5TH GRADE LIFE SCIENCE: Terrestrial And Aquatic Ecosystems

Please note: The standards listed below each Session are from the South Carolina State Science Standards adopted in 2005. There is a support document for each indicator and it has been provided as needed with each lesson as well.

SESSION 1: What is an ecosystem?

Standard 5-2.2 Summarize the composition of an ecosystem, considering both biotic factors (including populations to the level of microorganisms and communities) and abiotic factors.

➲ Show an image of an ecosystem (salt marsh, lake/pond, forest, grassland, etc.) and ask students to identify all the items in which they observe. Remind students that observations can be qualitative (using your five senses) or quantitative (using numbers/counting). A sample is provided below. Create a list or chart of student observations. Generate deeper thinking by posing the following questions: (1) Would there be anything we might not be able to see with our eyes? [microorganisms like bacteria] (2) How are the organisms and objects that you observe interconnected? [living organisms need other organisms for food, shelter, reproduction; they need objects like water and air to survive]

http://bhargavikorlipara.edublogs.org/files/2012/04/pond_ecosystem-1pvz1wg.jpg

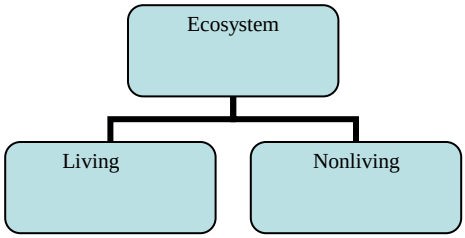
➲ Display the term ECOSYSTEM and inform students that the image (as well as all the items we wrote on the chart) are an example of an ecosystem. Remind students to recall what they remember from previous grades about habitats and the interconnectedness of organisms within that habitat. Have students formulate a definition for this term. [an ecosystem is the combination of the living and nonliving components in a given area]

- Discuss the two word parts: ECO and SYSTEM [eco-house ; system- group of parts that work together in some way] to see if that helps students deepen their understanding of the term. [The

living and nonliving groups are the parts that work together and depend on each other like in a house or home]

➲ Invite students to look for ways to group or classify their observations based on what they have in common. Scientists look for patterns in their observations that help them group ideas that are similar. It is important to provide students the time to converse about the possible patterns observed, hoping they will eventually determine the two main classification areas are living and nonliving. Pose questions as needed to help facilitate their thinking. [Factors can be living or nonliving. Living factors include organisms such as plants and animals as well as microscopic organisms. Nonliving factors are in the physical surroundings, such as soil, water, air, temperature, salinity, rocks, etc. These factors were never alive to begin with. Eventually students will use the terms biotic/abiotic factors for these classification later in session 2.]

- Create a classification chart for Ecosystem with two sub components labeled living and nonliving. Have students write examples from the chart under each component. Living should include examples such as plants, grass, trees, animals, bacteria, insects, etc. Nonliving should include water, air, temperature, soil, rocks, salinity, climate, etc.



Sample:

ECOSYSTEM	
Living	**Non Living**
▪ Deer ▪ Bird ▪ Grass ▪ Trees ▪ Fern ▪ Fish ▪ Turtle ▪ Horsefly ▪ Lady bug (?) ▪ Lilly pad ▪ Cattails ▪ Raccoon ▪ frog	▪ air ▪ heat/temperature/light/sun ▪ climate ▪ salinity (or lack of)

➲ Either display the following website on a board or print copies for students (either partner/shared reading with the teacher reading it aloud or for independent reading). It contains background information regarding ecosystems. The website can define key words, be written in Spanish or French, and contains a short multiple-choice quiz that could be used as an informal assessment.

- The site is http://askabiologist.asu.edu/explore/i-spy-ecosystem
  [Tamara Harms . (2009, September 22). I Spy an Ecosystem. ASU - Ask A Biologist. Retrieved July 30, 2013 from http://askabiologist.asu.edu/explore/i-spy-ecosystem].
- If you choose to use as a shared reading experience, pause at appropriate places to have students discuss important information. Students should take notes while they read the site's informational text. Have students use the following graphic organizer, Cornell note-taking, or some other way to document their reading and learning.

➲ Exit Slip: Parts of an Ecosystem

1. What are the two main components or factors found in every ecosystem?
2. Provide at least three (3) examples of each factor.

I SPY AN ECOSYSTEM!

[Located at http://askabiologist.asu.edu/explore/i-spy-ecosystem]

Section/Sub Heading	My Notes
What is an ecosystem?	
Where are ecosystems?	
How do ecosystems work?	
What do ecosystems do?	
How are ecosystems related?	

Session 2: What are biotic and abiotic factors in an ecosystem? What is the difference between a population and a community?

Standard 5-2.2 Summarize the composition of an ecosystem, considering both biotic factors (including populations to the level of microorganisms and communities) and abiotic factors.

From the SC Science Support Document: It is essential that students be able to give examples of biotic and abiotic factors in aquatic and terrestrial ecosystems including populations from microscopic organisms to communities with varieties of organisms.

Biotic factors	The living parts of an ecosystem are called biotic factors. All of these organisms have an effect on the others. An organism must get food, shelter water and other things in order to live, grow and reproduce from the area that it lives in. An organism depends on other biotic factors for food, shelter, protection, and reproduction.
Abiotic factors	Nonliving things that we find in an ecosystem are called abiotic factors**.** Abiotic factors have an effect on the type and number of organisms living in an ecosystem. Examples of abiotic factors are soil, water, temperature, and sunlight.
Organism	A single form of life; the simplest level of organization in ecology. (Microorganisms are very small, often one-celled, living things.)
Population	All the members of one kind of organism that live in a particular area.
Communities	A group of different populations of organisms.
Ecosystems	A collection of different communities and the abiotic factors.

Students should know that an *ecosystem* (types identified in 5-2.3) is an interacting system of plants, animals and humans and the surrounding physical environment. An ecosystem contains living and non-living factors that contribute to the functioning of other organisms. An ecosystem is not just a collection of organisms. It is a system of interrelationships, interactions, and processes. Ecosystems can be as small as a puddle or a rotting log to a whole forest or the planet.

➲Have students view the following digital texts (videos) regarding abiotic factors and organisms in their environment and take notes of their learning. A blank sample is provided below.

- VIDEO #1= Biology: The Science of Life: Ecosystems : The role of Abiotic Factors (15:00) [*Biology: The Science of Life: Ecosystems: The Role of Abiotic Factors* Ancient Lights, 2003 . Full Video. *Discovery Education*. Web. 30 July 2013. http://www.discoveryeducation.com/ >.] This fifteen-minute program examines the role of non-living, abiotic factors and the role they play in shaping ecosystems. Five abiotic factors are examined: water, air, soil, heat, and light. In addition, three air-mediated cycles are presented: the water cycle, the carbon-dioxide/oxygen cycle, and the nitrogen cycle. There is a short quiz after the video you can use as an informal assessment or

have students share their new knowledge with classmates. http://player.discoveryeducation.com/index.cfm?guidAssetId=2C732E32-E564-4F96-A45C-3BF6D0BAFB1E&blnFromSearch=1&productcode=US

- Questions to ponder with students after the video: What are examples of abiotic factors? [water, light, heat, air] How is water important to an ecosystem/environment? [examples may include bodies are made up of water; acts as a solvent to dissolve chemicals in/out of cells; part of photosynthesis] Air? [used in respiration/breathing; is a mixture of gases]. Lead students to creating a definition for abiotic factors [the physical part of an ecosystem or environment that is nonliving]
- Write the word ABIOTIC. Invite students to notice a word part they recognize within this word [bio=life]. If abiotic are nonliving factors, then what would be the opposite of these factors [biotic or living factors]. Have students go back to their organizer and write these new terms under living and nonliving.

- VIDEO #2= Biology: The Science of Life: Ecology: Organisms in Their Environment (15:00) [*Biology: The Science of Life: Ecology: Organisms in Their Environment* Ancient Lights, 2003 . Full Video. *Discovery Education*. Web. 31 July 2013. <http://www.discoveryeducation.com/]. This fifteen-minute program examines the interactions between organisms in their environments. The concepts of ecosystem, population, niche, food chain, food web, food pyramid, and the carbon cycle are all explained in this very useful program. http://player.discoveryeducation.com/index.cfm?guidAssetId=0B666D65-13A0-46AD-9914-4C7BA106DA46&blnFromSearch=1&productcode=US
  - Questions to ponder with students after the video: What are ecosystems and how do organisms interact in them? (all the interactions of a group of organisms in an area with one other and their physical environment; the abiotic factors support the living organisms and the biotic factors help to renew the nonliving environment) What is a population? (a group of the same species of organism that can produce living offspring that share the same environment) What is a community? (groups of populations) How do matter and energy flow in the environment? (when organisms consume or feed on other organisms through food chains) Are there organisms in an ecosystem that cannot be seen, and if so, what are they? (microorganisms, like bacteria)

➲ Exit Slip: Ecosystem and abiotic/biotic factors

1. What is an ecosystem?
2. What are biotic factors in an ecosystem?
3. What are abiotic factors in an ecosystem?

My Learning from Digital Texts (Videos)

Video #1- The Role of Abiotic Factors	Video #2- Organisms In Their Environment
MY NOTES	**MY NOTES**

SIX VIPs (Very Important Points):

Abiotic Factors: _____
Examples:

Population : _____
Examples:

Community: _____
Examples:

How organisms in an ecosystem interact with each other: _____

_____

_____

How does energy flow in an ecosystem? _____

_____

_____

How is a population different from a community? _____

_____

_____

Session 3: What are terrestrial and aquatic ecosystems?

Standard 5-2.3 Compare the characteristics of different ecosystems (including estuaries/salt marshes, oceans, lakes and ponds, forests, and grasslands).

From the SC Science Support Document: It is essential that students be able to determine the difference between different ecosystems:

Terrestrial	forests and grasslands
Aquatic	Fresh water: ponds and lakes Saltwater: oceans, estuaries and saltwater marshes

Students need to be able to compare these different ecosystems in terms of *biotic* and *abiotic* components.

- Examples of biotic factors are the types and numbers of organisms living in the ecosystem.
- Examples of abiotic factors are amount of sunlight, temperature, soil, nutrients, salinity, water clarity, or depth, all of which affect the variety and abundance of species.

➲ Display an arrangement of images of various terrestrial and aquatic ecosystems, including grasslands (prairies in USA and savanna of Africa), forests (rain, deciduous, coniferous), lakes, ponds, salt marshes, and ocean.

- Allow students to discuss what they observe in the images and if they can name the various ecosystems based on the factors they observe. Chart their answers.
- Pose the following questions: What do you notice about the ecosystems? Are there any that share common characteristics or factors? If we could classify all of the ecosystems into two large groups, what would be the heading of the groups? Guide their thinking to notice that some of the ecosystems are terrestrial (land) and some are aquatic (water). Some may seem like they are both, but look at the predominant factor.
- Complete the chart, labeling the various ecosystems and including biotic and abiotic factors found in each. Have students add to the chart as they view the following video clips for the different ecosystems.

http://saltmarshlife.com/salt-marsh/what_is_a_salt_marsh.html

http://cdn.zmescience.com/wp-content/uploads/2011/06/forest.jpg

http://cdn.assets-phoenix.net/content/dam/altcloud/img/articles2012/forward/11/are-wildfires-good-for-the-environment-662x214.jpg

http://www.roguevalleydoor.com/apps/default/asset/img/product_information/environment_image.jpg
http://www.desktopclass.com/wp-content/uploads/2011/01/Forest-environment-300x225.jpg

http://biomef.wikispaces.com/file/view/rainforest-2.jpg/32964331/rainforest-2.jpg

http://www.marietta.edu/~biol/biomes/images/alpine/cforestmt.jpg

http://earthdata.nasa.gov/sites/default/files/styles/large/public/2006_grasslands_wheat.jpg
http://www.doctordisruption.com/wp-content/uploads/2011/04/African-savanna.jpg

http://sustainablefoodtrust.org/wp-content/uploads/2013/04/Grassland-e1365532563164.jpg
http://ourenvironment.berkeley.edu/wp-content/uploads/2011/05/cows-and-pond-300x218.jpg

http://www.post-journal.com/photos/news/md/609764_1.jpg
http://star.txstate.edu/sites/default/files/users/austin.humphreys/worldlakeconferencecv.jpg

http://media.mlive.com/chronicle/living_impact/photo/9602771-large.jpg
http://www.ypte.org.uk/UserFiles/Image/Factsheet%20images/Ponds/pondmakinga.jpg

http://hawaiisurfingcamp.files.wordpress.com/2010/09/reefs-at-risk-ocean-girl-project-hawaii.jpg
http://www.drsfostersmith.com/images/articles/a-koi-ponds-43571.jpg

http://www.thefeltsource.com/Down-By-The-Pond.html
http://www.thefeltsource.com/Animals-Environments.html#SeaLife

http://cdn.beach.com/sites/default/files/styles/travel_guide_post_image/public/hilton%20head%20island%20salt%20marsh.jpg

http://www.mafiaisland.com/blog/wp-content/uploads/2010/09/RacoonButterflyfish.jpg

➲ The following digital texts (videos) are available to help students understand the various ecosystems required of this standard. Choose the ones you prefer and have students add to their "Ecosystem Chart" as they view the videos. Include characteristics of the ecosystem as well as biotic and abiotic factors. Share key details after each clip.

Biotrackers Mazzarella Educational Media, 2003 . Full Video.*Discovery Education*. Web. 31 July 2013. http://www.discoveryeducation.com/>

- Biotrackers: Grasslands (3:07) http://app.discoveryeducation.com/player/view/assetGuid/890560A6-E14A-404F-A8E6-412780EB56F7
- Biotrackers: Different Types of Forest Habitats (5:56) http://app.discoveryeducation.com/player/view/assetGuid/E70D432E-48F4-4872-892B-7C2C6EDAE340

Physical Geography Video Dialog, 1997 . Full Video. *Discovery Education*. Web. 31 July 2013. http://www.discoveryeducation.com/>

- Physical Geography: Water: Oceans, Fresh Water, and the Water Cycle (2:55) http://app.discoveryeducation.com/player/view/assetGuid/2A9215CD-779D-41E1-B7E1-6880C33F76CD

Freshwater Wetlands: Lakes, Ponds, and Pools Box Lunch Media, 2001 . Full Video. *Discovery Education*. Web. 31 July 2013. http://www.discoveryeducation.com/>

- Freshwater Wetlands: Lakes, Ponds, and Pools (2:16) http://player.discoveryeducation.com/index.cfm?guidAssetId=83ED0E88-9210-46BD-93E3-95E60B7BB1B6&blnFromSearch=1&productcode=US

The Biology of Water: Mud And Salt: The World of the Estuary Ancient Lights, 1991 . Full Video. *Discovery Education*. Web. 31 July 2013. http://www.discoveryeducation.com/>

- The Biology of Water: What is an Estuary (1:04) http://app.discoveryeducation.com/player/view/assetGuid/F2BC64E8-34C3-4E05-B118-81AA9AF5B1F3 The Shorelines: Bays- What is an Estuary (2:29) http://app.discoveryeducation.com/player/view/assetGuid/C985DD6D-694C-4BD3-B4AB-0CF0A3C1F514

Coastal Biomes: Where The Land Meets The Sea Cochran, 2001 . Full Video. *Discovery Education*. Web. 31 July 2013. http://www.discoveryeducation.com/>

- Coastal Biomes: Where the Land Meets the Sea- Salt Marshes (3:39) http://app.discoveryeducation.com/search?Ntt=salt+marsh

Oceans Alive: The Salt Marsh Box Lunch Media, 1990 . Full Video. *Discovery Education*. Web. 31 July 2013. http://www.discoveryeducation.com/>

- Oceans Alive: The Salt Marsh (5:00) http://player.discoveryeducation.com/index.cfm?guidAssetId=CEF8B284-A131-4F26-B2CB-491BBEA1FF9D&blnFromSearch=1&productcode=US
- Oceans Alive: Oceans- The Largest Ecosystem on Earth (3:40) http://app.discoveryeducation.com/player/view/assetGuid/32A52087-1AF3-49FE-8514-DA07C732721C

Biomes: Our Earth's Major Life Zones Creative Adventures, 1998 . Full Video. *Discovery Education*. Web. 31 July 2013. http://www.discoveryeducation.com/

- Biomes: Our Earth's Largest Biomes- Aquatic Marine Biomes (2:46) http://app.discoveryeducation.com/player/view/assetGuid/19770297-194E-4756-8B12-20A2A2857EF4

ECOSYSTEMS

TERRESTRIAL (LAND)			AQUATIC (WATER)		
Example/ Properties of	**Biotic Factors**	**Abiotic Factors**	**Example**	**Biotic Factors**	**Abiotic Factors**
grasslands			**Lake (fresh)**		
forests			**Pond (fresh)**		
			Estuary (salt and fresh)		
			Salt Marsh		
			Ocean (salt)		

➲ To review the various ecosystems and informally assess their knowledge of the characteristics of terrestrial and aquatic ecosystems, play a simple game of "What Am I?" or create a paper copy (a chart where students have to place checkmarks under the correct ecosystem). The teacher will provide various hints for the ecosystems studied and have students identify the correct ecosystem. There are a variety of ways the students may respond: race a classmate (like boys vs girls) to write the name on the board, write the name on individual white boards, oral quiz, written quiz, first to stand, etc.

Example of hints:

- I make up over 70% of the water on Earth. (ocean)
- I receive lots of rain. (forests)
- Plants and trees grow according to the amount of light they require. (forests)
- Examples of me include the Great Plains in the US and the savanna in Africa.(grassland)
- I am where salt and fresh water meet. (salt marsh)
- I am a shallow body of fresh water. (pond)
- I am an enclosed body of fresh water with various depths and temperature. (lake)
- I am a large body of salt water (ocean)
- Abiotic factors in me include air, water, temperature, and light (all)
- I am made up of predominantly fresh water (lakes and ponds)

➲ Exit Slip: Types of Ecosystems

1. Name two examples of terrestrial ecosystems.
2. Name five examples of aquatic ecosystems.

Session 4:
How do organisms in an ecosystem interact with each other?
What roles do organisms play in ecosystems?

Standard 5-2.4 Identify the roles of organisms as they interact and depend on one another through food chains and food webs in an ecosystem, considering producers and consumers (herbivores, carnivores, and omnivores), decomposers (microorganisms, termites, worms, and fungi), predators and prey, and parasites and hosts.

From the SC Science Support Document: It is essential that students be able to recognize a food chain and a food web and be able to explain the roles of each member (herbivore, carnivore, omnivores, microorganisms, termites, worms, fungi, predators, prey, parasites, and hosts). Students have not previously explored predator/prey relationships nor parasites and hosts.

- No community can carry more organisms than its food, water, and shelter can accommodate. Food and territory are often balanced by nature for example: fire, disease, or the number of predators.
- The flow of energy and the cycling of matter are two important processes in an ecosystem. Green plants capture and process solar energy, and through food webs and other organisms transfer the energy throughout the ecosystem. Organisms continually use and recycle organic material and nutrients in an ecosystem.

A *food chain* shows how organisms get their food. The first organism in a food chain is a producer; consumers or decomposers follow.

Producers Plants are called producers because they are able to use light energy from the Sun to produce food (sugar) from carbon dioxide and water.

Consumers Animals cannot make their own food so they must eat plants and/or other animals. They are called consumers. There are three groups of consumers.

- Animals that eat ONLY PLANTS are called *herbivores*.
- Animals that eat OTHER ANIMALS are called *carnivores*.
- Animals and people who eat BOTH animals and plants are called *omnivores*.

Decomposers Bacteria, microorganisms, fungi or other animals (such as termites and worms) that aid decomposition, feed on decaying matter. These decomposers speed up the decaying process that releases nutrients back into the food chain for absorption by plants.

Most food chains have no more than six organisms. There cannot be too many links in a single food chain because the animals at the end of the chain would not get enough food (energy) to stay alive.

An example of a grassland food chain:

Grass →	**Grasshopper** →	**Toad** →	**Snake** →	**Hawk** →	**Bacteria of decay**
Producers	Herbivores	Carnivores			Decomposers

- Note that the arrows are drawn from *food source* →to *food consumer*

Most animals are part of more than one food chain and eat more than one kind of food in order to meet their food and energy requirements. These interconnected food chains form a *food web*.

The relationship between *predators* (the hunters) and *prey* (the hunted) is often described as the *balance of nature.*

- Predators in a particular area control the populations of prey species, so that numbers of predators and prey remain fairly constant.
- The prey is prevented from overpopulating and destroying the habitat.
- There is a degree of balance in nature with the numbers of plants and animals, becoming neither too great nor too small. But predators are not the sole controlling factor. In most cases, a variety of things influence the abundance of life, such as predators, food availability, and competition with other species, disease, and even the weather.

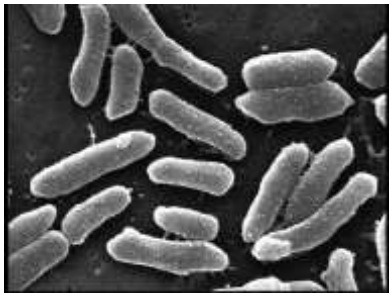
A *parasite* is an organism that spends a significant portion of its life in or on a living *host* organism usually causing harm to the host without immediately killing it. Parasites commonly show highly specialized adaptations allowing them to exploit host resources.
Examples of some common parasites are fleas and ticks.

➲ [This idea came from http://www.nhptv.org/natureworks/nwep9tg.htm.]. Have students list all of the food they have eaten so far during the day. For each thing eaten, have the student describe that food's relationship to a plant. For example, if a student had eggs for breakfast, they should identify the eggs as having come from a chicken and the chicken as having received its food from the seeds of plants.

- Pass out labels from a variety of foods to students - candy bars, cookies, cheese, tuna ... Have the students trace the source of the ingredients to plants. For example, the milk in cheese comes from cows that eat plants. The chocolate in candy comes from the cacao plant. The sugar in cookies comes from sugar cane.

➲ Display the following pictures/words: *oak tree, squirrel, bacteria*. Ask the students to turn and talk to a neighbor to determine which ecosystem they would most likely find these organisms. Pose the following questions:

- Do these organisms interact with each other in any way? If so, how?
- Do these organisms depend on each other in any way? If so, how?
- What does the oak tree produce or make? Does it consume or eat anything? If so, what? What do you think its job or niche would be in the ecosystem?
- What does the squirrel consume or eat? Can the squirrel produce or make anything? If so, what? What do you think its job or niche would be in the ecosystem?
- Does the bacteria produce or make anything? If so, what? Can the bacteria consume or eat anything? If so, what? What job or niche do you think the bacteria has in the ecosystem?
- What would happen if we add a hawk to this group of organisms?
- What does the hawk consume or eat? Can it produce or make anything? If so, what?

➲ Have students view two or more of the following videos. Remind students that before they finish the videos, they should be able to share the various niches or jobs that organisms assume in ecosystems. They may use words or images to help them understand these niches/jobs.

- Guide students to create definitions for the following terms and look for how some of the terms are related in a food chain: *producers, consumers, decomposers, predator, prey, herbivores, carnivores, omnivores, parasite, host*. What adaptations have been made to enable the animals to be producers, herbivores, carnivores, omnivores, predators, prey? [possibilities include teeth, claws, beaks, processes like photosynthesis vs digestion, body size, location of eyes- just to name a few]

- Go back to the original images of the oak tree, squirrel, bacteria, and hawk. Have students determine which organisms would fit with each term and label them as such. Some organisms will have more than one label. [oak tree = producer; squirrel= consumer, herbivore, prey; bacteria= decomposer, sometimes it can be a parasite; hawk= consumer, carnivore, predator]

- Have students discuss the relationships between the following terms and create a way to remember that relationship. For example, they may create a word association (what is is/is not; use word study phonemes like herb/carne/omni/vore), sketch/draw, role play, determine a good example, etc. The terms are *producers/consumers/decomposers; predator/prey; parasite/host; herbivore/carnivore/omnivore*. Are all predators consumers? Can producers ever be prey? If you did not show a video that explained parasite/host, lead a discussion as to their relationship. (Common parasites include ticks, fleas, leeches, hookworms, some bacteria and fungi).

- Begin a discussion on what is a food chain and what its purpose is in an ecosystem (to show the flow or path that energy and nutrients take as they are passed from one organism to another). Encourage students to refer back to all of their notes taken during the various videos. Use this data (i.e. student notes) to think like a scientist and construct a definition for a food chain and its purpose in an ecosystem. By doing this, students are using their data to draw conclusions,

just like a scientist. Focus on the three terms *producer, consumer, and decomposer* and determine how they are related. Pose the following questions: Does it matter which order they occur in a food chain? If we receive energy from the food we eat, where does the oak tree receive its energy? (the sun). Place the words in the order in which they should occur in a food chain. Producer > consumer > decomposer. Point out the importance of the direction of the arrow. It should always point TO the organism RECEIVING the energy.

- Does the hawk only eat squirrels? (no- it can eat mice, rats, doves, pigeons, fish, snakes) Do the squirrels only eat acorns? (no-it can eat other nuts, fruits, seeds, mushrooms, leaves, apples). Introduce the term *food web* and determine how it is different from a *food chain* (the web shows how the chains are interconnected since animals consume more than one kind of food; it will show several sources of food energy for consumers).

- Assess using an exit slip (see below).

Possible Video Clips:
The Food Chain Mystery (15:00), available at http://player.discoveryeducation.com/index.cfm?guidAssetId=020DAEF5-FCDA-4996-B414-0FA0657E82CD&blnFromSearch=1&productcode=US [*The Food Chain Mystery* 100% Educational Videos, 2000 . Full Video. *Discovery Education*. Web. 31 July 2013. http://www.discoveryeducation.com/.]

Planet Earth: Ocean Chain (6:04)
http://app.discoveryeducation.com/player/view/assetGuid/861441CA-598C-4D0B-98FF-DFFD463AFB40 [*PLANET EARTH: Deep Ocean* BBC. All Rights Reserved., 2007 . Full Video. *Discovery Education*. Web. 31 July 2013. http://www.discoveryeducation.com/ >]

The Science of Plants: Food chains and food webs (2:23)
http://app.discoveryeducation.com/player/view/assetGuid/5CF60DF6-5EB4-49E9-93F3-937BB2DF18EE [*The Science of Plants (Audio Description Version): Grades 06-08: Environmental Enclaves* Discovery Education, 2006 . Full Video. *Discovery Education*. Web. 31 July 2013. http://www.discoveryeducation.com/ >]

Song: Teacher and the Rockbots : The Food Chain (3:59)
http://app.discoveryeducation.com/player/view/assetGuid/2D79BCA8-53AC-4424-94B6-FE8218D6B557

Biology : The Science of Life- Food Chains and Food Webs (3:30)
(http://app.discoveryeducation.com/player/view/assetGuid/1EF9F359-0278-48D6-8020-3723EC8DD82B [*Biology: The Science of Life: Ecology: Organisms in Their Environment* Ancient Lights, 2003 . Full Video. *Discovery Education*. Web. 31 July 2013 http://www.discoveryeducation.com/>

Life Science: Ecology- The Food Chain: Predator and Prey (2:40)
http://app.discoveryeducation.com/player/view/assetGuid/35622F43-07F9-43FC-A815-A8B533B4A567 [*Life Science: Ecology* Discovery Education, 2002 . Full Video. *Discovery Education*. Web. 31 July 2013. http://www.discoveryeducation.com/ >]

TLC Elementary School: Earth's Ecology: Segment 14 (or 4/4) Producers, Consumers, Decomposers (4:39) http://app.discoveryeducation.com/player/view/assetGuid/0EB7B913-4BD8-43CA-9E9B-FEB5984A42D8 [*TLC Elementary School: Earth's Ecology* Discovery Education, 2004 . Full Video. *Discovery Education*. Web. 31 July 2013. <http://www.discoveryeducation.com/>]

New Hampshire Public TV: Natureworks- Episodes: #9 Wildlife Web 1-Producers and Herbivores (14:42) http://video.nhptv.org/video/1491187653 , #10 Wildlife Web II- Herbivores and Carnivores (14:43) http://video.nhptv.org/video/1491185781 , #11 Decomposers and Scavengers (14:45) http://video.nhptv.org/video/1491195223

➲**Exit slip: Parts of a Food Chain**

1. What is the difference between a producer and a consumer?
2. What is the difference between a food chain and a food web?
3. What are the three main roles in a food chain? Be sure to place them in the correct order using arrows.
4. What is the relationship between a predator and its prey?
5. What is the difference between a herbivore, carnivore, and omnivore?
6. What does a decomposer do in a food chain?

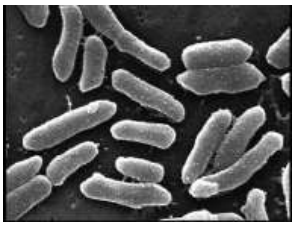
WHAT I LEARNED FROM THE VIDEO CLIPS:

Use words or sketches to help you understand the following terms:

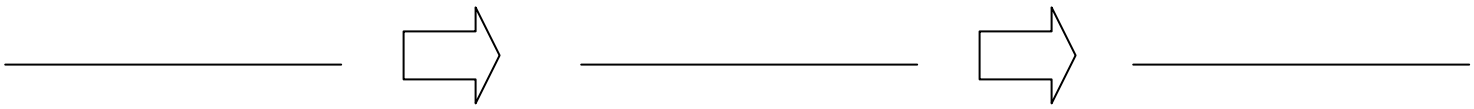
PRODUCER	**CONSUMER**	**DECOMPOSER**
HERBIVORE	**CARNIVORE**	**OMNIVORE**
PARASITE	**HOST**	**PREDATOR**
PREY	**FOOD CHAIN**	**FOOD WEB**

WHICH WORDS ARE RELATED TO EACH OTHER IN SOME WAY? WRITE THEM BELOW. BE ABLE TO EXPLAIN HOW THEY ARE RELATED.

WHICH TERMS WOULD YOU ASSOCIATE OR GROUP WITH THE FOLLOWING IMAGES? WRITE THE TERM(S) UNDER THE IMAGE

The three main parts of a food chain:

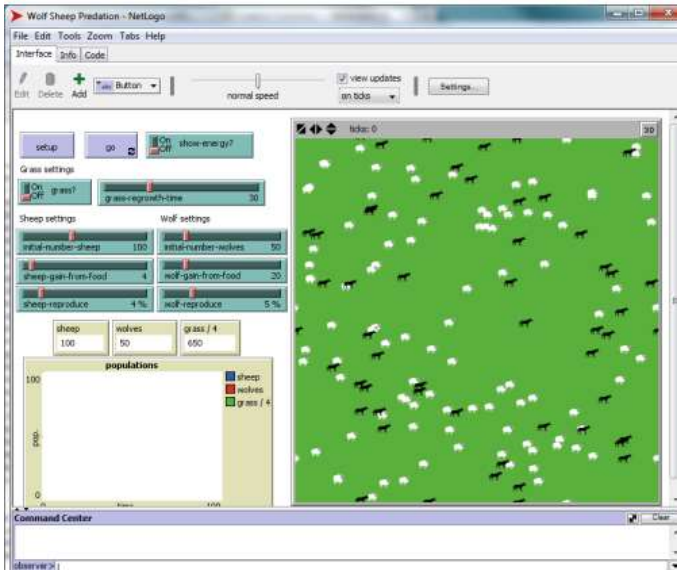


Session 5: Model of a Predator/Prey Relationship

➲ Download or visit the site NetLogo http://ccl.northwestern.edu/netlogo/. NetLogo is a computer simulation program that looks and feels much like a video game, but teaches biological principles. Look under FILES for MODELS LIBRARY. Click on BIOLOGY to open that folder and look for the file titled WOLF SHEEP PREDATION. This model explores the stability of predator-prey ecosystems. Such a system is called unstable if it tends to result in extinction for one or more species involved. In contrast, a system is stable if it tends to maintain itself over time, despite fluctuations in population sizes. The citation for NetLogo is provided at the end of this session.

- Double click to open the model.
- If you click on INFO, it will provide additional information for you. This information has been cut/pasted here for you from this NetLogo model/ program. It states, "There are two main variations to this model. (1) In the first variation, wolves and sheep wander randomly around the landscape, while the wolves look for sheep to prey on. Each step costs the wolves energy, and they must eat sheep in order to replenish their energy because when they run out of energy they die. To allow the population to continue, each wolf or sheep has a fixed probability of reproducing at each time step. This variation produces interesting changes in the population sizes of the sheep/wolves relationship since both the wolf and sheep will die out. (2) The second variation includes grass (green) in addition to wolves and sheep. The behavior of the wolves is identical to the first variation, however this time the sheep must eat grass in order to maintain their energy because when they run out of energy they die. Once grass is eaten it will only regrow after a fixed amount of time. This variation is more complex than the first, but the numbers of all three (grass, wolf, sheep) remain relatively the same."
- The information in the program also states "**Things to notice**: (1) When grass is not included, watch as the sheep and wolf populations fluctuate. Notice that increases and decreases in the sizes of each population are related. In what way are they related? What eventually happens? (2) Once grass is added, notice the green line added to the population plot (graph) representing fluctuations in the amount of grass. How do the sizes of the three populations appear to relate now? What is the explanation for this? (3) Why do you suppose that some variations of the model might be stable while others are not?"
- **Ways to Change**: Try adjusting the parameters under various settings. Manipulate the numbers of sheep and wolves, the amount of energy used by each animal, and their reproduction times. Just be sure to only change ONE variable at a time, and see what effect that has on the population of sheep and wolves. Use the plot/graph to look for patterns. This is a great opportunity to reinforce MANIPULATED (INDEPENDENT) AND RESPONDING (DEPENDENT) VARIABLES. What do the students observe with each manipulation? In a small or whole group setting, have the students choose one setting to manipulate and observe the effects. Have students write their observations down in a chart/log. For example, reduce the number of sheep by half and chart the effects.

Share results/findings/observations with whole class. Guide students towards understanding that as change happens within an animal's environment there is a cause/effect relationship. This concept will support them as they come to understand what happens when other animals invade their habitat which will be explored in future sessions.



This is what the screen will look like. The blue boxes are the parameters that can be adjusted or manipulated by simply sliding the bar from left to right. SETUP will display the colored portion of the model (grass/sheep/wolves) and must be clicked prior to starting the model. GO will start the model. Whenever a parameter is changed, be sure to click SETUP and then GO.

Citation for this model/program at NetLogo:

- Wilensky, U. (1997). NetLogo Wolf Sheep Predation model. http://ccl.northwestern.edu/netlogo/models/WolfSheepPredation. Center for Connected Learning and Computer-Based Modeling, Northwestern Institute on Complex Systems, Northwestern University, Evanston, IL.
- Wilensky, U. (1999). NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern Institute on Complex Systems, Northwestern University, Evanston, IL.

Session 6: How can limiting factors affect populations in ecosystems?

Standard 5-2.5 Explain how limiting factors (including food, water, space, and shelter) affect populations in ecosystems.

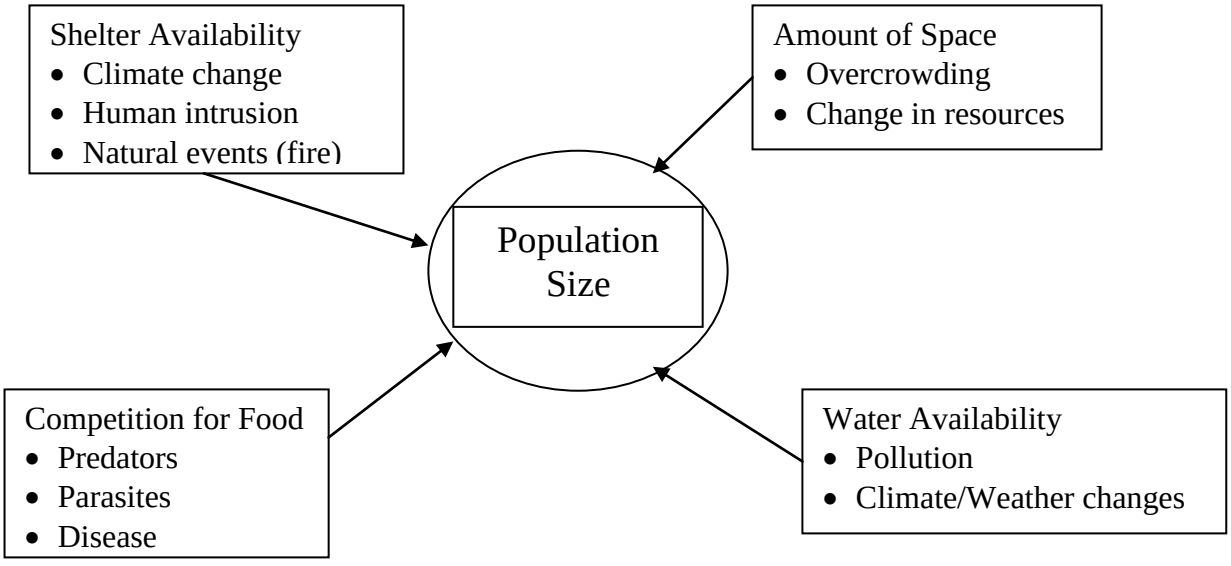
From the SC Science Support Document: It is essential that students be able to explain effects that limiting factors, such as food, water, space and shelter, have on a living things and their ecosystem.

- In the natural world, limiting factors, including the availability of food, water, shelter and space, can change animal and plant populations.
- If any of the limiting factors change, animal and plant populations also change. Some changes may cause a population to increase others may cause a population decrease.

Population Increase If there are more plants than usual in an area, populations of animals that eat that plant may increase. If one animal's population increases, the population of animals that eat that animal might also increase. Increases in population are not always good. Sometimes a population will grow too large for the environment to support.

Population Decrease Other changes in limiting factors will cause a population to decrease. If the water supply in an area decreases, the population that needs that water may decrease. Then the population of animals that eat that animal could decrease too.

DIAGRAM of SOME FACTORS that influence Populations



➲ [From http://www.nhptv.org/natureworks/nwep12tg.htm] Mark off an area of the classroom that is at least six feet by six feet. One-by-one have the students step into the area. Have the students indicate when the space has become too full to hold any more students. Discuss with the students how they felt as the space filled up. What made the space uncomfortable?

➲ Pose the following scenario and have students turn and talk to their neighbor.

We know that in the grasslands of Africa, wildebeests graze on the grasses but they must watch for predators like cheetahs and lions. Suppose there were no predators for the wildebeests. What would most likely happen to this population?

The discussion should include but is not limited to:

- Why would the population of wildebeests increase?
- How would the increased population impact the grass that is eaten?
- What might happen if the population gets too big for the amount of grass available?
- Can predators be a helpful thing when looking at the population of the wildebeests?
- In their normal environment, what other factors besides predators would create limits to the size of the wildebeest population?
- Begin to record these factors on an ongoing chart labeled "What We Are Learning."

Refer back to the NetLogo model seen in the previous session. See if students can connect what caused the changes in populations for sheep and wolves. What factors or reasons created these changes in the two populations? Add this new thinking to the "What We Are Learning" chart.

➲ [From http://www.nhptv.org/natureworks/nwep10tg.htm] Passing the Energy- This will require students to go outside to a relatively large playing field. Identify a home base on the playing field. Pass out name tags to each student. Use one color for plants, one color for herbivores and one color for predators. Place the "plants" on the playing field first after each has received five tokens (coins, beans, or something than can be handed off to another student). Tokens represent energy that gets passed up the food chain as organisms are consumed. The plants should be scattered over the playing field. Once the plants are in place, release the herbivores.

- Herbivores must collect three tokens (i.e. energy from an organism) from three different plants and return home to survive. If/Once a plant has given away all its tokens/energy, it should sit down. Give the herbivores a ten-second start and then release the carnivores. The carnivores must tag a herbivore to survive. Once a herbivore is tagged, it should release its tokens/energy to the carnivore and sit down.
- Give the students a chance to play each role.
- Discuss with the students what skills helped them survive. What factors caused them to die.
- **Note**: You can alter the outcome of the game by changing the number of plants, herbivores and carnivores.
- After the game, have a class discussion reviewing the factors that caused the creatures to survive and die and record this information on the "What We Are Learning" chart.

When producing this chart, see if students can notice any patterns or similarities. For example, in each activity, food was a factor that determined the size of populations. Through questioning, help students draw the conclusion that in each scenario, there were factors that limited the numbers of populations. We call these factors limiting factors. Basic factors will include water, food, shelter/habitat.

What We Are Learing:

Africa Scenario Factors	NetLogo Factors	Passing the Energy Factors

What do we call these factors? _____

➲ View the following video http://video.nhptv.org/video/1491196512 Population Dynamics (14:39) at the New Hampshire Public TV website. In this video clip, Patrice looks at a population and the limiting factors that can impact it. Next, she visits with Dave and they explore how a variety of factors can impact porcupine populations. Then we take an up-close look at the white-tailed deer. And finally, Von and Daniel visit with Professor Peter Pekins from the University of New Hampshire to learn about how he is helping to control deer numbers. This video will serve as an introduction to limiting factors.

- After the video, discuss the idea of limiting factors. Relate this concept to the activities the students participated in to begin the lesson (space, Africa scenario, on the playing field).
- Create a chart or web of possible factors that could influence the size or number of populations in an ecosystem. Guide students to include ideas such as the number of predators, available space, climate conditions, disease/parasites, availability of water/competition for food, pollution.
- Pose the following questions for discussion/debate: Do limiting factors have a positive or negative effect on population sizes? Can they be harmful or helpful? How can they create an increase/decrease in a population?
- Have the students identify causes and impact of animal and plant over- or under- population in your community. For example, is there a new subdivision being built? How does that affect the habitat of certain organisms? What effect will that have on the number of that organism in that environment?

➲ Ebb and Flow Activity- Write three limiting factors (food, water, shelter) each on a note card and place in a zip lock bag. Make enough bags for each student in your class. You can color-code the factors, but it is not necessary to do so. It is a way to adapt for students who may have reading difficulties.

- Divide your class into two groups: animals and suppliers. There should be fewer animals than suppliers (1:3). Have the suppliers line up on one side of the room and the animals on the other. Each group should have their backs turned away from the other.
- While their backs are turned, the animals must decide what they are in need of while at the same time the supplier is determining what it wants to supply. When the choice is made, each should pull out that card from their bag (without others seeing) and wait for your command to begin.
- At your command, have the animals go and search for their need. Only one animal per supplier. If they can match their need to that of a supplier, then they are permitted to live another day (play again) but the supplier must sit out (since it was used). If the need is not met, the animal must sit out. This could have a few implications: the animal dies out or it will have to relocate in order to find its needs.
- Repeat until either the animals or suppliers are no longer standing.
- Discuss the implications of the activity for the animals. What will happen to animals if their basic needs are not met in their environment?
- Play again as time permits, allowing students to swap roles until each has been able to be an animal.

➲ Limiting Factors Simulation Investigation (found at http://capone.mtsu.edu/gladectr/teaching/21_Limiting%20Factors%20in%20the%20Glades.pdf):

QUESTION: What types of factors limit the carrying capacity of the system in the cedar glade ecosystem?

- MATERIALS needed : masking tape, yard stick or measuring tape, pipe cleaners bent into 10 x 10 cm squares to represent the owls, colored pencils, graph paper, large bag of pinto beans (or other dried beans) to represent the mice, student data sheet
- BACKGROUND: In nature, populations of organisms rarely grow uncontrolled. Each ecosystem has a carrying capacity or number of organisms it can sustain due to its limiting factors. *Limiting Factors* are **biotic** and **abiotic** factors that prevent the continuous growth of a population. This activity will look at limiting factors found in the Cedar Glade ecosystem, and their impact on population growth.

PROCEDURE:

1. Divide class into groups of four. Assign these roles:
   - bean counter (mice counter) – scatters beans between rounds and records the number of beans caught. Beans represent mice.
   - Recorder – reads directions for the activity and records the data
   - female owl – stands outside the glade area, tosses the sampling square (to model the owl feeding), collects all beans (mice) located inside the square
   - male owl – same role as female

2. With masking tape, mark off an area (approximately 4 ft. square) on the floor. This represents an area in the glade where the owls will hunt.

3. Have the bean/mice counter scatter 80 beans over the grid. Each bean represents a mouse in the glade.

4. The two pipe cleaner squares represent a male and female owl, which separately hunt the area. Student should stand about one foot from the grid and toss the square into the grid.

5. Once the squares are tossed into the grid, the counter should remove any beans that are inside the square, count the number and write it on the student data sheet. Owls should repeat this step (but do not add more beans). Each "owl" has two chances to "hunt" (toss) each day. Do the same thing with the other owl. This process represents hunting mice. In nature, each owl hunts twice a day. *In order to stay alive, each owl must eat at least 4 mice in a three day period!* If fewer than 4 mice are eaten in any three-day period, the owl grows too weak to hunt and dies. Repeat the hunting (to a maximum of 10 days if needed) until there are no more mice for the owls. Create a graph for your data.

6. Manipulate the conditions of the glade (lack of rain) by removing 25% (or 20) of the beans from the grid. Continue to hunt for mice as before until the owls "die out" and don't forget to write your mice numbers in the data chart. Answer the two questions on the Data Sheet.

7. Manipulate the conditions of the glade again (adding a snake predator) by removing 3 mice prior to the hunting of each of the owls (for a total of 6 per day). Chart the number of mice consumed by the owls in the data chart. Continue to hunt as before until the owls "die out." Create a graph for your data. Answer the last question on the Data Sheet.

➲ After the simulation, look at the basic limiting factors of food, water, and shelter/space. See if students can think deeper regarding conditions that could limit the amount of these factors in an ecosystem and thus limit population sizes. Refer to the diagram found in the support document.

POPULATION SIZE IS AFFECTED BY:

Food	**Water**	**Space/Shelter**
Competition Predators Parasites Disease Invasive species Climate changes	Pollution Climate changes (flooding, droughts) Weather changes dams	Climate changes Human interactions or intrusions (construction) Fires, hurricanes, tornadoes Overcrowding

➲ Exit slip: Limiting factors.

1. What are limiting factors?
2. Name four examples of living factors.

LIMITING FACTORS SIMULATION DATA SHEET

Name _____

Investigation 1: In early spring, conditions are usually favorable for mouse populations in the glade.

A. Each owl hunts 2 times per day beginning with the female. Any mice caught must be removed before the next owl hunts. Enter the numbers in Table 1. Continue as long as there is a surviving owl. Enter an X in the appropriate box on the table indicating the date of death (if it occurs).

Table 1

Mice Eaten	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**	**Day 8**	**Day 9**	**Day 10**
Female Owl										
Male Owl										

B. Using graph paper, graph the data you recorded in Table 1: male vs. female
a) Label the X (manipulated variable) and Y axis (responding variable).
b) Make a legend for graph

Investigation 2: Lack of rain has led to drought-like conditions in the glade, so 25% of the mice die (20 total). Remove these 20 from your area before the owls hunt.

C. Complete Table 2 for 10 days like you did in Investigation 1.

Table 2

Mice Eaten	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
Female Owl										
Male Owl										

D. How did the dry conditions affect the hunting success of the owls as compared with Investigation 1. (Use data to compare).

E. What do you think would happen if the drought-like conditions had killed 50% of the mice?

Investigation 3: The spring season this year has been a successful one for the Eastern Garter Snake. Its numbers have increased by 25% and the owls are in direct **competition** with the snakes for mice. Begin with 80 mice; remove 3 mice (beans) each day before each of the owls hunt (6 removed total each day for male and female) to represent those mice being consumed by the snake.

F. Complete Table 3 for 10 days as in Investigation 1.

Table 3

Mice Eaten	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
Female Owl										
Male Owl										

G. Using graph paper, prepare a line graph using data from Table 4: male vs. female
a) Label the X and Y axis
b) Make a legend for the graph

H. How did the addition of competitors affect the survival rate of the owls?

Session 7: Challenges Facing Estuaries

➲ Review the characteristics of an estuary (a place where fresh and salt water meet; salt marshes are found here). View the following video about marine communities at the New Hampshire Public TV website (http://video.nhptv.org/video/1491162286/). Background information about estuaries can also be found at http://www.nhptv.org/natureworks/nwep6a.htm which provides a good summary of them.

- Visit EPA's Estuary site at http://water.epa.gov/learn/kids/estuaries/index.cfm. There is a tab that focuses on the challenges facing estuaries, including too many nutrients, pathogens, habitat loss, invasive species, and changes in water flow. A teacher has several options with this site. If you have access to multiple computers, divide students into groups for each challenge to become an expert on that challenge. If you don't have access to computers, try to cut/paste the information from each challenge into a document and provide that information to each group. There are links within each challenge to learn even more information, but note the reading level for the extras may be challenging.
- Have students share the information learned on the various challenges.
- Click on the games/activities tab and play the "Solve a Mystery" game by clicking on the first question. Read the scenario and have students determine which challenge might have caused the condition in the scenario. The computer will tell you if the answer is correct or not and then will send you to a new scenario.
- Have students complete an exit slip for challenges facing estuaries.

➲ Exit slip: Challenges Facing Estuaries

1. Describe at least two problems or challenges facing estuaries today.

Session 8: Invasive Species

In this session students will discover how container ships displace a group of sea animals from one environment to another. This can cause an invasion of space having adverse effects on ecosystems.

For sessions 8-10, students should use the "Invasive Species Notes" chart to document their learning and thinking.

➲Ask students if they've ever noticed tags like the images below in their clothes, toys, etc… If items they use everyday are made in other countries, how do they get to local stores? Students generate possibilities.

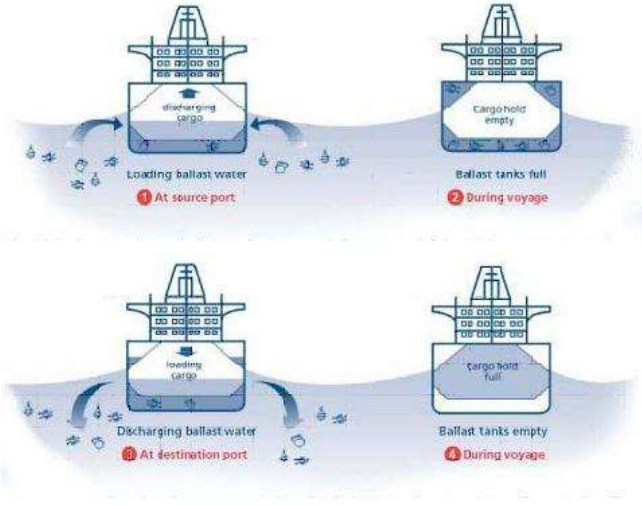
http://us.123rf.com/400wm/400/400/zagorskid/zagorskid0901/zagorskid090100480/4149787-made-in-china-label.jpg
http://guitargas.com/wp-content/uploads/2013/01/mex-strat-serial-tuners-hs.jpg

Show students the image below of container ships like the one below. Explain that ships like this one in the image are loaded with goods and shipped to other countries all over the world.

http://earthfirstnews.files.wordpress.com/2012/01/evergreen_container_vessel.jpg

Explain to students, using the images below, that the very bottom of these ships (called the *ballast)* is filled with water *(ballast water).* Generate thinking by posing these questions: Why are these ships filling and/or emptying all of this water? Where does the water come from? What might be in the water that is filling the ballast and then emptying back into the ocean? Guide students towards the conclusion

that these ships fill up with ocean water to balance out their weight. In the process of filling the ship with ballast water, small sea creatures are sucked into the ballast as well. Once the container ship has reached its destination, the ballast water is emptied along with the animals.



http://www.seanews.com.tr/images/articles/2011_01/49347/20080712_ballast_33.jpg
http://articles.maritimepropulsion.com/image.axd?picture=2011%2F1%2FD1+Ballast+water+exchange.jpg

Give students a concrete example of the ballast of a ship filling up with water. You could use a small clear basin and a bath toy boat. Put sprinkles/glitter in the water to represent an invasive species. Fill the toy boat up with a little bit of water/sprinkles/glitter, move it to another small basin, and empty it. The sprinkles should come out with the water.

If the sprinkles/glitter represent other creatures, say, a species of fish, what would happen to that fish if the ship leaves a European country on its way to the Charleston, SC port where it dumps the ballast water? {that species of fish would then be dumped into the Charleston harbor where it will need to find a new habitat)

At this point, students may begin to make the connection using what they know about how environments support specific needs of living things to figure out the problem these container ships are causing to different species in other ecosystems.

Have students add to their “Invasive Species Notes” chart. It is located at the end of session 10.

Session 9: Invasive species that can possibly limit the size/number of species

➲ The following is part of Dr. Blaine Griffen's presentation of his research regarding understanding the link between extinction and invasive species. Dr Griffen can be reached via email at bgriffen@biol.sc.edu. He is an Assistant Professor in the Biological Sciences and the Marine Sciences Program and the University of South Carolina in Columbia, SC.

Much of the information provided below is from Dr. Griffen's presentation regarding his research and is provided as background for the teacher. However, many parts can also be incorporated into a presentation for students (via powerpoint, Smart file, etc.). You could also use his video clip as an introduction to his research presented below. Click on the link to Dr. Blaine Griffen's research webpage to learn more about animals that have invaded other animals' environments. http://ww2.biol.sc.edu/~bgriffen/invasivecrabs.html (video)

Visit a video of his research at http://ww2.biol.sc.edu/~bgriffen/invasivecrabs.html . This video summarizes work that he has conducted to explore why one invasive crab (the European green crab) has been replaced by another (the Asian shore crab) on New England shores.

Systems today and the organisms they support are facing lots of environmental challenges and changes (climate change, habitat destruction, invasive species, pollution, ocean acidification, overfishing, etc.) Every organism must respond to these changes in basically one of two ways: respond appropriately and survive or respond inappropriately and become extinct.

Look at populations or species that have become extinct: wooly mammoth, dodo bird, dinosaurs, Galapagos giant tortoise. Many of these mass extinctions have been associated with rapid environmental changes.

Let's look at one of these challenges: invasive species.

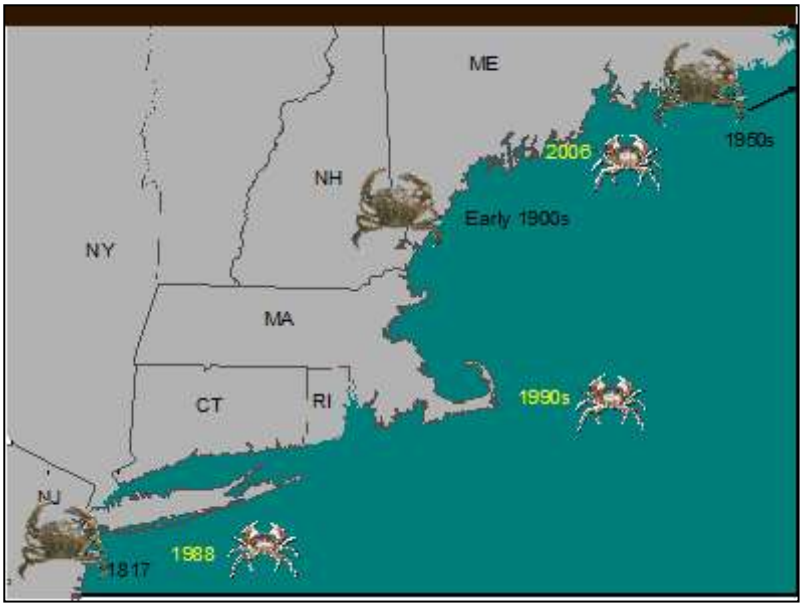
An invasive species is a species that gets introduced some place it should not be and eventually increases in numbers but at the same time causes a negative environmental challenge in its new habitat. As it turns out, many of the animals that are extinct are so due to an invasive species.

Carcinus maenas

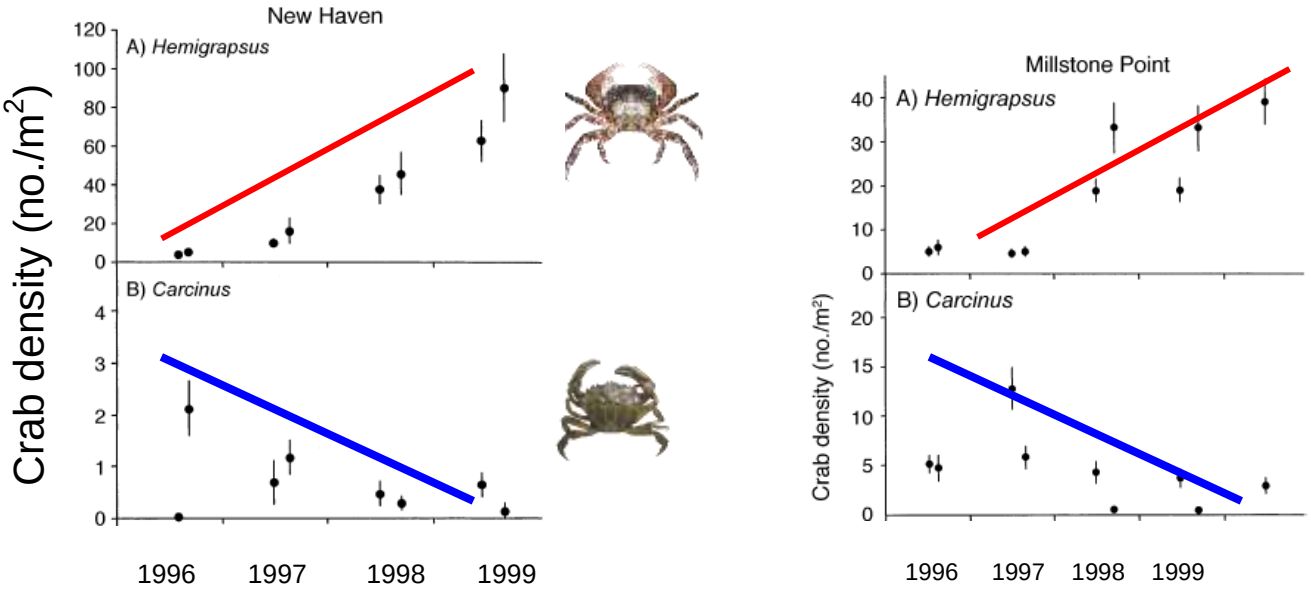
(Green crabs)

Hemigrapsus sanguineus

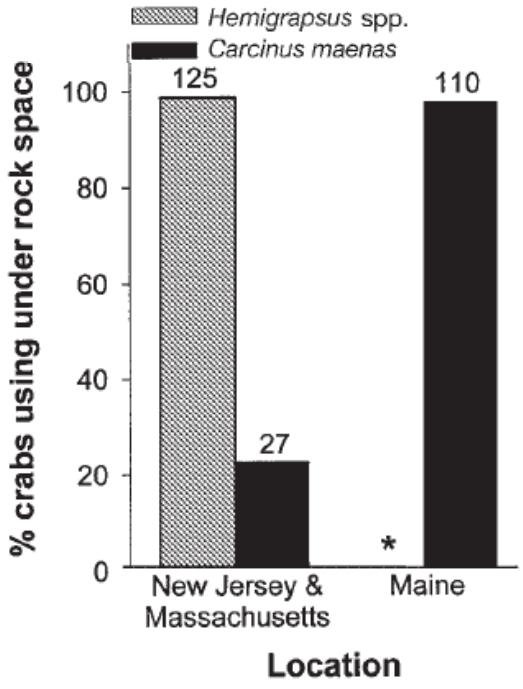
(Asian crabs)



These are two invasive species that are currently found on our Atlantic coast. Both of them presumably arrived here through ballast water transport. The green crab *Carcinus maenas*, originated in Europe over 200 years ago. It showed up in New Jersey in the early 1800s and spread slowly, arriving in the Gulf of Maine by the 1900s and spread into northern Maine and Canada by the 1950s. The Asian shore crab *Hemigrapsus sanguineus* came from Asia in the late 1980s and has invaded the same area. It reached the Gulf of Maine by the early 1990ss. As it has advanced up the coast, it has caused the local extinction of the green crab from site after site.



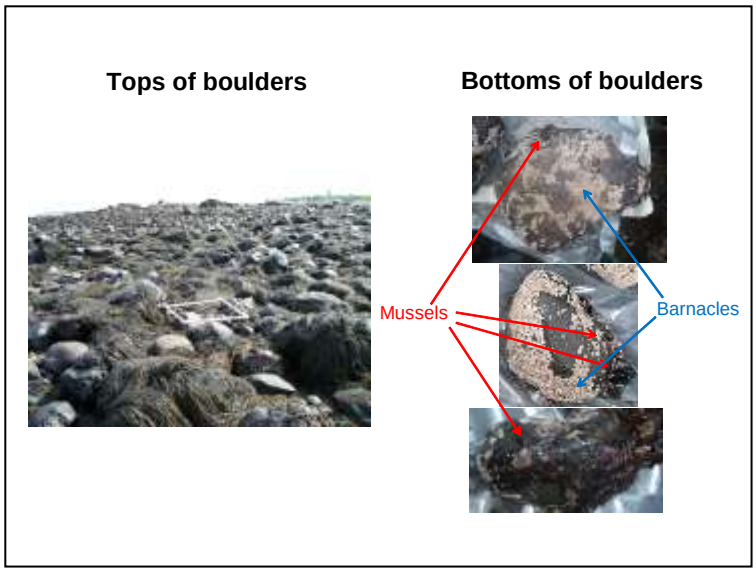
What can we conclude about the effects of the new invasive species on the older one? Why do you think this is so?



This figure shows the percentage of crabs found using rocks as refuge in the field. They compared interactions between the two species in two different regions of New England. The southern region was New Jersey and Massachusetts where, at the time of this study, the two species overlapped. And the second was Maine, where at the time of this study, the Asian crab (noted with an *) had not yet arrived. Notice that in NJ and MA few green crabs were found under rocks – only about 20% of them.

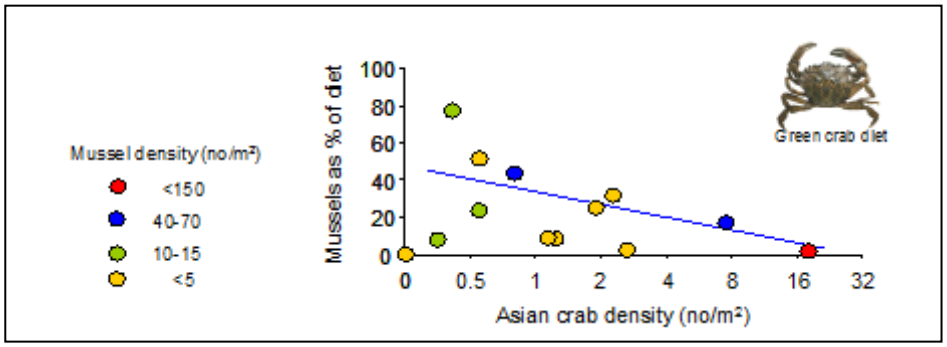
In contrast to this, in Maine, all green crabs that were observed were found under rocks, using the rocks as refuge habitat.

Questions to ponder: Why do you think there were fewer green crabs (black bar) found under rocks in NJ and MA? [green crabs stop using rocks – they are moving to get away from these amazingly high densities of the new invader who were more aggressive] Why were there more found in Maine? [the Asian crab hadn't made it that far up the coast yet, so the green crab didn't have to leave the rocks]



The problem with this habitat shift of leaving rock refuges is that mussels, barnacles, urchins, and other potential animal prey that crabs like to eat are found primarily attached to the underneath side of these rocks. [crab is predominantly a carnivore- although technically crabs are omnivores, but this one species prefers meat]

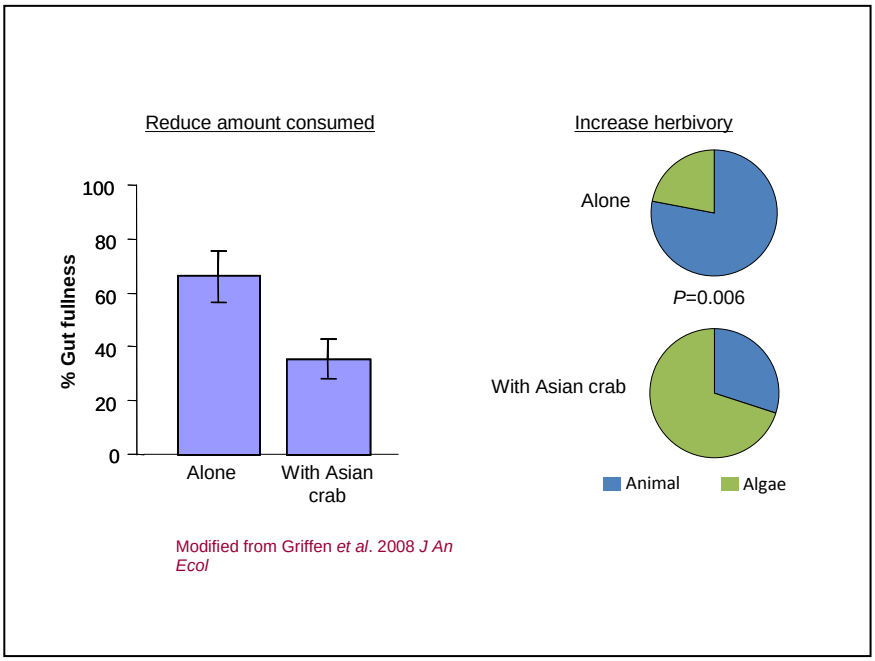
- The picture here on the left shows the site where Dr. Griffen studied the crabs for the last 10 years. What do you see? (the hair-like material on the rocks is algae).
- On the right it shows some pictures of the same site where he flipped some rocks over, and looked at what was underneath. Notice all the mussels and barnacles.
- Thus, as crabs use boulders for refuge habitat they simultaneously gain access to animal prey that are under those boulders. When they stop using boulders as refuge, they simultaneously lose access to this prey. And what is left for them to eat on top of the rocks? (Algae).
- So we should expect that this habitat shift would lead to a shift in diets. They would go from being a carnivore to an herbivore (or technically an omnivore that focuses on eating plants).



Mussels are an important food source for both of these species, particularly for green crabs. This figure shows the percent of mussels in the diet of green crabs as the density of Asian crabs increases, even after accounting for differences in the availability of mussel prey at each site as shown by the different colored circles.

- The general pattern is that green crabs reduce mussel consumption as the new invader becomes more dense. So notice that at the site we sampled where the Asian crabs were most dense, it also had the highest mussel abundance (shown by the red dot), but green crabs just weren't eating those mussels, even though they were there. Why do you think this happened?

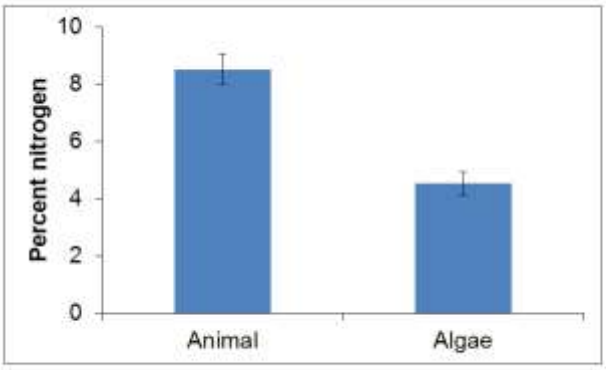
Dr Griffen and his team placed individual crabs into field cages together with a representative sample of all the natural food types that were found in the surrounding habitat. Then they let the crabs forage for 48 hours, either with each species alone or with the two placed together. After that, they removed the crabs and analyzed their gut (stomach) content.



The bar graph on the left shows the % gut fullness of green crabs that foraged alone or when Asian crabs were present. When the two species were placed together, green crabs ate about 50% less food overall. Not only that, but they also altered their diets.

The circle graphs on the right show the gut contents by category from the same experiment and lumps food together into two broad categories: algae or animal material. These pie charts demonstrate that when green crabs were alone, they ate more than 75% animal material, but when the two species were placed together, green crabs flipped their diet and ate almost 75% algae or plant material. Why do you think this occurred? [Make sure they make a connection back to leaving the boulders where the animal's prey is/ are found. Due to the large number of Asian crabs, the green crab changed its location to above the boulders in order to eat.

FYI: In regards to the gut, ultimately, food consumption by crabs is limited by the size of this holding tank called the cardiac stomach. The bigger it is, the more they can consume at any one time. But the green crab is mostly a carnivore, so its gut is relatively small. There is a lot of nitrogen found in animal tissue, so the crab doesn't need a large gut to gain the nitrogen it needs to survive and reproduce. There is not as much nitrogen in plant matter, so the crab has to eat tons more plants to get enough nitrogen. The problem is in the normally small gut size (due to being carnivores prior to the Asian crab's invasion). It is too small to eat or hold the large quantity of plant matter needed for the nitrogen intake. Less nitrogen intake = decreases the chance of survival and reproduction.



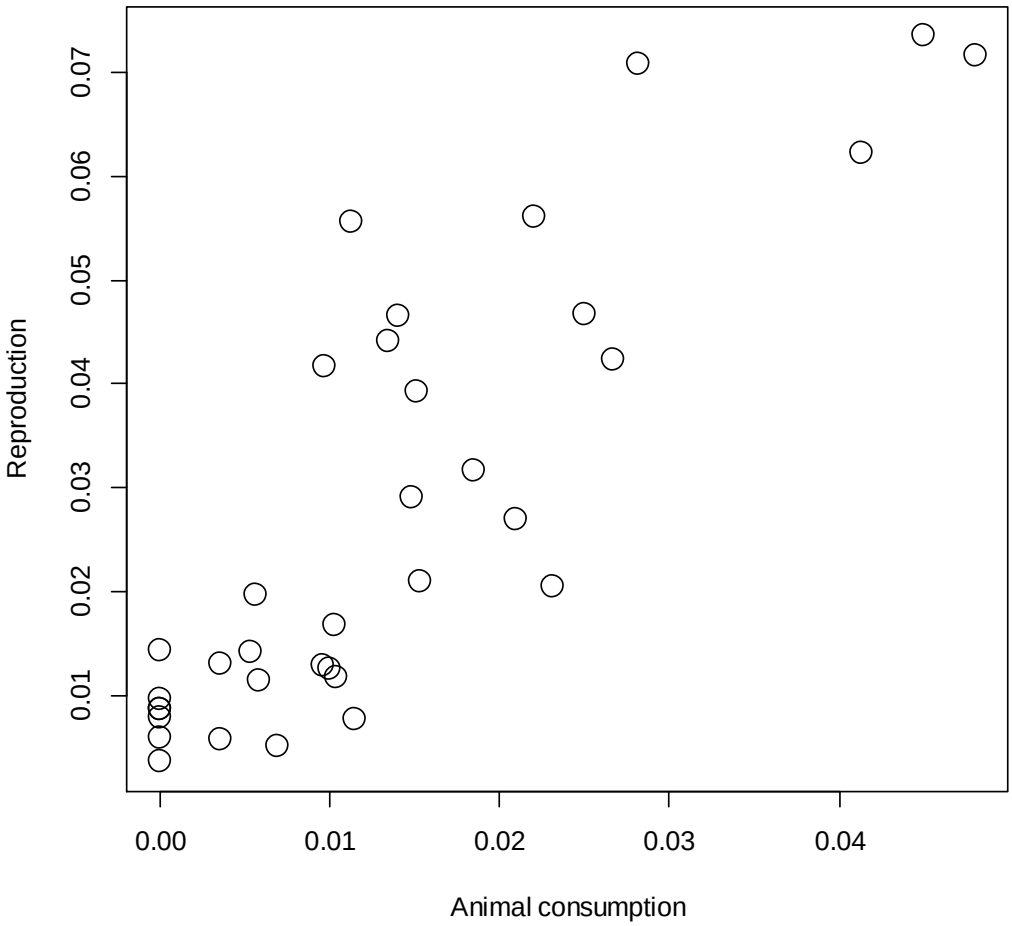
Crab eating a turtle

Crab eating a leaf

Show students the graph and have them explain what it is showing. Crabs are generally omnivorous, consuming both plant and animal foods. But some crabs naturally eat more plants and others naturally eat more animals. But plant and animal foods are not the same chemically, and one way that they tend to differ is in their nitrogen content. As shown in this figure, common marine animal prey are generally more nitrogen-rich than common algal foods. But all crabs need nitrogen in order to grow and reproduce.

This lack of nitrogen will also affect the reproduction of the European green crab. In his experiments Dr Griffen found that the general trend is that the more animal tissue a crab consumed, the higher the reproductive effort. However, consumption of algae for food had no impact on reproduction. The highest amount of reproductive effort occurred at the highest animal consumption and no algal consumption, while crabs with the lowest reproductive effort had no animal consumption but considerable algal consumption. If the crabs are not producing due to the smaller quantities of nitrogen in its herbivorous diet, what can happen to this species??

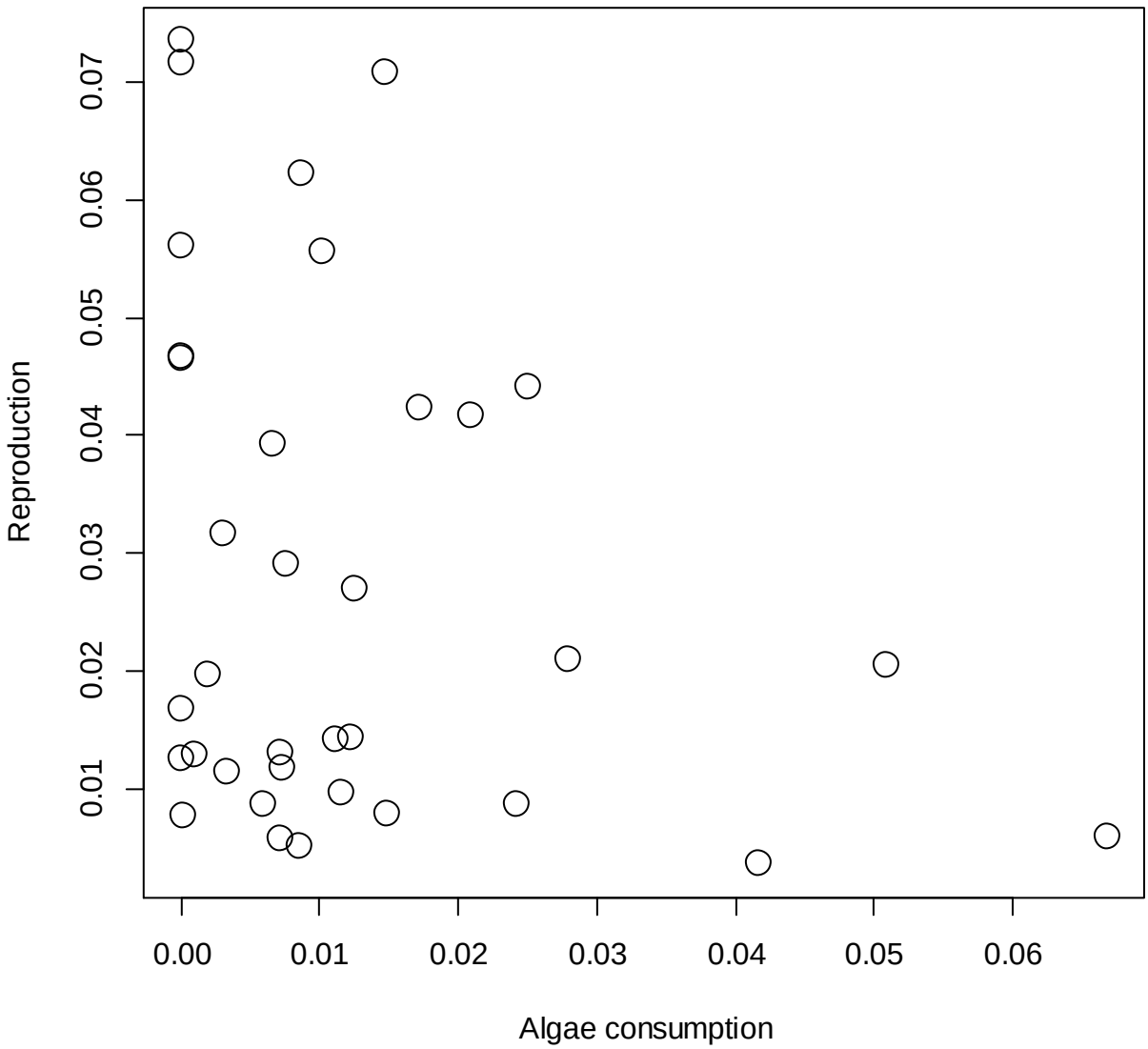
TITLE OF GRAPH:
THE LINK BETWEEN ANIMAL CONSUMPTION AND REPRODUCTION



The X axis represents the proportion of the animal's body weight in consumed food. For example, 0.05 equals 5% of your body weight. If you weighed 100 pounds, you would have consumed 5 pounds of animal food.

The Y axis represents the proportion of body weight that is dedicated to reproduction when eating animal food.

TITLE OF GRAPH:
THE LINK BETWEEN PLANT CONSUMPTION AND REPRODUCTION



The X axis represents the proportion of the animal's body weight in consumed food. For example, 0.05 equals 5% of your body weight. If you weighed 100 pounds, you would have consumed 5 pounds of plant food

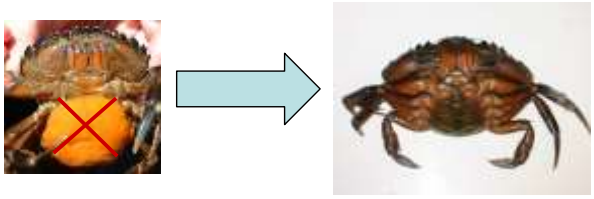
The Y axis represents the proportion of body weight that is dedicated to reproduction when eating plant material.

So what's happening?

- Green crab shift habitats in the presence of Asian shore crabs and this causes diet change from animals to plants

- Green crab has a small gut because it is adapted to a carnivorous lifestyle

- Green crab is unable to consume enough plants to meet nitrogen demands, leading to reproductive failure



So in his conclusion, Dr. Griffen showed that aggressive interactions between these species cause green crabs to shift their habitat in the presence of very high densities of Asian shore crabs. This habitat shift brings along with it a shift in diets from eating primarily animals to eating primarily plants. But because green crabs have evolved to use a more carnivorous lifestyle, they have a fairly small gut. This small gut limits the total amount that they can consume, which means that when they consumes primarily plants that are low in nitrogen, they can't eat enough food to meet their metabolic nitrogen demands, and this subsequently leads to reproductive failure.

Lead students into a discussion of limiting factors for this situation. Are there any limiting factors that affect the green crab's survival and numbers? Therefore the lack of needed nitrogen is a limiting factor for the population size of the European green crabs. Since the diet of this crab basically swapped percentages (going from 75% of its diet being meat without the Asian crab to 25% with the Asian crab), and it is predominantly an herbivore now, the European green crab can't reproduce.

Invasive species is just one of many types of environmental change that species have to deal with. There are many other types of environmental change. Well it turns out that initial responses to these environmental changes are often behavioral, and a common behavioral response of crabs is a shift in diet, just like the one shown in Dr. Griffen's research.

➲ View the following video clip on Invasion Species Awareness (6:49).
http://safeshare.tv/w/GPQMhIMUCt

- What is an invasive species? (species that spread widely to a place where it hasn't lived before, can be harmful, can impact other organisms)
- What are some ways that invasive species move from one place to another (transported in the ballast of container ships; hitchhike on vessels or organisms).
- What are some examples of invasive species (pythons in the Everglades, piranha in the Great Lakes).
- What can people do to keep invasive species from invading? (keep pets/don't dump them out in the environment; buy locally)

Session 10: Invasive Species without limiting factors (Lionfish)

➲ Background Info: The Lionfish is a poisonous fish found in the Indonsian/ Pacific area of the world. It is a massive predator to many fish but they will avoid it when it is near (their hiding would be considered a limiting factor). The lionfish therefore has adapted to being avoided since the other fish are hiding in fear. Therefore, when it is around food, the Lionfish will gorge itself.

Today we are now finding the Lionfish along the Caribbean areas up the East coast of North America. However, fish in these areas have not recognized it as a predator. What do you think this means for these fish and the Lionfish? The Lionfish swims around and eats all the time now due to inability of fish recognizing it as a predator. Its limiting factor has been removed. But the Lionfish is having an effect on the quantities other species of fish, like the grouper and snapper, two of the most common commercial fish in the area. Since it is new to the area and other fish don't recognize it as a predator, it basically has free reign in the waters. It is a quick reproducer as well, reproducing thousands every 2 weeks!

How did the Lionfish get in this area of the world? We believe it is an aquarium trade issue (where people dump fish from their aquariums into the ocean) or maybe due to a major hurricane form the 1980s that spilled a tank.

It is a poisonous fish. But once it is cooked, the poison is neutralized and is safe to eat (and is supposedly very tasty!). But they don't travel in schools, so each has to be killed individually with a spear.

SC invasive species: lionfish

- Believed to have been unintentionally released from private aquaria

➲Watch the following video clip (Lionfish: The Ultimate Invasive Species (20:44) http://safeshare.tv/w/fmcddlPOIu). Phillipe Cousteau Jr and his team investigate how the Atlantic Ocean has been invaded by the poisonous lionfish. A few years ago they didn't exist in the Atlantic, but now they are decimating the local fish stocks and have been seen as far apart as Puerto Rico and New York. Have students take notes (Invasive Species Notes) as they view the video.

- Why is the marine park trying to get rid of the lionfish? (they eat other fish that are smaller predators in the area)
- What special marine formation surrounds the island of Bonair in the Caribbean and provides shelter for the lionfish? (coral reef)
- What tool is used to "catch" the lionfish? (ELF)
- Why do the scientists cut open the stomach of the lionfish? (to see what fish it is eating; to track the number/species of fish on which it is feeding)

➲View the following video clip: Venomous Lionfish- Oceans BBC (4:03) http://safeshare.tv/w/WBVfYGupRv and have students add to their notes. Discuss what was learned about the Lionfish from this video.

➲ **Exit Slip:** What effect can invasive species have on other native species?
What effect did the lack of limiting factors in the Lionfish's new habitat in the Caribbean have on the Lionfish?
What effect is the Lionfish having on other fish in the Caribbean and Atlantic Ocean?

INVASIVE SPECIES NOTES

Name _____

Invasive Species Part 1: How they get to new places

My Notes:

How do some invasive species arrive at new destinations?

Invasive Species Part 2: How they limit the size/number of populations

My notes:

What effect can an invasive species have on other populations?

Invasive Species Part 3: No limiting factors (Lionfish)

My notes:

How did the lack of limiting factors in its new ecosystem have on the lionfish?