Agriculture

321 – Maintained pasture
322 – Crops (wheat, canola, etc.)
324 – CRP land

Developed

204 – Alongside of roads or between a road and field
231 – Home

Disturbed non-forested habitats – areas people use a lot

612 – Man-made scab patch
616 – A dried stream bank inside or along farm fields or hedgerow

Non-disturbed habitats – areas people rarely use

622 – A naturally occurring scab patch
626 – A dried up stream bank with sagebrush around it

Students Track Range Using Radio Collars

Students collect two to three horny toads larger than four grams in a farm field near the school. The lizards are brought back to school to get weighed (if they are too small, they are put back into the fields). Students attach a radio collar to each lizard using silicon glue, and the lizards are released were they were found.

Groups of three or four students go out after school hours (as many nights as are possible) and some Saturdays during the six weeks the radios are transmitting. Following the protocol developed by a Central Washington University graduate student, they locate the lizards and record the latitude/longitude and temperature measurements at multiple heights and distances from the scab patch. Data are entered into a spreadsheet and plotted onto ArcView.

How is the data collected and organized?

Farmers come into the class, and each of their sightings is given an unique number. Students work with their farmers going to multiple stations (e.g., topographic maps, paper graphs) for each of the attributes farmers collect. Farmers are trained by the students to digitize their sightings over aerial photos in ArcView, and add the unique number in the associated table.

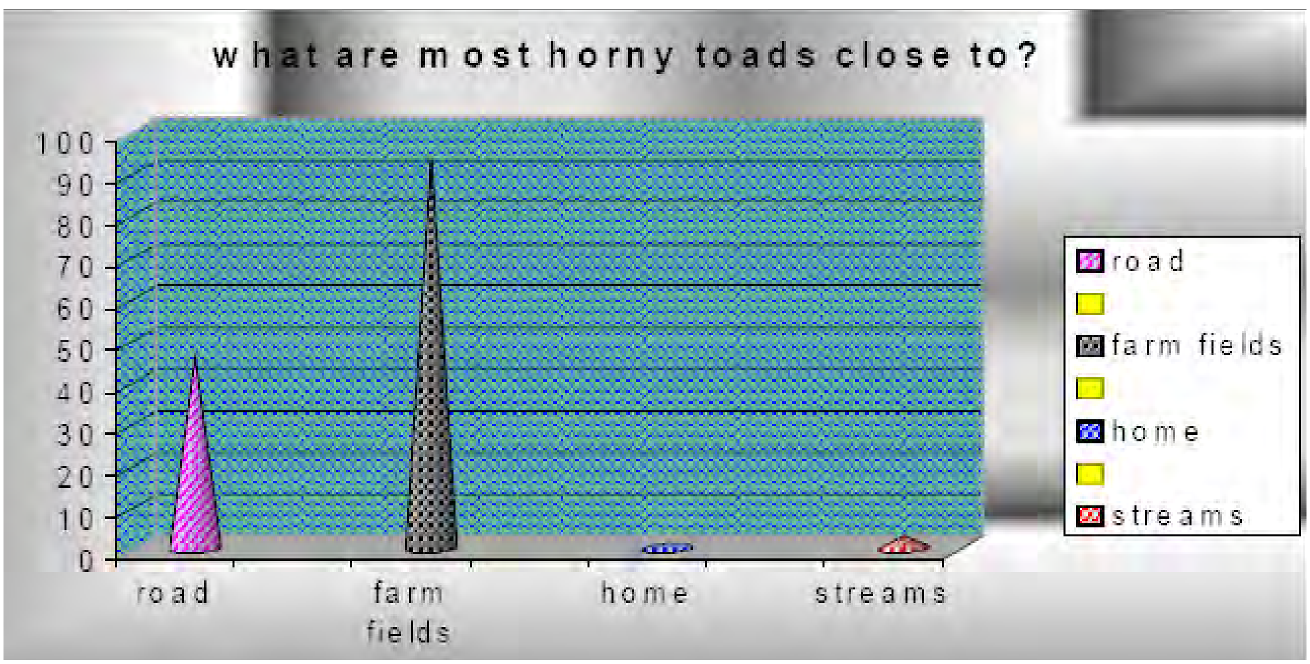
Two students use the data collection forms to enter data into an Excel spreadsheet that contains all of the attributes of the data collection form, plus the unique identification code to relate to the GIS file.

Two other students go over the same data to proof read it. Each pair of students chooses a question and selects the data column to answer their question. They sort the column(s) and group it to make graphs depending on their question. They choose comparative or descriptive questions. This past year, a correlative question was graphed. Students analyze each others' graphs to make sure they make sense and are accurate. The graphs that answer the questions the best are sent to the website at the University of Washington. Below are two graphs that were created by students, as well as their field investigation questions and interpretations of the data.

Question: What are most horny toads close to?

Prediction/hypothesis:
I think most horny toads are will be found by a wheat field because there are a lot of bugs in a wheat field.

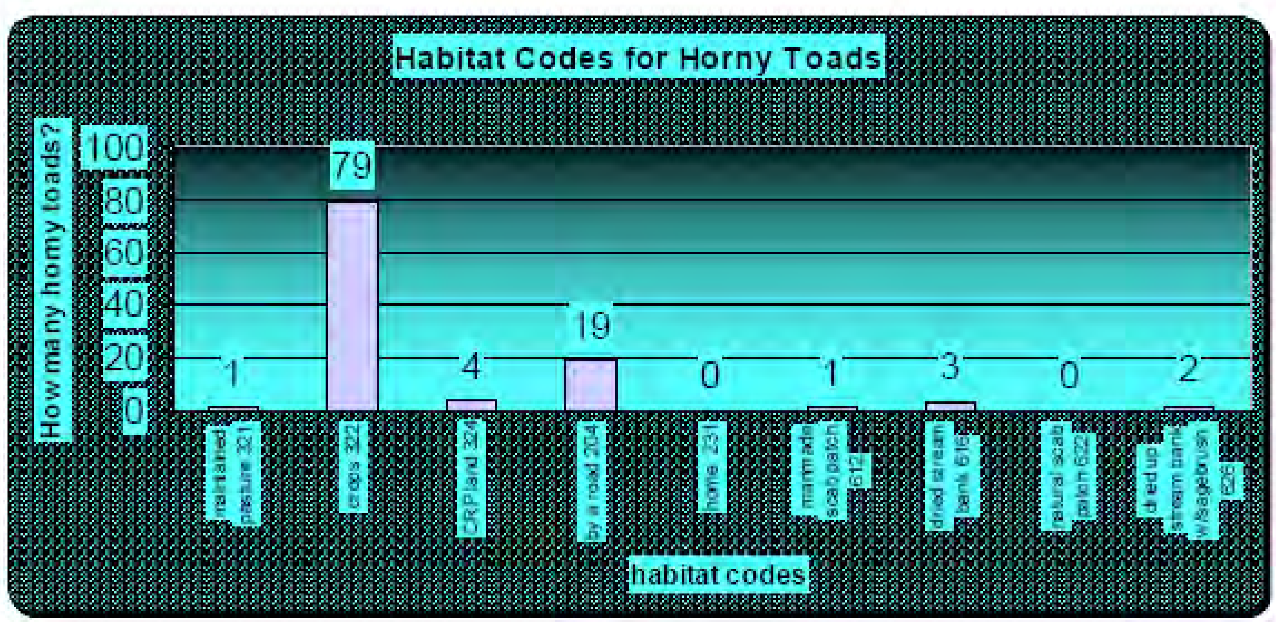
Conclusion:
My prediction that most horny toads would be found close to wheat fields was correct. The maximum number was 96 horny toads in wheat fields. The minimum number was 3 horny toads found by streams. For habitats like a manmade shelter there are 0 horny toads living there.



Question: what habitat code is used most often?

Prediction/Hypothesis: I think habitat code 322 will be found most often because they live there.

My prediction for habitat codes was correct. The maximum number was 78 in farm fields. The minimum number was 1 in a scab patch. For habitats 622,321,324 there were 0 seen.



What is your most important finding to date?

1. Horny toads do co-exist with farmers in the fields.
2. Their prey food is not exclusively ants. We have learned that they also eat medium sized grasshoppers and meal worms.
3. Their range of movement is greater than what has been written in literature. We found ranges as up to fours times the range of the lizards in Southern California __________________________.

What challenges have you faced?

1. Weather
2. Money
3. Technology (purchasing, use)
4. Time
5. Data management (making sure your data are stored where they can't be erased or damaged)

What advice do you have for a teacher who would like to design and organize a long-term field investigation?

Take one step at a time, begin simply, and get help from an expert. Don't be afraid to jump in and see where it goes. There's no way you can predict or plan for everything. Begin with the kids' questions. We always predict what we believe we will find out in our research. We look next at what the scientific literature (usually field guides) says. Then, we collect data, and we see how the data compares to our predictions and our research.

- Find something that is real to the kids, that they are interested in and is do-able…think it through.
- Find a mentor who can advise and help train students. The Fish and Wildlife Cooperative Research Unit (UW) scientists and graduate students have been very helpful to us.
- Plan ahead on how you are going to store the information (where and how you are going to store it) and write it down.
- Develop a constant format for entering data (e.g., all caps, etc.)
- Put the data onto the spreadsheet as soon as possible and make sure you verify what was entered.
- Write notes of the problems and what you did because you will forget.
- Find local community support and involvement to help with the project…chaperones on field trips, donations from business for bus money, local professionals to help in the field, or in our case local farmers to collect data.
- Plan for changes to the protocols and database over time. For example, some of our questions were removed because other ones became more important.
- If you are going onto private land be sure to get permission from the land owner.
- If you are going to display pictures of students on the web, student picture release forms are needed.

What do students learn from the field investigation process?

Students learn how to conduct scientific projects that can be replicated. They discover the importance of consistent data collection and data entry (students do not like to fix other students' errors) and use data to make better sense of the local environment.

Students have a real reason for using math and writing skills. They learn how to analyze their data in multiple ways by presenting their results and discussing their methodology with natural resource professionals using PowerPoint, graphs, and a website. Thus, they learn they can make a real contribution to the scientific knowledge base and gain the personal skills of meeting people of different ages and vocations and feel comfortable discussing their work.

Project CAT: Cougars and Teaching

http://depts.washington.edu/natmap/projects/cat/
Contributed by Trish Griswold, Teacher, Walter Strom Middle School and Gary Koehler, Ph.D., Wildlife Biologist, Washington Department of Fish and Wildlife.

Investigating where cougars go when their habitat is changed by human developments is a research collaboration between K-12 students in the Cle Elum-Roslyn (CER) School District in eastern Washington and biologists with the Washington Department of Fish and Wildlife. Students work with wildlife scientists to study the indigenous cougar's ecology and behavior to understand how to better manage human-cougar interactions.

What research questions guide the field investigation?

Where do cougars go when their habitat is changed by housing development?	
Descriptive Questions	**Comparative Questions**
What areas do cougars select to hunt?	How much space do male and females cougars occupy during each season? Is there a difference in numbers of deer and elk (cougar prey) killed by male and female cougars?

What is the field investigation design?

Middle school students collect and analyze data over time. They work along side wildlife biologists, capture cougars, tag them with global positioning system (GPS) collars (which provide more than 2,000 location readings for each animal per year), mark them with ear tags, and collect physical data that includes length, neck girth, chest girth, length, weight, and condition of canine teeth. Students plot coordinates of cougar locations on computer-generated maps of the study area, and use computer programs to calculate the space each cougar travels annually. The location information allows scientists to study what habitats cougar use and where cougars prey on deer and elk. Students present their findings at scientific conferences and through a program called Cougar Wise in which they inform community members how to coexist with cougars.

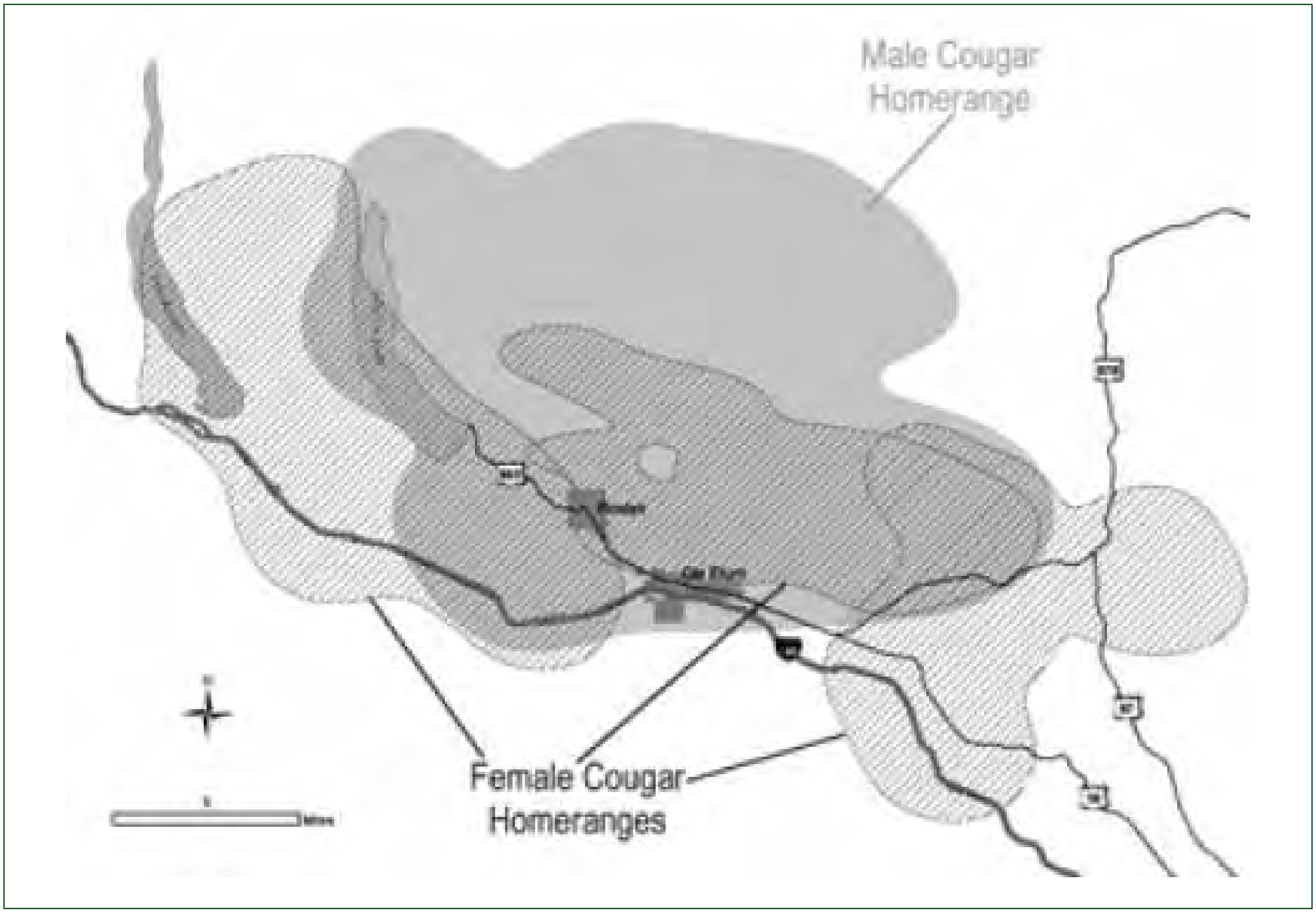
How is data collected and organized?

GPS collars collect location coordinates at four hour intervals throughout the year. Location data is downloaded onto spreadsheets and onto computer generated maps of the study area. Coordinates for clusters of GPS locations are inputted onto a hand-held GPS to help students and the research team to navigate to the cluster site to investigate what may have attracted the cougar to the location. Evidence of prey remains (bones, skulls, and hair) is collected and the species identified. Data from site inspections is categorized into age and sex of cougars, date the cougar was present, species of prey remains, as well as whether no remains were identified. Information on sex and age of cougar is compiled and correlated with species of prey remains to assess whether different ages and sexes of cougars select different species of prey animals.

What has been your most important finding to date?

In the Cle Elum area, a mature male cougar can defend about 150 square miles; dominant males constantly patrol their territory to protect prey and females from other males. Within this territory, there may be two or three females, each one demanding about 50 square miles of territory to meet her needs to raise a litter. GPS data has documented young male cougars traveling as far as 160 miles through rugged mountain and desert terrain to establish their own territory. We have also observed that male cougars tend to select for larger prey species like elk, while females tend to select for smaller sized deer.

Map of Cougar Homerange



What challenges have you faced?

I have included field investigations in 8th grade science because I desire to share my passion and training in forestry/wildlife science and encourage curiosity in science related areas. The field work is a perfect venue for teaching thinking skills, inquiry methods, and career connections. The challenge has been getting students to focus their work on one specific question, one question that they own. Working in the field allows students to see that science is "messy" and that mistakes are as valuable as successes. In addition, when they study a large animal like the cougar, students learn that their actions affect other species.

What advice do you have for a teacher who would like to design and organize a long term field investigation?

Truth about Science, a NSTA publication is a great place to start. The lessons walk the teacher and students through designing a quarter-long research project, from writing a good question through data analysis. Students will be outside in an organized way and gaining a sense of place. Teachers will become more confident. In the second phase, a class discussion focused on local issues will help create a relevant and personal research question on a larger scale. Students need to be involved in all steps of defining the problem and designing a solution. Professional scientists can assist at any time or bring their research question to the students and possibly allow them to participate. Motivation comes from passionate students! At some point, they will want to share their passion, so projects like CougarWise come to be.

What do students learn from the field investigation process?

Students educate the community and are learning first hand the impact humans have on cougar behavior. They participate in the science and then, using their findings, they educate the public. This next year they hope to take the next step by sponsoring a voters' initiative to stop wildlife feeding. The students have learned that feeding wildlife like deer creates a lot of the human/wildlife conflicts.

Kevin White, wildlife ecology major at Washington State University, began his involvement with Project CAT as a high school junior. He shares what he has learned by studying cougar/human interactions, "As Cle Elum gets more developed there will be more sightings of cougars and the potential for more cougar/human encounters. The cougars have such a large home range; it is impossible for them to not walk by people's houses. Since I began working in 2003 more houses have been built in prime cougar habitat. The cougars I have documented kill deer and elk amongst people's property. In several instances I have found kill sites within 200 meters of homes and yet the owners were unaware of a cougar's presence in the area. That is what I enjoy about what I do; these cougars can kill a deer in the open, conceal it and itself in dense brush and no one knows they're even there."

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National Research Council. (1996). *National science education standards.* Washington, DC: National Academy Press.

Office of Superintendent of Public Instruction. (2005). *Science K-10 grade level expectations: A new level of specificity.* Washington State's Essential Academic Learning Requirements. OSPI Document Number 04-0051.

White, R. (2003). *Changing the script for science teaching.* In R. Cross (Ed.), A vision for science education: Responding to the work of Peter Fensham (pp. 170-183). London: Routledge Falmer.

Windschitl, M., Ryken, A. E., Dvornich, K., Tudor, M., & Koehler, G. (2007). A comparative model of field investigations: Aligning school science inquiry with the practices of contemporary science. *School Science and Mathematics, 1(107), 367-390*

Appendices

Appendix A: Generic Rubrics for Assessing Data Sheets, Written Procedures, and Conclusions

Appendix B: Washington State Weighted Rubrics for Assessing Data Sheets, Written Procedures, and Conclusions

Appendix C: Washington State Generic Weighted Rubrics for Assessing Written Procedures and Conclusions

Appendix D: Matrix of Descriptive and Comparative Activities in Project WILD, Project WET, and Project Learning Tree curriculum guides

Appendix E: Field Investigation Resources

Appendix F: Scientific Field Investigations described in Washington State Science Standards (2005)

Appendix G: Science as Inquiry. National Science Education Standards. (National Reseach Council 1996) Guide to Content Standard Grades K-4, 5-8, 9-12)

Appendix A

Generic Rubrics for Assessing Data Sheets, Written Procedures, and Conclusions

Assessing Data Sheets

Review students' data sheets for four important attributes: 1) question/prediction, 2) study site conditions, 3) study site description, and 4) data table.

Question and Prediction	Student states investigative questions and a prediction.
Study Site Conditions	Date, time, location, and weather conditions are noted.
Study Site Description	A written description of the study site is included.
Data Table	Clear title describes what is changed (manipulated variable) and what is observed/measured (responding variable). Manipulated (changed) variable is on left hand side of the data table Observations/counts/measurements are made with proper units. Table includes: blank space to record data for planned investigation, manipulated variable is labeled in the left column, responding variable is labeled across top row. There is a place on the data table for multiple trials to be recorded.

Appendix A

Generic Rubrics for Assessing Data Sheets, Written Procedures, and Conclusions

Assessing Written Procedures

Review students' written procedures for the four important attributes of a procedure: 1) prediction, 2) materials, 3) variables identified, and 4) logical steps in which trials are repeated. See Appendix C for a weighted rubric.

Prediction/Hypothesis	Student predicts how manipulated variable (e.g., time, location, organism, population) impacts the responding variable. Secondary students should provide a reason for their prediction/hypothesis.
Materials	Student lists materials and tools needed to perform the investigation.
Controlled Variable (kept the same)	Student states or implies at least one way that measuring variables and/or sampling are kept the same. High school students state or imply at least two ways.
Manipulated Variable (changed)	Student states what is changed (e.g., location, substrate, habitat, time, organism, or population).
Responding Variable (measured)	Student states how data is measured/observed and recorded.
Logical Steps with Trials Repeated	The steps of the procedure are detailed enough to repeat the procedure effectively. Student indicates that data will be recorded or creates a data table that includes date, time and weather conditions. Student notes that data will be measured more than once at each location.

Appendix A

Generic Rubrics for Assessing Data Sheets, Written Procedures, and Conclusions

Assessing Conclusions

Review students' written conclusions for the five important attributes of a conclusion: 1) limits conclusion to study place, date and time, 2) includes a conclusive statement, 3) gives lowest supporting data, 4) gives highest supporting data, 5) uses explanatory language. See Appendix C for a weighted rubric.

Limits Conclusion to Place, Date, and Time of Study	Student gives location, date, and time where field study took place.
A Conclusive Statement	Student makes a conclusive statement that clearly answers the investigation question or explains whether or not the prediction was correct. In descriptive investigations, the conclusive statement may be a detailed description or model of observations.
Lowest Supporting Data	Student gives data for lowest measurement. For descriptive investigations, trend data or descriptive data are given. For comparative investigations, data points (or data averages) or observations are given for the "lowest" condition. If there is no difference, all conditions are stated.
Highest Supporting Data	Student gives data for highest measurement. For comparative investigations, data points (or data averages) or observations are given for the "highest" condition. If there is no difference, all conditions are stated.
Explanatory Language	An explanation compares what happened between or among changed (manipulated) variable conditions and states how the given data supports the conclusion. For comparative investigations, student gives a comparative explanation using words like highest, lowest, largest, most or only.

Appendix B

Washington State Weighted Rubrics for Surface Temperature Comparative Investigation

Scoring the Procedure

Review students' procedure for the following procedure attributes:

Procedure Attributes		**Points**
Prediction	Student predicts which location under the bushes, on the grass, or on the black top has the highest temperature by stating which location (manipulated variable) will have the highest/lowest temperature (responding variable).	1
Prediction Reason	Secondary students must give a reason for the prediction	1
Materials	Student lists materials and tools needed to perform the procedure. Thermometer, stopwatch, devise to shade thermometer	1
Study Site	Student describes recording date and time and weather	1
Controlled Variable (kept the same)	5th and 8th grade students must describe or imply one controlled variable in the procedure or the materials list. 10th grade students must describe or imply two controlled variables. Examples: · Temperature taken on top of ground each time · Wait the same # of minutes each time before reading temperature · Thermometer laid flat on the ground · Thermometer shaded from direct sun	1
Manipulated Variable (changed)	Location is implied or stated as the variable that is changed in the investigation.	1
Responding Variable (measured-5th, dependent-10th)	The responding (measured) variable of temperature is identified or implied.	1
Validity Measures (10th)	10th grade. Extra validity measures e.g. .random sampling; calibrate thermometers; wait for # of minutes for thermometer to calibrate.	1

Appendix B

Washington State Weighted Rubrics for Surface Temperature Comparative Investigation

Record Measurements	The temperature is recorded after so many minutes lying on the ground.	1
Trials Repeated	The temperature is measured more than once at each location.	1
Logical Steps	The steps of the procedure are detailed enough to repeat the procedure effectively.	1
	Total Points	9-11

Possible point conversions for the various grade levels

5th grade	8th grade	10th grade	Rubric score
7-9	8-10	9-11	4
5-6	6-7	7-8	3
3-4	4-5	5-6	2
2	2-3	3-4	1
0-1	0-1	0-2	0

Appendix B

Washington State Weighted Rubrics for Surface Temperature Comparative Investigation

Scoring the Conclusion

Review students' conclusions for the following conclusion attributes:

Conclusion Attributes		Points
Limits Conclusion to Place, Date, and Time of Study	Student gives location, date, and time where field study took place.	1
A Conclusive Statement	Student clearly describes which location has the highest temperature OR describes that there were no differences among the temperatures.	1
Lowest Supporting Data	Student gives location and temperature for location with the lowest degrees °F/°C. OR gives the data that supports there were no differences among the locations.	1
Highest Supporting Data	Student gives location and temperature for location with the highest degrees °F/°C if data is different.	1
Comparison to Standards	Compare data to standards if applicable	N/A
Explanatory Language	Student uses explanatory language to connect or compare the supporting data to a correct conclusion. An explanation of how the given data supports the conclusion is stated or implied by using words like highest or lowest. Notes: 1. Points may be awarded even without supporting data given as long as conditions (manipulated variables) are given with a general trend of the responding variable. Example: The black top was the hottest and under the bushes was the coolest. 2. Points may be awarded when derived data is given. Example: The black top was 4 °F warmer than under the bushes.	1
	Total	5

Note:

1. When no conclusion is given data points are not awarded
2. A "data point' is numerical values for both the manipulated and responding variables (at 5th grade the changed or manipulated variable may simply be referenced)
3. When derived data is given explanatory language points are given along with both the highest and lowest supporting data points.

Example: The black top was 4 °F warmer than under the bushes.

Value Points	Score Points
4-5	2
2-3	1
0-1	0

Appendix C

Washington State Generic Weighted Rubrics for Assessing Written Procedures and Conclusions

Scoring the Procedure

Review students' procedure for the following procedure attributes:

Procedure Attributes		Points
Prediction	Student predicts what manipulated variable (time, location, organism, population) will do to the responding variable.	1
Prediction Reason	8th and 10th grade students must give a reason for the prediction.	1
Materials	Student lists materials and tools needed to perform the procedure.	1
Study Site	Student describes recording the description of study site-location, weather, date, and time	1
Controlled Variable (kept the same)	5th and 8th grade students must describe or imply one controlled variable in the procedure or the materials list. 10th grade students must describe or imply two controlled variables.	1
Manipulated Variable (changed)	Only one manipulated (changed) variable is identified or implied. What was changed to make a comparison is identified, for example, change in location, habitat, time, organism, population, or substrate	1
Responding Variable (measured-5th dependent-10th)	The responding (measured) variable is identified or implied. Procedure describes how data are measured/observed.	1
Validity Measures (10th)	Extra validity measures are included (e.g. random sampling, representative sampling, taking both sampling repeated trials and measurement repeated trials, rinsing equipment between measurements)	1
Record Measurements	Student states or implies measurements are recorded periodically or gives a data table.	1
Trials Repeated	Student describes or implies that either samples and/or measured data are repeated.	1
Logical Steps	The steps of the procedure are detailed enough to repeat the procedure effectively.	1
	Total Points	9-11

Possible conversions for the various grade levels

5th grade	8th grade	10th grade	Points
7-9	8-10	9-11	4
5-6	6-7	7-8	3
3-4	4-5	5-6	2
2	2-3	3-4	1
0-1	0-1	0-2	0

Appendix C

Washington State Generic Weighted Rubrics for Assessing Written Procedures and Conclusions

Scoring the Conclusion

Review students' procedure for the following conclusion attributes:

Conclusion Attributes		Points
A Conclusive Statement	Student clearly answers the investigative question or explains whether or not the prediction was correct.	1
Limits Conclusion to Place, Date, and Time of Study	Gives location, date, and time where field investigation took place.	1
Lowest Supporting Data	Data points (or derived data-averages) or observations are given for the "lowest" condition OR data that supports the "null" hypothesis that there is no difference-all conditions are identified. 8th and 10th grade must use averages or final data for support.	1
Highest Supporting Data	Data points (or derived data-averages) or observations are given for the "highest" condition when there is a difference. 8th and 10th grade must use averages or final data for support.	1
Comparison to Standards	Compare data to standards if applicable	1
Explanatory Language	Student uses explanatory language to connect or compare the supporting data to a correct conclusion. Explanation of how the given data supports the conclusion is stated or implied by using comparative words like highest or lowest. Student compares what happened between or among changed (manipulated) variable conditions. Notes: 1. Points may be awarded even without supporting data points as long as conditions (manipulated variables) are given with a general trend of the responding variable. Example: The grass with the most light grew the tallest. The grass with the least light grew less than grass given more light. 2. When derived data is given explanatory language points are given. Example: Twig growth on north side had an average of 8cm more growth than twigs on the south side of the bush.	1
	Total	5-6

1. A response with an incorrect conclusive statement or no conclusive statement may not be credited any value points.
2. a "data point' is numerical values for both the manipulated and responding variables (at 5th grade the changed or manipulated variable may simply be referenced)
3. When correct derived data is given explanatory language points are given The supporting data points are also given if derived data comes from both the high and low supporting data points.

Value Points	Score Points
4-6	2
2-3	1
0-1	0

Appendix D

Field Investigation Resources in Project WILD, Project WET, and Project Learning Tree

The curriculum and activity guides listed below are useful resources. Each contains activities which can be used to prepare students to conduct field investigations. The list on the following page identifies field investigation activities. Activities or guides marked with an asterisk (*) are particularly suited for adaptation to comparative field investigations or learning the skills required to do comparative field investigations.

Project WILD focuses on wildlife

www.projectwild.org
K-12 Curriculum and Activity Guide
K-12 Aquatic Curriculum and Activity Guide
Science and Civics: Sustaining Wildlife (Secondary)*

Project WET focuses on water

www.projectwet.org
Project WET Curriculum and Activity Guide
Healthy Water, Healthy People (Secondary)*

Project Learning Tree focuses on the forest

www.plt.org
PreK-8 Environmental Education Activity Guide
The Changing Forest: Forest Ecology (Secondary)*
Municipal Solid Waste (Secondary)*

Field Investigation Resources

Project WILD

Project WILD
Grasshopper Gravity
Bearly Growing*
How Many Bears Can Live in This Forest?
My Kingdom for a Shelter
Tracks!
Spider Web Geometry
Oh Deer!*
Graphananimal
Wildlife is Everywhere
Urban Nature Search
Rainfall and the Forest
Environmental Barometer
Habitrekking
Microtrek Treasure Hunt
Ants on a Twig
Seed Need
Owl Pellets*
Eco-Enrichers*
Birds of Prey*
Who Fits Here?
Forest in a Jar
Forest Ecologies
Ecosystem Facelift
Drawing on Nature
World Travelers
Turkey Trouble
From Bison to Bread: The American Prairie
Bird Song Survey*
Wildlife Research*
Dropping in on Deer*
Improving Wildlife Habitat in the Community

Aquatic WILD

Water Canaries
Marsh Munchers
Micro Odyssey
The Edge of Home
Where does Water Run Off after School?
Where have all the Salmon Gone?
The Glass Menagerie
Deadly Waters
Blue Ribbon Niche

Project WET

Adventures in Density
Back to the Future*
Cold Cash in the Icebox *
Easy Street
Every Drop Counts*
H2O Olympics
Irrigation Interpretation
The Pucker Effect*
Rainy Day Hike
Sparkling Water
Stream Sense
Thirsty Plants
Water Log
Water Meter *
Wet Vacation
Wetland Soils in Living Color*
What's Happening
Where are the Frogs*

Healthy Water Healthy People

Snapshot in Time*
Benthic Bugs*
Invertebrates as Monitors*
Water Quality Monitoring*

Project Learning Tree

Sounds Around*
Planet Diversity*
Adopt a Tree
Trees as Habitats*
Fallen Log*
Nature's Recyclers*
Pollution Search
How Plants Grow*
Sunlight and Shades* of Green
Have Seeds, Will Travel*
Water Wonders*
Web of Life
School Yard Safari
Are Vacant Lots Vacant?
Loving it Too Much?
Field, Forest, Stream*
The Closer You Look
Looking at Leaves*
Bursting Buds*
Germinating Giants*
How Big Is Your Tree?*
Name that Tree
Soil Stories*
Watch on Wetlands*
Trees in Trouble*
Signs of Fall*
Tree Lifecycle
Nothing Succeeds Like Succession?
Air We Breathe
Waste Watchers
The Global Climate*

* These activities are particularly suited for adaption to descriptive and comparative field investigations.

Appendix E
Field Investigation Resources

Barrett, K, & Willard, C. (1998). LHS GEMS: *Schoolyard ecology.* Berkeley, CA: Regents of the University of California.

Brune, J. (2002). *Take it outside!* Science and Children, 39(7), 29-33.

Burton, S., Miller, H., & Roossinck, C. (2007). *Fall colors, temperature and day length.* The Science Teacher, 74(6), 31-37.

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Fulwiler, B.R. (2007). *Writing in science: How to scaffold instruction to support learning.* Portsmouth, NH: Heineman.

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Appendix F

Scientific Field Investigations described in Washington State Science Education Standards (2005)

Appendix E: Scientific Field Investigations

Field investigations allow students to connect abstract ideas to the world around them, starting from their immediate environment in the lower grades to the world as planet Earth in the upper grades. Field investigations generally take place in the outdoors. However they may encompass investigations of human systems such as water treatment facilities. The important point of field investigations is that students are able to make connections to the real world of ideas they may have learned about from print and media resources and laboratory investigations. Using the environment as a context for learning creates opportunities for multiple intelligences, critical thinking, and problem solving while opening possibilities to integrate reading, writing, mathematics, social studies, visual arts, speaking, and listening. The following charts summarize important attributes of scientific field investigations.

Grades Kindergarten through 2

Essential (general) question: Identifies and asks overreaching question about the system being investigated.

Question: Ask the question being investigated in the field study.

Planning the field investigation:

- Ask questions about objects and events in the immediate environment, and develop ideas about how those questions might be answered.
- Demonstrate and describe ways of using materials and tools to help answer the question.
- Describe the study site and time frame.
- Make a list of what is to be measured or observed.
- Record how, when, and where samples are taken.
- Record logical steps so that the field study could be repeated.
- Identify and follow all safety rules for exploring the immediate environment.

Collecting and analyzing data:

- Record data (measurements) in a systematic way using drawings, tables, charts, graphs, or maps.
- Identify patterns and order in objects and events studied: create drawings, graphs, tables, or maps.
- Work with others and share and communicate ideas about explorations during the investigation.
- Undertake personal actions to care for the immediate environment and contribute to responsible group decisions.

Grades 3 through 5

Essential (general) question: Identifies and asks overreaching question about the system being investigated.

Question: Ask the question being investigated in the field study.

Planning the field investigation:

- Predict (hypothesize), when appropriate, comparative and correlative studies.
- List materials.
- Describe the study site and time frame.
- Identify manipulated or changed variable(s).
- Identify consistent sampling (controls).
- Record responding variable(s) (measured or observed) when appropriate.
- Record how, when, and where samples are taken.
- Record logical steps so that the field study could be repeated.
- Identify and follow all safety rules for a field investigation.

Collecting and analyzing data:

- Record data (measurements) in a systematic way using drawings, tables, charts, graphs, or maps.
- Organize and analyze data to look for patterns and trends. When appropriate sort measurements (observations) into categories; calculate means, modes, or medians; and create graphs, tables, or maps.
- Construct a reasonable explanation using evidence: Answer the investigative (study) question or respond to the prediction using supporting data.

Appendix F

Scientific Field Investigations in the Washington State Science Essential Academic Learning Requirements

Grades 6 through 8

Essential (general) question: Identifies and asks overreaching question about the system being investigated.

Question: Ask the question being investigated in the field study.

Planning the field investigation:

- Predict (hypothesize), when appropriate, comparative and correlative studies.
- List materials.
- Describe the study site and time frame.
- Record manipulated (changed) variable(s).
- Record consistent sampling (controls).
- Conduct representative (random) sampling when appropriate.
- Record responding (dependent) variable when appropriate.
- Record how, when, and where samples are taken.
- Identify and account for extraneous factors — factors that might have an effect on the focus variable(s).
- Record logical steps so that the field study could be repeated.
- Understand and follow all safety rules for a field investigation.

Collecting and analyzing data:

- Record data (measurements) in a systematic way using tables, charts, graphs, or maps.
- Organize and analyze data to look for patterns and trends. When appropriate sort measurements (observations) into categories; calculate means, modes, or medians; create graphs, tables, or maps; and compare data to standards.

Constructing a reasonable explanation using evidence:

- Answer the investigative (study) question or respond to the prediction using supporting data.
- Compare data to other studies, when appropriate, to answer essential (general) question.

Grades 9 through 10

Essential (general) question: Identifies and asks overreaching question about the system being investigated.

Question: Ask the question being investigated in the field study.

Planning the field investigation:

- Predict (hypothesize), when appropriate, comparative and correlative studies.
- List materials.
- Describe the study site and time frame.
- Record manipulated variable(s).
- Record consistent sampling (controls).
- Conduct representative (random) sampling when appropriate.
- Record responding (dependent) variable (measured, observed, changed, or continuous) when appropriate.
- Record how, when, and where samples are taken.
- Identify and account for extraneous factors — factors that might have an effect on the focus variable(s).
- Record logical steps so that the field study could be repeated.
- Plan, explain, and follow safety rules for a field investigation.

Collecting and analyzing data:

- Record data (measurements) in a systematic way using tables, charts, graphs, or maps.
- Organize and analyze data to look for patterns and trends. When appropriate sort measurements (observations) into categories; calculate means, modes, or medians; create graphs, tables, or maps; compare data to standards; and perform statistical analysis to correlate continuous variables (10th grade).

Constructing a reasonable explanation using evidence:

- Answer the investigative (study) question or respond to the hypothesis using supporting data.
- Compare data to other studies, when appropriate, to answer the essential question.
- Compare data to standards, when appropriate, to answer a larger question.

Appendix G

Science as Inquiry. National Science Education Standards. (National Reseach Council 1996) Guide to Content Standard Grades K-4, 5-8, 9-12)

Science as Inquiry

National Science Education Standards (NRC 1996)

Guide to the Content Standard K-4

Fundamental abilities and concepts that underlie this standard include

ABILITIES NECESSARY TO DO SCIENTIFIC INQUIRY

ASK A QUESTION ABOUT OBJECTS, ORGANISMS, AND EVENTS IN THE ENVIRONMENT. This aspect of the standard emphasizes students asking questions that they can answer with scientific knowledge, combined with their own observations. Students should answer their questions by seeking information from reliable sources of scientific information and from their own observations and investigations.

PLAN AND CONDUCT A SIMPLE INVESTIGATION. In the earliest years, investigations are largely based on systematic observations. As students develop, they may design and conduct simple experiments to answer questions. The idea of a fair test is possible for many students to consider by fourth grade.

EMPLOY SIMPLE EQUIPMENT AND TOOLS TO GATHER DATA AND EXTEND THE SENSES. In early years, students develop simple skills, such as how to observe, measure, cut, connect, switch, turn on and off, pour, hold, tie, and hook. Beginning with simple instruments, students can use rulers to measure the length, height, and depth of objects and materials; thermometers to measure temperature; watches to measure time; beam balances and spring scales to measure weight and force; magnifiers to observe objects and organisms; and microscopes to observe the finer details of plants, animals, rocks, and other materials. Children also develop skills in the use of computers and calculators for conducting investigations.

USE DATA TO CONSTRUCT A REASONABLE EXPLANATION. This aspect of the standard emphasizes the students' thinking as they use data to formulate explanations. Even at the earliest grade levels, students should learn what constitutes evidence and judge the merits or strength of the data and information that will be used to make explanations. After students propose an explanation, they will appeal to the knowledge and evidence they obtained to support their explanations. Students should check their explanations against scientific knowledge, experiences, and observations of others.

[See Teaching Standard B]

COMMUNICATE INVESTIGATIONS AND EXPLANATIONS. Students should begin developing the abilities to communicate, critique, and analyze their work and the work of other students. This communication might be spoken or drawn as well as written.

UNDERSTANDINGS ABOUT SCIENTIFIC INQUIRY

[See Content Standard G (grades K-4)]

[See Program Standard C]

- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
- Scientists use different kinds of investigations depending on the questions they are trying to answer. Types

Appendix G

Science as Inquiry. National Science Education Standards. (National Reseach Council 1996) Guide to Content Standard Grades K-4, 5-8, 9-12)

of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting).

- Simple instruments, such as magnifiers, thermometers, and rulers, provide more information than scientists obtain using only their senses.
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.
- Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations.
- Scientists review and ask questions about the results of other scientists' work.

Guide to the Content Standard 5-8

Fundamental abilities and concepts that underlie this standard include

ABILITIES NECESSARY TO DO SCIENTIFIC INQUIRY

IDENTIFY QUESTIONS THAT CAN BE ANSWERED THROUGH SCIENTIFIC INVESTIGATIONS. Students should develop the ability to refine and refocus broad and ill-defined questions. An important aspect of this ability consists of students' ability to clarify questions and inquiries and direct them toward objects and phenomena that can be described, explained, or predicted by scientific investigations. Students should develop the ability to identify their questions with scientific ideas, concepts, and quantitative relationships that guide investigation.

DESIGN AND CONDUCT A SCIENTIFIC INVESTIGATION. Students should develop general abilities, such as systematic observation, making accurate measurements, and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding the inquiry, and to understand how those ideas compare with current scientific knowledge. Students can learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures.

USE APPROPRIATE TOOLS AND TECHNIQUES TO GATHER, ANALYZE, AND INTERPRET DATA. The use of tools and techniques, including mathematics, will be guided by the question asked and the investigations students design. The use of computers for the collection, summary, and display of evidence is part of this standard. Students should be able to access, gather, store, retrieve, and organize data, using hardware and software designed for these purposes.

DEVELOP DESCRIPTIONS, EXPLANATIONS, PREDICTIONS, AND MODELS USING EVIDENCE. Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description—providing causes for effects and establishing relationships based on evidence and logical argument. This standard requires a subject matter knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the content of science and the contexts within which students develop new knowledge.

Appendix G

Science as Inquiry. National Science Education Standards. (National Reseach Council 1996) Guide to Content Standard Grades K-4, 5-8, 9-12)

THINK CRITICALLY AND LOGICALLY TO MAKE THE RELATIONSHIPS BETWEEN EVIDENCE AND EXPLANATIONS. Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically, students should be able to review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment.

Guide to the Content Standard 9-12

Fundamental abilities and concepts that underlie this standard include

ABILITIES NECESSARY TO DO SCIENTIFIC INQUIRY

IDENTIFY QUESTIONS AND CONCEPTS THAT GUIDE SCIENTIFIC INVESTIGATIONS. Students should formulate a testable hypothesis and demonstrate the logical connections between the scientific concepts guiding a hypothesis and the design of an experiment. They should demonstrate appropriate procedures, a knowledge base, and conceptual understanding of scientific investigations.

DESIGN AND CONDUCT SCIENTIFIC INVESTIGATIONS. Designing and conducting a scientific investigation requires introduction to the major concepts in the area being investigated, proper equipment, safety precautions, assistance with methodological problems, recommendations for use of technologies, clarification of ideas that guide the inquiry, and scientific knowledge obtained from sources other than the actual investigation. The investigation may also require student clarification of the question, method, controls, and variables; student organization and display of data; student revision of methods and explanations; and a public presentation of the results with a critical response from peers. Regardless of the scientific investigation performed, students must use evidence, apply logic, and construct an argument for their proposed explanations.

USE TECHNOLOGY AND MATHEMATICS TO IMPROVE INVESTIGATIONS AND COMMUNICATIONS. A variety of technologies, such as hand tools, measuring instruments, and calculators, should be an integral component of scientific investigations. The use of computers for the collection, analysis, and display of data is also a part of this standard. Mathematics plays an essential role in all aspects of an inquiry. For example, measurement is used for posing questions, formulas are used for developing explanations, and charts and graphs are used for communicating results.

FORMULATE AND REVISE SCIENTIFIC EXPLANATIONS AND MODELS USING LOGIC AND EVIDENCE. Student inquiries should culminate in formulating an explanation or model. Models should be physical, conceptual, and mathematical. In the process of answering the questions, the students should engage in discussions and arguments that result in the revision of their explanations. These discussions should be based on scientific knowledge, the use of logic, and evidence from their investigation.

RECOGNIZE AND ANALYZE ALTERNATIVE EXPLANATIONS AND MODELS. This aspect of the standard emphasizes the critical abilities of analyzing an argument by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models are best. In other words, although there may be several plausible explanations, they do not all have equal weight. Students should be able to use scientific criteria to find the preferred explanations.

November 27

It's early. Like, birds-aren't-even-chirping-yet early. But the way the grass crunches under my feet in this frost almost makes 7 a.m. bearable.

Using the GPS device to tell our group we're exactly 2,912 ft. above sea level definitely makes it worth it. We hike north with our instructor - I announce our exact longitude and latitude - into deep forest. Signs are all around us. Signs, the instructor says, of cougars. We all laugh nervously. Everyone works together.

We collect evidence - cougar evidence - that we'll use in our classroom labs over the next few weeks. We're not only learning how cougars hunt and live and survive, but we're actually using math and science to figure it all out.

Best of all, my work could actually help make a difference for the cougars.

Stewardship Education Best Practices Planning Guide

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A Project of the Association of Fish and Wildlife Agencies'
North American Conservation Education Strategy

Funded by a Multistate Grant of the Sport Fish and Wildlife Restoration Program

Acknowledgments

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May 2008

The Association of Fish and Wildlife Agencies would like to thank the following people for contributing time and expertise to the development of this Guide.

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Recreational Boating and Fishing Foundation

This document draws heavily on Chapter 9 of the Recreational Boating and Fishing Foundation's *Best Practices Workbook for Boating, Fishing and Aquatic Resources Stewardship* (Seng and Rushton, 2003). Portions of this chapter and other information from the *Workbook* are reprinted verbatim with the gracious permission of RBFF. The Best Practices *Workbook* and other tools are available for download at www.rbff.org. The following experts and researchers were intimately involved in development of the *Workbook*, and should be recognized individually for their contributions:

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Bruce E. Matthews, Recreational Boating and Fishing Foundation (formerly)
Martha C. Monroe, University of Florida
Janice D. McDonnell, Rutgers University
Jo-Ellen Ross, Chicago State University
William F. Siemer, Cornell University
Kathleen E. Vos, University of Wisconsin Extension
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McKenzie-Mohr Associates

Doug McKenzie-Mohr, Ph.D., granted permission to excerpt portions of his *Quick Reference: Community-Based Social Marketing*.

Table of Contents

Introduction

What are Best Practices?

A “Best Practice” is a program or practice with specific outcomes that has been clearly defined, refined, and evaluated through repeated delivery and supported by a substantial body of research. These practices represent the best knowledge available for use under specified circumstances. It’s important to note that best practices may change over time. They are recommendations based on what has been observed or documented to be effective to date, but which may change given additional experience, evaluation, and research.
For natural resources management agencies and organizations trying to educate people about conservation, the use of best educational practices is simply a matter of applying tested, science-based practices to educational efforts, the same way biologists apply science to the management of fish, wildlife and other natural resources.

Best practices are process-oriented.

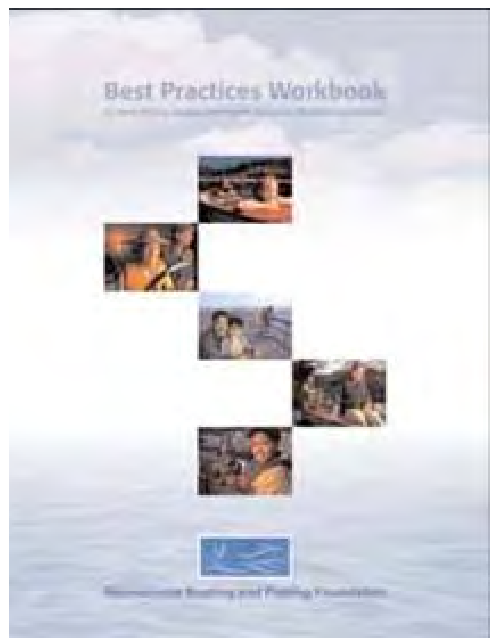
Best practices do not suggest *what* content you teach; but rather *how* you plan it, approach it, teach it, and evaluate it. Therefore, all the recommendations in this *Planning Guide* are applicable to nearly every sector within conservation education.

Best practices are meant to enhance, not replace, existing efforts.

The best practices in this *Planning Guide* do not constitute a “program” unto themselves. Rather, they are tools you can use to make your existing (or developing) programs more effective. Measuring effectiveness can be difficult; however, to be accountable for their programs, educators need to use appropriate evaluation tools and methods to measure intended outcomes. Furthermore, programs need to be designed and evaluated based on the best information research and practical experience has to offer.

Fortunately, today there are a variety of tools that can help conservation educators identify and achieve realistic goals and objectives for their programs. This *Planning Guide* is one such tool.

Getting the Most out of this *Planning Guide*



Although this *Planning Guide* was designed to be used as a stand-alone document, it can perhaps achieve its greatest effectiveness if used as a partner piece to the Recreational Boating and Fishing Foundation’s (RBFF) landmark document *Best Practices Workbook for Boating, Fishing and Aquatic Resources Stewardship* (RBFF *Workbook*). Chapter 9 (Aquatic Stewardship Education) of the RBFF *Workbook* is the foundation of this *Planning Guide*—expanded and adapted to cover stewardship within a broad conservation education perspective, not just stewardship of aquatic resources. For maximum benefit, review some or all of the RBFF *Workbook* (especially the first two chapters) before working on the specific information provided in this *Planning Guide*. (Access the RBFF *Workbook* at www.rbff.org.)

Worksheets

Worksheets provided within this *Planning Guide* and throughout the RBFF *Workbook* give you the opportunity to apply the best practice information to your own situation. By completing these as you go, you'll have the basis or blueprint for an outstanding stewardship program.

New versus existing program

This *Planning Guide* can help you achieve your goals and objectives whether you are just developing a conservation education program, or whether you've been at it for years. If you are starting a new program, consider reviewing all chapters within the RBFF *Workbook* in addition to this *Planning Guide*. That information will help you make informed decisions on how to plan and implement your program and help you avoid pitfalls others have learned the hard way.

Administrators of existing programs can benefit from the RBFF *Workbook* by reviewing the chapters to see how closely their programs meet the best practice guidelines. You may find valuable ideas you want to add, holes in your program you can fill, or scientific research to back up or justify what you've been doing all along or plan to do in the future.

Where are the footnotes and citations?

This *Planning Guide* is based on scientific research and empirical evidence. Nearly every paragraph could contain one or more citations from other sources. However, to make this document easier to read and use by practitioners, footnotes and citations have been omitted from the body of the text. Original sources of information compiled in this *Planning Guide* are listed in the Bibliography. Most can be found in the technical publication: *Defining Best Practices in Boating, Fishing, and Aquatic Resources Stewardship Education* (Fedler et al., 2001). This document is available at www.rbff.org . The Association of Fish and Wildlife Agencies, RBFF and their partners are deeply indebted to all who made this compilation possible.

Creating Stewards of Natural Resources

Most people involved in outdoor education of any kind will agree that, as expansion of human development puts more and more pressure on the natural world, stewardship of our natural resources is critically important.

But what does *stewardship* mean? People have different perceptions about what stewardship means, and understanding those perceptions is an important first step in ensuring that stewardship messages and programs are well designed and delivered.

For the purposes of this Planning Guide, **natural resource stewardship** is defined as:

Informed, responsible action/behavior on behalf of the environment and future generations.

In a recent study by the RBFF, researchers asked U.S. residents to describe what they think of when they hear the term "natural resource stewardship." Responses were fit into one of three perception categories:

- Ethical (e.g., protecting the environment for future generations),
- Ecocentric (e.g., preserving the environment in its natural state for its own sake), or
- Responsible Use (e.g., managing natural resources wisely to provide for human needs).

Results were clear that the public does not have one, universal perception of stewardship. Respondents often hold simultaneous multiple (and seemingly opposing) perceptions. Respondents generally expressed some level of agreement with all three perceptions, although frequency scores for *responsible use* and *ethical* perceptions tended to be higher than for *ecocentric* perceptions.

What is a Steward?

Who is the "good steward" you are striving to develop with your program? What characteristics does he or she have? As part of your program "outcomes" and "impacts," develop a list of characteristics a good steward would have. Make this part of your instructional objectives. Some examples are listed below, although your list may be different.

A good steward:

- Has knowledge of basic ecological concepts.
- Has knowledge of pertinent problems and issues.
- Feels a personal connection to natural resources.
- Has skill in employing systems-thinking and a systems-based approach to identifying, analyzing, investigating, and evaluating problems and solutions (thinks of the world as a system of interconnected, interacting parts; considers how affecting a part affects the whole).
- Seeks to understand all aspects of an issue (e.g., environmental, scientific, social, political, historical, and economic).
- Has acquired a knowledge of and demonstrated skill in using action strategies essential to sound stewardship.
- Reflects a sense of obligation to future generations and the earth.
- Recognizes the difference between intention and consequence (does the action truly have the desired effect?).
- Has an internal "locus of control" (the belief and/or feeling that working alone or with others, an individual can influence or bring about desired outcomes through his actions) and takes personal responsibility.
- Acts in an informed and responsible manner.
- Is willing and able to pass stewardship concepts on to peers and others.

The Role of Conservation Education

Conservation education is a process to help individuals acquire and learn to apply stewardship skills and build the capacities needed to enable them to make informed choices and take environmentally responsible actions.

The terms *ethics*, *morals*, and *character* are used interchangeably here to refer to the same concept—an internal system that determines socially acceptable behavior. *A stewardship ethic is at work when people feel an obligation to consider, not only their own personal well-being, but also that of their surroundings and human society as a whole.*

Researchers have come to three important conclusions about environmental and conservation education:

1. Ecological awareness and knowledge are not enough to cause long-lasting behavior changes, but they can provide a basis or readiness for learning and participation.
2. Ownership (a personal connection with one or more natural areas, and knowledge of and/or investment in problems/issues) is critical to responsible environmental behaviors.
3. Instruction and experiences intended to foster ownership and empowerment (a sense of being able to make changes and resolve important problems, and use critical issues investigation skills to do so) often permit individuals and groups to change their behavior.

The best practices in this *Planning Guide* are based on and flow from these critical conclusions.

Best Practices for Stewardship Education

The best practices in *Figure 1* are research-based guidelines for developing and/or maintaining an effective stewardship education program. Each practice is described in detail following the list.

Figure 1: Best Practices for Stewardship Education

Effective programs:

- Have organizational mission, strategic vision, education program goals, and instructional objectives aligned with one another.
- Address each stage of a participant's progression from entry-level to ownership, to empowerment, and then to environmentally responsible behavior.
- Consider the role that ethical principles and reasoning can play in supporting stewardship.
- Provide opportunities for individuals to have positive and repeated contact with the outdoors over a long period of time.
- Match the developmental stages of the learner.
- Consider the social context in which the education takes place and provide avenues to enhance social support for learners.
- Help learners consider all aspects of the natural resource issue of interest (including historical, social, scientific, political, ecological and economic) with a systems-based approach.
- Encourage long-term stewardship behavior.
- Structure effective curricula to give learners a well thought-out and data-supported sequence of stewardship opportunities.
- Evaluate all aspects of the stewardship education program to determine what is working and where improvement is needed.

Mission, Goals and Objectives

Best Practice: Effective programs have organizational mission, strategic vision, education program goals, and instructional objectives aligned with one another to reflect stewardship education.

There may not be anything you can do that will have a greater impact on your program's chances for success than to identify your mission, vision, goals, and specific objectives regarding stewardship. If you don't know why your organization or program exists, any parameters can define you, and if you don't know where you're going, any road will get you there. Think strategically to identify why your program exists, what sets you apart from similar organizations, what you want your program to accomplish, and get agreement from the others who will help you implement a plan to achieve it.

- The mission statement is a broad, philosophical statement about what the program hopes to contribute. It provides overall guidance for program goals and objectives. It answers the questions: Why is this program in existence? What is it trying to do?
- The vision statement paints a picture of where you want to be. It is clarifying and often inspirational.
- Goals help define how the program will help achieve the mission. Goals explain why you are using a particular program or approach.
- Objectives spell out what, specifically, you want to accomplish. Objectives should be measurable, and generally—though not always—are set up on a relatively short time-frame "As a result of this program, participants will be able to ______."

Sometimes, the differences between missions, goals, and objectives can get fuzzy, especially when you're working in partnership with other organizations. Also, goals and objectives may overlap. Regardless of what you call the various levels, it is critical to ask the questions:

"Why are we doing this program?" and "What do we want to accomplish with this program?"

Definitions and explanations of mission, vision, goals, and objectives and much more can be found in RBFF *Workbook* Chapter 1. If you have not completed a strategic plan or a goal-setting process, you should start there.

Worksheet 1: Mission, Goals and Objectives

How does your program define the characteristics of an environmental (or natural resource) steward?

List the characteristics.

List the mission, vision, goals, and objectives of your program related to stewardship.

Stewardship Mission Statement:

Stewardship Vision Statement:

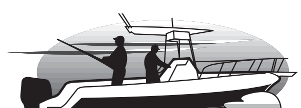
Stewardship Goal 1:
Stewardship Objectives:
Stewardship Objectives:

Stewardship Goal 2:
Stewardship Objectives:
Stewardship Objectives:

Do the mission, vision, goals, and objectives align to reflect stewardship education?

How could you refine them to better accomplish stewardship education?

Developing Stewardship



Best Practice: Effective programs address each stage of a participant's progression from *entry-level* to *ownership* to *empowerment* to environmentally responsible, stewardship behavior.

These three stages contribute to environmentally responsible behavior.

<u>Entry Level</u>

Entry-level characteristics include a person's environmental sensitivity and knowledge about ecology. When individuals have little knowledge of or sensitivity toward the environment, programs must provide information and teach basic ecological concepts.

Without some understanding about the living and nonliving components of the environment and how they influence one another, individuals most likely will not progress to the ownership stage. For example, when people learn about the source of their drinking water, especially a local river or lake, they are more likely to take interest in what happens to that body of water. Building awareness, relevance and meaningful threshold experiences will provide a good foundation toward the next stage, developing a sense of ownership.

Ownership Level

A sense of ownership occurs when individuals and groups personalize environmental problems and issues, and thus take ownership of them. These characteristics include a personal connection with one or more natural areas, an in-depth understanding of the issues, and personal investment in and identification with an issue.

Individuals and groups who develop knowledge and apply skills, investing their own time, energy, and resources in addressing a particular problem or issue, often develop a sense of ownership for that problem or issue. Research indicates that when people directly experience the destruction of natural areas with which they are intimately familiar, they develop a sense of ownership for those areas. A sense of ownership is a motivator to move on to the next stage, empowerment.

Empowerment Level

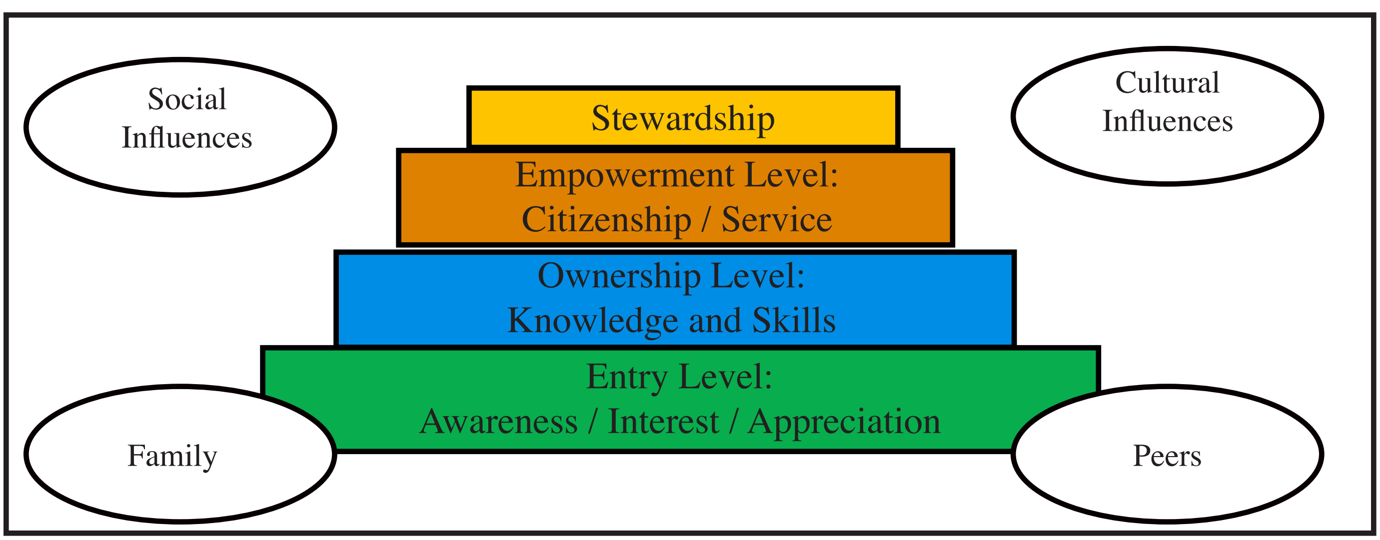
Empowerment experiences give people a sense that they can make changes and help resolve important environmental issues. Empowerment characteristics include perceived skill in using environmental action strategies and skills, knowledge of action strategies, an internal locus of control, the intention to act, and assumption of personal responsibility. To accomplish empowerment, programs should help participants develop guidelines and foster internal motivations for responsible behavior toward other people and the natural world.

Given enough time and experience in the empowerment level, people truly becomes stewards. They internalize stewardship—it becomes a part of them. Stewardship behavior results from a long-term process of learning through a series of developmental stages (*Figure 2*). It calls for a series of complementary education efforts and usually works best when learning takes place in a combination of formal and non-formal learning environments.

The Entry-level is the bottom of the pyramid in *Figure 2*. At this stage, learners are exposed to new themes, concepts, and activities in a positive way, consistent with the mission of the organization. The focus is on giving participants a "gee-whiz" experience that engages them and makes them want more. Program activities that characterize this stage include exhibits/demonstrations at fairs, TV shows, park visits and exhibits, school presentations, etc.

Entry-level experiences should lead participants to learn more about and acquire skills regarding the activity—as participants take some ownership in the issue, they move a step closer to the top of the pyramid. Examples of ownership-level opportunities include: park day camps; Becoming an Outdoors Woman; hunter education; boater education; fishing clinics; some Project WILD activities; etc.

Figure 2. Progression toward environmentally responsible (stewardship) behavior.



As knowledge and skills are obtained and as a participant gains more ownership in a topic or activity, he or she hopefully will be empowered to give service—to be a steward of natural resources. Showing participants the impacts their choices and actions have on interconnected natural and social systems can help them understand their place in these systems, which can aid and strengthen their empowerment and facilitate their willingness to adopt stewardship behaviors. It's important that learners have ample opportunities to "practice" stewardship behaviors at this stage. Examples of empowerment-level activities include: volunteers and friends groups; hunter and boater education instructors; Project WILD facilitators; Master Naturalists; student internships; advisory groups, etc.

When participants sustain service and citizenship behaviors over time, they become stewards. Examples of stewards include: long-term volunteers; those who actively participate in actions and community decision-making that benefit the environment and future generations; and safe, responsible and mentoring enthusiasts.

Obviously, the progression from entry level experience to becoming a steward does not occur in a vacuum. Myriad social and cultural factors influence participants every step of the way, and these need to be considered during program development.

Table 1 was adapted from materials developed by the Texas Parks and Wildlife Department. It is a practical application of the pyramid model in *Figure 2*. The text describes each stage from the perspective of the participant and gives tips for program planners.

Table 1. Characteristics of and recommendations for each stage in the progression toward environmentally responsible (stewardship) behavior.

Stage	What the Participant Experiences	What the Program Planner Should Do
Awareness/ Appreciation (Entry-level)	A "wow" threshold experience Exposure to new concepts and activities in positive ways, consistent with organizational mission. Short duration or limited scope.	Provide exposure or introduction to themes, concepts, and activities in positive ways, consistent with organizational mission. • Address the needs of the target audience. • Meet the audience "where they are." • Provide multiple, short/limited scope activities or events offered or repeated over time. • Includes most outreach and interpretation activities.
Knowledge/ Skills (Ownership)	In-depth learning/skill development. Critical thinking skills. Systems thinking skills. Greater time commitment. More involved activities/ programs. May involve certification, skill testing.	• Teach learning or skill development. Offer certifications, skill tests. • Address the needs of the target audience. • Meet the audience "where they are." • Foster partnerships for ongoing support of the learners' participation. • Include more complex/challenging curricula and programs that employ a systems-based approach to learning and investigating issues. • Engage participants by fostering stronger connections to their local natural places/natural resources.
Service/ Citizenship (Empower-ment)	Involvement in actual stewardship activity. Application of critical thinking skills—solve problems. Extended time investment. Commitment beyond self-interests.	Provide opportunities for participants to be stewards of the resource. • Encourage and facilitate extended time investment. • Promote volunteer programs and advisory groups. • Provide active ways for people to be involved in decision-making. • Offer opportunities to identify, investigate and address local environmental issues.
Stewardship	Life-long behaviors consistent with managing and conserving natural resources for sustainable use and enjoyment of present and future generations. Law-abiding citizens. Active decision-makers.	Provide support for individuals to develop and maintain life-long behaviors that are consistent with managing and conserving resources for the sustainable use and enjoyment of present and future generations. • Support activities/opportunities to remain involved. • Provide opportunities for active participation in decision-making and problem solving. • Provide opportunities to model good behaviors and be mentors. • Provide rewards, recognize and celebrate successes.

Worksheet 2: Developing Stewardship

How does your program address stewardship and how can you enhance:

- Entry-level characteristics (awareness, environmental sensitivity, attitudes)?
- Ownership characteristics (knowledge, personal commitment)?
- Empowerment characteristics (intention to act, in-depth knowledge, skill development)?

What programs in your local area can your program partner with to provide sequential and developmentally appropriate stewardship education experiences?

Ethical Principles and Reasoning

Best Practice: Effective programs consider the role ethical principles and reasoning can play in supporting stewardship.

Many of the behaviors that people exhibit are based on their personal ethics. So in addition to developing critical thinking and decision-making skills and empowering participants to take action, stewardship education should consider how an individual's ethics support natural resources stewardship. Programs should encourage development of personal ethical competence, including the:

- Sensitivity to recognize when a situation poses one or more ethical considerations.
- Knowledge of what behaviors are *legal* versus what behaviors might be *ethical* in a given situation.
- Willingness to contribute, participate and act in an ethical manner.
- Judgment to weigh various considerations where there are no laws or other guidelines for action.
- Humility to seek advice and additional knowledge to guide action.
- Ability to discern needs versus wants, and the various different contexts for decision-making.
- Awareness of and sensitivity for social and environmental justice.

The Institute for Global Ethics (www.globalethics.org) has identified a set of core ethical values that most people share: responsibility, fairness, honesty, respect, tolerance and caring. An education program should incorporate these core values and should look for ways to impart them to participants.

The Washington Department of Fish and Wildlife (WDFW) formally included ethics and the core values mentioned below into its 1999 Education Program Plan (O'Malley 1999).

An Individual's Code of Ethics for Protecting Washington's Fish and Wildlife

Responsibility

I want to be a responsible steward of fish and wildlife. I will learn what needs to be done to help preserve resources.
I will identify what changes I need to make in my personal actions to lighten my impact on the land, and I will make those necessary life-style changes.
I will donate a portion of my time and other resources to help improve fish and wildlife habitat.

Fairness

If I impact the habitat as a recreationist, commercial harvester or developer, I will choose the least-damaging option for fish and wildlife.
I will consider the effects of my actions on fish and wildlife when I use the land.
I recognize that I am a steward of the resources of the state, which belong to all people of the state and to future generations.
I recognize that I have an obligation to other users and future generations who are not here to represent themselves.

Honesty

I am honest with myself regarding my environmental actions and inactions.

Respect

I believe that all native fish, wildlife and plant populations have an intrinsic value in our landscape.

Tolerance

I recognize that each issue has differing points of view. While I may not agree with someone, I will allow him or her the right to express his or her side.

Caring

Fish and wildlife are critical to my way of life. I take the time to observe fish and wildlife and reflect on their condition.

WDFW's Code of Ethics in Education Program Development

In addition to helping to foster a code of ethics among Washington's citizens, department employees should adopt and use the following ethic in developing educational programs.

Responsibility

WDFW will identify the needs of fish and wildlife and make that information available to the public.
WDFW will identify issues and actions that impact fish and wildlife.
WDFW will recruit, train and direct volunteers to improve fish and wildlife habitats and populations and provide opportunities for people to help as individuals.
WDFW will advocate for the needs of fish and wildlife biodiversity and conservation.
WDFW will develop volunteer opportunities from the participant's point of view as well as from the department's point of view, to provide meaningful and enjoyable projects.

Fairness

Programs will be accessible to all.
Education efforts will include diverse audiences who currently impact wildlife or who may be encouraged to appreciate wildlife.

Honesty

Program materials will incorporate sound science; be accurate, timely and unbiased.
WDFW recognizes the limits of its ability to affect change.

Respect

Similar educational efforts by other agencies and organizations are appreciated and recognized.
WDFW will collaborate and cooperate with others.

Tolerance

Other points of view are respected.

Caring

The individuals who are helping to make a difference are appreciated, recognized and thanked.
We work as colleagues in a positive, encouraging atmosphere.
Shared work creates a common sense of community–we work with each others' strengths and help with weaknesses.

Worksheet 3: Ethical Principles and Reasoning

What is your program doing currently to help participants gain ethical competence?

What is your program doing currently to help participants identify and consider how the role of their personal ethics affect their behavior regarding natural resources?

How might your program help participants become more ethically competent?

How do your programs incorporate the core ethical values that most people share?
Responsibility:

Fairness:

Honesty:

Respect:

Tolerance:

Caring:

Positive and Repeated Contact

Best Practice: Effective programs provide opportunities for individuals to have positive and repeated contact with the outdoors over a long period of time.

Environmental sensitivity refers to an increased level of empathy toward the natural environment. Research shows that environmental sensitivity is developed through significant, positive contact with the outdoors over a long period of time. For example, adults who are leaders in conservation or involved in environmental careers usually share a common set of experiences involving the outdoors when they were youngsters.

To have a meaningful environmental ethic, a person must have a fundamental sense of affection for and identification with nature, and see himself as an integral, necessary member of the ecological community.

Unethical behavior often is associated with feelings of alienation from nature, which allows an individual to abuse and exploit the resource without feelings of personal guilt or long-term responsibility.

Hunting, trapping, fishing, hiking, wildlife watching and boating are outdoor activities that may help people develop deeply personal connections with nature. However, a 2005 survey completed for the RBFF found that participation does not automatically translate to stewardship. Participation alone did not increase "lifestyle" behaviors such as recycling, picking up litter, etc., but did slightly increase "activism" behaviors like beach or stream clean-up or letter-writing to politicians. Interestingly, people who boated or fished before age 5, and those who perceived fishing and "getting away to nature" as central to their lives, had higher rates of stewardship.

Newly acquired behaviors require follow-up support to maintain. Research clearly shows that, even when strong, short-term behavioral change occurs, long-term change is doubtful without continued reinforcement. For example, if you teach a group of second-graders about water pollution (or boating or fishing), but then never do anything more with them over time, it is not likely they will retain that learning. Even if they left your program with new skills, knowledge and motivation, it is not likely to last without follow-up support. Apprenticeship experiences that the learner shares over time with a personally significant person are one (but not the only) way to encourage and maintain that follow-up support.

As you plan your program, consider how you might provide opportunities to reach a given target audience in multiple ways (such as through formal and non-formal learning), as well as over a span of time. Realistically, this can be accomplished only through partnership efforts among schools, agencies, and non-governmental organizations.

Worksheet 4: Positive and Repeated Contact

How does your program currently provide positive contact with the outdoors?

List additional ways your program can provide positive contact with the outdoors.

What might you include in your program so participants are comfortable returning to the outdoors?

What might you include in your program to encourage participants to return to the outdoors?

How can your program provide multiple outdoor exposures over an extended time period? (Include opportunities to partner with others involved in outdoor education.)

Match Developmental Stages

Best Practice: Effective programs match the developmental stages of the learners.

Research shows that children think and learn differently from adults. As children develop, they reorganize and reconstruct their base of knowledge, replacing one set of assumptions with another. They usually accept new information at face value and rely on others to decide what is important to be learned.

Real learning can occur only when the task is useful to the learner and when he or she is psychologically ready. Teaching is the act of creating environments that allow and encourage learners to move from their current stage to the next–providing learning opportunities at a level just above a student's current cognitive level.

Develop your program to facilitate stage-relevant thinking that allows students to discover for themselves the logical connections between objects or events. Consider providing learners with choices about what to learn, because they tend to choose learning experiences appropriate for their cognitive levels. It also helps to provide students with many opportunities to explore the natural world and think about it within their various stages of intellectual development.

Adults learn differently from children. They usually decide for themselves what is important to be learned. They have a lot of life experience, and need to validate new information based on this experience and their personal beliefs. Sometimes this makes learning more difficult, as adults may have preconceived ideas about a subject that may not be "true."

Adults often tackle learning with the purpose of solving a problem or applying the information right away, as opposed to learning a new subject for its own sake. Therefore, learning occurs best when new information is relevant to learner experiences and situations. Adult learners like to contribute to the process, and like to be recognized for their contributions.

Developmental Stages of Children

Following is a generalized overview of developmental stages children go through from kindergarten through high school. Children develop at their own pace and all characteristics will not be observed in all children at the same age or same stage of development; however, the order of the stages does not change much. But it is important to remember that each child is unique.

Kindergarten-Grade 3. Five- to nine-year olds are optimistic, eager and excited about learning. They have short attention spans. Five-year-olds can sit still and listen for 10-15 minutes; nine-year-olds for 20-30 minutes. They still think and learn primarily by experience. Rather than simply giving instructions verbally, demonstrate the activity. They enjoy doing, want to be active and are always in motion. They are more interested in working on a project than completing it. Children this age need rules to guide their behavior, information to make good choices and decisions, and consistency once the rule is established. Provide small group activities and lots of opportunity for them to be active.

Grades 4-6. This is a period of slowed physical growth when a lot of energy goes into learning. Children 10-12 years old love to learn facts, especially unique ones, and they want to know how things work and what sources of information are available to them. They still think in terms of concrete objects and handle ideas better if they are related to something they can do or experience with their senses. They are beginning to move toward understanding abstract ideas. They still look to adults for approval and need guidance to stay on task and to achieve their best performance. They often are surprised at what they can accomplish, especially with encouragement from an adult.

Grades 7-9. Youth 13-15 years of age are in a period characterized by much "storm and stress." Although they look older, most remain emotionally and intellectually immature. Young teens move from concrete to more abstract thinking. They can be very self-conscious, and a smaller group usually is less intimidating. Help them get over inferiority complexes by concentrating on developing skills. They are ready for in-depth, longer learning experiences. They can begin to deal with abstractions and the future. "Fitting in" with friends is a controlling influence.

Grades 10-12. High school students are future-oriented and can engage in abstract thinking. Teenagers continue to be group-oriented, and belonging to the group motivates much of their behavior and actions. They have more time constraints such as work, social ties or sports interests. They want to help plan their own programs. Involve them in the planning process. Use the discussion method when working with them. Instead of providing detailed instructions for how to put something together, provide suggestions and several alternatives.

Adult Learning Styles

Adults vary tremendously in how they acquire knowledge, and no single theory on adult learning styles can adequately address the diversity of each learner. However, a synthesis of the research findings on adult learning is illustrated in the following:

Structure of Learning Experiences

1. Adults prefer flexible schedules that respond to their own time constraints.
2. Adults learn better when learning is individualized.
3. Adults prefer face-to-face learning rather than through the use of video or audio tools.
4. Adults benefit from interactions with others who differ in age, level of experience, and professional preparation.

Learning Climate

1. Adults seem to learn better in an atmosphere of mutual helpfulness and peer support.
2. Since adult learners are reluctant to take risks, the climate should be characterized by a sense of trust and acceptance.
3. Adults appreciate the invitation to express their views and are open to the views of others.
4. Adults bring clear expectations to the learning environment and expect instructors to accommodate these expectations.

Focus of Learning

1. Since adult learners are often focused on problem-solving or immediate application of their learning, they derive the greatest benefit from instructional methods that assist them in processing their experi ence through reflection, analysis, and critical examination.
2. Adult learners value teaching methods that increase their autonomy.
3. Adult learners are motivated by practical, how-to learning.

Source: Stroot, S., Keil, V., Stedman, P., Lohr, L., Faust, R., Schincariol-Randall, L., Sullivan, A., Czerniak, G., Kuchcinski, J., Orel, N., & Richter, M. (1998). Peer assistance and review guidebook. Columbus, OH: Ohio Department of Education.

Worksheet 5: Match Developmental Stages

To what age group(s) is your program targeted?

How have you customized your program to most effectively address age group/developmental stages?

Pre-Kindergarten:

Grades K-3:

Grades 4-6:

Grades 7-9:

Grades 10-12:

Adult:

How can you improve your program to better match the targeted developmental stages?

Social Context and Social Support

Best Practice: Effective programs consider the social context in which education takes place and provide avenues to enhance social support for learners.

Research clearly shows that the social context in which education takes place is at least as important as the methods by which stewardship concepts are taught. If not grounded within the particular community and cultural context of the learner, stewardship education will remain abstract, outside the scope of experience of the learner, inconsistent with cultural norms, and ultimately irrelevant.

Family, peers, and others in the community transmit their attitudes, beliefs, and values to participants in stewardship programs. Group members can encourage or discourage stewardship behaviors.

Stewardship programs are most effective in reaching behavioral goals if they incorporate parents, family, and neighborhoods as part of the learning community. Participants also can be given guidance on how to involve family and other peers in stewardship behavior. One of the premier illustrations for this technique is David Sobel's book, Place-based Education: Connecting Classrooms and Communities. The book offers research and practical examples of how schools and communities have incorporated the environment to facilitate learning, strengthen communities, and foster an appreciation for the natural world and a commitment to citizenship engagement (www.orionsociety.org).

The influence of the social context also may explain why the most effective service learning projects for schools are those that share information with the community (storm drain stenciling, flyers about control of exotic species, posters about how to recognize harmful situations, etc.).

How Communities Help Children Grow

Search Institute is a nonprofit organization whose mission is to provide leadership, knowledge, and resources to promote healthy children, youth, and communities. At the heart of this work is the framework of 40 Developmental Assets, which are experiences and personal qualities that young people need to grow up healthy, caring, and responsible. By considering how your subject matter can be used to help an individual develop these assets, you strengthen your program's overall impact on the individual's ability to become a steward.

External Assets
The first 20 assets focus on positive experiences young people receive from the people and institutions in their lives. Four categories of external assets are included in the framework:

Support - Young people need to experience support, care, and love from their families, neighbors, and many others. They need organizations and institutions that provide positive, supportive environments.
Empowerment - Young people need to be valued by their community and have opportunities to contribute to others. For this to occur, they must be safe and feel secure.
Boundaries and expectations - Young people need to know what is expected of them and whether activities and behaviors are in bounds and out of bounds.
Constructive use of time - Young people need constructive, enriching opportunities for growth through creative activities, programs, congregational involvement, and quality time at home.

Internal Assets
A community's responsibility for its young people does not end with external assets. There needs to be a similar commitment to nurturing internal qualities that guides choices and creates a sense of centeredness, purpose, and focus. Shaping internal dispositions that encourage wise, responsible, and compassionate judgments is particularly important in a society that prizes individualism. Four categories of internal assets are included:

Commitment to learning - the need to develop a lifelong commitment to education and learning.
Positive values - the need to develop strong values that guide their choices.
Social competencies - the need for skills and competencies that equip them to make positive choices, to build relationships, and to succeed in life.
Positive identity – the need for a strong sense of their own power, purpose, worth, and promise.
You strengthen your program's overall impact on the individual's ability to become a steward by integrating formation of developmental assets in your program design.

For more information on Developmental Assets, see the Search Institute's web site at www.search-institute.org/assets/.

Worksheet 6: Social Context and Support

To what communities or peer groups do your participants belong?

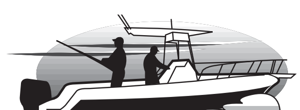
What are the primary social influences on your participants (family, peers, media, school, organizations, community norms, etc)?

How can you enlist socially influential groups to help achieve your program goals?

How have you incorporated peer activities into your program?

How can you help create social support for participants' actions?

Consider All Aspects of an Issue



Best Practice: Effective programs help learners consider all aspects of the resource issue of interest (including historical, social, scientific, political, and economic).

Effective programs help participants look at and review all sides of an environmental issue. It is just as important that individuals understand and weigh the historical, social, political, and economic aspects of an issue as it is for them to understand the scientific and environmental issue itself. Understanding and weighing different cultural and social values of stakeholders, and identifying and managing potential conflicts, is critical. For example, in Florida, management decisions regarding manatees could impact boaters, property owners, real estate, and the economy of several industries. Decisions that protect manatees but have minimal impact on other concerns likely will receive greater social support.

Worksheet 7: Consider All Aspects of an Issue

How does your program currently incorporate the influence of social, scientific, historical, political, and economic implications on environmental issue decisions?

How might you better address social, scientific, historical, political, and economic implications on environmental issue decisions?

How does your program help students consider all social, scientific, historical, political, and economic implications on environmental issue decisions?

How does your program encourage learners to consider compromise and consensus as they reach conclusions/solutions to issues?

Encourage Long-term Stewardship Behavior

Best Practice: Effective programs encourage long-term stewardship behavior.

Effective programs utilize strategies that result in long-term stewardship behavior. Many contemporary stewardship education efforts seem to take the form of short-term program modules or individual lessons. These piecemeal approaches need to be replaced or combined with in-depth and sustained programs. Program developers must be aware that some strategies provide for only short-term behavior changes.

Research indicates that goal-setting, commitment, and practicing positive citizenship behavior demonstration strategies can be effective in encouraging environmentally responsible behavior. Feedback, rewards, and penalties can produce short-term behavior change. However, when these consequence conditions are removed, people often immediately return to their original behavior patterns. Rewards and penalties may have a place in stewardship education, but by themselves, they are not likely to produce lasting behavior change or environmental citizenship.

Also, there is very little evidence that mass media campaigns that promote conservation—even *intensive* mass media campaigns—have appreciable effects. *Information alone is not enough to change behavior*.

Information and Education: A Big Difference

The Random House Dictionary of the English Language (1987) defines these words as follows:

Information – knowledge of a specific event or situation, derived from study, experience or instruction.

Education – the act or process of imparting or acquiring general knowledge, developing the powers of reasoning and judgment, and generally of preparing oneself or others intellectually for mature life.

So *how do you* change behavior? A body of knowledge from the social sciences called Community-Based Social Marketing has identified a series of tools that can be effective in achieving behavior change. Some of these tools include:

- Commitment – Get participants to *commit* to doing one or more target behaviors. Research shows that commitment—even to small behaviors—predisposes people to accepting bigger commitments over time.

- Prompts – People forget things. Provide noticeable, self-explanatory, positive prompts to remind them of their commitments (e.g., stickers to turn off lights).
- Norms – Make stewardship behavior the acceptable thing to do within your community. If stewardship is the norm in a community, it can have a strong influence on behavior, even among people who have not made a personal commitment.
- Communication – Use lively, engaging communications to get the word out about stewardship efforts. Select and understand specific target audiences, customize your information to those audiences, and deliver it through sources your audiences will find credible. Be cautious about using threatening messages (e.g., your water is polluted); these can be effective, but may lead to backlash or hopelessness among your audience.
- Incentives – Rewarding people for taking stewardship actions can be very effective, but if not coupled with other methods to encourage stewardship behavior, people may stop taking the appropriate action when the incentive is removed.

More information on each of these tools can be found in Appendix A. For more information on community-based social marketing, go to www.cbsm.com.

Equally important for obtaining long-term results, formal and nonformal educators must seek to understand and identify barriers and constraints to stewardship behaviors and then design programs to minimize or eliminate them.

Sample constraints include:

- Not feeling able to engage in or perform the activity or behavior due to lack of knowledge, skill, and/or confidence.
- Not having social support—others with whom to engage in or carry out the activity or behavior, or having others who are discouraging them from taking part.
- Lack of time, money, or access to a site to perform the activity.

To create long-lasting outcomes, stewardship programs must be sustained over time. There must be follow-up support to help maintain change. Even when strong, short-term behavioral change occurs, long-term change still is highly doubtful without continued reinforcement. Learners need in-depth educational experiences over time.

Service-learning

Service-learning can be a good method for building a pathway to long-term stewardship behaviors and citizenship skills.

Service-learning is a teaching and learning strategy that integrates community service with instruction and reflection to enrich the learning experience, teach civic responsibility, and strengthen communities. Communities help identify real problems and needs. Students are involved in the selection, design, implementation and evaluation of a project to address the problem or need. Teachers integrate the project into learning objectives. Through a careful process of building awareness, knowledge and skills, critical thinking, active service and reflection, students learn problem-solving and citizenship skills.

For example, if school students collect trash out of an urban streambed, they are providing an important community service as volunteers. But if they first observe the condition of the stream bed, decide a clean up is necessary, collect the trash, test the stream's water quality, analyze what they found and possible sources of the litter, then share the results with local residents along with suggestions for reducing pollution, they are engaging in service-learning. They are providing an important service to the community AND, at the same time, learning about water quality and laboratory analysis, developing an understanding of pollution issues, learning to interpret science issues to the public, and practicing communications skills. They may also reflect on their personal and career interests in science, the environment, public policy or other related areas.

The students' and community's investment of time, energy and problem-solving builds a sense of ownership with the area and empowerment as part of the solution. Note how closely Service-learning closely follows the Stewardship model described on page 9.

Adapted from the National Service-learning Clearinghouse. For more information see www.servicelearning.org/index.php.

Structured and Data-Supported Curricula

Best Practice: Effective programs are structured with curricula that give learners a well thought-out and data-supported sequence of educational opportunities.

It is important to provide learners a well thought-out sequence of opportunities to help them develop, build upon or practice, and eventually apply their awareness, knowledge, skills, and participation strategies. Utilize curricula that incorporate best practices and that will:

- Result in an in-depth knowledge of issues.
- Teach learners the skills of issue investigation and analysis as well as provide time to learn to apply these skills.
- Teach learners the citizenship skills needed for issue remediation and provide the time needed to learn to apply these skills.
- Provide an instructional setting that helps learners develop an internal locus of control.

The Association of Fish and Wildlife Agencies has identified a set of Core Concepts that support the North American Model of fish and wildlife management. The North American model is unique in the world in that fish and wildlife are public trust resources managed by governmental agencies. The public retains ownership and shared responsibility in the conservation of fish and wildlife resources. Stewardship of resources is a key objective for the North American Model.

Worksheet 8: Encourage Long-term Stewardship Behavior

How does your program:

- Get the learner to commit to doing one or more target behaviors?
- Prompt participants to participate in the target behaviors?
- Help create community norms for stewardship behaviors?
- Actively communicate with target audiences?
- Provide incentives to encourage stewardship behaviors?

What barriers prevent your participants from adopting stewardship behaviors?

How does your program help participants overcome these barriers and constraints?

How might your program better address these constraints?

The Core Concepts outline basic wildlife, ecological and wildlife management concepts. The concepts follow the vision of the AFWA Conservation Education Strategy for an informed and involved citizenry that:

1. Understands the value of our fish and wildlife resources as a public trust;
2. Appreciates that conservation and management of terrestrial and water resources are essential to sustaining fish and wildlife, the outdoor landscape, and the quality of our lives;
3. Understands and actively participates in the stewardship and support of our natural resources;
4. Understands and accepts and/or lawfully participates in hunting, fishing, trapping, boating, wildlife watching, shooting sports, and other types of resource-related outdoor recreation; and
5. Understands and actively supports funding for fish and wildlife conservation.

The full set of Core Concepts may be found in the appendices of this planning guide and may be used as a framework for conservation education programs.

Stewardship-oriented curricula that are project-driven can be set up so learners are adequately prepared to take each step. They also can be set up so teachers can prepare learners and guide them through the entire process. These strategies take into consideration the learner's developmental level(s), readiness to learn, prior knowledge and experience, and aptitude. These opportunities should be challenging, but within the participants' reach.

The North American Association for Environmental Education (NAAEE) has developed a series of excellent resources to assist educators with selecting, evaluating, and implementing stewardship-related curricula and programs. These tools are part of the *National Project for Excellence in Environmental Education*. Appendix B contains a brief description of these tools. All of the tools are available on NAAEE's website at www.naaee.org/programs-and-initiatives/guidelines-for-excellence/

Worksheet 9: Structured and Data-supported Curricula

How do your curricula give learners appropriate sequences of activities that build on one another?

How can your programs address the AFWA Conservation Education Core Concepts?

How can your program incorporate NAAEE's Guidelines for Excellence to ensure your curricula are effective?

Evaluation

Best Practice: Effective programs evaluate all aspects to determine what is working and what is not.

Probably the most neglected component of all educational programs is evaluation. Far too often programs are based, not on research evidence supporting their effectiveness or on accepted education theory, but only on what another program or agency is doing. And most evaluation efforts rarely report more than simple program outputs such as the number of participants at an event, participant satisfaction, and cost of delivery. What do these simple outputs tell you about how well you are educating your audiences? If you are asked what kind of impact your program is having on the knowledge, attitudes or behaviors of your audience, how will you answer?

The rarity of formal evaluations of the short- and long-term impacts of education programs is somewhat puzzling, given what evaluation has to offer. *Programs that implement formal evaluation are successful* (or on their way to success), because the evaluation process shows what works and what doesn't. By building on what works and changing or removing what doesn't, you continually work toward and/or achieve your program goals and objectives.

Evaluation provides tangible evidence that your education efforts are based on sound educational theory and are accomplishing agency/organizational goals and objectives.

Program evaluation is a complex endeavor that requires considerable attention to be done effectively. Evaluation should be considered during the program planning phase, not after program completion. RBFF *Workbook* Chapter 4 provides a good primer on basic program evaluation. RBFF also developed a stand-alone companion piece to the *Workbook* that covers program evaluation in detail. The Best Practices Evaluation Companion is available at www.rbff.org.

For more information on program evaluation of all kinds, including tools, resources, publications, and experts, visit the American Evaluation Association website at: www.eval.org

Case Studies

Appendix D offers a set of case studies on efforts that encourage stewardship. Check the AFWA web site for future additional case studies and updates.

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Appendices

Appendix A. Information on Community-Based Social Marketing

The following is excerpted from *Quick Reference: Community-Based Social Marketing*, by Doug McKenzie-Mohr, Ph.D. Additional information is available at www.cbsm.com.

Tools of Behavior Change

Community-based social marketing draws upon research in the social sciences, and particularly psychology, which has identified a variety of effective "tools" for promoting behavior change. These tools are often most effective when used in combination with one another.

Commitment

In a wide variety of settings people who have initially agreed to a small request, such as to wear a button saying they support the purchase of products with recycled-content, have subsequently been found to be far more likely to agree to a larger request, such as actually purchasing these products.

Why does seeking commitment to an initial small request work? There are likely two reasons. First, when people go along with an initial request, it often alters the way they perceive themselves. That is, they come to see themselves, for example, as the type of person who believes it is important to purchase products that have recycled content. Second, we have a strong desire to be seen as consistent by others. Indeed, our society emphasizes consistency and people who are inconsistent are often viewed negatively. As a result, if we agree to wear a button supporting the purchase of products with recycled content, it would be inconsistent not to purchase these products when we shop.

Commitment as a behavior change tool has been utilized in a variety of studies with often dramatic results (see Chapter 3 of the online guide at www.cbsm.com). In considering using commitment, follow these guidelines:

Emphasize written over verbal commitments. Written commitments have been found to be more effective in bringing about long-term change.

Ask for public commitments. When commitments are made public, such as by having names advertised in a newspaper, behavior change is more likely.

Seek commitments in groups. If possible, seek commitments from groups of people that are highly cohesive, such as a church group. The close ties of these individuals, coupled with the importance of being consistent, make it more likely that people will follow through with their commitment.

Actively involve the person. When people are actively involved, such as being asked to peer into an attic or hold a container to measure the flow-rate of a shower, they are more likely to see themselves as committed to the activity.

Use existing points of contact to obtain commitments. Wherever natural contact occurs, look for opportunities to seek a commitment. For example, when people purchase paint ask them to sign a commitment that they will dispose of any left-over paint properly, or, better yet, take it to a paint exchange if one exists.

Help people to view themselves as environmentally concerned. Help people to see themselves as environmentally concerned, and therefore more committed to other sustainable activities, by commenting on their past actions. For example, when someone comes to pick up a composter, ask them if they recycle. If they do, note that their recycling is evidence of their concern for the environment and that beginning composting is a natural way to reduce waste even more.

Don't use coercion. In order for this behavior change tool to be effective, the commitment has to be freely volunteered. That is, only ask for commitments when people appear to be interested.

See the cases studies and graphics at www.cbsm.com for examples of how to use commitment.

Prompts

Numerous behaviors that support sustainability are susceptible to the most human of traits: forgetfulness. People have to *remember* to turn off lights, check the air pressure in car tires, turn down the thermostat, select items that have recycled-content, etc. Fortunately, prompts can be very effective in reminding us to perform these activities (see Chapter 4 of the online guide at www.cbsm.com). Prompts are visual or auditory aids that remind us to carry out an activity that we might otherwise forget. Follow these guidelines when using prompts:

Make the prompt noticeable. In order for a prompt to be effective it has to first be noticed. Make sure that your prompt is vivid (a bright color) and eye-catching.

Make the prompt self-explanatory. All the information that is needed for someone to take the appropriate action should be conveyed in the prompt. For example, if you were using a prompt to increase the likelihood that people with odd-numbered street addresses would only water their lawns on odd-numbered calendar days (and vice versa), the prompt that you attach to an outside faucet could read: "water your lawn only on odd numbered calendar days."

Present the prompt in as close proximity as is possible to where the action is to be taken. If you want to encourage people to turn off lights upon leaving a room, for example, affix the prompt beside or directly on the light switch plate.

Use prompts to encourage people to engage in positive behaviors. Wherever possible, encourage positive behaviors. If you want people to purchase environmentally friendly products when shopping, place prompts throughout a store that bring attention to those items, rather than bringing attention to items that should be avoided. Not only is the encouragement of positive behaviors more likely to be supported by retail outlets (few would post negative prompts), but positive behaviors also make people feel good about their actions, which increases the likelihood that the actions will be carried out in the future.

See the cases studies and graphics at www.cbsm.com for examples of how to use prompts.

Norms

To date, few programs have emphasized the development of community norms that support people engaging in sustainable behavior. This lack of attention to norms is unfortunate, given the impact they can have upon behavior (see Chapter 5 of the online guide at www.cbsm.com). Norms guide how we should behave. If we observe others acting unsustainably, such as using water inefficiently, we are more likely to act similarly. In contrast, if we observe members of our community acting in a sustainable fashion we are more likely to do the same.

When considering including norms in programs you develop, keep the following guidelines in mind:
Make the Norm Visible. For norms to influence the behavior of others, they have to be aware of the norm. The very act of taking recyclables to the curbside, for example, communicates a community norm about the importance of recycling. Most sustainable activities, however, do not have the community visibility that recycling has, and norms that support the activity, therefore, have to be promoted more actively. Find ways to publicize involvement in sustainable activities, such as providing ongoing community feedback on the amount of water that has been saved by homes using water efficiently.

Use Personal Contact to Reinforce Norms. Research suggests that internalization of norms is more likely to occur as a result of personal contact. As a consequence, use personal contact as an opportunity to reinforce norms that support sustainable behavior.

See the cases studies and graphics at www.cbsm.com for examples of how to use norms.

Communication

All programs to foster sustainable behavior include a communication component. The impact of communications upon behavior can vary dramatically based upon how the communication is developed (see Chapter 6 of the online guide at www.cbsm.com). You must know your audience and have clearly defined goals for your communications. To develop effective communications, include the following elements:

Use Captivating Information. All persuasion depends upon capturing attention. Without attention, persuasion is impossible. Communications can be made more effective by ensuring that they are vivid, personal and concrete.

Know your Audience. All communications should be developed with your audience in mind. Before developing communications, you should have a firm sense of the attitudes, beliefs and behavior of your intended audience(s).

Use a Credible Source. The individual or organization that presents your message can have a dramatic impact upon how it is received, as well as upon subsequent behavior. Ensure that whoever delivers your message is seen as credible. Individuals or organizations tend to be viewed as credible when they have expertise, or are seen as trustworthy.

Frame your Message. How you present or "frame" your activity can impact upon the likelihood that people will engage in it. In general, you should emphasize the losses that occur as a result of inaction (e.g., from not insulating) rather than the savings that occur from action (e.g. insulating).

Carefully Consider Threatening Messages. While environmental issues lend themselves easily to the use of threatening or fearful messages, do so with caution. While the public needs to understand the implications of such serious issues as global warming, toxic waste, or ozone depletion, they also need to be told what positive action they can take if threatening information is to be useful. In short, whenever you contemplate using a threatening message consider whether you can at the same time present concrete actions that individuals can take to reduce the threat.

Decide on a One-Sided versus Two-Sided Message. One-sided communications are usually more persuasive with audiences who have little or no comprehension of an issue. As knowledge increases, however, two-sided messages are generally more persuasive.

Make Your Message Easy to Remember. All sustainable activities depend upon memory. People have to remember *what* to do, *when* to do it, and *how* to do it. Use prompts (Chapter 4) to assist people in remembering. Also develop messages that are clear and specific.

Provide Personal or Community Goals. Providing targets for a household or community to achieve can help to provide motivation for sustainable behavior.

Emphasize Personal Contact. Research on persuasion documents indicates that the major influence upon our attitudes and behavior is the people we interact with rather than the media. Create opportunities for people to talk to one another through programs such as block leaders, in which individuals from a neighborhood who already have experience in a sustainable activity, such as composting, speak to others who live close by. Through personal contact, provide opportunities for people to model sustainable behavior for one another, such as installing weather-stripping, and facilitate ongoing discussions in your community to allow social diffusion of new behaviors to occur.

Provide Feedback. Remember to provide members of your community with feedback about the effectiveness of their actions. Feedback has been found to have a positive impact upon the adoption and maintenance of sustainable behaviors.

See the cases studies and graphics at www.cbsm.com for examples of how to effectively communicate.

Incentives

Incentives have been shown to have a substantial impact on a variety of sustainable activities including waste reduction, energy efficiency and transportation (see Chapter 7 of the online guide at www.cbsm.com). They are particularly useful when motivation to engage in action is low or people are not doing the activity as effectively as they could. Gardner and Stern (1996) suggest the following guidelines in using incentives:

Closely Pair the Incentive and the Behavior. The closer in time the incentive is presented to the behavior it is meant to affect, the more likely that it will be effective.

Use Incentives to Reward Positive Behavior. Where possible, use incentives to reward people for taking positive actions, such as returning beverage containers, rather than fining them for engaging in negative actions, such as littering.

Make the Incentive Visible. For incentives to be effective, you need to draw people's attention to them. Consider using vivid techniques to make incentives noticeable (see Chapter 6 of the online guide at www.cbsm.com). Also, incentives can be made more visible by closely associating them with the behavior they are meant to effect, such as having people attach tags to their garbage bags in order to have them picked up in a user pay garbage disposal program.

Be Cautious about Removing Incentives. Incentives can be powerful levers to motivate behavior, but they can also undermine internal motivations that people have for engaging in an activity. If you plan to use an incentive to encourage a sustainable behavior, remember that if you elect to remove the incentive at a later time the level of motivation that existed prior to the introduction of the incentive may no longer exist.

Prepare for People's Attempts to Avoid the Incentive. Incentives such as separate laneways for multiple occupant vehicles can have a significant impact upon behavior. However, because these incentives powerfully reward one behavior (car pooling) and strongly punish another (single occupant driving), there is strong motivation to try to "beat" the incentive. In preparing incentives, give careful consideration to how people may try to avoid the incentive and plan accordingly.

Carefully Consider the Size of the Incentive. In arriving at what size of incentive to use, study the experience of other communities in applying incentives to motivate the same behavior.

Use Non-Monetary Incentives. While most incentives are monetary, non-monetary incentives, such as social approval, can also exert a strong influence upon behavior. Consider ways that social approval and other non-monetary incentives can be integrated into your program.

See the cases studies and graphics at www.cbsm.com for examples of how to use incentives.

Appendix B. National Project for Excellence in Environmental Education

The North American Association for Environmental Education (NAAEE) initiated the *National Project for Excellence in Environmental Education* in 1993. As part of this project, NAAEE has developed a series of Guidelines that set the standards for high-quality environmental education. Each of these resources was developed by a diverse team of professionals, and each has gone through a substantive review by thousands of professionals prior to publication.

Quality environmental education programs help develop an environmentally literate citizenry that can compete in our global economy. These citizens then have the skills, knowledge, and inclinations to make well-informed choices. They then will exercise their rights and responsibilities as members of a community.

The National Project for Excellence in Environmental Education resources include:
1. *Environmental Education Materials: Guidelines for Excellence*, recommendations for developing and selecting environmental education materials, and companion publication, *Environmental Education Materials: Guidelines for Excellence - The Workbook,* which leads educators, step by step, through the process of using the *Guidelines for Excellence*.

2. *Environmental Education Collection - A Review of Resources for Educators:* A four-volume series of guides to quality environmental education materials:

3. Environmental education learner guidelines: *Excellence in EE - Guidelines for Learning (Pre K-12),* and its companion piece, the *Guidelines for Learning (Pre K-12) - Executive Summary & Self Assessment Tool*, developed to support state and local environmental education efforts by setting expectations for performance and achievement in grades 4, 8, and 12.

4. *Guidelines for the Preparation and Professional Development of Environmental Educators*, a set of recommendations for the preparation and continuing education of teachers and other environmental educators.

5. *Nonformal Environmental Education Programs: Guidelines for Excellence*, a set of recommendations for the design and implementation of comprehensive nonformal environmental education programs.

6. The Guidelines Trainers' Bureau is a list of environmental educators who are able to give presentations to a variety of audiences on the *Guidelines* and how they can be used.

7. Adopt the Guidelines is an initiative to encourage organizations and agencies to promote and use the *Guidelines*.

For more information on the *National Project for Excellence in Environmental Education*, or to download and/or order these resources, go to:

www.naaee.org/programs-and-initiatives/guidelines-for-excellence/

Appendix C. Association of Fish and Wildlife Agencies Core Concepts

These Core Concepts reflect the knowledge, actions and values that further the North American Model and were developed as part of the Conservation Education Strategy.

Conservation Education Strategy Mission

To unify and strengthen conservation education efforts of the Association of Fish and Wildlife Agencies (AFWA) member agencies and partners in a manner that effectively advances the AFWA Strategic Plan and the North American Model of Fish and Wildlife Conservation.

Conservation Education Strategy Vision

Conservation Education becomes an effective, dynamic means for the Association of Fish and Wildlife Agencies (AFWA), its members and partners to achieve the AFWA Strategic Plan through an informed and involved citizenry that:

I. Understands the value of our fish and wildlife resources as a public trust.

II. Appreciates that conservation and management of terrestrial and water resources are essential to sustaining fish and wildlife, the outdoor landscape, and the quality of our lives.

III. Understands and actively participates in the stewardship and support of our natural resources.

IV. Understands and accepts and/or lawfully participates in hunting, fishing, trapping, boating, wildlife watching, shooting sports, and other types of resource-related outdoor recreation.

V. Understands and actively supports funding for fish and wildlife conservation.

Core Concepts for Conservation Education

Please Note: Order does not indicate relative importance.

I. Understands the value of our fish and wildlife resources as a public trust.

A. In North America fish and wildlife are public trust resources managed by governmental agencies.

1. Ownership of land does not convey ownership of wildlife.

2. Primary responsibility for most fish and wildlife management programs in North America is delegated to governmental agencies.

    a. State, provincial, and tribal fish and wildlife agencies are responsible for managing most fish and wildlife on public and private lands and water within their geographic jurisdictions.

        i. In Mexico, only the six northern border states have been given authority over resident wildlife. In other parts of Mexico, the federal government maintains jurisdiction over resident wildlife and all inland fisheries.

    b. Federal agencies, in cooperation with state and tribal agencies, are responsible for managing migratory fish and wildlife and federally listed threatened and endangered species, and for regulating wildlife trade. (In Canada, federal provincial and territorial agencies share responsibility for federally-listed endangered species.)

3. Non government organizations, businesses, and individuals play important roles as advocates and conservation partners with fish and wildlife agencies.

4. Since most wildlife live on private lands, private landowners play an important role in sustaining and improving habitat.

5. Many species move across state, provincial, and national boundaries, requiring interstate and international agreements and partnerships to manage these species.

B. Sustainable natural resources depend on the support of an informed and responsible citizenry.

C. Regulations are necessary for natural resources conservation.

1. The adoption and enforcement of regulations help conserve fish and wildlife resources.

2. Regulations allow for sustainable human use of fish and wildlife resources.

3. Regulations combat illegal trafficking and exploitation of fish and wildlife resources.

II. Appreciates that conservation and management of terrestrial and water resources are essential to sustaining fish and wildlife, the outdoor landscape, and the quality of our lives.

A. The health and well-being of fish, wildlife, and humans depend on the quality of their environment.

1. All living things depend on habitat that includes adequate and suitably arranged food, water, shelter, and space.

    a. Fish and wildlife numbers and species compositions are constantly changing based on a variety of natural and human-caused conditions.

    b. Loss and degradation of habitat are the greatest problems facing fish and wildlife; therefore, enhancing and protecting habitat is critical to managing and conserving them.

        i. Human changes to the landscape alter fish and wildlife habitat, changing the amount and type available.

        ii. Natural events alter the landscape, changing the amount and type of fish and wildlife habitats available. The effects of these events can be exacerbated by human changes to the landscape.

        iii. Fragmentation of habitats alters fish and wildlife distribution, movement, and composition.

2. The carrying capacity of an area determines the size of the population that can exist or will be tolerated there.

    a. Biological carrying capacity is an equilibrium between the availability of habitat and the number of animals of a given species the habitat can support over time.

    b. Cultural carrying capacity is the number and type of a given species that people will tolerate over time.

    c. Carrying capacity is dynamic and can change from season to season and from year to year.

    d. Regulated hunting, fishing, and trapping are important tools for preventing populations of certain species from exceeding the carrying capacity of their habitat.

3. Living things tend to reproduce in numbers greater than their habitat can support. The populations are limited by factors such as quantity and quality of food, water, shelter, and space. Other limiting factors may include disease, predation, and climatic conditions.

a. When a population becomes too large it may damage or destroy its habitat as well as habitat for many other species.

b. When a population exceeds the carrying capacity for an area, individuals of that population must out-compete others, emigrate, or die.

4. Fish and wildlife are present in nearly all areas of the earth. Each ecosystem has characteristic species.

   a. Climate, topography, and habitats influence species diversity.

   b. All living things are connected to each other and their environment.

      i. Plants and animals in ecological systems live in a web of interdependence in which each species contributes to the function of the overall system.

      ii. Energy from the sun is captured by plants and enters the animal world primarilythrough animals that eat plants.

      iii. Interactions between different fish and wildlife populations include competition, predation, and symbiosis.

   c. Each species occupies a niche within its environment.

5. Ecological succession is a process involving continuous replacement of one community by another.

   a. As succession occurs fish and wildlife found in that community will change.

   b. Natural events and human activities affect the rate and direction of succession.

6. Species differ in their ability to adapt.

   a. Fish and wildlife are adapted to their environment in ways that enable them to compete and survive.

   b. The more adaptable a species is, the more likely it is to thrive.

   c. Most species that are endangered or threatened in North America became so as a result of natural or human-caused changes in their habitat and their inability to adapt or adjust to such changes.

7. Conserving biodiversity is important.

   a. Isolated ecosystems and populations are more vulnerable to environmental change than well connected ecosystems.

   b. Native species are important to the stability of an ecosystem.

   c. Exotic/non-native species introduced into a community can change the dynamics of that community.

   d. Reintroduction of fish or wildlife into its former range may be possible if conditions such as suitable habitat and social acceptance exist.

8. Many species are indicators of environmental health.

B. Fish and wildlife can be conserved and restored through science based management which considers the needs of humans as well as those of fish and wildlife.

1. Fish and wildlife management practices are based on natural, physical, and social sciences.

2. Wildlife management practices involve population and habitat inventory and monitoring, research, manipulation of populations, protection and manipulation of habitat, regulation, and education.

   a. Wildlife populations are managed through such practices as regulated hunting, fishing and trapping; artificial propagation; stocking; and transplanting as well as predator and damage control.

   b. Enhancing and protecting healthy habitat are critical to managing and conserving fish and wildlife.

   c. Management of one species may affect other species within the same ecosystem.

3. Fish and wildlife management decisions consider biological, economic, social, and political factors.

4. Conservation of fish and wildlife habitats provides human health, recreation, aesthetic, and economic benefits.

III. Understands and actively participates in the stewardship and support of our natural resources.

A. A person's culture affects his or her view and use of fish and wildlife and their habitats.

1. People use fish and wildlife resources for food, shelter, clothing, and other products; practices that have continued throughout history.

2. Fish and wildlife provide a recreational focus for millions of people in North America.

B. The distribution and abundance of fish and wildlife provide significant economic benefits.

C. Everyone impacts fish and wildlife and their habitats and as human populations grow, impacts on natural resources increase.

1. Conversion of fish and wildlife habitat for human uses has altered the amount of land and water available for fish, wildlife, and associated recreation.

2. Humans are agents in the spread of invasive species and fish and wildlife diseases; and therefore, must take steps to avoid associated problems

D. Unlike other organisms, only humans have the capacity and responsibility to consider the effects of their actions on their environment.

1. People make decisions collectively and individually each day that directly and indirectly impact fish and wildlife and their habitats.

2. Decisions people make relative to fish and wildlife are based on their values, as well as knowledge of and experiences with those resources.

3.

IV. Understands and accepts and/or lawfully participates in hunting, fishing, trapping, boating, wildlife watching, shooting sports, and other types of resource-related outdoor recreation.

A. Regulated hunting, fishing, and trapping are important tools for managing some wildlife populations and habitats.

B. Fish and wildlife-based resources provide recreational benefits directly to participants and increase advocacy for conservation.

C. Responsible users of fish, wildlife, and the outdoors respect the rights and property of others.

V. Understands and actively supports funding for fish and wildlife conservation.

A. Within the U.S., state fish and wildlife management is funded primarily through hunting, fishing and trapping licenses and through federal excise taxes collected from the sale of hunting, target shooting, and fishing equipment and motor boat fuels.

1. Wildlife Restoration - Federal Aid in Wildlife Restoration (Pittman-Robertson Act [1937]) provides funding in the U.S. for the protection, restoration, rehabilitation and improvement of wildlife habitat, wildlife management research, hunter education, and the distribution of information produced by the projects.

2. Sport Fish Restoration - Federal Aid in Sport Fish Restoration (Dingell-Johnson [1950] and Wallop-Breaux amendment [1984]) is a parallel program to Pittman Robertson for management, conservation, restoration of fishery resources, access and boating and aquatic resource education.

B. Wildlife-based activities, such as hunting, fishing, viewing, and photography provide people with millions of days of outdoor recreation each year and generate billions of dollars for the economy.

C. The future of fish and wildlife conservation requires additional funding from a broad-based constituency.

Appendix D. Case Studies

Case Study: Connecting Classrooms and Communities

Great Brook Middle School in Antrim, New Hampshire has focused on using its school grounds and community as a place for learning for over 15 years. Antrim is a small, history-rich community nestled in a typical New Hampshire landscape with forested hills, wetlands, rivers and a few open fields. The support of two committed teachers and administrators, Antioch University New England and the Harris Center for Conservation Education have helped turn the entire school into a model for place-based education and as a launching pad for students to become good stewards and citizens.

Great Brook fifth grade teachers Ann Kenney and Barbara Black recognized that using the local environment as a teaching tool held lots of promise for enriching the curriculum and motivating students. With support from Harris Center staff, Kenney and Black developed the Wetlands project to take advantage of the namesake Great Brook which runs behind the middle school. Over the course of three years, students, teachers and community artists-in-residence designed and built a boardwalk and elegant gateway, and they wrote and produced a theater piece. A comprehensive fifth grade water-studies curriculum emerged. Once the students understood how to use pH monitors and test the water of the marshland behind the school, they were able to expand outward to other places in the watershed.

"We wanted the students to look at a stream environment that was different from the marsh behind the school," recalls Kenney. "No Name Brook (a small stream in nearby McCabe Forest) is steep and rocky and we thought the water quality and macro-invertebrates might be different, so we started making regular field trips to McCabe to expand our water studies curriculum."

Indeed, water testing in No Name Brook helped the students understand that even after you've seen one stream, you certainly haven't seen them all. This was just the beginning of using the community and local places to enliven the curriculum. The work at Antrim spurred the development of a program developed at Antioch University New England to provide additional opportunities to the school and community through the CO-SEED (Community-based School Environmental Education) project.

Through community forums and other connections, Great Brook continues to be involved in not only providing learning opportunities for students but also in providing projects that benefit the entire community. Projects have included developing entranceway gardens to the Hancock town offices, the creation of an historical walking guide to the center of Antrim as well as interpretive trails in McCabe Forest. The community curriculum connections at Great Brook have been going on for a substantial amount of time. Consequently, the students involved in the early years of the model have now become active and contributing members of their community.

Adapted from Place-Based Education, Connecting Classrooms and Communities, David Sobel, Orion Nature Literacy Series Number 4, 2004.

Case Study: Project CAT

Traditionally, field biologists at the Department of Fish and Wildlife have used telemetry procedures to locate cougars. A directional antenna, mounted on a fixed wing aircraft, picks up signals from a radio collar on a cougar. The technique does not pinpoint the location of the animal, but rather identifies a general location that is accurate to within a 250-meter radius of the actual animal. Flights are done every two weeks.

Cle Elum Senior High School students have been involved for several years with tracking cougar locations in western Kittitas County, using a different technique. Cougar radio collars have been outfitted with a global positioning system (GPS) unit, which provides 600 precise locations of each animal per year. Students participate in capturing the cougars by assisting the research biologist from the state Department of Fish and Wildlife. Students also assist with marking the cougars with an ear tag, and with radio collaring them. Students collect physical data including length, neck girth, chest girth, length and condition of canine teeth, and weight, and they collect blood and tissue samples for disease analysis and DNA profiling, respectively.

Students are also involved with radio-tracking animals from the airplane and from the ground. They plot coordinates of cougar locations on computer-generated maps of the study area, and use computer programs to calculate the space each individual occupies during each season and annually. They compare estimates of a cougar's use of space calculated from locations obtained during bi-weekly telemetry flights to those estimates from GPS data collected from data remotely downloaded from collars. They present these findings to classmates and at professional conferences.

The location information allows scientists to study the home range of the animal throughout the year.

Case Study: The Short-horned Lizard Studies

<u>Descriptive Studies</u>
Students at Waterville Elementary School in Washington State and local area farmers have worked together since 1999 to examine several aspects of short-horned lizard biology. With guidance from Karen Dvornich, the National Director for NatureMapping at the University of Washington, and Diane Petersen, a teacher at the elementary school, second graders have recorded and graphed food preferences for the local lizards, their habitat niches, and body characteristics such as length, weight, and color. Fourth graders at the school wanted to know what the short-horned lizard did over the winter; however a literature search and discussions with experts provided little data on hibernating lizards. The students then decided to build an enclosure in the schoolyard in an attempt to mimic conditions in the field. The students' work provided new descriptive insights into how the lizards behave during the change of seasons.

<u>Comparative Studies</u>
Some fourth-graders were interested in learning about home range and daily and seasonal movements of the lizards. Local area farmers brought information about lizard sightings to the students, and the students then identified and marked these locations on maps. While this is another type of descriptive inquiry, the students are currently planning a comparative study, based on this descriptive information. They are planning on fitting a number of lizards with radio collars and will collect data comparing the amount of movement they make during each of the four seasons.

<u>Correlative Studies</u>
Another study being planned at Waterville Elementary includes correlating lizard abundance with temperature and rainfall data, using tools such as geographic information systems (GIS) and spreadsheets. Once several years of data are collected, students will begin to make predictions about lizard abundance based on weather forecast information.

Case Study: Wetlands Estonoa Learning Center Project

St. Paul is a small southwest Virginia town of 1,000 nestled in a karst river valley having the Clinch River as its primary water source. The area's karst topography results from the dissolving and weathering of limestone mountains and has resulted in numerous caves and sinkholes.

In the spring of 1999, Appalachian ecology students were assigned a project. One student, Stevie Sabo, chose to do his project on a local, forgotten lake, Lake Estonoa. His project covered the lake's history, present condition, and his desire to see the lake returned to its former pristine state. The project piqued the interest of another student, Nikki Buffalow, in the fall of 1999. From her research, she discovered the "lake" was a wetland, and an existing law protected wetlands. With the hope of preserving Lake Estonoa, she began a quest to have the lake officially dubbed a wetland. She succeeded in this endeavor and began her mission to preserve the site. Because of her accomplishments, an interest began to grow and the entire Appalachian ecology and physics classes soon undertook the project. The students became known as Team Estonoa and the protection and conservation of Wetlands Estonoa became their mission. Semester after semester, it is with excitement, curiosity and high expectations that the team looks forward and ventures forth with the Wetlands Estonoa Learning Center Project. Team Estonoa members accept the responsibility for their project and realize this student directed project mandates hours of commitment from them as they participate in an innovative service-learning program. Seeing how enthusiastic and dedicated students are year after year, the Town of St. Paul is honored to be a partner in a project to preserve and protect the wetlands.

St. Paul High School is the smallest of Wise County's six high schools with 204 students, including grades 8-12. St. Paul High School is approximately in the center of the town. Wetlands Estonoa, our project's focus, is immediately adjacent to the school complex and acts as a buffer zone for the town's water source – the Clinch River. According to the Nature Conservancy, the Clinch River is the number one river for biodiversity in the United States. Although the Clinch has been recognized for its diversity, it is in dire need of protection.

During the past six years, Team Estonoa has built partnerships, pursued grant opportunities, performed hours of public outreach and maintained the outdoor classroom. To date, the team has removed many truckloads of trash and brush from Wetlands Estonoa, constructed a crusher run walk path, built and installed bridges, picnic tables, a floating dock, benches, and has constructed a beautiful learning center building. The building's stunning log exterior is complemented by the native stone on the basement and highlighted by the green metal roof. Inside, the walls are a textured bleached Spanish lace, and the hardwood floors match the kitchen cabinets.

Over the past six years, Team Estonoa students have amassed over 4,000 hours outside school time. Activities range from maintaining the center to presenting their project at the White House. Team members present to groups, host visitors, mop floors, mow and trim and have landscaped the grounds around the center. This area serves as a learning lab for area schools and citizens. The lab contains native Appalachian flora, interpretive signs, an observation area with a seating area and a rain garden. The rain garden controls storm water and serves as a teaching tool, which illustrates its value as a low impact method of storm water management. Throughout the past six years, the team has conducted wetlands workshops for area teachers and students, presented for/hosted college groups, conducted a two-week long environmental institutes. A few of the projects recognitions include being selected as a VA Naturally School (2000-2006), receiving the 2003 SeaWorld Environmental Excellence Award, and the 2004 EPA Presidential Environmental Youth Award. To date, the team has presented to/hosted over 200 groups, looks forward to hosting many more, and is excited about working with local watershed groups for the improvement of our environment.

Some groups that visit Estonoa require overnight accommodations, but due to the lack of lodging in the area, a bunkhouse is desperately needed to house these visitors. In past years, Team Estonoa has invited guests to stay with members in their homes, but this custom has posed quite an inconvenience. The presence of a bunkhouse would alleviate this problem and facilitate future weeklong environmental camps for students and educators.

Team Estonoa's dream is to revitalize the Lion's Den, a town-owned property located immediately adjacent to the wetlands that would be a convenient location for lodging.

Please visit our web site at – estonoa.org

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Case Study: What Do Horny Toads Have To Do With Education?

By Diane Petersen

When, after reading recent newspaper articles, my mother asked me "What do horny toads have to do with reading, writing and arithmetic?" I realized that many of you might have asked yourself the same question. In this article I will try to explain how horny toads, the Gates Foundation work, the state targets and testing, and Waterville elementary students all fit together.

We are in a very exciting time in education right now. In the Waterville School we have the honor, information and responsibility that come with dollars from the Gates grant. Gates' expectations include personalized work, using technology as a tool, and performance-based learning, among others. We also have, like all other schools in the nation, the job of making sure all students reach the state standards.

Our school has developed a mission statement that puts "personalization" at the center of our work. We know that different kids learn in different ways. When one of my students brought a mother horny toad and three babies to school on the first day and I saw the excitement of the other students and heard their questions and comments, I knew that this year the horny toad project could take on deeper meaning and integrate lots of subjects. This personal attachment of the students to the little critter would be the impetus for the first few weeks of our work together.

Science provides the structure for this project. We follow the steps of scientific inquiry as outlined in the state guidelines as we ask questions, set up research and report our results. Scientific inquiry begins with questions. Some of our questions can be answered by reading.

Before beginning our reading, each student predicted what they believed would be true about the lizard Then we read the available information on short horned lizards using field guides. Students learned to decipher some really tough reading material. We literally read the field guides word by word and sentence by sentence, taking notes, making drawings, looking up new words, acting out predator/prey relationships and recording our findings on charts. Students understood in personalized ways, then, what the book said about the day and the year and the characteristics of the pygmy short-horned lizard. Now they could compare that to what they had predicted.

Finally, the farmers brought in the real data and we will begin compiling that to compare it to what the field guide says. Past years have shown some discrepancies. Is it possible that 4th graders could add to the actual body of scientific knowledge about a common species? Indeed, groups of Waterville students have presented their findings to teachers and scientists in Idaho, Cle Elum and San Diego. Preparing for these presentations takes a great deal of organizing, writing and speaking practice.

In our elementary classes we have been teaching our students about the different purposes for writing. They are required to identify the writer's purpose for anything they read. To solidify this understanding of different purposes for writing, students were asked to write about horny toads in different ways: a description of a horny toad, an informative article about the lizard, a list of steps to follow in catching a horny toad, a paragraph to persuade someone to capture a lizard, an explanation of why horny toads look like dirt clods (camouflage). The intensity of interest in this writing was fascinating!

Personal projects are used to show student learning. Some students made posters to show the yearly or daily activities of horny toads. Some used art to show their knowledge. One wrote a song and is putting it to music on a CD with the help of our music teacher.

Data analysis through graphing is one of the state targeted skills for our students. In the horny toad project, students plot each sighting on a computer map (we had to learn township, range and section to do this), then put all the associated information on a large spreadsheet. From the spreadsheet, students select data to answer a question they have and use the computer to help them make a graph of the information. They spend time scrutinizing each other's graphs for clarity and then write an analysis of the results before these are put on our website along with samples of the other work they have done. The Arcview program, seldom used in elementary schools, is a powerful tool that the students can continue to use in more sophisticated ways as they move through the grades. This year, for the first time, we were able to add aerial photos of the farmer's lands as an overlay to the maps. Several farmers worked with students to plot very exact horny toad sightings.

We are currently working on gathering information for two questions that no one seems to really know the answer to: What is the actual range of the horny toad? and Where do horny toads go in the winter? The tracking project you read about in the Empire Press article will help us answer those two questions. Funds from the South Douglas Conservation District have allowed us to purchase some transmitters to begin our tracking next spring and fall.

We are fortunate to be partners with farmers, parents, the conservation district, Karen Dvornich from the University of Washington Naturemapping program and Dan Hannifous, Arcview expert. It was through Karen's efforts that GLEF heard about our project and decided to film it. The filming day gave our students an opportunity to use their manners and social skills as we greeted farmers and filmers. They were filmed doing real science with real people who have real jobs in the real world and the students were working as partners. I was so proud of their professionalism and knowledge. Now they feel like stars and that is a powerful thing!

So, Mom, and anyone else who was wondering, I hope that gives you an idea of how students can learn from horny toads or anything else that really interests them and how they can do it in a variety of interesting ways.

Virginia's Water Resources
A Tool for Teachers

Correlated to Virginia's Standards of Learning

Supporting the Chesapeake 2000 Agreement's goal to "*provide a meaningful Bay or stream outdoor experience for every school student in the watershed before graduation from high school.*"

Written by **Jeremy M. Lloyd** and **Kathleen M. Register**
Illustrations and graphic design by **Kevin R. Bopp**

Funding provided by the *Virginia Environmental Endowment*

Virginia's Water Resources
A Tool for Teachers

Information and activities for teachers to support interdisciplinary and problem-based teaching about watersheds, water quality, stewardship, and management issues.

Jeremy M. Lloyd
Assistant Professor of Science Education, Longwood University

Kathleen M. Register
Executive Director, Clean Virginia Waterways

Kevin R. Bopp
Illustrations and graphic design

These materials have been developed through a grant from the Virginia Environmental Endowment. Through a cooperative agreement with the Virginia Department of Environmental Quality's Office of Environmental Education and the Virginia Department of Education, they are available to all teachers in Virginia.

Dedication

This curriculum packet is dedicated to Virginia's teachers who are committed to providing meaningful Bay or stream experiences to all students.

Disclaimer
No responsibility is implied or taken for anyone who sustains injuries as a result of using the materials or ideas, or performing the procedures described in this book. Adult supervision is required when students are working on science activities and projects, as well as when students are on field trips. Use proper equipment and take all safety precautions. Use extra care with chemicals, hazardous chemicals, and when around water bodies. Follow all instructions that come with field test kits.

Possessing Animals
Virginia has regulations that restrict the number of wild, nongame fish, reptiles, amphibians, or aquatic invertebrates a person may possess. Basically, you can take (capture and keep live) up to 5 of any one species of reptile or amphibian. Any more than five, you need a permit. Once in captivity for 40 days the animal may not be returned to the wild. Any animal purchased from a supply house (such as tadpoles) may never ever be released. It is recommended that no wild animal be brought into the classroom for more than a day. Instead, the school grounds can be converted into a habitat and the animals allowed to come and go as they please. Also, it is illegal to possess threatened and endangered species unless you have a special permit. The goal of these regulations is to protect the populations of nongame species. In addition, there are fishing, hunting, and trapping regulations for game species. It is important for all teachers to know the law. To learn about current regulations, call your local office of the Virginia Game and Inland Fisheries (DGIF), or visit the DGIF website (*www.dgif.state.va.us/fishing*) and select "Virginia Freshwater Fishing Regulations," and then "Nongame Fish, Reptile, Amphibian, and Aquatic Invertebrate Regulations."

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Clean Virginia Waterways, affiliated with Longwood University's Department of Natural Sciences, is a statewide, nonprofit organization dedicated to improving the cleanliness and quality of Virginia's waterways by promoting citizen stewardship.

About the Illustrator and Graphic Designer

Kevin R. Bopp, a graphic designer from Richmond, received a Bachelor of Arts degree from Longwood University in 2003 with a concentration in graphic design. Mr. Bopp has served as an intern for Longwood University's public relations department, the Longwood Center for The Visual Arts, and Clean Virginia Waterways. Through these internships, he designed and helped produce various printed pieces such as the alumni magazine, invitations, a variety of brochures for art exhibitions, and these curriculum materials. After pursuing a graduate degree in communication design, Mr. Bopp plans a career in graphic design.

Acknowledgements

The following people and institutions have generously contributed their expertise and time to reviewing or directing portions of this publication, and the authors thank them very sincerely:

- Thomas Aley, Ozark Underground Laboratory
- Samuel Austin, Forest Hydrologist, Virginia Department of Forestry
- Diane Barns, Coastal Program, Virginia Department of Environmental Quality
- Joyce F. Brooks, Citizen Monitoring Coordinator, Virginia Department of Environmental Quality
- Stacey T. Brown, Virginia Save Our Streams
- Dixon M. Butler, Chief Scientist, GLOBE program
- Alecia Daves, Piedmont Soil and Water Conservation District
- Dan Downey, James Madison University
- Delores Dunn, Secondary Instruction Science Specialist, Virginia Department of Education
- Alix Fink, Assistant Professor of Biology, Longwood University
- Mark Fink, Lecturer in Science Education, Longwood University
- James Firebaugh, Assoc. Director, Middle /Science, Virginia Department of Education
- Patrick P. Fleming, K–12 Education Coordinator, Virginia Office of Environmental Education, Virginia Department of Environmental Quality
- James Galloway, Professor of Environmental Sciences, University of Virginia
- Fran Geissler, Community Watershed Stewardship Manager, Division of Soil and Water Conservation, Virginia Department of Conservation and Recreation
- Suzie Gilley, Project WILD Coordinator, Virginia Department of Game and Inland Fisheries
- Lorelei Hartman, graduate student, Longwood University
- David Hubbard, Geologist Specialist for Karst and Applied Geology, State of Virginia
- Nelson LaFon, Virginia Department of Game and Inland Fisheries
- Rachel Loveday, Longwood University graduate student and Clean Virginia Waterways intern
- Mary Ann Massie, Office of Water Resources Management, Virginia Department of Environmental Quality
- Gerald P. McCarthy, Executive Director, Virginia Environmental Endowment
- Laura McKay, Coastal Program, Virginia Department of Environmental Quality
- Robert Northington, student, Longwood University
- Ron Ohrel, Species Conservation Specialist, National Wildlife Federation
- Robin Patton, Office of Water Resources Management, Virginia Department of Environmental Quality
- Christopher M. Register, Assistant Professor of Art, Longwood University
- Ann Regn, Director, Virginia Office of Environmental Education, Virginia Department of Environmental Quality
- Eric M. Rhoades, Elementary Science Specialist, Virginia Department of Education
- Seba B. Sheavly, Director, Office of Pollution Prevention and Monitoring, The Ocean Conservancy
- Keith Tignor, Office of Plant Protection, Virginia Department of Agriculture and Consumer Services
- Don Waye, Senior Water Resources Planner, Northern Virginia Regional Commission
- Rick Webb, Department of Environmental Sciences, University of Virginia
- James Wesson, Virginia Marine Resources Commission
- Lisa Wilkins, graduate student, Longwood University
- Pam Wright, Region 8 Governors Best Practice Center, Farmville
- Carol Zokaites, Project Underground, Virginia Department of Conservation and Recreation

In addition, we thank the following people who also contributed to this packet in essential ways: Laura Mossler, Christopher Mossler, Jon Willcox, Nic Willcox, Lucus Munson, Christian Lehman, Mary Prevo, and Lynn Ferguson.

And finally, we thank the teachers who attended workshops at Longwood University in the summer of 2002 for their excellent feedback on the early formation of this packet of materials, and the Virginia Environmental Endowment for funding the production of these materials.

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Section 1

Introduction to Teaching Virginia's Water Resources

CONTENTS

Introduction to Teaching Virginia's Water Resources

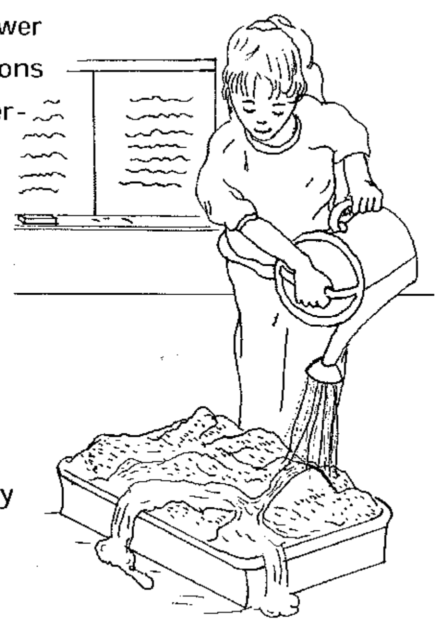
This curriculum packet was created with three broad goals in mind.

1. To support K-12 teachers in Virginia as they teach students material from the Virginia Standards of Learning.
2. To help meet the stated goals of the Chesapeake 2000 Agreement, signed by the states surrounding the Chesapeake Bay and by the District of Columbia.
3. To provide K-12 teachers with useful resources for teaching students a greater appreciation of our important water resources.

There are already many other excellent curriculum materials for teaching about water. We have tried to produce a packet that will stand beside these and be as Virginia-specific and teacher-friendly as possible.

Our curriculum packet is organized by the Virginia Standards of Learning (SOL). The main sections of the packet include a mixture of content chapters and lesson plans. The content chapters provide specific information about water resources and about teaching strategies. Alongside these content chapters are new lesson plans written for Virginia's classroom teachers.

Both the content chapters and the lesson plans are written to support the Virginia SOL and also the Chesapeake 2000 Agreement. The Chesapeake 2000 Agreement (described later in this Introduction) recommends K-12 students carry out meaningful field investigations, including preplanning, investigation, and analysis and communication of findings. We have also written our materials using the inquiry-based approach to teaching science SOL. Our lessons are designed for students to answer questions. The lessons can be more teacher-directed or more student-directed depending on teacher preference, but students will prepare, investigate, then discuss and apply what they are learning.

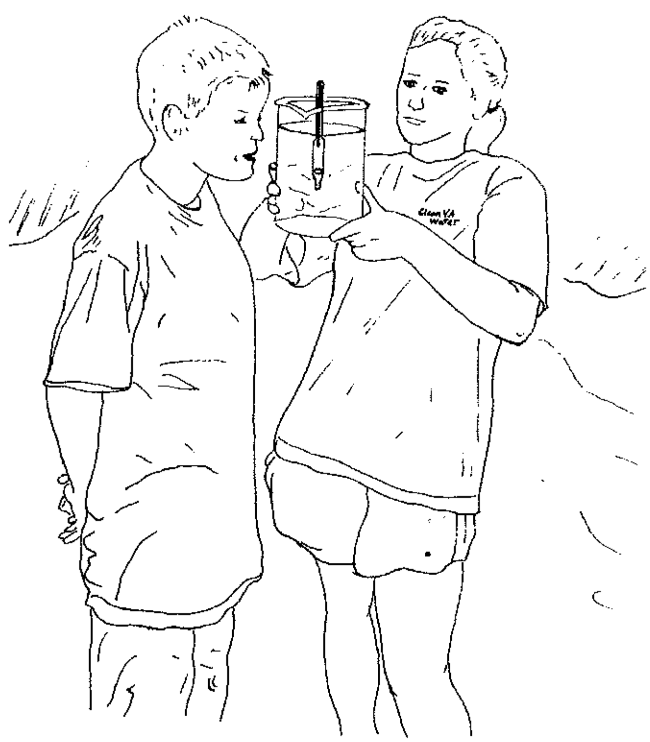


Following this Introduction section of the curriculum packet is a section listing specific local water resource issues for Virginia. The listing is organized by Virginia counties. The main part of the curriculum packet is made of five sections, each dealing with a different aspect of water resources and corresponding SOL. At the end of the packet is a short section describing some other curric-ulum materials available for teaching water resources and correlating available materials with the SOL. Appendices include an extensive glossary of water terms and information about obtaining materials and other resources.

A Tool to Help Students Learn About Water and Succeed with the SOL...

This curriculum packet is organized according to the Virginia Standards of Learning (SOL). Four of the five main packet sections corre spond to different groups of Science SOL. The last main section of the packet is directed to the History and Social Science SOL. Each of these five packet sections contains a mix of content chapters and lesson plans relating to the targeted SOL.

One of the sections, "How Can We Understand Our Water Resources?" is written to support the science SOL dealing with "Scientific Investigation, Reasoning, and Logic." This section contains content chapters and lesson plans dealing with the science process skills, data analysis, and experimental design. The lessons in this section also teach about water resources. The other sections target different content SOL relating to water resources. Lessons in these sections also emphasize students using science process skills appropriate for the grade level of that lesson. As mentioned above, the whole curriculum packet reflects broad recommendations that students learn by carrying out meaningful field investigations and using an inquiry approach.



The following table lists the content chapters and lesson plans in each of the main sections of this curriculum packet. The sections each contain a short introductory chapter describing the target SOL for that section in more detail.

PACKET SECTION & SOL CATERGORY	CONTENT CHAPTERS AND LESSONS
"How Can We Help Protect Our Water Resources?" SOL Strand: Resources	Litter and Debris in Our Waterways Endangered Aquatic Species Lesson 1 – Classifying Aquatic Debris (Science SOL – 1.8, 3.10) Lesson 2 – Helping Clean Up a Waterway (Science SOL – 6.9)
"How Can We Help Maintain Our Water Supply?" Earth Science & Environmental Science SOL	The Importance of Groundwater Lesson 3 – Conserving Water (Science SOL – 6.5) Lesson 4 – Nitrate Levels in Wells (Science SOL – ES.7, ES.9)
"How Healthy Are Our Waterways?" Life Science & Biology SOL	Water Quality Monitoring Lesson 5 – Evaluating a Stream (Science SOL – 6.7, LS.7, LS.11, LS.12) Lesson 6 – Restoring a Stream (Science SOL – 6.7, LS.12) Lesson 7 – Optical Brighteners and Water Quality (Science SOL – BIO.9)
"How Can We Understand Our Water Resources?" Scientific Investigation, Reasoning, and Logic SOL	Teaching the Science Process Skills Analyzing Experimental Data Designing an Experiment Lesson 8 – Observing a Stream (Science SOL – K.2, K.4, 1.8, 3.6, 3.10) Lesson 9 – Comparing Water Quality Data (Science SOL – ES.2) Lesson 10 – A Scientific Cleanup (Science SOL – BIO.9)
"What Relationships Exist Between People and Water?" Social Science SOL	Lesson 11 – Mapping a Watershed History (Science SOL – 4.8 Social Science SOL – VS.1) Lesson 12 – Making Decisions for Water Use (Science SOL – 6.5, 6.7, 6.9, LS.12 Social Science SOL CE.1, CE.7)

Although all the lessons are adaptable for different grade levels, each lesson plan in the curriculum packet has been written for use primarily at one grade level. The following table lists the lessons according to the recommended grade level.

GRADE LEVEL	LESSONS IN THIS CURRICULUM PACKET
Grade 3	Lesson 1 – Classifying Aquatic Debris Lesson 8 – Observing a Stream
Grade 4 Virginia Studies	Lesson 11 – Mapping a Watershed History
Grade 6	Lesson 2 – Helping Clean Up a Waterway Lesson 3 – Conserving Water Lesson 5 – Evaluating a Stream
Grade 7 Life Science	Lesson 6 – Restoring a Stream
Grade 7 Civics and Economics	Lesson 12 – Making Decisions for Water Use
Grade 9 Earth Science	Lesson 4 – Nitrate Levels in Wells Lesson 9 – Comparing Water Quality Data
Grade 10 Biology	Lesson 7 – Optical Brighteners and Water Quality Lesson 10 – A Scientific Cleanup

As stated above, each section of the curriculum packet is organized around a group of science SOL or, for one of the sections, a group of social science SOL. Those SOL are the main focus for that section of the packet and also the lesson plans within that section. However, each lesson plan was written to be interdisciplinary in nature. Each lesson lists related SOL in all the areas of science, social science, mathematics, English, and computers and technology. Using an interdisciplinary teaching approach is discussed later in this Introduction.

Designing a Meaningful Field Investigation...

The Chesapeake 2000 Agreement calls for all students to learn more about the Chesapeake Bay through meaningful field experiences investigating water resources during their K-12 schooling. This recommendation applies to all students living within the Chesapeake Bay watershed and also those Virginians outside of the Bay watershed. Meaningful field experiences are considered to have three separate components.

1. Advance planning
2. Field work
3. Analysis and communication of findings

A primary goal of our curriculum packet is to support teachers in providing students with such meaningful field investigations. Each of the lessons was written with the hope that teachers will involve students in simple field investigations. As much as possible, these field investigations will be carried out locally, close to the school and even on the school site itself. In addition, many of the lessons in this packet present opportunities for students to carry out or participate in action projects in their school or their community. For younger students, these projects can be carried out as class projects. Older students may extend projects as individual investigations.

The Chesapeake 2000 Agreement

The Chesapeake 2000 Agreement is intended to protect and restore the Chesapeake Bay ecosystem. The Chesapeake Bay is North America's largest and most biologically diverse estuary and home to more than 3,600 species of plants, fish, and animals. The Chesapeake 2000 Agreement was agreed and signed by Virginia, Maryland, Pennsylvania, and the District of Columbia, as well as The Chesapeake Bay Commission and the U.S. Environmental Protection Agency. The Chesapeake 2000 Agreement is a reaffirmation of earlier agreements in 1983 and 1987 that established the Chesapeake Bay Program partnership.

The Chesapeake 2000 Agreement makes specific recommendations for achieving the overall goals of protecting and restoring the Chesapeake Bay. These recommendations involve participation of everyone in the Bay watershed including businesses, individuals, and schools. The following table summarizes the Chesapeake 2000 goals and focus areas for recommendations. Full details of the Chesapeake 2000 Agreement and the different recommendations can be found at the Chesapeake Bay Program web site (*www.chesapeakebay.net/agreement.htm*).

Chesapeake 2000 Goals	Specific Focus Areas
Living Resource Protection and Restoration Restore, enhance and protect the finfish, shellfish and other living resources, their habitats and ecological relationships to sustain all fisheries and provide for a balanced ecosystem.	• Oysters • Exotic Species • Fish Passage / Migratory and Resident Fish • Multi-Species Management • Crabs
Vital Habitat Protection and Restoration Preserve, protect and restore those habitats and natural areas that are vital to the survival and diversity of the living resources of the Bay and its rivers.	• Submerged Aquatic Vegetation • Watersheds • Wetlands • Forests
Water Quality Protection and Restoration Achieve and maintain the water quality necessary to support the aquatic living resources of the Bay and its tributaries and to protect human health.	• Nutrients and Sediments • Chemical Contaminants • Priority Urban Waters • Air Pollution • Boat Discharge
Sound Land Use Develop, promote and achieve sound land use practices which protect and restore watershed resources and water quality, maintain reduced pollutant loadings for the Bay and its tributaries, and restore and preserve aquatic living resources.	• Land Conservation • Development, Redevelopment, and Revitalization • Transportation • Public Access

Stewardship and Community Engagement Promote individual stewardship and assist individuals, community-based organizations, businesses, local governments and schools to undertake initiatives to achieve the goals and commitments of this agreement.	• Education and Outreach • Beginning with the class of 2005, provide a meaningful Bay or stream outdoor experience for every school student in the watershed before graduation from high school. • Continue to forge partnerships with the Departments of Education and institutions of higher learning in each jurisdiction to integrate information about the Chesapeake Bay and its watershed into school curricula and university programs. • Provide students and teachers alike with opportunities to directly participate in local restoration and protection projects, and to support stewardship efforts in schools and on school property. • Community Engagement • Government by Example • Partnerships

USING AN INQUIRY APPROACH TO TEACHING...

The lessons in this curriculum packet have been written following an inquiry approach to teaching science. Each lesson is written around a focus question that students work to answer. The role of the teacher is to present information, lead students in answering the focus question, guide students to learn the lesson material, and make assessments of students progress to lesson objectives. One of the most important skills for a teacher using an inquiry approach is being able to prompt students with a variety of questions throughout the learning process. This skill is discussed further in the next part of this Introduction, and a selection of possible prompting questions is included in each lesson plan.

The inquiry approach for teaching science is one of the foundations of the recommendations contained within the National Science Education Standards published by the National Research Council in 1996. The essence of inquiry-based teaching is for students to develop answers to questions, using evidence and critical thinking to support their answers, and then to practice ways of communicating their answers and conclusions. Inquiry-based instruction can range from teacher-directed "structured inquiry," in which the teacher provides a question and procedure for students; through "guided inquiry," with the teacher providing the question but having students help develop the procedure to be followed; to student-directed "open inquiry," in which students are free to raise and answer their own questions. Students will use open inquiry when carrying out projects. Many shorter investigations will be structured inquiry or guided inquiry.

According to a recent article in The Science Teacher magazine, any version of inquiry-based instruction should include students participating in the following five activities (Martin-Hansen, 2002).

1. Asking a scientifically-oriented question
2. Using evidence to answer the question
3. Building an explanation based on evidence
4. Using critical thinking to relate the explanation to existing scientific knowledge
5. Communicating and justifying the explanation

Teacher input and student ownership in each of the five steps will vary depending on the style of inquiry that is being used.

The well-known learning cycle method is an excellent inquiry-based approach for teaching new concepts in science. The basic learning cycle model includes the following three steps.

1. Concept Exploration
2. Concept Introduction
3. Concept Application

Students gather concrete experience of the topic of study by initial exploratory activities. Only then does the teacher formally introduce the concept to the students, along with new vocabulary. The third step of the learning cycle has students working to apply the new concept and relate it to previous knowledge by carrying out new activities of different kinds. In addition to the basic three steps of the learning cycle, an initial "Engagement" step is useful, and a fifth step of "Evaluation" of student learning can be carried out throughout. The Engagement step involves capturing the students' attention and interesting them in a question to be investigated. Using all of these five steps is the modified learning cycle model known as the 5Es model.

1. Engagement
2. Exploration
3. Explanation
4. Elaboration
5. Evaluation

Teachers using the lessons in this curriculum packet may teach the lessons in a more teacher-directed or more student-directed style depending on their preference and circumstances. The lessons are written so that, in either case, students will work through the five activities described above that are common to all forms of inquiry. The lessons are also written so that students will complete learning cycles of exploration and discussion, followed by concept development, followed by concept application. The inquiry steps parallel the steps of meaningful field investigations called for in the Chesapeake 2000 Agreement.

Asking Students Questions...

Beisenherz, Dantonio, and Richardson wrote a Science Scope article in 2001 about the importance of teacher questioning when using learning cycles to teach concepts to students.

They described how good questioning by the teacher can focus students' thinking and help them engage with the new concepts to be learned. They recommended a questioning strategy of four questions to help students see patterns and understand the significance of their observations when carrying out a series of activities to explore a new concept.

1. What do you think will happen if ...?
2. What did you observe?
3. How can you explain your observations?
4. How are your observations in this activity like the observations you made in the last activity?

In their article, Beisenherz, Dantonio, and Richardson suggest that "one of the primary reasons that inquiry teaching doesn't work is because teachers fail to cue and sequence the thinking students must do to form concepts [by using] instructional cues, such as specific activities and core questions."

Each of the lessons in this curriculum packet contains a selection of questions for teachers to use in prompting students as they work through their learning activities. Five different kinds of questions are included as recommended by Penick, Crow, and Bonnstetter in a 1996 article in The Science Teacher magazine. They suggest a "HRASE" model for asking questions. In this model, teachers first ask easier, descriptive questions, and work towards harder questions requiring higher-level thinking. All students should be able to answer initial questions, to build up their confidence and allow them to successfully begin the path to new concept development. Each of the five question types is briefly described below.

- *History Questions*

  Ask students questions about what they have done. Even though these are descriptive questions, they should not be yes-no questions.

  Examples: What did you do? What happened? What made you think of doing that?

- *Relationships Questions*

  Ask students to compare their activities, findings, or ideas with other activities, outcomes, and students. Describing relationships leads to recognizing patterns, a major initial step in ultimately devising explanations of phenomena.

  Examples: How does this compare to (other students' outcomes or other experiments)? Where have you seen something like this before? What seems to be a common element in all your findings?

- *Application Questions*

  This requires more of the student and also reveals more of the student's depth of understanding.

  Examples: How could you use this? What problems could this solve? Where can we find other examples of this?

- *Speculation Questions*

  Students must go beyond the data and given information, to new and unusual situations. They must become creative.

  Examples: What if you (changed, eliminated, added, mixed, waited)? What would it take to prove that? If you wanted to prevent that from happening, what would you do?

- *Explanation Questions*

  Ask students to communicate an idea, process, or theory to clarify both the nature of a phenomenon and how it occurs. It can be useful to ask them to limit their vocabulary to do this, or eliminate certain words.

  Examples: How does that work? What causes that to happen? How does your explanation fit this other phenomenon?

The list of questions that is part of each lesson in this curriculum packet includes most or all of these five different levels of questions, and the questions in the lesson are arranged in order of increasing difficulty. Teachers can use the suggested questions and other similar questions to prompt students as they carry out the lesson activities.

Using an Interdisciplinary Approach to Teaching...

For each lesson in this packet, we have listed a variety of Virginia Standards of Learning (SOL) that are supported by the various lesson activities. SOL are listed for science, social studies, language arts, math, and technology. There are sound educational advantages for using an interdisciplinary teaching approach at all grade levels. Our state and national science education standards call for science subjects to be taught in a meaningful way and related whenever possible to students' experiences. Relating science to other disciplines is a way to help students form meaningful connections between science and other subjects as well as real-life experiences. Also, and particularly in the elementary grades, it is easier to justify spending time on science field activities and projects if Standards of Learning are being met in other disciplines at the same time.

Elementary teachers who need to emphasize language arts can easily teach language skills through science. It has been said that learning science and learning language are reciprocal processes (Casteel & Isom, 1994). Also, when students are actively engaged in learning science, they have multiple opportunities for reading, writing, and communicating. Language arts skills are incorporated extensively into all our lessons. As part of the inquiry approach, students spend a lot of time discussing open questions in groups. Students also can usually produce written summaries of their investigations and make oral presentations. All of these activities relate directly to the English SOL.

Whenever it is appropriate, we have also related different lessons to SOL for social studies, math, and technology. These connections are listed at the beginning of each lesson plan. Two of the lessons, Mapping a Watershed

History (Grade 4), and Making Decisions for Water Use (Grade 7), are written primarily as social studies lessons. At the same time, these lessons also support science SOL for fourth grade and seventh grade Life Science respectively. They are truly interdisciplinary lessons.

Planning a Safe Trip...

In any science activity, the safety and well being of students is the most important priority. Teachers are ultimately responsible for their students and must follow all school and professional requirements to ensure student safety. It is not the intent in these short paragraphs to make specific safety recommendations for every situation and eventuality. Excellent resources are available on safety in science teaching and all teachers should be aware of these. Less safety information is available for science at the elementary level, but the National Science Teachers Association has produced one excellent new book (Kwan & Texley, 2002, see the end of the chapter for full information). Here we only offer a few general suggestions to help ensure that field trips and other outdoor investigations are successful, meaningful, and safe.

As a general rule, try to imagine a worst-case scenario for your activity, and then make your plans so that scenario will not occur. Before ever planning any activities, you should have communicated with parents and obtained written information of specific health problems, allergies, or other safety concerns for individual students. Parent permission forms are essential for all field trips and outdoor activities. Make sure you have enough chaperones for your trip and have followed all other school rules and procedures.

If you take students to visit a stream or beach, you should visit the site before taking the students. Ask yourself the following questions.

- Is the site appropriate for the lesson? For example, if your students will look for insect larvae in a stream, make sure the stream supports such animals.
- Is the site safe and free from natural or man-made dangers? For example, is the stream bank free of dangerous litter or poisonous plants? Be alert for any indication of animals that could bite or sting.
- Check the depth of the water, the speed of the current, and the water temperature.
- Are all aspects of the site accessible for your students with special needs?
- Is there parking and/or turn-around space for a school bus or other vehicle to be used?
- Is there access to bathrooms when needed?
- If you plan to have a meal or snack during your visit, learn if there are picnic areas and a place for students to wash their hands before eating.

If the site you are to visit is located in a local, state, or federal park, make contact with park rangers or staff as part of your planning before the trip.

- Meet the rangers or staff and discuss with them the date and time for your class visit.
- Ask if the park staff can recommend a good site for your visit. Ask if they are able to give you any assistance in planning or presenting activities to be held at the site.
- Learn if there is a visitor center, park office, or other buildings that could be part of your visit. Are there bathrooms available for students? Also, if students may need to change clothes, where can they do this?
- Find out the emergency phone number for the park so that you can share this with your school and with parents.

Make sure students are well prepared before any field trip or outdoor activity. In addition to class preparations for learning activities, students should know why and when they will take the trip, and they should know exactly what to bring with them. Parents should also be well informed by a written letter explaining the purpose of the trip, the date and times, and everything students will need to bring with them on that day. Depending on the trip, students may need to bring the following.

- Shoes and clothes to get wet and muddy.
- A change of clothes.
- Jacket, hat, gloves, and rain gear. It is often cooler on the water than it is on land.
- Long pants, not shorts. Shoes or boots, not flip flops or sandals.
- Sunscreen, sunglasses, and bug spray.
- Bagged lunch or snacks and water.
- Notebook and pencil.

On the day of a field trip or outdoor activity, make sure you review all safety rules with students and chaperones. Your safety rules might include the following.

- Stay with your group members at all times.
- Stay in the designated area, and do not go near or into the water.
- Keep your shoes on at all times to protect your feet from harm.
- Keep out of dunes and do not step on any plants.
- Do not touch any wildlife that you find or taste any water or plants.
- Learn what poison ivy and poison oak look like, and avoid these plants.
- Do not eat any food without first carefully washing your hands.

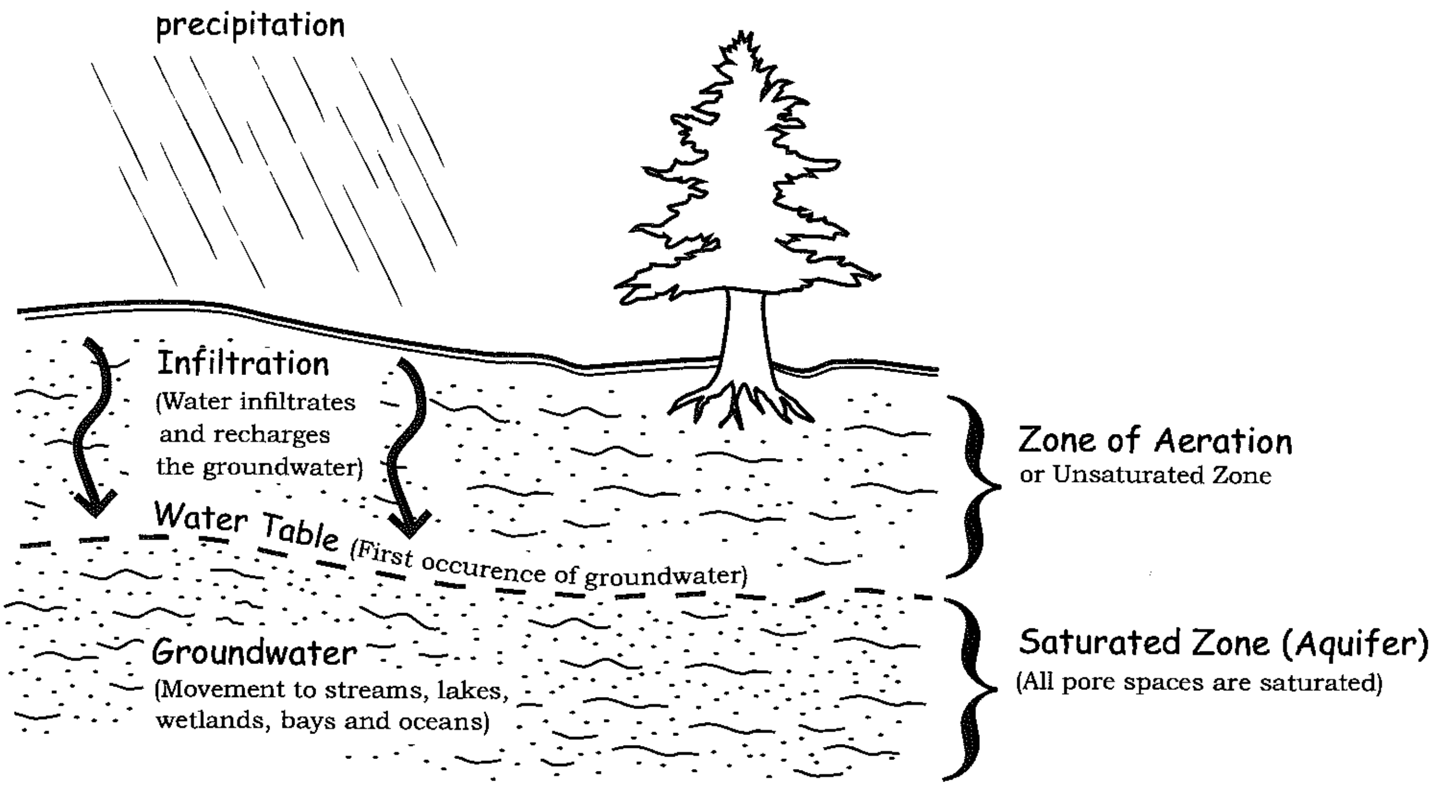
Finally, when you take students on a field trip or outdoor activity, make sure that you are well prepared yourself. Have a first aid kit with you and know how to use it. Make sure you have not overlooked any of your school requirements for field trips. You should certainly have health information for all your students with you, and contact numbers so you can quickly reach a parent or guardian in the case of any accident. Remember the most important rule: think of the worst thing that might happen and then plan accordingly.

Resources...

- An Inquiry Primer. Colburn, A. (2000). *Science Scope, 23*(6), 42-44.
- Chesapeake 2000 Agreement. *www.chespeakebay.net/agreement.htm*
- Defining Inquiry: Exploring the Many Types of Inquiry in the Science Classroom. Martin-Hansen, L. (2002). *The Science Teacher, 69*(2), 34–37.
- *Exploring Safely: A Guide for Elementary Teachers.* Kwan, T., & Texley, J. (2002). Arlington, VA: National Science Teachers Association Press.
- Questions are the Answer: A Logical Questioning Strategy for Any Topic. Penick, J. E., Crow, L. W., & Bonnstetter, R. J. (1996). *The Science Teacher, 63*(1), 26–29.
- The Learning Cycle. Barman, C. R., & Kotar, M. (1989). *Science and Children, 26* (7), 30–32.
- The Learning Cycle and Instructional Conversations. Beisenherz, P. C., Dantonio, M., & Richardson, L. (2001). *Science Scope, 24*(4), 34–38.
- Reciprocal Processes in Science and Literacy Learning. Casteel, C. P., & Isom, B. A. (1994). The Reading Teacher, 47(7), 538-545.
- *Stewardship and Meaningful Watershed Educational Experiences.* Chesapeake Bay Program Education Workgroup.(2001).

Section 2

Virginia's Watersheds and Water Resource Issues



Virginia's Watersheds and Water Resource Issues

County/ Selected Cities	Watershed(s)	In Chesapeake Bay Watershed?	Geographic Region	Excessive nutrients	Bacteria (fecal coliform contamination)	Sediment & Turbidity	Toxins (Ex: PCBs, Mercury)	Invasive non-native plants or animals	Groundwater Protection	Debris in aquatic ecosystems	**Special Issues** * = *Aquatic and semiaquatic animals (other than birds and marine mammals) that are endangered, threatened or are of special concern.* ***Fishing advisories and counties with Karst*** *are also listed here. See notes at end of chart for references and sources.*
Accomack	Chesapeake Bay Coastal and Atlantic Ocean Coastal	Partly	Atlantic Coastal Plain	XXX	X	X		XXX	X	X	Depleted SAV & oyster populations. * 5 sea turtle species, northern diamond-backed terrapin, Atlantic sturgeon, river otter.
Albemarle	Most of the county is in the Middle James River (Piedmont) watershed; .63% is in the Rapidan/ Rappahannock River and 1.39% is in the York River watershed.	Yes	Piedmont and Blue Ridge Mountains	X	X	X		X	X	X	* 2 mussel species, roughhead shiner, river otter.
Alleghany	Upper James River (Mountain)	Yes	Valley and Ridge	X		X		X	XXX	X	Karst. * 2 mussel species, roughhead shiner, river otter.
Amelia	Appomattox River (which flows into the James River near Hopewell)	Yes	Piedmont	X	X	X		X	X	X	* Bridle shiner, river otter.
Amherst	Middle James River (Piedmont)	Yes	Piedmont and Blue Ridge Mountains	X	X	X		X	X	X	Lynchburg-- Combined Sewer Overflow. * 4 mussel species, bridle shiner, river otter.
Appomattox	70.81% is in the James River (Piedmont) watershed and 29.2% is in the Roanoke River watershed.	Partly	Piedmont	X	X	X		X	X	X	* 2 fish species, river otter.
Arlington	Lower Potomac River	Yes	Piedmont	X	XX	X	X	XX	X	X	* Atlantic sturgeon, river otter.
Augusta	74.74% of Augusta County is in the Upper Potomac River/Shenandoah River watershed, and 25.26% is in the Upper James River (Mountain) watershed.	Yes	Valley & Ridge and Blue Ridge Mountains	X	XXX	X	XX	X	XXX		Karst. Fish caught in the South River from Waynesboro to Port Republic may contain mercury. See VDH for details. * Roughhead shiner (fish), eastern tiger salamander, Madisons Cave isopod, Madisons Cave amphipod, river otter.
Bath	Upper James River (Mountain)	Yes	Valley & Ridge	X		X		X	XXX	X	Karst * James spiny mussel, 2 fish species, water shrew, river otter.
Bedford	86.1% is in the Roanoke River watershed, and 13.9% is in the Middle James River (Piedmont).	Partly	Piedmont and Blue Ridge Mountains	X	XX	X	XX	X	XXX	X	Some Karst * 3 fish species, 2 mussel species, Peaks of Otter salamander, river otter.
Bland	86.68% is in the New River watershed, and 13.32% is in the Holston River watershed.	No	Valley & Ridge	X	X	X		X	XXX	X	Karst * 2 fish species, eastern hellbender (amphibian), Tennessee clubshell mussel.
Botetourt	87.39% is in the Upper James River (Mountain) watershed, and 12.61% is in the Roanoke River watershed.	Partly	Valley & Ridge and Blue Ridge Mountains	X	X	X		X	XXX	X	Karst. * 2 fish species, 3 mussels species, Peaks of Otter salamander, river otter.
Brunswick	88.07% is in the Chowan River watershed, and 11.93 is in the Roanoke River watershed.	No	Piedmont	X	XX	X	XX	XX	X	X	* 4 mussels species, 4 fish species, Chowanoke crayfish, river otter.
Buchanan	Big Sandy River	No	Appalachian Plateau and Valley & Ridge	X	X	X	XX	X	X	X	Impacts from mining. Fish taken from the Levisa Fork River downstream from Grundy to the southwest Virginia/Kentucky border (~12 miles) may contain PCBs. 17 miles of Knox Creek aslo had PCB advisory. See VDH for advisory details. * Yellow lance mussel, 2 fish species, river otter.
Buckingham	Middle James River (Piedmont) watershed.	Yes	Piedmont	X	XX	XX		X	X	X	* River otter.

See last page in this section for references and sources.

Virginia's Watersheds and Water Resource Issues

County/ Selected Cities	Watershed(s)	In Chesapeake Bay Watershed?	Geographic Region	Excessive nutrients	Bacteria (fecal coliform contamination)	Sediment & Turbidity	Toxins (Ex: PCBs, Mercury)	Invasive non-native plants or animals	Groundwater Protection	Debris in aquatic ecosystems	**Special Issues** ** = Aquatic and semiaquatic animals (other than birds and marine mammals) that are endangered, threatened or are of special concern.* ***Fishing advisories and counties with Karst*** *are also listed here. See notes at end of chart for references and sources.*
Campbell	86.54% is in the Roanoke River watershed, and 13.46% is in the Middle James River (Piedmont) watershed.	Partly	Piedmont	X	XX	XX	XX	X	X	X	Some fish taken from the Roanoke River (Staunton River) from the Leesville Dam downstream (~79 miles) may have PCBs. See VDH for advisory details. * 2 mussel species, 4 fish species, mole salamander, river otter.
Caroline	78.27% is in the York River watershed, and 21.73% is in the Rappahannock River watershed.	Yes	Atlantic Coastal Plain	XXX		XX		X	X	X	* 2 mussel species, bridle shiner, carpenter frog, river otter.
Carroll	86.02% is in the New River watershed, and 13.98% is in the Ararat River watershed.	No	Blue Ridge Mountains and Piedmont	X		X		X	X	X	Impacts from mining. * Bog turtle, eastern hellbender, green floater mussel, Kanawha minnow, pygmy dragonfly.
Charles City	Lower James River (Tidal)	Yes	Atlantic Coastal Plain	XXX	X	XX	XX	X	X	X	PCBs and zinc in James River (Hopewell area). Kepone in James and tributaries. A fish-eating advisory exists for those who consume fish from these waters on daily basis. See VDH for details. * Northern diamond-backed terrapin, bridle shiner, Atlantic sturgeon, river otter.
Charlotte	95.97% is in the Roanoke River watershed; 4.04% is in the Chowan River watershed; and .01% is in the Appomattox River (James River) watershed.	Partly (only .01%)	Piedmont	X	XX	X	XX	X	X	X	Some fish taken from the Roanoke River (Staunton River) from the Leesville Dam downstream (~79 miles) may have PCBs. See VDH for advisory details. * 3 fish species, mole salamander, river otter.
Chesapeake City	73.90% is in the Chowan River watershed, and 26.10% is in the Lower James River (Tidal) watershed.	Partly	Atlantic Coastal Plain	XXX	X	XX	XX	XXX	X	X	TBT, contaminated sediments, and high potential for toxic compounds in Elizabeth River. See VDH for details. Depleted SAV & oyster populations. * Florida manatee, loggerhead sea turtle, northern diamond-backed terrapin, Atlantic sturgeon, carpenter frog, oak toad, river otter.
Chesterfield	James River (Piedmont and Tidal) watershed.	Yes	Atlantic Coastal Plain	XXX	XX	XX	XX	X	X	X	Kepone in James and tributaries. A fish-eating advisory exists for those who consume fish from these waters on daily basis. See VDH for details. * Yellow lance mussel, barking tree frog, bridle shiner, Atlantic sturgeon, river otter.
Clarke	Upper Potomac River/Shenandoah River	Yes	Valley & Ridge and Blue Ridge Mountains	X		XX	XX	X	XXX	X	Karst. Portions of the Shenandoah, South Fork Shenandoah, and North Fork Shenandoah Rivers may contain PCBs. Fish caught in these waters should not be consumed. See VDH for details. * Green floater mussel, wood turtle, river otter.
Craig	86.47% is in the Upper James River (Mountain) watershed, and 13.53% is in the New River watershed.	Partly	Valley & Ridge	X		XX		X	XXX	X	Karst. * 3 mussel species, 2 fish species, river otter.
Culpeper	Rappahannock River	Yes	Piedmont	X	X	XX		X	X	X	* Yellow lance mussel, river otter.
Cumberland	64.41% is in the Middle James River (Piedmont) watershed, and 35.59% is in the Appomattox River watershed.	Yes	Piedmont	X	X	XX		X	X	X	* 2 mussel species, river otter.

See last page in this section for references and sources.

Virginia's Watersheds and Water Resource Issues

County/ Selected Cities	Watershed(s)	In Chesapeake Bay Watershed?	Geographic Region	Excessive nutrients	Bacteria (fecal coliform contamination)	Sediment & Turbidity	Toxins (Ex: PCBs, Mercury)	Invasive non-native plants or animals	Groundwater Protection	Debris in aquatic ecosystems	**Special Issues** * = *Aquatic and semiaquatic animals (other than birds and marine mammals) that are endangered, threatened or are of special concern.* ***Fishing advisories and counties with Karst*** *are also listed here. See notes at end of chart for references and sources.*
Dickenson	98.49% is in the Big Sandy River watershed, and 1.51% is in the Clinch River/Powell River watershed.	No	Appalachian Plateau and Valley & Ridge	X		X	X	X	X	X	Impacts from mining. * 2 fish species, river otter.
Dinwiddie	84.42% is in the Chowan River watershed, and 15.58% is in the Appomattox River (James River) watershed.	Partly	Atlantic Coastal Plain	XXX	X	XX		X	X	X	* 4 mussel species, 5 fish species, Chowanoke crayfish, river otter.
Essex	89.86% is in the Rappahannock River watershed; 10.09% is in the Chesapeake Bay Coastal River watershed, and .05% is in the York River watershed.	Yes	Atlantic Coastal Plain	XXX		XX	X	X	X	X	* Atlantic sturgeon, river otter.
Fairfax	Lower Potomac River	Yes	Atlantic Coastal Plain	XXX	X	XX	XX	XX	X	X	Fish Consumption Advisory in several streams and the Potomac from Woodrow Wilson Bridge to Brent Point due to PCBs. See VDH for details. * 4 mussel species, 2 fish species, wood turtle, river otter.
Fauquier	56.32% is in the Lower Potomac River watershed, and 43.68% is in the Rappahannock River watershed.	Yes	Piedmont and Blue Ridge Mountains	X	XX	XX		X	X	X	* 3 mussel species, river otter.
Floyd	91.06% is in the New River watershed, and 8.94% is in the Roanoke River watershed.	No	Piedmont and Blue Ridge Mountains	X	X	X		X	X	X	* 4 fish species, bog turtle, eastern hellbender, elk toe mussel, river otter.
Fluvanna	99.77% is in the Middle James River (Piedmont) watershed, and .23% is in the York River watershed.	Yes	Piedmont	X	X	XX		X	X	X	* 3 mussel species, river otter.
Franklin	Roanoke River	No	Piedmont and Blue Ridge Mountains	X	XXX	X		X	XXX	X	Some karst. * 3 fish species, Atlantic pigtoe mussel, river otter.
Frederick	Upper Potomac River/Shenandoah River	Yes	Valley & Ridge	X	XX	XX		X	XXX	X	Karst. * Green floater mussel, wood turtle, river otter.
Giles	96.48% is in the New River watershed, and 3.52% is in the Upper James River (Mountain) watershed.	Partly	Valley & Ridge	X		X	XX	X	XXX	X	Karst. Carp caught in the New River between Radford and Glen Lyn should not be consumed due to PCBs. See VDH for details. * James spiny mussel, 2 fish species, eastern hellbender, river otter.
Gloucester	64.01% is in the Chesapeake Bay Coastal River watershed, and 35.99% is in the York River watershed.	Yes	Atlantic Coastal Plain	XXX	X	XX		XXX	X	X	Depleted SAV & oyster populations. * 4 sea turtle species, northern diamond-backed terrapin, Mabee's salamander, Atlantic sturgeon, river otter.
Goochland	96.67% is in the Middle James River (Piedmont) watershed, and 3.33% is in the York River watershed.	Yes	Piedmont	X	XX	XX		X	X	X	* 5 mussel species, river otter.
Grayson	98.57% is in the New River watershed; 1.14% is in the Holston River watershed; and .31% is in the Ararat River watershed.	No	Blue Ridge Mountains	X	X	X		X	X	X	Impacts from mining. * Bog turtle, eastern hellbender, green floater mussel, Kanawha minnow, pygmy dragonfly, 3 salamander species.
Greene	59.34% is in the Middle James River (Piedmont) watershed, and 40.66% is in the Rappahannock River watershed.	Yes	Piedmont and Blue Ridge Mountains	X	X	XX		X	X	X	* River otter.

See last page in this section for references and sources.

Virginia's Watersheds and Water Resource Issues

County/ Selected Cities	Watershed(s)	In Chesapeake Bay Watershed?	Geographic Region	Excessive nutrients	Bacteria (fecal coliform contamination)	Sediment & Turbidity	Toxins (Ex: PCBs, Mercury)	Invasive non-native plants or animals	Groundwater Protection	Debris in aquatic ecosystems	**Special Issues** * = *Aquatic and semiaquatic animals (other than birds and marine mammals) that are endangered, threatened or are of special concern.* ***Fishing advisories and counties with Karst*** *are also listed here. See notes at end of chart for references and sources.*
Greensville	Chowan River	No	Atlantic Coastal Plain	XXX	X	X	X	X	X	X	* 2 fish species, 4 mussel species, Chowanoke crayfish, Mabee's salamander, oak toad, river otter.
Halifax	Roanoke River	No	Piedmont	X	XXX	X	XX	X	X	X	Some fish taken from the Roanoke River (Staunton River) from the Leesville Dam downstream (~79 miles) may have PCBs. Fish taken from the Dan River may contain PCBs. See VDH for advisory details. * 2 mussel species, 4 fish species, river otter.
Hampton	74.28% is in the Back River/Poquoson River; 4.18% is in the James River/ PagenRiver/Warwick Creek/Chuckatuck Creek; and 21.54% is in the Hampton Roads/Elizabeth River watershed.	Yes	Atlantic Coastal Plain	XXX		XX	XX	XXX	X	X	Kepone in James and tributaries. A fish-eating advisory exists for those who consume fish from these waters on daily basis. See VDH for details. Depleted SAV & oyster populations. * 4 sea turtle species, Florida manatee, northern diamond-backed terrapin, Mabee's salamander, Atlantic sturgeon, river otter.
Hanover	84.38% is in the York River watershed; 15.30% is in the Lower James River (Tidal) watershed; and .32% is in the Middle James River (Piedmont) watershed.	Yes	Atlantic Coastal Plain	XXX	XX	XX		X	X	X	* 4 mussel species, carpenter frog, river otter.
Henrico	84.59% is in the Lower James River (Tidal) watershed, and 15.41% is in the Middle James River (Piedmont) watershed.	Yes	Atlantic Coastal Plain	XXX	XX	XX	XX	X	X	X	James River: Sewage from Combined Sewer Overflow; Kepone in James and tributaries. A fish-eating advisory exists for those who consume fish from these waters on daily basis. See VDH for details. * Atlantic pigtoe mussel, Atlantic sturgeon, river otter.
Henry	Roanoke River	No	Piedmont	X	X	X		X	X	X	* Roanoke logperch, Roanoke bass, river otter.
Highland	74.04% is in the Upper James River (Mountain) watershed, and 25.96% is in the Upper Potomac River/Shenandoah River watershed.	Yes	Valley & Ridge	X		XX		X	XXX	X	Karst. * Roughhead shiner, water shrew, river otter.
Isle Of Wight	56.03% is in the Lower James River (Tidal) watershed, and 43.97% is in the Chowan River watershed.	Partly	Atlantic Coastal Plain	XXX	X	XX	XX	XXX	X	X	Kepone in James and tributaries. A fish-eating advisory exists for those who consume fish from these waters on daily basis. See VDH for details. Depleted SAV & oyster populations. * Loggerhead sea turtle, northern diamond-back terrapin, eastern tiger salamander, eastern chicken turtle, Mabee's salamander, barking tree frog, Atlantic sturgeon, oak toad, river otter, eastern lamp mussel.
James City	78.37% is in the Lower James River (Tidal) watershed, and 21.63% is in the York River watershed.	Yes	Atlantic Coastal Plain	XXX		XX	XX	XXX	X	X	Kepone in James and tributaries. A fish-eating advisory exists for those who consume fish from these waters on daily basis. See VDH for details. Depleted SAV & oyster populations. * Northern diamond-back terrapin, Mabee's salamander, 2 fish species, river otter.

See last page in this section for references and sources.

Virginia's Watersheds and Water Resource Issues

County/ Selected Cities	Watershed(s)	In Chesapeake Bay Watershed?	Geographic Region	Excessive nutrients	Bacteria (fecal coliform contamination)	Sediment & Turbidity	Toxins (Ex: PCBs, Mercury)	Invasive non-native plants or animals	Groundwater Protection	Debris in aquatic ecosystems	**Special Issues** * = *Aquatic and semiaquatic animals (other than birds and marine mammals) that are endangered, threatened or are of special concern.* ***Fishing advisories and counties with Karst*** *are also listed here. See notes at end of chart for references and sources.*
King And Queen	77.78% is in the York River watershed, and 22.22% is in the Chesapeake Bay Coastal River watershed.	Yes	Atlantic Coastal Plain	XXX	X	XX		X	X	X	* Yellow lamp mussel, Atlantic sturgeon, river otter.
King George	61.93% is in the Lower Potomac River watershed, and 38.07% is in the Rappahannock River watershed.	Yes	Atlantic Coastal Plain	XXX		XX		XX	X	X	* Atlantic sturgeon, river otter.
King William	York River	Yes	Atlantic Coastal Plain	XXX	X	XX		X	X	X	* Yellow lamp mussel, northern diamond-backed terrapin, Atlantic sturgeon, river otter.
Lancaster	87.99% is in the Rappahannock River watershed, and 12.01% is in the Chesapeake Bay Coastal River watershed.	Yes	Atlantic Coastal Plain	XXX		XX	XX	XXX	X	X	Depleted SAV & oyster populations. * 3 sea turtle species, northern diamond-backed terrapin, Atlantic sturgeon, river otter.
Lee	Clinch River/Powell River	No	Valley & Ridge	X	X	X		X	XXX	X	Karst. Impacts from mining. * 28 mussel species, Lee County Cave isopod, 11 fish species, eastern hellbender, 2 snail species, river otter.
Loudoun	Lower Potomac River	Yes	Piedmont and Blue Ridge Mountains	X	XX	XX		X	XXX	X	Some karst. * 3 mussel species, wood turtle, river otter.
Louisa	96.33% is in the York River watershed, and 3.67% is in the Middle James River (Piedmont) watershed.	Yes	Piedmont	X	X	XX		X	X	X	Impacts from mining. * 4 mussel species, bridle shiner, river otter.
Lunenburg	99.98% is in the Chowan River watershed, and .02% is in the Appomattox River (James River) watershed.	Partly (only .02%)	Piedmont	X	X	X		X	X	X	* 5 mussel species, 4 fish species, Chowanoke crayfish, river otter.
Madison	Rappahannock River	Yes	Piedmont and Blue Ridge Mountains	X	X	XX		X	X	X	* Shenandoah salamander, yellow lance mussel, river otter.
Mathews	Chesapeake Bay Coastal	Yes	Atlantic Coastal Plain	XXX		XX		XXX	X	X	Depleted SAV & oyster populations. * 4 sea turtle species, northern diamond-backed terrapin, eastern tiger salamander, barking tree frog, Atlantic sturgeon, river otter.
Mecklenburg	84.34% is in the Roanoke River watershed, and 15.66% is in the Chowan River watershed.	No	Piedmont	X	X	X		XX	X	X	Fish Consumption Advisory for portions of the Dan River. See VDH for advisory details. * 3 mussel species, 4 fish species, river otter.
Middlesex	62.16% is in the Rappahannock River watershed, and 37.84% is in the Chesapeake Bay Coastal River watershed.	Yes	Atlantic Coastal Plain	XXX	X	XX		X	X	X	Depleted SAV & oyster populations. * Shortnose sturgeon, 3 sea turtle species, Northern diamond-backed terrapin, Atlantic sturgeon, river otter.
Montgomery	48.74% is in the Roanoke River watershed; 45.51% is in the New River watershed; and 5.75% is in the Upper James River (Mountain) watershed.	Partly	Valley & Ridge and Blue Ridge Mountains	X	XX	X	XX	X	XXX	X	Karst. Carp caught in the New River between Radford and Glen Lyn should not be consumed due to PCBs. See VDH for details. * 4 fish species, eastern hellbender, river otter.

See last page in this section for references and sources.

Virginia's Watersheds and Water Resource Issues

County/ Selected Cities	Watershed(s)	In Chesapeake Bay Watershed?	Geographic Region	Excessive nutrients	Bacteria (fecal coliform contamination)	Sediment & Turbidity	Toxins (Ex: PCBs, Mercury)	Invasive non-native plants or animals	Groundwater Protection	Debris in aquatic ecosystems	**Special Issues** * = *Aquatic and semiaquatic animals (other than birds and marine mammals) that are endangered, threatened or are of special concern.* ***Fishing advisories and counties with Karst*** *are also listed here. See notes at end of chart for references and sources.*
Nelson	99.98% is in the Middle James River (Piedmont) watershed, and .02% is in the Upper James River (Mountain) watershed.	Yes	Piedmont and Blue Ridge Mountains	X	X	XX		X	X	X	* Green floater mussel, river otter.
New Kent	52.90% is in the Lower James River (Tidal) watershed, and 47.10% is in the York River watershed.	Yes	Atlantic Coastal Plain	XXX	X	XX		X	X	X	* Northern diamond-backed terrapin, 2 fish species, river otter.
Newport News	7.02% is in the Back River/Poquoson River; 82.24% is in the James River/ PagenRiver/Warwick Creek/Chuckatuck Creek; and 10.74% is in the Hampton Roads/Elizabeth River watershed.	Yes	Atlantic Coastal Plain		X	XX	XX	XXX	X	X	Kepone in James and tributaries. A fish-eating advisory exists for those who consume fish from these waters on daily basis. See VDH for details. Depleted SAV & oyster populations. * 3 sea turtle species, Florida manatee, northern diamond-backed terrapin, Mabee's salamander, Atlantic sturgeon, river otter.
Norfolk City	80.80% is in the Hampton Roads and Elizabeth River watersheds, which are part of the Lower James River (Tidal) watershed. 19.20% is in the Chesapeake Bay Coastal watershed.	Yes	Atlantic Coastal Plain	XXX	X	XX	XX	XXX	X	X	TBT, contaminated sediments, and high potential for toxic compounds in Elizabeth River. Kepone in James and tributaries. A fish-eating advisory exists for those who consume fish from these waters on daily basis. See VDH for details. Depleted SAV & oyster populations. *5 sea turtle species, Florida manatee, northern diamond-backed terrapin, Atlantic sturgeon, river otter.
Northampton	72.81% is in the Atlantic Ocean Coastal River watershed, and 27.19% is in the Chesapeake Bay Coastal River watershed.	Partly	Atlantic Coastal Plain	XXX		XX		XXX	X	X	Depleted SAV & oyster populations. * 5 sea turtle species, northern diamond-backed terrapin, Atlantic sturgeon, river otter.
Northumberland	50.33% is in the Lower Potomac River watershed; 48.84% is in the Chesapeake Bay Coastal River watershed; and .83% is in the Rappahannock River watershed.	Yes	Atlantic Coastal Plain	XXX	X	XX		XXX	X	X	Depleted SAV & oyster populations. * 3 sea turtle species, northern diamond-backed terrapin, Atlantic sturgeon, river otter.
Nottoway	52.72% is in the Appomattox River (James River) watershed, and 47.28% is in the Chowan River watershed.	Partly	Piedmont	X	X	XX		X	X	X	* 4 mussel species, 3 fish species, river otter.
Orange	55.83% is in the Rappahannock River watershed; 42.07% is in the York River watershed, and 2.10% is in the Middle James River (Piedmont) watershed.	Yes	Piedmont	X	X	XX		X	X	X	* Yellow lance mussel, bridle shiner (fish), river otter.
Page	Upper Potomac River/ Shenandoah River	Yes	Valley & Ridge and Blue Ridge Mountains	X	X	XX	XX	X	XXX	X	Karst. Portions of the Shenandoah, South Fork Shenandoah, and North Fork Shenandoah Rivers may contain mercury and/or PCBs. Fish caught in these waters should not be consumed. See VDH for details. * Shenandoah salamander, wood turtle, river otter.
Patrick	89.65% is in the Roanoke River watershed, and 10.35% is in the Ararat River watershed.	No	Piedmont	X	X	X		X	X	X	* 5 fish species, bog turtle, river otter.

See last page in this section for references and sources.

Virginia's Watersheds and Water Resource Issues

County/ Selected Cities	Watershed(s)	In Chesapeake Bay Watershed?	Geographic Region	Excessive nutrients	Bacteria (fecal coliform contamination)	Sediment & Turbidity	Toxins (Ex: PCBs, Mercury)	Invasive non-native plants or animals	Groundwater Protection	Debris in aquatic ecosystems	**Special Issues** * = *Aquatic and semiaquatic animals (other than birds and marine mammals) that are endangered, threatened or are of special concern.* ***Fishing advisories and counties with Karst*** *are also listed here. See notes at end of chart for references and sources.*
Pittsylvania	Roanoke River	No	Piedmont	X	XXX	X	XX	X	X	X	Some fish taken from the Roanoke River (Staunton River) from the Leesville Dam downstream (~79 miles) may have PCBs. Fish taken from the Dan River may contain PCBs. See VDH for advisory details. * 4 fish species, river otter.
Portsmouth City	Hampton Roads and Elizabeth River watersheds, which are part of the Lower James River (Tidal) watershed.	Yes	Atlantic Coastal Plain	XXX		XX	XX	XXX	X	X	TBT, contaminated sediments, and high potential for toxic compounds in Elizabeth River. Kepone in James and tributaries. A fish-eating advisory exists for those who consume fish from these waters on daily basis. See VDH for details. Depleted SAV & oyster populations. * 2 sea turtle species, northern diamond-backed terrapin, Atlantic sturgeon, oak toad, river otter.
Powhatan	James River (Piedmont) watershed.	Yes	Piedmont	X		XX		X	X	X	* 4 mussel species, river otter.
Prince Edward	95.40% is in the Appomattox River (James River) watershed; 4.45% is in the Chowan River watershed; and .14% is in the Roanoke River watershed.	Partly	Piedmont	X	XX	XX	X	X	X	X	* 2 mussel species, bridle shiner, river otter.
Prince George	51.44% is in the Chowan River watershed; remainder is in the James River watershed.	Partly	Atlantic Coastal Plain	XXX	X	XX	XX	X	X	X	PCBs and zinc in James River (Hopewell area). Kepone in James and tributaries. A fish-eating advisory exists for those who consume fish from these waters on daily basis. See VDH for details. * 4 fish species, river otter.
Prince William	Lower Potomac River	Yes	Piedmont and Atlantic Coastal Plain	XXX	XX	XX	XX	XX	X	X	Large catfish taken from the Potomac River and tributaries from the Woodrow Wilson Bridge downstream (~33 miles) to Brent Point at the mouth of Aquia Creek may contain PCBs. See VDH for advisory details. * 2 mussel species, 2 fish species, river otter.
Pulaski	New River	No	Valley & Ridge and Blue Ridge Mountains	X	X	X	XX	X	XXX	X	Karst. Carp caught in the New River between Radford and Glen Lyn should not be consumed due to PCBs. See VDH for details. * 3 fish species, eastern hellbender, green floater mussel, river otter.
Rappahannock	Rappahannock River	Yes	Piedmont and Blue Ridge Mountains	X		X		X	X	X	* Shenandoah salamander, 2 mussel species, river otter.
Richmond County	99.96% is in the Rappahannock River watershed; .02% is in the Lower Potomac River watershed; and .02% is in the Chesapeake Bay Coastal River watershed.	Yes	Atlantic Coastal Plain	XXX	X	XX		X	X	X	* Atlantic sturgeon, river otter.
City of Richmond	James River	Yes	Piedmont	XXX	XX	XX	XX	X	X	X	Kepone in James and tributaries. A fish-eating advisory exists for those who consume fish from these waters on daily basis. See VDH for details. See Chesterfield and Henrico Counties for lists of endangered and threatened aquatic animals.

See last page in this section for references and sources.

Virginia's Watersheds and Water Resource Issues

County/ Selected Cities	Watershed(s)	In Chesapeake Bay Watershed?	Geographic Region	Excessive nutrients	Bacteria (fecal coliform contamination)	Sediment & Turbidity	Toxins (Ex: PCBs, Mercury)	Invasive non-native plants or animals	Groundwater Protection	Debris in aquatic ecosystems	**Special Issues** * = *Aquatic and semiaquatic animals (other than birds and marine mammals) that are endangered, threatened or are of special concern.* ***Fishing advisories and counties with Karst** are also listed here. See notes at end of chart for references and sources.*
Roanoke	89.63% is in the Roanoke River watershed, and 10.37% is in the Upper James River (Mountain) watershed.	Partly	Valley & Ridge and Blue Ridge Mountains	X	XX	XX	XX	X	XXX	X	Karst. * 4 fish species, river otter.
Rockbridge	Upper James River (Mountain)	Yes	Valley & Ridge and Blue Ridge Mountains	X	X	XX		X	XXX	X	Karst. * 4 mussel species, roughhead shiner, Peaks of Otter salamander.
Rockingham	Upper Potomac River/ Shenandoah River	Yes	Valley & Ridge and Blue Ridge Mountains	X	XXX	XX	XX	X	XXX	X	Karst. Fish caught in the South River from Waynesboro to Port Republic may contain mercury. Portions of the Shenandoah, South Fork Shenandoah, and North Fork Shenandoah Rivers may contain mercury and/or PCBs. Fish caught in these waters should not be consumed. See VDH for details. * 2 mussel species, water shrew, wood turtle, river otter.
Russell	88.09% is in the Clinch River/Powell River watershed, and 11.91% is in the Holston River watershed.	No	Valley & Ridge	X	X	X		X	XXX	X	Karst. Impacts from mining. * 26 mussel species, 14 fish species, spiny riversnail, eastern hellbender, river otter.
Scott	70.72% is in the Clinch River/Powell River watershed, and 29.28% is in the Holston River watershed.	No	Valley & Ridge	X	X	X	XX	X	XXX	X	Karst. Mercury in North Fork Holston River (consumption ban for all species). See VDH for details. * 35 mussel species, 19 fish species, spiny riversnail, eastern hellbender, river otter.
Shenandoah	Upper Potomac River/ Shenandoah River	Yes	Valley & Ridge	X	X	XX	XX	X	XXX	X	Karst. * 4 mussel species, wood turtle, river otter.
Smyth	92.51% is in the Holston River watershed, and 7.49% is in the New River watershed.	No	Valley & Ridge and Blue Ridge Mountains	X	X	X	XX	X	XXX	X	Karst. Mercury in North Fork Holston River (consumption ban for all species). See VDH for details. * 12 mussel species, 11 fish species, 3 salamander species, spiny riversnail, eastern hellbender, river otter.
Southampton	Chowan River	No	Atlantic Coastal Plain	XXX	X	X		X	X	X	* 3 fish species, 3 mussel species, Chowanoke crayfish, Mabee's salamander, oak toad, river otter.
Spotsylvania	77.00% is in the York River watershed, and 23.00% is in the Rappahannock River watershed.	Yes	Atlantic Coastal Plain	XXX	X	XX		X	X	X	* 4 mussel species, bridle shiner, river otter.
Stafford	70.64% is in the Lower Potomac River watershed, and 29.36% is in the Rappahonnock River watershed.	Yes	Atlantic Coastal Plain	XXX	X	XX	XX	XX	X	X	Large catfish taken from the Potomac River and tributaries from the Woodrow Wilson Bridge downstream (~33 miles) to Brent Point at the mouth of Aquia Creek may contain PCBs. See VDH for advisory details. * Dwarf wedge mussel, 2 fish species, river otter.
Suffolk	57.19% is in the Chowan River watershed, and 42.81% is in the Lower James River (Tidal) watershed.	Partly	Atlantic Coastal Plain	XXX		XX	XX	XXX	X	X	Kepone in James and tributaries. A fish-eating advisory exists for those who consume fish from these waters on daily basis. See VDH for details. Depleted SAV & oyster populations. * 2 sea turtle species, northern diamond-backed terrapin, Mabee's salamander, Atlantic sturgeon, carpenter frog, oak toad, river otter.

See last page in this section for references and sources.

Virginia's Watersheds and Water Resource Issues

County/ Selected Cities	Watershed(s)	In Chesapeake Bay Watershed?	Geographic Region	Excessive nutrients	Bacteria (fecal coliform contamination)	Sediment & Turbidity	Toxins (Ex: PCBs, Mercury)	Invasive non-native plants or animals	Groundwater Protection	Debris in aquatic ecosystems	**Special Issues** * = *Aquatic and semiaquatic animals (other than birds and marine mammals) that are endangered, threatened or are of special concern.* ***Fishing advisories and counties with Karst** are also listed here. See notes at end of chart for references and sources.*
Surry	54.84% is in the Chowan River watershed, and 45.16% is in the Lower James River (Tidal) watershed.	Partly	Atlantic Coastal Plain	XXX	X	XX	XX	XX	X	X	Kepone in James and tributaries. A fish-eating advisory exists for those who consume fish from these waters on daily basis. See VDH for details. Depleted SAV & oyster populations. * Chowanoke crayfish, 3 fish species, Mabee's salamander, barking tree frog, oak toad, river otter.
Sussex	Chowan River	No	Atlantic Coastal Plain	XXX	XXX	X		X	X	X	* 4 fish species, 3 mussel species, Chowanoke crayfish, Mabee's salamander, carpenter frog, oak toad, river otter.
Tazewell	52.83% is in the Clinch River/Powell River watershed; 28.08% is in the New River watershed; 10.13% is in the Holston River watershed; and 8.95% is in the Big Sandy River watershed.	No	Appalachian Plateau and Valley & Ridge	X	X	X	XX	X	XXX	X	Karst. Impacts from mining. Carp caught in the Bluestone River between Bluefield and Yards should not be consumed due to PCBs. See VDH for details. * 16 mussel species, 7 fish species, spiny riversnail, eastern hellbender, river otter.
Virginia Beach	66.83% is in the Chowan River watershed; 26.89% is in the Chesapeake Bay Coastal River watershed; 4.89% is in the Lower James River (Tidal) watershed; and 1.39% is in the Atlantic Ocean Coastal River watershed.	Partly	Atlantic Coastal Plain	XXX	X	XX	XX	XXX	X	X	Contaminated sediments and high potential for toxic compounds in Elizabeth River. See VDH for details. Depleted SAV & oyster populations. * 5 sea turtle species, Florida manatee, northern diamond-backed terrapin, eastern chicken turtle, Atlantic sturgeon, carpenter frog, river otter.
Warren	Upper Potomac River/ Shenandoah River	Yes	Valley & Ridge and Blue Ridge Mountains	X		XX	XX	X	XXX	X	Karst. Portions of the Shenandoah, South Fork Shenandoah, and North Fork Shenandoah Rivers may contain mercury and/or PCBs. Fish caught in these waters should not be consumed. See VDH for details. * Madisons Cave isopod, brook floater mussel, wood turtle, river otter.
Washington	Holston River	No	Valley & Ridge and Blue Ridge Mountains	X	X	X	XX	X	XXX	X	Karst. Mercury in N. Fork Holston River (consumption ban for all species). Portion of Beaver Creek has advisory due to PCBs. See VDH for details. * 12 mussel species, 12 fish species, spiny riversnail, eastern hellbender, Cherokee clubtail dragonfly, 3 salamander species.
Westmoreland	73.83% is in the Lower Potomac River watershed, and 26.17% is in the Rappahannock River watershed.	Yes	Atlantic Coastal Plain	XXX	X	XX	X	XX	X	X	* Northern diamond-backed terrapin, Atlantic sturgeon, river otter.
Wise	70.39% is in the Clinch River/Powell River watershed, and 29.61% is in the Big Sandy River watershed.	No	Appalachian Plateau and Valley & Ridge	X	X	X	X	X	XXX	X	Karst. Impacts from mining. * 14 mussel species, spiny riversnail, 10 fish species, river otter.
Wythe	99.00% is in the New River watershed, and 1.00% is in the Holston River watershed.	No	Valley & Ridge and Blue Ridge Mountains	X		X		X	XXX	X	Karst. * 3 fish species, eastern hellbender, green floater mussel, river otter.
York	60.57% is in the York River watershed; 30.55% is in the Chesapeake Bay Coastal River watershed; and 8.88% is in the Lower James River (Tidal) watershed.	Yes	Atlantic Coastal Plain	XXX		XX	X	XXX	X	X	Depleted SAV & oyster populations. * 2 sea turtle species, northern diamond-backed terrapin, 2 salamander species, barking tree frog, Atlantic sturgeon, river otter.

See last page in this section for references and sources.

Virginia's Watersheds and Water Resource Issues
References and Sources

The information in this chart is for general guidelines only. Teachers can use it as a tool to select lessons that will be of most relevance to their local water issues. Not all surface waters in Virginia have been monitored for pollutants, and the health of streams and rivers can change over time becoming more or less polluted. For complete, current, and less simplified information, see the following references.

Bacteria (fecal coliform contamination)
For information on the presence of bacteria (fecal coliform or *E. coli*), see the "303(d) Report on Impaired Waters in Virginia," a compilation of waters in the state that do not meet water quality standards. This report is compiled by the Virginia Department of Environmental Quality. To access the report's table of contents on the Internet, go to http://www.deq.state.va.us/water/303d.html. Here, you may search for water bodies in your county, or, in the report's Appendix, you can view fact sheets for each of Virginia's major watersheds. Select the fact sheet for your watershed, and then scroll through the pages looking for your county.

Toxins
Health advisories in Virginia due to mercury, PCBs, etc. can be found on the Virginia Department of Health web site: www.vdh.state.va.us/HHControl/fishing_advisories.htm

Invasive non-native plants or animals
Invasive species include plants, animals, and pathogens (i.e., viruses, fungi, and bacteria that can cause illness or death of native plants and animals including diseases that kill hemlocks, chestnuts, dogwoods and others.) Sources include:
The Alliance for the Chesapeake Bay: http://www.acb-online.org/pubs/invasives_fact_sheet.pdf

The Virginia Natural Heritage Program (in the Department of Conservation and Recreation):
http://www.dcr.state.va.us/dnh/invinfo.htm
http://www.dcr.state.va.us/dnh/bookeduc.htm

Invasivespecies.gov:
http://www.invasivespecies.gov

The Chesapeake Bay Program:
http://www.chesapeakebay.net/baybio.htm

Groundwater Protection
While all Virginians need to protect groundwater from pollutants, people living in areas with Karst topography must be extra careful to protect groundwater from pollution.
Atlas of Groundwater in Virginia:
http://capp.water.usgs.gov/gwa/ch_l/index.html

Virginia Ground Water Protection Steering Committee (GWPSC):
www.deq.state.va.us/gwpsc/

Special Issues
Counties with Karst topography and Fish Consumption Advisories from the Virginia Department of Health are listed here.

Information about the aquatic animals which are endangered, threatened, or are of special concern can be found on the Virginia Department of Game and Inland Fisheries: www.dgif.state.va.us/wildlife/index.cfm Also, many bird species which depend on aquatic ecosystems are also endangered, threatened or are of special concern, including herons, pelicans, terns and shorebirds. Information on these species can also be found on the Game and Inland Fisheries website.

More Information on Water Issues In Virginia
The Virginia Department of Conservation and Recreation has a wealth of water and watershed information on their website: www.dcr.state.va.us/waterways/index.htm

The Virginia Department of Environmental Quality has a very informative site called the "Geographic Environmental Mapping System." You or your students can search "What's in My Backyard," "Impaired Waters" and other topics.
http://www.deq.state.va.us/watermaps/
http://lexington.yesvirginia.org/

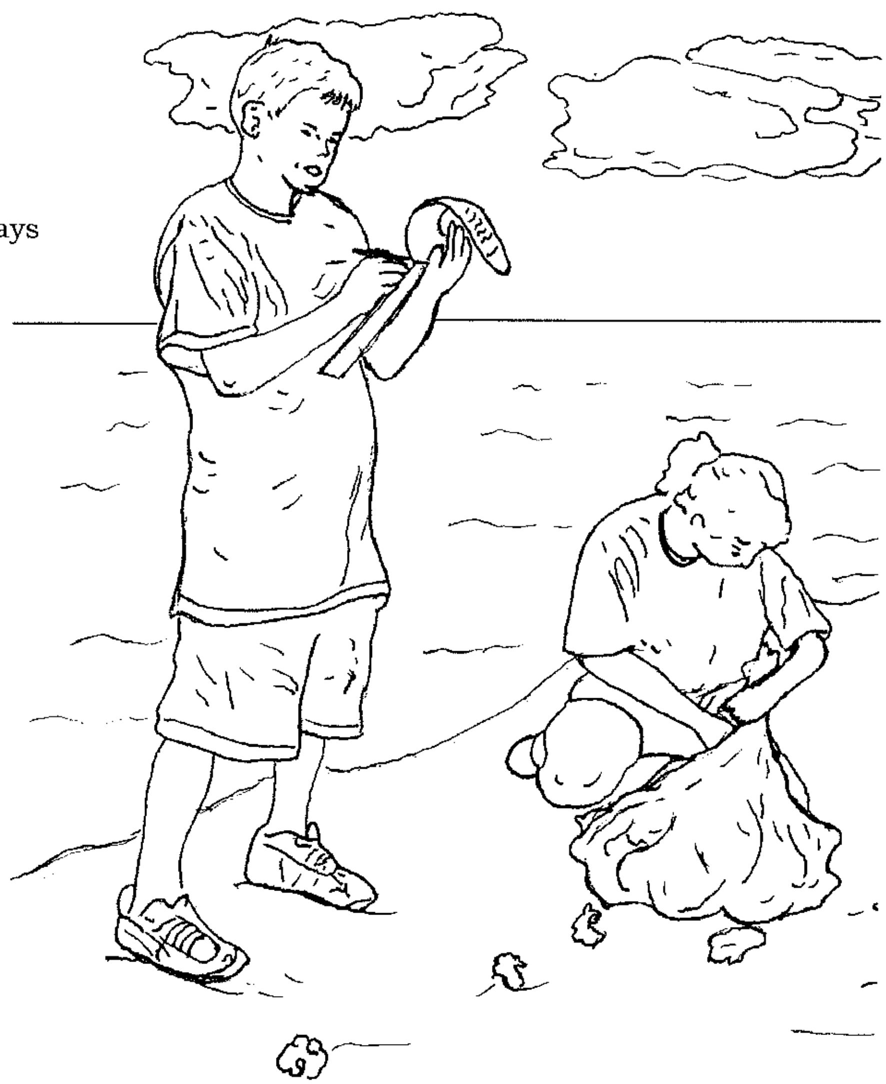
Other water quality reports published by the Virginia Department of Environmental Quality can be found at this website:
www.deq.state.va.us/water/reports.html

Acid deposition in Virginia
While all of Virginia receives acid deposition (rain, snow, fog, dry particles), negative impacts tend to be greater in higher elevation headwater streams which, due to their geology, lack natural buffering capabilities. To learn more, see: U.S. Geological Service
http://nadp.sws.uiuc.edu/ and
http://bqs.usgs.gov/acidrain/

Section 3

How Can We Help Protect Our Water Resources?

CONTENTS



SOL Strand: Resources

Investigating and Understanding while Learning Science

The Virginia Science Standards of Learning (SOL) for each grade include one standard that specifically lists science process skills for that grade level. In addition, many of the other science standards begin with the phrase, "Students will investigate and understand..." For example, standard K.8, for kindergarten students, begins, "The student will investigate and understand that materials can be reused, recycled, and conserved." The phrase "investigate and understand" is explained in the introduction to the Science SOL, but, briefly, "investigate" refers to scientific methodology and systematic use of inquiry skills. It is expected that each of the content SOL will be taught to students in a context of raising and answering questions, and active learning by the students.

The Resources SOL Strand

"Resources" is one of the strands running through the Virginia Science Standards of Learning for Grades K–6. Like the other parallel strands, the Resources SOL progress in complexity at each grade level. The SOL strand of Resources includes the following standards (Standards of Learning for Virginia Public Schools, Virginia Board of Education, 1995 – Revised 2003).

— Water-Related SOL in the Resources Strand —

Grade Level	Standards of Learning
Kindergarten *K.10*	The student will investigate and understand that materials can be reused, recycled, and conserved. Key concepts include a) materials and objects can be used over and over again; b) everyday materials can be recycled; and c) water and energy conservation at home and in school helps preserve resources for future use.
Grade 1 *1.8*	The student will investigate and understand that natural resources are limited. Key concepts include a) identification of natural resources (plants and animals, water, air, land, minerals, forests, and soil); b) factors that affect air and water quality; and c) recycling, reusing, and reducing consumption of natural resources.

Grade 3 *3.10*	The student will investigate and understand that natural events and human influences can affect the survival of species. Key concepts include a) the interdependency of plants and animals; b) human effects on the quality of air, water, and habitat; c) the effects of fire, flood, disease, and erosion; and d) conservation and resource renewal.
Grade 4 *4.8*	The student will investigate and understand important Virginia natural resources. Key concepts include a) watershed and water resources; b) animals and plants; c) minerals, rocks, ores, and energy sources; and d) forests, soil, and land.
Grade 6 *6.9*	The student will investigate and understand public policy decisions relating to the environment. Key concepts include a) management of renewable resources (water, air, plant life, animal life); b) management of nonrenewable resources (coal, oil, natural gas, nuclear power, mineral resources); c) the mitigation of land-use hazards through preventative measures; and d) cost/benefit tradeoffs in conservation policies.

Water as a precious resource is a part of the Resources SOL that is to be taught to students at kindergarten, first grade, third grade, fourth grade, and sixth grade. In kindergarten, the emphasis of SOL K.10 is on reusing, recycling, and conservation. In first grade (SOL 1.8), this theme is continued and students also learn about water as a limited natural resource as well as different factors that affect water quality. In third grade, SOL 3.10 deals with the impact of natural events and human influences on the survival of species. Specifically, 3.10 includes human effects on water quality and also the concepts of conservation and resource renewal. The fourth grade SOL 4.8 covers important Virginia natural resources, including watershed and water resources. Finally, for sixth grade, SOL 6.9 focuses on public policy decisions and the environment. Included in 6.9 are the concepts of resource management, mitigation of land-use hazards through preventative measures, and cost/benefit tradeoffs in conservation policies.

USING THIS PACKET

For this section of the curriculum packet, "How Can We Help Protect Our Water Resources?" we have chosen to emphasize problems and solutions associated with the issue of litter and debris in our waterways.

The two content chapters in the section describe "Litter and Debris in Our Waterways" and"Endangered Aquatic Species." This theme correlates most clearly with the elementary standards for first grade and third grade, 1.8 and 3.10, and the middle school standard for sixth grade, 6.9.

Using the two lessons included with this section of the packet, students are able to learn about different types of aquatic debris and they are able to participate in a simple cleanup of a waterway. The first lesson, "Lesson 1 – Classifying Aquatic Debris," is targeted to the third grade level. The second lesson, "Lesson 2 – Helping Clean Up a Waterway" is targeted to sixth grade. Of course, both lessons can be adapted for different age levels.

Litter and Debris in Our Waterways

Defining Aquatic Litter and Debris

Aquatic litter and debris are any manufactured or processed solid waste that enter the aquatic environment from any source. In short, it is our misplaced waste and trash. It is a highly pervasive and visible form of pollution that has harmful impacts on wildlife and human health.

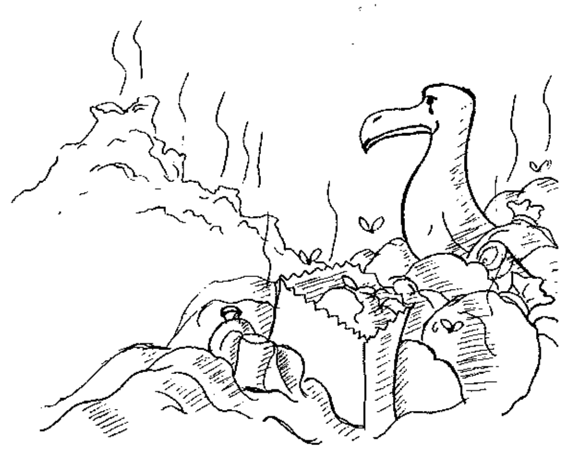
Aquatic ecosystems–streams, rivers, wetlands, and estuaries–are under considerable pressure from human activities, including incorrect disposal of trash. While the world's oceans are vast, they do not have an infinite ability to safely absorb our wastes. Preserving and restoring the quality of freshwater and marine environments requires that we understand how much trash we create, what we do with that trash, and how we can prevent it from entering our waterways.

Sources of Aquatic Debris

According to The Ocean Conservancy, all the trash in our water shares a common origin: "...at a critical decision point, someone, somewhere, mishandled it, either thoughtlessly or deliberately."

Some debris originates from the sea and inland waterways. This includes debris from ships, boats, offshore drilling platforms, and offshore rigs.

The rest of the debris we find in our waterways comes from land-based sources, including people who litter, landfills, and storm drains. Another source of land-based debris is from *combined sewer overflows*. In some cities with older infrastructures, such as Richmond and Lynchburg, Virginia, the water that enters a stormdrain during a rainstorm enters the same pipes that take wastewater from homes and businesses. This mixture of wastewater and storm water travels to the cities' wastewater treatment plants. During times of heavy rain, the volume of this water coming into the wastewater treatment plant can overwhelm the capacity of the plant, thereby causing an overflow. In combined sewer overflow situations, untreated wastewater (including raw sewage and untreated pollutants) directly enters the receiving stream or river. Therefore, items flushed down the toilet can end up in our waterways. Millions of dollars are being spent in Virginia and across the U.S. to eliminate this problem.



It should be noted that in most towns and cities, storm drains flow directly to streams and rivers. Litter on sidewalks and streets and in gutters is swept into the storm drain system when it rains. Just as a drop of rain can travel from a small stream to a river to the Chesapeake Bay or the Atlantic Ocean, so can a piece of litter. According to The Ocean Conservancy, 60% to 80% of debris found on ocean beaches is washed, blown, or dumped from shore.

Behavior Behind the Debris

Deliberate littering and illegal dumping contribute debris to our waterways, as do other non-deliberate actions—such as having a piece of debris blow out of your car window or off your boat. Sometimes our trash cans will be knocked over by animals or the wind, resulting in more accidental litter. One important concept for students to grasp is that there is a behavior and a person behind every piece of debris we find in our waterways. Some of these behaviors are:

Litter from Recreational Activities and Fast Food Consumption

This category includes trash from fast-food restaurants that is littered by people in cars, or is left behind after a picnic. People who litter fast-food items contribute a significant amount of debris to our waterways. Other items include bags, balloons, beverage containers, clothing, and toys.

Debris from Ocean and Waterway Activities

This category includes fishing-related items from recreational and commercial fishermen like nets, fishing line, and bait boxes. Debris can also come from offshore oil and gas rigs, and from ships (military, cruise, and commercial).

Litter from Smoking

This category includes cigarette butts, cigar tips, lighters, and the wrappers on cigarette packs. Smoking-related activities account for a tremendous amount of litter—in some places cigarette butts make up more than 85% of all littered items.

Illegal Dumping Activities

This category includes household waste, refrigerators and other appliances, building and construction waste, tires and sometimes entire cars.

Personal Hygiene and Medical Debris

This category includes items from sewers that overflow, diapers, needles, and other related items.

Whether these items enter the aquatic environment from dumping, litter, or accidental routes, debris not only looks ugly, but it can harm the animals and plants that make their homes in stream, lake, wetland, and coastal environments.

Types of Aquatic Debris

Every year, volunteers across the world participate in the International Coastal Cleanup, picking up aquatic debris and collecting data about the quantity and types of litter they find. The *top ten* list from these cleanups gives us a tremendous amount of information about the behaviors and activities that contribute most to the aquatic debris problem. The Top Ten items vary little year-to-year.

Plastics — A Special Problem

Plastic is widely used due to its light weight, strength, durability, versatility, and low cost. We use plastic bags, bottles, cups, forks, spoons, straws, and six-pack rings. Many toys are made from plastics, as are tools including strapping bands, and plastic sheeting. Plastic is also used in making packing materials and fishing gear. Plastics can take hundreds of years to break down, so they may continue to entangle and kill animals year after year. One study found that almost 90 percent of the debris floating on our oceans is plastic. The filters on cigarettes are also made from plastic fibers.

Top Ten Litter Items in the United States

In the 2001 International Coastal Cleanup, these items comprised 82% of all debris found in the U.S.

1. Cigarette butts/cigarette filters
2. Bags/food wrappers
3. Caps, lids
4. Beverage bottles (glass)
5. Beverage cans
6. Cups, plates, forks, knives, spoons
7. Beverage bottles (plastic) 2 liters or less
8. Straws, stirrers
9. Fast food Containers
10. Cigar tips

Top Ten Litter Items in Virginia

In the 2001 International Coastal Cleanup, these items comprised 85% of all debris found in Virginia.

1. Cigarette butts/cigarette filters
2. Bags/food wrappers
3. Beverage bottles (plastic) 2 liters or less
4. Beverage bottles (glass)
5. Beverage cans
6. Cups, plates, forks, knives, spoons
7. Caps, lids
8. Fast-food containers
9. Straws, stirrers
10. Tobacco packaging/wrappers

Any trash that is improperly disposed of can potentially enter a waterway and have negative impacts on aquatic animals, plants, and humans. Aquatic debris can be categorized in several ways:

- By material (plastic, metal, glass, cloth, paper)
- By source or by the activity which led the trash to be in the water. Some activities include fast food consumption, smoking, fishing, illegal dumping, sports/ games, balloons used in advertising, etc.
- By impact the items have on the environment and wildlife
- By biodegradable / nondegradable (Much of our solid waste contains synthetic materials that do not degrade quickly, if at all.)
- By recyclable / non-recyclable

IMPACTS OF AQUATIC DEBRIS

Litter not only detracts from the beauty of a riverside park or beach, but also can be a health and safety hazard for humans, and aquatic wildlife. Another big impact of litter is the cost to society. Millions of dollars are spent every year in Virginia by state and local governments, parks, schools, and businesses to pick up litter.

Impacts on Aquatic Habitat

Habitat destruction or harm is caused when submerged debris (for example, a piece of plastic sheeting) covers seagrass beds, or smothers bottom-dwelling species. Some debris can also cause physical damage.

Impacts on Water Quality

Debris can also affect the water quality by adding chemicals to the water. Construction waste illegally dumped in a stream can include buckets that once held paints, solvents, and other chemicals that can enter the water. Cigarette butts and some other littered items contain toxic chemicals that leach into the water.

Impacts on Aquatic Animals — Entanglement and Ingestion

Aquatic debris can be particularly dangerous and often lethal to wildlife. Each year, more than 100,000 marine mammals die when they ingest debris or become entangled in ropes, fishing line, fishing nets, and other debris dumped into the ocean. Seals are especially prone to become entangled because they are by nature curious and will investigate unusual items in their environment.

As many as 2 million seabirds also die every year due to debris ingestion and entanglement. Fishing line, fishing nets, strapping bands, and six-pack rings can hamper the mobility of aquatic animals. Once entangled, animals have trouble eating, breathing, finding food, escaping predators, or swimming, all of which can have fatal results. Entanglement can also cause wounds that can become infected. According to the National Oceanic and Atmospheric Administration (NOAA), marine debris threatens over 265 different species of marine and coastal wild-life through entanglement, smothering, and interference with digestive systems.

Sea turtles, birds, fish, and mammals often mistake plastic items for food. For instance, sea turtles often mistake plastic bags for jellyfish, one of their favorite foods. With plastic filling their stomachs, animals have a false feeling of being full, and may die of starvation. Ingested items can also block the intestinal tract and prevent digestion.

Impacts on Human Health and Safety

Trash in our waterways can also affect human health and safety. Hazards include glass and metal left on the beach, or hospital needles and syringes that can carry disease. Fishermen and recreational boaters can also be endangered as nets and monofilament fishing line wrap around a boat's propeller. Plastic sheeting and bags can also block the cooling intakes on boats. Such damage is hazardous and costly in terms of repair and lost fishing time. A survey in Oregon revealed that nearly 60 percent of fishermen had experienced equipment damage due to marine debris, costing thousands of dollars in repairs.

Economic Impacts from Aquatic Debris

A tremendous amount of time, effort, and machinery is devoted in Virginia to cleaning up litter on the land and in our waterways. Many Virginian coastal communities and parks have regular beach sweeping to remove trash left behind by visitors. Virginia's Department of Transportation spends more than $6 million to remove litter from our roadsides in addition to the thousands of hours Adopt-A-Highway volunteers spend picking it up. For information on the Adopt-A-Highway program, see *http://www.virginiadot.org/infoservice/prog-aah-default.asp* College grounds maintenance crews spend thousands of hours every year picking up litter, as do employees of restaurants, hotels, stores, and other businesses.

Every county in Virginia has a Litter Prevention and Recycling Coordinator. To find the coordinator in your county, visit this website: *http://www.deq.state.va.us/recycle/city-countylist.html*

Cigarette Butts—A Special Problem

During the International Coastal Cleanup, sponsored by The Ocean Conservancy, cigarette butts are the #1 most frequently found litter item. Trillions of cigarette butts are disposed of yearly, many directly tossed into the environment. Cigarette filters are made out of cellulose acetate, a plastic that takes several years to degrade.

Cigarette butts accumulate outside of buildings, on parking lots, and in streets where they can be transported through storm drains into streams and rivers. In addition to being unsightly, the chemicals that leach out of cigarette butt litter present a toxic threat to aquatic animals. The compounds in discarded cigarette butts (the filters and remnant tobacco) are biohazards to the water flea, *Daphnia magna*, a small crustacean at the lower end of, but important to, the aquatic food chain. Cigarette butts in the environment are an important litter issue – not a smoking issue.

In addition to costly cleanup procedures, there are other economic impacts that are harder to put a price on. Littered parks, marinas, and beaches suffer from lost tourist income, and fisheries that are full of debris can result in decreased yield of food such as crabs and fish.

Solutions to Aquatic Debris

Cleanup

One solution to the aquatic debris problem is cleaning up the trash using paid employees and volunteers.

Several groups organize volunteer cleanups in Virginia, and are happy to include school groups in their efforts to make our streams and beaches cleaner. The International Coastal Cleanup in Virginia, an annual statewide cleanup of all water bodies in Virginia, is organized by Clean Virginia Waterways, located at Longwood University in Farmville. In addition to this statewide event, there are several regional cleanup events held every spring including the James River Regional Cleanup (organized by the James River Advisory Council), Clean the Bay Day (organized by the Chesapeake Bay Foundation), and the Potomac River Cleanup (organized by the Alice Ferguson Foundation). Hundreds of local cleanups are also organized every year through the *Adopt-a-Stream* program (run by the Virginia Department of Conservation and Recreation), where groups of interested citizens adopt a stream in their area. Virginia also has dozens of *Friends of...* groups, including Friends of the Rappahannock, Friends of the Shenandoah River, and Friends of the Appomattox River. These groups offer a variety of stewardship opportunities for citizens and students. See the list at end of chapter for contact information.

Are Cleanups the Answer?

Cleaning up pollution after it has entered the water is important, but it can be only a temporary solution if the sources of pollution are not also addressed. As mentioned above, the costs associated with cleanups can also be high. While both pollution cleanup and pollution prevention are needed, when it comes to the very preventable problem of aquatic debris, emphasizing prevention will yield greater results.

Pollution Prevention

There are two main approaches to preventing litter and trash from entering our waterways.

1. Proper Disposal. Educate people on the need to dispose of their trash properly, and make it easy for them to do so.
2. Waste Reduction. Examine how much waste we produce, and find ways to reduce it.

Proper Disposal

What a difference proper disposal of waste can make! As seen above, the vast majority of the aquatic litter is from items we can all easily carry until we find a trash can. Fast-food wrappers, bottles, cans, and cigarette butts are more than 80% of the litter we find in our waterways.

Waste Reduction

In the United States, we have 4.6% of the world's population, but we produce about 33% of the world's solid waste. Each of us can make incredible strides in reducing the amount of waste we are responsible for creating by employing the three "**Rs**"- **Recycle, Reuse, Reduce**. For every item we recycle or reuse, there will be one less piece of trash that can become a part of the aquatic debris cycle.

People can reduce the amount of trash they dispose of by:

- Buying reusable items rather than disposable ones. This can include reusable lunchboxes, plates, cups, eating utensils, and food containers instead of disposable items.
- Reusing items several times before throwing them away.
- Recycling plastics, glass, metals, and paper, and buying recycled goods too.
- Choosing items that have the least packaging.
- Not buying helium-filled balloons, and discouraging the release of balloons. Ask communities to celebrate in a way that

BALLOONS — A SPECIAL PROBLEM

What goes up must come down! Balloons return to the land and sea where they can be mistaken for prey and eaten by animals. Sea turtles, dolphins, whales, fish, and seabirds have been reported with balloons in their stomachs. It is believed that they mistake balloons for jelly-fish which are their natural prey. In 1985, an infant sperm whale was found dead of starvation as a result of ingestion of an inflated Mylar balloon which had lodged in its intestines. Ribbons and strings tied to balloons can also lead to entanglement.

In 1991, Virginia joined a handful of states in banning the mass release of balloons. The law states:

> "It shall be unlawful for any person to knowingly release or cause to be released into the atmosphere within a one-hour period fifty or more balloons which are (i) made of a non-biodegradable or nonphotodegradable material or any material which requires more than five minutes' contact with air or water to degrade and (ii) inflated with a substance which is lighter than air."

Balloons released for scientfic or meteorological purposes are allowed.

doesn't add these deadly balloons to our aquatic environment.

- Composting kitchen and yard waste.
- Using rechargeable batteries and recycling them when their useful life is over.
- Using a canvas or string bag to carry groceries and other items.
- Using cloth napkins, dishtowels, and handkerchiefs instead of paper ones.

Laws and Regulations

Growing public awareness and concern for controlling debris in our oceans and waterways has led to international, national, and state-wide laws that prohibit littering and the dumping of trash in waterways. In the United States and in Virginia, there are several laws regulating the use, disposal, and effects of solid waste on aquatic environments.

In 1988, the U.S. signed onto the International Convention for the Prevention of Pollution from Ships—called MARPOL for short—joining 64 other countries that signed this international protocol that made dumping plastic into the ocean illegal. After signing MARPOL, the U.S. passed the Marine Plastic Pollution Research and Control Act. This act makes it against the law to dump plastics at sea and in all U.S. navigable waters. Laws like this have reduced the amount of trash on our beaches and in our ocean. Even so, it is estimated that there are more than 46,000 pieces of plastic debris floating on every square mile of ocean today.

In Virginia, we have litter laws, and also a ban on the mass release of balloons (see box on page 7 of this chapter). To read Virginia's litter laws, go to the Virginia General Assembly's web site (*http://legis.state.va.us*) and select *Code of Virginia*. Type *litter* in the search box, and then click on *Submit*. You will see a list of statutes and regulations addressing this topic.

LITTER AS A TEACHING TOOL

For young students, litter is often the first thing they think of when they are asked to visualize pollution. And unlike less visible forms of aquatic pollution (pesticides, gasoline, oil, toxic chemicals, sewage), children can play a significant role in reducing the aquatic debris problem. They can help by cleaning debris out of a stream or off a beach, and they can also learn to dispose of all trash properly and never be a source of litter. Other ways litter can be a valuable teaching tool include:

- Teaching the connection between our actions and environmental impacts. Decisions we make can lead to pollution, or to a cleaner environment. The environmental consequences of our actions can be hard to predict.
- Understanding how trash becomes aquatic debris (storm drain connection).
- Participating in a cleanup activity, gathering data about the debris found, and analyzing the data can lead to a student's development of an environmental ethic, and heightened commitment to preserve water quality, beauty, and wildlife. Participating in cleaning

an area can help them realize that solving water pollution problems requires everyone's involvement.

- Cleaning up aquatic debris is one way students can have a direct and positive role in protecting our aquatic habitats.
- Animals are dependent on a safe and healthy habitat. Their water and land homes should be free from litter.
- Trash that is not in the right place (like a recycling bin, a trash can, or other waste container) is litter.
- Litter makes our communities less attractive and less healthy places to live in.

RESOURCES

For the teacher...

Marine Debris Education. National Oceanic and Atmospheric Administration (NOAA). *http://www.education.noaa.gov/books/debris/debris1.htmhttp://www.publicaffairs.noaa.gov/oceanreport/marinedebris.html*

Pocket Guide to Marine Debris. The Ocean Conservancy (2002).

Pollution Solutions: Litter Prevention Activities for Virginia Teachers. Virginia Department of Environmental Quality, Department of Environmental Education.

*Trash in our Oceans—You Can Be Part of the Solution: Marine Debris Abatement.*U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds. *http://www.epa.gov/owow/oceans/debris/index.html*

Turning the Tide on Trash: Marine Debris Curriculum. U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds *http://www.epa.gov/owow/OCPD/Marine/contents.html*

Virginia Department of Environmental Quality's Office of Litter Prevention and Recycling. *http://www.deq.state.va.us/recycle/*

For the student...

Marine Debris Coloring Book. National Oceanic and Atmospheric Administration (NOAA). *http://www.education.noaa.gov/books/debris/debris1.htm*

WATERWAYS CLEANUP EVENTS IN VIRGINIA:

- *The International Coastal Cleanup in Virginia* (Every September) organized by Clean Virginia Waterways

Email:	*cleanva@longwood.edu*
Phone:	434-395-2602
Web Site:	*http://web/longwood.edu/cleanva*

- *Clean the Bay Day* (Every Spring) organized by Chesapeake Bay Foundation

Email:	*chesapeake@cbf.org*
Phone:	757-622-1964 or 1-800-savebay
Web Site:	*http://www.savethebay.cbf.org/clean*

- *Potomac River Watershed Cleanup* (Every Spring) coordinated by the Alice Ferguson Foundation

Email:	*potomaccleanup@ferguson foundation.org*
Phone:	301-292-6665
Web Site:	*http://www.ferguson foundation.org*

- *James River Regional Cleanup* (Every Spring within the counties of Chesterfield, Henrico, Powhatan, Goochland, Cumberland, and Charles City and the cities of Richmond and Lynchburg) sponsored by the James River Advisory Council

Email:	*conleyk@chesterfield.gov*
Phone:	804-748-1567
Web Site:	*www.jamesriveradvisory council.com*

- *Adopt-a-Stream* and storm-drain stenciling programs sponsored by the Virginia Department of Conservation and Recreation

Phone:	804-692-0148
Web Site:	*http://www.dcr.state.va.us/sw/ adopt.htm*

Virginia also has dozens of *Friends of...* groups, including Friends of the Rappahannock, Friends of the Shenandoah River, and Friends of the Appomattox River. A list of these organizations can be found on this web site: *http://www.deq.state.va.us/cmonitor /links.html*

Endangered Aquatic Species

Virginia's unique natural heritage includes aquatic communities and ecosystems such as in tidal and nontidal wetlands, the Chesapeake Bay estuary, the Atlantic Ocean coast and 49,000 miles of rivers. These marvelous natural environments are home to more than 10,000 animal species and thousands of plant species – some of which are endangered or threatened.

What are endangered aquatic species?

Aquatic species are those organisms that live wholly or mostly in or on the water (fresh, brackish, or salt). These birds, mammals, fish, reptiles, amphibians, invertebrates and plants depend on aquatic environments for food, shelter, protection from predators, and other requirements of life. A list of aquatic species in Virginia that are endangered or threatened appears at the end of this chapter.

Every Species' Unique Role

Why should we be concerned about endangered species at all? Should we care if a few more species of freshwater mussels in Virginia become extinct? Who would miss the Shiny Pigtoe (one of Virginia's endangered clams) if it were to disappear? In other words, what is the importance of wildlife?

Endangered species: Organisms (animals or plants) that are at risk of becoming extinct.

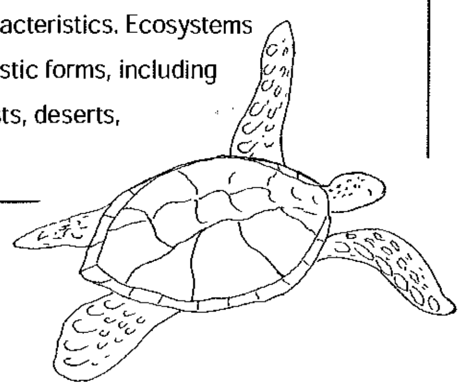
Threatened species: Organisms that are at risk of becoming endangered.

Species of special concern: Organisms that are at risk of becoming threatened or endangered.

Niche: Total role or way of life of a species in an ecosystem; its physical location and function within an ecosystem. Includes all physical, chemical and biological conditions a species needs to live and reproduce. Also called ecological niche.

Habitat: The specific environment (swamp, stream, woods) where an organism or a population of organisms lives or grows, characterized by physical features or by dominant plants.

Ecosystem: A functioning unit of nature that combines biotic communities (plants, animals and other organisms) interacting with each other and with the abiotic environment. Ecosystems vary in size and characteristics. Ecosystems have characteristic forms, including deciduous forests, deserts, grasslands, etc.



In order to understand the value of wildlife, it is important to first understand that all living things are interrelated and dependent in some way on other living things and their environment. An ecosystem, then, consists of all the interacting, interdependent species and the abiotic (nonliving) environment in a given geographic area. As investigated in the Living Systems strand of Virginia's SOLs, plants and animals each contribute to the functioning of the ecological system in this web of interdependence. Every plant and animal has a physical location and function within their ecosystem. The important role they fill is called their niche.

In water-related environments (as in dry-land environments), there are producers, consumers and decomposers. Some aquatic animals are herbivores, while others are carnivores or omnivores. And aquatic food chains have predator-prey relationships just as terrestrial food chains. When the population of one species is eliminated from a biological community, the relationship among producers, consumers and decomposers will undergo a shift.

U.S. Fish and Wildlife Service defines biodi versity as, "The variety of life and its processes, including the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur." More simply stated, biodiversity is all life on Earth including all of its many forms and processes. So, when species go extinct, biodiversity is decreased. Today, scientists around the word believe that protection of biodiversity should be a main priority for world leaders.

Reasons to protect wildlife

There are additional reasons why we should care about the protection of wildlife. First, species have intrinsic value or value just for being unique and irreplaceable. Species are also ecologically valuable in terms of their relationship and usefulness to other species (including us). When one species becomes endangered or extinct, it can affect all other species that interact with it.

Many aquatic species also have "instrumental" value to humans. This means the species have economic value because they provide us with food, recreation, materials or important services. For example, fish are an important part of our diet. Many species of mollusks, such as mussels, are useful to us as indicators of water quality. They can alert us to water that is not safe. Species can also provide medicines. Many of our medicines today such as aspirin and penicillin originally were obtained from organisms. Beyond their economic value, species are also important to humans for their scientific, spiritual, aesthetic and educational values. Many people greatly enjoy recreational activities such as whale watching. For all of these reasons, protection of wildlife and endangered species is extremely important.

What human activities endanger wildlife?

Species extinction today is occurring at a rate that is alarming many scientists. Biologist E.O. Wilson estimates that 27,000 species go extinct every year (an average of 73 – 74 species per day). He also estimated that only 10 species would become extinct in one year under "normal" circumstances. Human activity has accelerated the rate. Many species become extinct as a result of many stresses, not just one.

There are five main classes or groups of human activities that cause wildlife and plants to become endangered and eventually extinct. The acronym HIPPO provides an easy way to remember the five categories.

H = habitat destruction and fragmentation

I = introduction of invasive species

P = pollution

P = population growth (human)

O = over harvesting

HABITAT DESTRUCTION AND FRAGMENTATION

With the exception of the whales in our coastal waters, all the endangered and threatened species in Virginia have been listed in part or in whole due to habitat loss. Altering or destroying an ecosystem (or an animal's habitat) can profoundly impact the plant and animal species living there.

Human activities, such as draining and developing wetlands, destruction of aquatic reefs and sea grass beds, expansion of urban areas, logging, mining, farming, construction of roads and dams, and recreation, lead to the loss of important habitat for wildlife. When a species' habitat is altered such that it is unable to meet its daily needs for survival then it will become endangered and if enough critical habitat is lost, it will become extinct. The following examples illustrate the effects of human-caused habitat loss on Virginia's aquatic wildlife.

Example 1: Riparian Forest Habitat

Riparian means "...of, on, or relating to the bank of a natural course of water." So, riparian forests are forests along streams, rivers, and bays. They are extremely important as aquatic habitats for several reasons. They help to maintain stream and riverbanks and prevent erosion. Forest trees and shrubs remove nutrients from stormwater runoff and provide food to aquatic organisms from leaf debris. Riparian forest canopies shade and cool the water, improving habitat conditions for the fish, insects, salamanders, frogs and other in-stream organisms. They also provide critical food, shelter and nesting sites for many birds, small mammals and other wildlife. Wildlife such as ducks, herons, salamanders, turtles, and fish are all affected by loss of habitat, and many of these aquatic species are endangered in Virginia partly or wholly due to loss of this critical habitat. Today, hundreds of miles of riparian habitats are being replanted to restore these unique functions and benefits. The Virginia Department of Forestry has more information about riparian buffers in Virginia: *http://state.vipnet.org/dof/rfb/rfb-intro.htm*

Example 2: Wetland Habitat

Wetlands, such as bogs and marshes, have standing water for most of the year and have aquatic vegetation. They provide many direct and indirect benefits to human society, plus are critically important habitats for much of Virginia's aquatic wildlife. Many species of fish, shellfish, aquatic birds, and mammals depend on wetlands for survival, yet much of the wetland habitat in Virginia has been lost due to human activity. Wetlands and seasonal ponds have been drained or filled by humans for agriculture, road construction, or urban development, contributing to the endangerment of many of Virginia's aquatic species. Underwater habitats in Virginia's streams, rivers and bays have also been altered through increased sedimentation, reduced submerged vegetation beds, dredging, and other activities.

Example 3: Habitat Fragmentation

Development also leads to habitat **fragmentation**, where small, isolated fragments of natural habitat - referred to as ecological islands - are created from what was once continuous natural habitat. These fragmented bits and pieces are like islands surrounded by a sea of towns, roads, fences, power lines, farms and developed land. Fragmentation can lead to:

- local extinctions,
- changes in species abundance, distribution and diversity,
- changes in gene frequencies within a population,
- inbreeding in small, isolated populations,
- barriers (i.e., roads) that prevent movements and dispersal between smaller demographic units of animals,
- increases in the rate of exotic species invasion and
- other disruptions in the ecosystem.

Isolating a local population increases the probability of extinction. Fragmented areas can be too small to provide adequate room and food and so they support fewer species than a larger natural area. Many animal species require several different plant communities during their lifetimes, and may not find all the required elements in one fragmented area. For example, breeding sites requirements may be different than feeding sites. If these critical areas are separated by a road or other barrier, populations will decline.

Can Streams be Fragmented?

Habitat fragmentation can occur in aquatic systems too. Dams separate one part of a stream from another, creating a barrier that migrating fish cannot cross. The reservoir created behind the dam will also have very different characteristics than the natural stream habitat on the other side of the dam, rendering it unsuitable for many aquatic species. Streams that are encased, channelized or otherwise modified are often severed from their adjacent riparian zone, flood plain and wetlands.

To maintain biodiversity, and minimize fragmentation, ecologists recommend that we plan and manage our private and public lands in ways that minimize the isolation of our remaining natural habitats. In addition to minimizing vegetation clearing and road construction, we should restore habitat corridors to connect natural areas. For greatest success, conservation efforts need to be on the comprehensive landscape and watershed scales.

Invasive, Non-Native Species

Virginia's native plant and animal communities can be altered, and populations can be decimated, when non-native (non-indigenous) species invade and occupy areas outside of their natural geographic ranges. Invasive or exotic species are non-native plants or animals that lack natural predators and diseases that would control their population. Exotic parasites and pathogens also can inflict great damage to native biota. While not all exotic species cause serious damage, those that are successful in invading an ecosystem typically reproduce quickly and compete with native species for food and other resources such as space. Some native species, not able to compete effectively with the invasive species, quickly decline. Many scientists believe that invasive species are the second greatest threat to threatened and endangered species, behind habitat loss. It is estimated that about 42 percent of endangered and threatened species in the United States are in danger because of the effects of invasive species.

Human actions, both intentional and accidental, are the primary means of invasive species introductions. European colonists who wanted to make the New World more like home originally introduced many species not native to North America. Some intentional introductions of invasive species were intended to help with problems such as erosion and pest control. An example of a plant introduced to control erosion is kudzu, a climbing, perennial vine in the pea family. **Kudzu** was introduced into the U.S. from Japan in 1876 at the Philadelphia Centennial Exposition, where it was promoted as an ornamental plant, forage crop and soil stabilizer. Farmers were encouraged to plant it to reduce soil erosion, until the mid-1950s when it was recognized as a pest. Kudzu plants grow about one foot per day, and smother other plants under a solid blanket of leaves. Its vines can girdle trees, killing them.

Accidental introductions of non-native organisms can occur when people dump aquariums with exotic plant species or dump ballast water from ships. Organisms can also "hitchhike" on recreational boats, and be introduced to a different body of water. Scientists believe that the disease **MSX**, a leading cause of native oyster mortality in the Chesapeake Bay, was introduced when a foreign oyster was imported to bay waters in the 1930s. To learn more, see The Chesapeake Bay Program's website: *http://www.chesapeakebay.net/baybio.htm*

Invasive Aquatic Plant Species in Virginia

Hydrilla, an invasive submersed freshwater plant, forms dense mats in the Potomac River and Lake Gaston in Mecklenburg and Brunswick counties. It was introduced into Florida in the 1950s and spread to Virginia probably through recreational boating. Hydrilla mats obstruct water traffic and prevent light penetration necessary for the growth of native aquatic plants. **Purple loosestrife** is another invasive plant that grows particularly well in wetlands and marshes in Virginia and is sometimes called the "Purple Plague." Although its purple flowers are beautiful, purple loosestrife out-competes native plants, and causes loss of habitat for many endangered animals. **Eurasian water-milfoil**, indigenous to Europe, Asia and North Africa, is a submersed aquatic perennial that is found throughout the eastern United States. It reduces natural aquatic plant diversity much the way hydrilla does.

Invasive Aquatic Animal Species in Virginia

Rapa whelks, snails that are native to the Sea of Japan, are found in portions of the Chesapeake Bay where they prey on oysters, clams, and mussels. The **mute swan**, a native of Europe and Asia, is a beautiful bird, but is invasive and sometimes kills native waterfowl. It also destroys submerged aquatic vegetation that provides crucial habitat to many native species of fish and invertebrates. The **nutria** is an invasive rodent that lives and breeds in Virginia's fresh and saltwater ponds and swamps. Initially introduced into North America to be raised for fur, nutria destroy native aquatic vegetation.

More information on Aquatic Invasive Plants and Animals in Virginia and the Chesapeake Bay:

The Alliance for the Chesapeake Bay: *http://www.acb-online.org/pubs/invasives_fact_sheet.pdf*

The Virginia Natural Heritage Program (in the Department of Conservation and Recreation): *http://www.dcr.state.va.us/dnh/invinfo.htm* *http://www.dcr.state.va.us/dnh/bookeduc.htm*

Invasivespecies.gov: *http://www.invasivespecies.gov*

The Chesapeake Bay Program:*http://www.chesapeakebay.net/baybio.htm*

Pollution

Water pollution can have devastating effects on aquatic species. One of the most visible forms of water pollution is the tons of litter and debris that reach our waterways each year from intentional or accidental mishandling of trash. Litter such as cigarette butts, plastic bags, fast food containers, and fishing nets are deposited in streams, rivers and coastal waters. Aquatic species (particularly sea turtles, mammals, and birds) are often killed when they become entangled in or ingest these items. Virginia's sea turtles are endangered and two of the biggest threats to their survival are entanglement in discarded fishing nets and ingestion of marine debris. (See box.)

Toxic pollutants such as chemicals from factories and pesticides are not as visible as solid waste, but are just as harmful to aquatic wildlife. U.S. Fish and Wildlife Service estimates that 136 million pounds of toxic chemicals are discharged directly into streams, rivers, and lakes in the United States each year. Other chemical pollutants enter our waterways by way of polluted runoff from lawns, fields, streets and parking lots. Virginia issues fish consumption advisories every year because many of the fish in our waters have absorbed so many toxins that they are not safe for human consumption. In 2002, polychlorinated biphenyls (PCBs), mercury and a pesticide called Kepone resulted in fish consumption advisories for portions of the following rivers:

North Fork Holston River

South River

South Fork Shenandoah River

North Fork Shenandoah River

Shenandoah River

Roanoke River (Staunton River)

Potomac River and tributaries near Quantico

James River and its tributaries

Levisa Fork River

Dan River

New River

Bluestone River

For current fishing advisories, see the Virginia Department of Health's website:*http://www.vdh.state.va.us/HHControl/fishing_advisories.htm*

Used Motor Oil

It takes very little oil – just one quart – to contaminate 2 million gallons of water, yet each year millions of gallons of oil are dumped, spilled or leaked onto the land and into our waterways. Experts estimate that 50 to 90 percent of the oil polluting estuaries and oceans comes from land sources. Oil that is carelessly poured into roadside ditches or on the ground can enter groundwater and streams. Some people who change the oil in their cars deliberately dump used motor oil down stormdrains, not understanding that stormdrains usually discharge directly to waterways, and the oil will kill the animals that live there. Leaking underground tanks can also contaminate surface and groundwater with home heating oil and gasoline. In addition to the harm oil has on aquatic life, removing oil pollution from water is costly. All motorists, homeowners and commercial garages need to recycle used motor oil and have underground tanks inspected. In addition, oil and other toxic liquids should never be poured down a stormdrain or down any drain at all.

Nutrients

Excessive nutrients are a major source of pollution to Virginia's waterways and the Chesapeake Bay. Human activities that greatly accelerate the input of nutrients into a waterbody include runoff from home fertilizer use, agricultural fields, and confined animal feedlot operations (called CAFOs). Nitrate and phosphate-containing effluents from wastewater treatment plants, and some septic systems also lead to an increase of nutrients in streams, rivers, lakes, and coastal waters. Another major source of nitrogen entering the Chesapeake Bay and Virginia's waterways is from fossil fuel combustion, about a third of which come from vehicles. (See the box "Atmospheric Deposition of Nitrogen" for more information.) According to the Virginia Institute of Marine Science, excess inputs of nitrogen into the Chesapeake Bay from fertilizers and automobile exhaust can nurture harmful or toxic algal blooms so dense that they reduce water clarity and shade ecologically important Bay grasses. Also, when the algae die, its decomposition by bacteria depletes the dissolved oxygen in the water. Sometimes the dissolved oxygen level becomes too low to support any life, which can be detrimental to organisms such as mussels and clams that cannot move to new locations. Depleting the dissolved oxygen in an estuary like the Chesapeake Bay results in significant impacts on the people who depend economically on the Bay's living resources. More about the sources and impacts of excess nutrients can be found on the Alliance for the Chesapeake Bay's website: *www.bayjournal.com/02-10/qa.htm*

Sediment

Sediment, another important water pollutant, is caused by unchecked erosion from construction, logging, or agricultural activities. Riparian forest buffers and erosion-control measures can decrease erosion, and prevent the majority of sediment from entering waterways. Excess sediments can carry toxins to the water, narrow water channels for wildlife, clog fish gills, and cloud the water leading to decreased sunlight for aquatic vegetation. Sediment can also smother underwater habitats, effecting the populations of dragonflies, damselflies, mayflies, and other invertebrate species that have aquatic larva. Recreational boating and personal watercraft also stir up sediment leading to similar problems.

Atmospheric Deposition of Nitrogen

Pollution in the air from factories and vehicles becomes water pollution when it is deposited directly onto the surface of the water, or deposited onto land where it can run off into streams. Airborne pollution can fall to the ground in raindrops, snow, dust or simply due to gravity. According to the U.S. Environmental Protection Agency in their 2000 report "Deposition of Air Pollutants to the Great Waters," 21% of the nitrogen pollution entering Chesapeake Bay comes from the air. (See *http://www.epa.gov/oar/oaqps/gr8water/3rdrpt/index.html* for this report.) Nitrogen from atmospheric deposition is added to the nitrogen from other land-based sources, and can threaten the water quality and aquatic living resources. The U.S. Environmental Protection Agency's Office of Wetlands, Oceans and Watersheds has more information on atmospheric deposition: *http://www.epa.gov/owow/oceans/airdep/*

Population

The human populations of the United States and Virginia are increasing. According to the U.S. Census Bureau, the population in Virginia reached over 7 million (approximately 178 people per square mile) in 2000 and continues to increase. Wildlife has to compete with people for suitable habitat, and more people often mean less habitat for wildlife. As demand for housing increases, land is converted from wildlife habitat to residential areas including homes, roads, and shopping areas. Sprawled, low-density development causes the amount of land used per person to increase, thus decreasing forests, wetlands, and stream habitat for wildlife. Sprawl also increases the amount of air pollution as people drive more. Pavements, rooftops, and other impervious surfaces increase runoff, degrade water quality, and prevent rainwater from percolating into the soil.

Compounding this problem is the fact that 53 percent of the nation's population lives in coastal areas, making these areas the most developed in the nation. According to the Alliance for the Chesapeake Bay, about 14 acres of rural land were developed each hour in the Bay watershed during the mid-1990s, more than double the rate of the 1980s.

The Chesapeake 2000 Agreement (*www.chesapeakebay.net/agreement.htm*) has set a goal to reduce the rate of "harmful sprawl" 30 percent by 2012. This can be done by encouraging local governments to plan for smarter and more compact development and by increasing the initiatives for landowners to permanently conserve a portion of the landscape. The Alliance for the Chesapeake Bay has more information about urban sprawl: *www.bayjournal.com/01-03/develop.htm*

Over Harvesting

Many species are valuable to humans because they provide food or other goods. When done appropriately on a sustainable basis, harvesting of organisms like oysters, fish, and crabs for food is not detrimental to the species overall. However, some species have been over harvested by humans and are now threatened or endangered because of this detrimental human activity.

Whales provide an example of the effects of over harvesting by humans on species populations. Whale oil (oil made from whale fat) provided a major source of light for Americans in the 1800s. This oil was extremely valuable to humans, so whales were hunted to the point that their numbers were drastically depleted. Most whale species are endangered today because of this over harvesting. In Virginia's coastal waters, six whale species are in danger of becoming extinct. One of these species, the right whale, has an estimated total (worldwide) population of less than 400 according to the National Oceanic and Atmospheric Administration.

Some species are more likely to become extinct than others

Some species have traits that make them more vulnerable to extinction than others. Some species are specialists (as opposed to generalists) because they can only live in a very specialized type of habitat. For example, the piping plover, which is threatened with extinction, is a coastal bird in Virginia that only builds its nests on ocean beaches above the tide line. This specialized habitat requirement has led to the decline of the population of these birds as human development of the beaches and increased human activity on the beaches has greatly decreased the amount and quality of this critical habitat.

Species may also be rare and vulnerable to extinction if they are limited to a small area by barriers that prohibit their movement to other locations. Some species are rare because they naturally have low populations. Typically, very large organisms, organisms with long life spans and low reproductive rates, and top predators do not naturally have large populations. Other species are "nonadaptive," or cannot adapt quickly to changes in their habitat. If they do not have enough time to adapt, or move to new areas, their populations will be reduced. Some species will occur only in unfragmented, large patches of their preferred habitat, and cannot live in small patches.

CONSERVING AND RESTORING POPULATIONS OF RARE ANIMALS AND PLANTS

Because extinction is forever, and because public policy decisions can have major impacts

SEA TURTLES-PROTECTED BY THE ENDANGERED SPECIES ACT

Many sea turtle species can be found in Virginia's waters between May and November. According to Virginia's Department of Game and Inland Fisheries (one of the agencies and organizations that shares responsibility for protecting and conserving sea turtles in Virginia), between 5,000 and 10,000 sea turtles, mostly juvenile loggerheads and juvenile Kemp's ridleys, enter the Chesapeake Bay each spring/summer to feed in the warm, shallow waters. Green and leatherback sea turtles are also found within Virginia waters. Occasionally, female sea turtles will crawl out of the ocean to nest on Virginia's ocean-facing beaches.

All sea turtle species are listed as threatened or endangered and are protected under the Endangered Species Act. In fact, one of the most endangered animals in the world is the Kemp's ridleys sea turtle. Sea turtles produce many offspring but only about one in 5,000 baby turtles ever reach maturity. They grow slowly and do not reproduce until they are 20–30 years old. Most sea turtles are predators and depend on large invertebrate populations (such as crabs) for survival. Sea turtles' already low populations are threatened with extinction by human activities such as littering, development of their critical breeding habitat (beaches), and incidental catch by shrimp and fish trawlers.

Monitoring the distribution and abundance of sea turtles in state waters, examining turtle feeding ecology, and tracking movement patterns of adults and juveniles is coordinated by the Virginia Institute of Marine Science (VIMS). VIMS' Sea Turtle Program collects data on sea turtle migration, age and growth, physiology and habitat utilization. They work with fishermen and governments to develop fishing gear that can help save turtles' lives. VIMS' Sea Turtle Stranding Program treats and rehabilitates injured and ill sea turtles, and determines the cause of death when dead turtles are found. Although the cause of death cannot always be determined, some causes include: drowning due to entanglement, boat strike injuries, illness, and ingestion of fishing hooks, fishing gear or marine debris including plastic bags. In the water, plastic bags resemble on the geological, physical and biological characteristics of our aquatic ecosystems, governments pass laws to protect existing populations of rare species. In 1973, Congress passed the Endangered Species Act (ESA). The purpose of the act is to provide protection for and to conserve endangered and threatened species and the ecosystems that the species depend on for survival. Federal, state, and local agencies all work together and with private landowners to provide protection for threatened and endangered species.

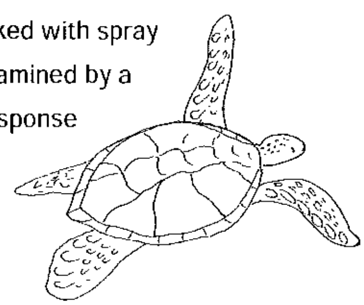
The goal of the ESA is "recovery" of endangered and threatened species. Recovery means that the species will no longer be in danger of extinction and will no longer need protection. A species is first listed as threatened or endangered after enough scientific evidence is collected to determine that its existence is threatened. Once a species is listed it is

Sea Turtles Continued...

jellyfish, a favorite food of some sea turtle species. When water temperatures drop (usually below 50 degrees Fahrenheit), some sea turtles suffer from cold stunning, where they become disoriented and lethargic and may appear to be dead. Without proper intervention a cold stunned sea turtle will likely die of exposure and hypothermia.

If You Find a Stranded Sea Turtle

If you find a stranded sea turtle (dead or alive) on the western shore of the Chesapeake Bay north of the James River, call the Virginia Institute of Marine Science Sea Turtle Program at 804-684-7313 or toll free at 866-493-1085. For all other strandings, call the Virginia Marine Science Museum Stranding Program at 757-437-6159. Note: Dead sea turtles marked with spray paint have already been examined by a member of the stranding response team and do not need to be reported again. Do not return live animals to the water and do not handle any animal without first contacting stranding response personnel for guidance.



More information and resources for teachers:

Virginia Institute of Marine Science Sea Turtle Stranding Program: *http://www.fisheries.vims.edu/turtletracking/stsp.html*

Virginia Marine Science Museum Stranding Team: http://www.vmsm.com/rescue.html

Virginia Department of Game and Inland Fisheries: *http://www.dgif.state.va.us/wildlife/sea_turtle_strandings.html http://vafwis.org/bova/lists/CAT03.htm* (species information)

Back Bay National Wildlife Refuge, Virginia Beach:*http://backbay.fws.gov/seaturtles.htm*

National Marine Fisheries Services, Sea Turtle information:*http://www.nmfs.noaa.gov/prot_res/PR3/Turtles/turtles.html*

Where Sea Turtles Roam by Virginia Department of Game and Inland Fisheries: *http://www.dgif.state.va.us/education/wildwoods/index.html* protected by the Endangered Species Act from harassment or harm from people. Recovery plans, developed for each listed animal or plant, identify threats and outline strategies for reducing these threats and increasing the populations of the species. Recovery plans can require that critical habitat be set aside and not be developed.

The U.S. Fish and Wildlife Service and the National Marine Fisheries Service (part of the National Oceanic and Atmospheric Administration) are the main federal agencies responsible for the implementation of the ESA. State agencies, such as Virginia's Department of Game and Inland Fisheries, Department of Conservation and Recreation's Division of Natural Heritage and Office of Plant Protection within the Department of Agriculture and Consumer Services also work toward the recovery of endangered and threatened species, as do local agencies, governments, and private landowners.

Private organizations involved in species protection and recovery efforts include The Ocean Conservancy and the World Wildlife Fund. Organizations in Virginia, such as the Chesapeake Bay Foundation, the Alliance for the Chesapeake Bay, and The Nature Conservancy, also work toward protection of endangered species through protection of habitat necessary for the survival of the species.

Virginia's Mussel Treasures

Virginia's rivers and streams are home to an amazing number of freshwater mussel species. The abundance and variety of Virginia's mussels (also called clams, shellfish, bivalves and unionids) have declined sharply in the last 100 years due to water pollution, sedimentation, dredging, and impoundment of rivers that have destroyed their habitat. Also, during the larval stage of the mussels' complex life cycle, they depend on certain species of fish. Many mussel species will not reproduce in the absence of host fish. Thus, reductions in fish populations due to pollution, dams or other human activities can also have negative impacts on mussel populations. An additional threat to our native freshwater mussels comes from the introduction of non-native species, especially the Asia clam (*Corbicula fluminea*).

Sixty-three counties in Virginia have endangered or threatened mussels in their streams. The majority of these counties have five or fewer, while seven counties in Virginia's southwest corner are home to more than a dozen each. Scott County has the largest number of protected mussel species – 35 in total. The other top counties are Lee (28 species), Russell (26), Tazewell (16), Wise (14), Washington (12) and Smyth (12). These counties are in the watersheds of the Clinch, Powell and Holston Rivers, ancient rivers in which mussels have had an extraordinarily long time to evolve into the diversity we see today. These rivers are unique because they escaped the glaciers of the Ice Age as well as periodic flooding with saltwater.

With colorful names such as snuffbox, monkey face, and heelsplitter, freshwater mussels

Whether employed by a business, private organization, government or school, biologists and specialists devote their careers to studying the habitat and behavior of animals and plants that are rare, threatened, or endangered. Their research and educational efforts help citizens and governments understand that our actions on land can have large impacts on freshwater and marine ecosystems.

Landowners can manage their land to protect natural communities of native plants and animals and improve water quality. Several land trusts operate in Virginia to assist conservation-minded landowners protect the health of our environment by putting conservation easements on their property. These conservation easements restrict the amount of development that can occur on the land in the future. Conservation, along with active restoration, will ensure that future generations can enjoy the spectacular natural gifts of our state.

Steps to Restore Populations of Rare Species

Communities, schools, and individuals can also help to restore populations of rare animals and plants. Schools and communities can:

- Research the benefits of native plants and locate a waterbody near your school that could benefit from riparian plantings. Plant native vegetation along the shoreline to provide food and shelter for migratory birds

Virginia's Mussels Treasures Continued...

burrow in the bottoms of clear, clean streams and rivers. Some species live in ponds and lakes. They look similar to the saltwater oysters and clams from which they have evolved.

Mussels are of unique ecological importance. As filter feeders, they consume algae, bacteria and organic particles that are suspended in the water column. They serve as natural water filters improving the water quality. They are also an important source of food for fish and wildlife, including muskrats, otters, raccoons and herons. Since the presence of mussels indicates that a waterbody is environmentally healthy, biologists study mussel abundance as an indication of past and present water quality. For example, if all the mussels in a stream die in a short period of time, this indicates a toxic contaminate has entered the water. Chronic water pollution leads to a gradual disappearance of freshwater mussels.

This extraordinary natural heritage needs protection. Today, Virginians are implementing conservation and recovery projects to inventory existing mussel populations and to artificially culture, reintroduce, and improve the habitats of mussels.

How many protected mussel species are in your county? Refer to the Virginia Water Resource Issues Chart, or visit the Virginia Game and Inland Fisheries web site: *http://vafwis.org/BOVA/LISTS/VCounty.HTM*

More about freshwater mussels: *http://www.ext.vt.edu/pubs/fisheries/420-014/420-014.html* and a filter for water entering your local stream, river, or bay. After the planting, monitor the success of the plantings and the wildlife that are using the area. See the Restoring a Stream lesson in this packet for details.

- Research ways local governments can set aside critical habitat for endangered species. Speak to your local government officials about their plans for "smart growth." Participate in community planning meetings and attend public hearings about development projects in your community.
- Research safe alternatives to the toxic products we use in our homes. Provide community education about correct disposal of hazardous household wastes and the safe alternatives.
- Plan a campaign to increase your community's recycling of motor oil, fishing line, metal items, plastic bags, bottles, cans and more. Include information about the harm litter causes to wildlife.
- Learn about the amount and types of pesticides and fertilizers that are used by your school and determine if their use could be decreased.
- Learn what happens to the leaves and grass clippings on your school grounds or in your community. Are they composted?
- Contact the Virginia Land Trust to learn if any landowners in your area have put conservation easements on their land to protect it from future development. Invite the landowner to speak to your class about their decision.

Aquatic Endangered or Threatened Species in Virginia

This list includes plants and animals that are listed as Endangered or Threatened on the Federal and/or Virginia lists. Additional species are considered "of special concern" or "candidate for listing." According to Virginia law, "It shall be unlawful to take, capture, kill, possess, transport, process, sell, or offer for sale within the Commonwealth any threatened or endangered species of fish or wildlife unless otherwise specifically permitted by law or regulation." Learn more from Virginia's Department of Game and Inland Fisheries: *http://vafwis.org/bova/lists/FSET.htm*

Marine Mammals:
- Manatee, West Indian
- Whale, blue
- Whale, finback
- Whale, humpback
- Whale, right
- Whale, Sei
- Whale, sperm

Mammals (Riparian and Swamp)
- Shrew, water
- Shrew, Dismal Swamp southeastern

Birds (Aquatic, Riparian and Semi-aquatic)
- Plover, piping
- Plover, Wilson's
- Falcon, Arctic peregrine
- Sandpiper, upland
- Tern, gull-billed

Fish
- Logperch, Roanoke
- Sturgeon, shortnose
- Chub, slender
- Chub, spotfin (= turquoise shiner)
- Madtom, yellowfin
- Darter, longhead
- Madtom, orangefin
- Paddlefish
- Dace, Tennessee
- Darter, sharphead
- Darter, variegate
- Darter, Carolina
- Darter, greenfin
- Darter, Tippecanoe
- Darter, western sand
- Shiner, emerald
- Shiner, steelcolor
- Shiner, whitemouth
- Sunfish, blackbanded

Frog
- Treefrog, barking

Salamanders
- Salamander, Shenandoah
- Salamander, eastern tiger
- Salamander, Mabee's

Sea Turtles
- Turtle, hawksbill
- Turtle, Kemp's (= Atlantic) ridley sea
- Turtle, leatherback sea
- Turtle, green sea
- Turtle, loggerhead sea

Turtles
- Turtle, bog
- Turtle, chicken

Mussels
- Monkeyface (pearlymussel), Appalachian
- Pearlymussel, birdwing
- Pearlymussel, cracking
- Bean (pearlymussel), Cumberland
- Monkeyface (pearlymussel), Cumberland
- Pearlymussel, dromedary
- Wedgemussel, dwarf
- Blossom (pearlymussel), green
- Spinymussel, James (= Virginia)
- Pearlymussel, little-wing
- Mussel, oyster
- Mucket (pearlymussel), pink
- Pearlymussel, slabside
- Floater, brook
- Lilliput, purple
- Snuffbox
- Spectaclecase
- Heelsplitter, Tennessee
- Coil, shaggy
- Mussel, slippershell
- Coil, rubble
- Supercoil, spirit

Clams
- Sandshell, black
- Papershell, fragile
- Pimpleback
- Sheepnose
- Supercoil, brown
- Fanshell
- Pigtoe, fine-rayed
- Bean, purple
- Pigtoe, rough
- Rabbitsfoot, rough
- Pigtoe, shiny
- Riffleshell, tan
- Pigtoe, Atlantic
- Pigtoe, pink (= pyramid)
- Deertoe
- Elephant-ear
- Pigtoe, Ohio

Aquatic Crustaceans
- Isopod, Lee County Cave
- Isopod, Madison Cave
- Amphipod, Madison Cave

Snails
- Snail, Virginia fringed mountain
- Ghostsnail, thankless
- Riversnail, spiny

Plants (Aquatic, Wetland, Riparian or Semi-aquatic)
- Northeastern bulrush
- Small-anthered bittercress
- Swamp-pink
- Virginia spiraea
- Mat-forming Water-hyssop
- Piratebush
- Variable sedge
- Virginia sneezeweed
- American ginseng

RESOURCES

For the teacher...

A Guide to Endangered and Threatened Species in Virginia. Terwilliger, K., Editor (1995). McDonald & Woodward Publishing Co.

Alliance For the Chesapeake Bay - Bay Journal *http://www.bayjournal.com/*

Chesapeake Bay Foundation - Environmental Education *http://education.cbf.org/*

Chesapeake Science on the internet for Educators *www.vims.edu/chessie*

Chesapeake Bay Program *http://www.chesapeakebay.net*

The Diversity of Life. Wilson, E.O. (1992). W.W. Norton & Company

Endangered Species Act *http://www4.law.cornell.edu/uscode/16/ch35.html*

Endangered Whales by National Oceanic and Atmospheric Association *http://www.yoto98.noaa.gov/books/whales/whale1.htm*

Fundamentals of Conservation Biology by Malcolm L. Hunter, Jr. 2002: Blackwell Science, Inc.

Invasivespecies.gov (fact sheets on invasive species) *http://www.invasivespecies.gov*

Marine Mammal Protection Act *http://www4.law.cornell.edu/uscode/16/ch31/html*

Marine Protection, Research and Sanctuaries Act *http://www4.law.cornell.edu/uscode/16/ch32.html*

National Marine Fisheries Service (part of the National Oceanic and Atmospheric Administration) *http://www.nmfs.noaa.gov/*

National Oceanic and Atmospheric Association - Education Program *http://www.education.noaa.gov/socean.html*

Natural Heritage Program (Virginia Department of Conservation and Recreation) *http://www.dcr.state.va.us/dnh/*

Project Wild sponsored by Virginia Department of Game and Inland Fisheries *http://www.projectwild.org/index.htm*

U.S. Census Bureau - Virginia Quick Facts *http://quickfacts.census.gov/qfd/states/51000.html*

U.S. Fish and Wildlife Service, Environmental Contaminants Program *http://sacramento.fws.gov/ec/default.htm*

U.S. Fish and Wildlife Service, Information on Invasive and Endangered Species:*http://www.fws.gov/*

U.S. Fish and Wildlife Service, Teacher's Packet *http://endangered.fws.gov/kids/heyteach.htm*

Virginia Department of Agriculture and Consumer Services Office of Plant Protection *http://www.vdacs.state.va.us/plant&pest/endangered.html*

Virginia Department of Conservation and Recreation's Division of Natural Heritage(Endangered species listed by county) *http://www.dcr.state.va.us/dnh/nhrinfo.htm*

Virginia Department of Game and Inland Fisheries *http://www.dgif.state.va.us/*

Virginia Fish and Wildlife Information Service *http://vafwis.org/perl/vafwis.pl/vafwis*

Virginia Institute for Marine Sciences - Ocean Sciences Teacher Resource Center *http://www.vims.edu/bridge/*

Virginia Marine Science Museum – Teacher's Corner *http://www.vmsm.com/teachers.html*

Virginia's Natural Resources Education Guide *http://www.deq.state.va.us/vanaturally/guide.html*

World Wildlife Fund's Endangered Species Program *http://www.worldwildlife.org/species/species.cfm*

For the student...

Kids Corner Endangered Species by U.S. Fish and Wildlife Services *http://endangered.fws.gov/kids/index.html*

Piping Plover Fun Stuff for Kids by U.S. Fish and Wildlife Services *http://pipingplover.fws.gov/fun/index.html*

Classifying Aquatic Debris

VIRGINIA SOL

- *Science* 1.8, 3.10
- *Social studies* 1.10, 2.10
- *Language arts* 1.3, 1.12, 2.3, 3.9
- *Math* K.17, 1.20

OBJECTIVES

- Predict the effects on animals of different kinds of aquatic debris (litter) in water
- Discuss the concept of debris and entanglement
- Describe specific examples of hazardous effects of debris on wildlife
- Discuss other harmful effects of debris in water
- Classify different kinds of debris found in water
- Identify different ways that debris can find its way into the water
- Discuss ways to reduce harmful debris
- Make a display presentation to publicize harmful effects and different types of aquatic debris, and possible solutions

MATERIALS

A large garbage bag of assorted trash items, provided by the teacher

SAFETY & REGULATIONS

All trash objects should be cleaned and checked by the teacher before being handled by students. Avoid any sharp objects or materials containing harmful chemicals.

For the field trip to the water site, follow all safety procedures as described in the Introduction to this packet.

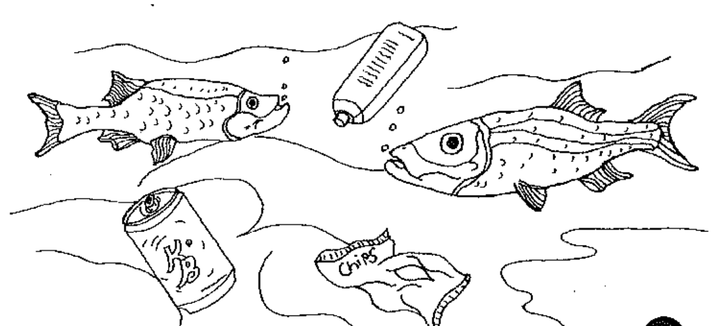
TIME NEEDED

2 class periods, and additional time to visit local water site

What different kinds of litter can be found in local water and how can it cause harm to people and animals?

This lesson is designed to increase students' awareness of different kinds of debris in water environments. Many times we think first of debris on our beaches and in our oceans. However, debris is also found in other aquatic environments, such as streams, rivers, ponds and lakes. Litter on beaches and in waterways is more than an ugly eyesore. Now we realize that debris has serious detrimental effects. Animals and humans can be harmed, aquatic habitats can be destroyed or damaged, littered beaches may need to be closed due to health concerns and it can be very costly to carry out cleanups or repair damage caused by debris.

Impact on animals is the first harmful effect of aquatic debris that most people think of. Fish, birds, mammals, and sea turtles can either ingest aquatic debris or become entangled. When animals ingest debris they have a false sense of being full and they can then die of starvation. Birds, fish, turtles and other animals that become entangled in fishing line, six-pack rings, or other packaging become restricted in their movement. Entanglement makes it harder for the animal to eat and breathe an often leads to death. Plastic trash is a particular danger to animals.



Plastics have many desirable qualities and so are widely used, but plastics also take hundreds of years to break down. Plastic materials can also look very similar to some animal foods and so are often mistakenly ingested by animals.

Other harmful effects of aquatic debris include risks to human health and safety, for example from pieces of glass or metal, or such things as discarded needles and syringes. Boaters can be endangered by entanglement of boat propellers. Aquatic habitat is diminished or destroyed when debris covers submerged aquatic vegetation or smothers bottom-dwelling species. Chemicals from debris can have detrimental effects on water quality. And there are also economic impacts from aquatic debris. It is very costly to carry out clean-ups of trash and debris, and there are other indirect consequences such as lost tourist income to littered parks and beaches.

In this lesson, students will first discuss these harmful effects of aquatic debris. They will then sort household garbage or trash into different categories to understand some different types of aquatic debris, and they will also discuss different sources of aquatic debris. Lastly, the students will discuss some solutions to the problem of aquatic debris, and they will make a display presentation to publicize harmful effects of aquatic debris, different kinds of trash, and possible solutions.

LESSON INTRODUCTION

Begin the lesson by talking with children about how different kinds of trash in water can affect the animals living in that habitat. Discuss with them the concepts of debris and entanglement. Emphasize to the students that trash or garbage refers to waste being generated, and when it is improperly disposed it then becomes debris or litter. First, ask children to work in groups to predict some effects that debris might have on different animals. After the groups have shared their suggestions, describe to the children some specific examples of hazardous effects of debris on wildlife.

Debris in water can have harmful effects on wildlife, but the debris can also have other harmful consequences. Ask the students what other harmful effects they can think of, and then discuss some examples with them. Other harmful effects include hazards for humans as well as animals, impacts on aquatic habitats, and economic impacts from costly cleanups and lost tourist revenues. As harmful effects of debris are discussed, organize these on the board in different categories.

Have students summarize the different harmful effects of aquatic debris in their science journals.

ACTIVITY PROCEDURES

Talk with students about different kinds of trash. Ask the children what different kinds of