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AP Environmental Science **Intro to Ecology** pg. 1

What are the major divisions of the Earth? What are the three main requirements for sustaining ecosystems? How are ecosystems organized? Describe each of the three main trophic levels that exist in ecosystems.

A. **Major divisions of Earth** (spheres)
1. Lithosphere: Contains the crust, this outer layer of solid earth, soil and rock

2. Hydrosphere: Water in all forms (71% of Earth's surface)
(surface and groundwater, ice, and water vapor) (97% salt, 3% freshwater (2%ice 1%liquid))

3. Atmosphere: Thin layer of air surrounding the Earth

a. 4 divisions
i. Troposphere: what we breathe, weather and most air pollution occurs here,
78% N 21% O_2
ii. Stratosphere: O_3 Layer (lower part of stratosphere)
iii. Mesosphere
iv. Thermosphere

4. Biosphere: Where living organisms exist and interact with the nonliving environment, within the Lithosphere, Hydrosphere and Atmosphere, broken down into ecosystems

B. What are ecosystems?
Group of interacting species and their physical environment

1. Biotic: living factors
Vegetation: trees-algae
Animals: large mammals-tiny insects
Microbial: microscopic bacteria/fungi

2. Abiotic: nonliving chemical and physical factors
Water, temperature, salinity, soil texture, DO

3. Ecotone: Ecosystems are not isolated from one another. One ecosystem blends into the next through a transitional region -> this is known as an ecotone.

C. Requirements to sustain ecosystems
1. Energy- ONE WAY FLOW of energy (Sun)

2. Cycles of matter and nutrients C, O, P, N, H_2O

3. Gravity – Holds requirements in place

D. Levels of ecological organization

1. organism: one individual

2. population: group of individuals of the same species

3. community: interacting groups of different species

4. ecosystem: group of interacting species combined with their physical environment

5. biosphere: sum of ecosystems

E. Structure of Ecosystems

1. Producers: Organisms that capture energy from the sun or chemical reactions to create organic matter. Producers are absolutely essential to every ecosystem. Convert simple inorganic to complex organic. *Autotrophs*. Most producers are green plants.

   a. Photosynthesis: Converts simple inorganic to complex organic
   $6CO_2+6H_2O+energy \rightarrow C_6H_{12}O_6+6O_2$

   b. Chemosynthesis: occurs in deep ocean vents; bacteria generate energy with hydrogen sulfide to support plant-less ecosystems of tubeworms, sea spiders and bacteria.

2. Consumers: *Heterotrophs*
   a. Primary- feed directly on producers- herbivores

   b. Secondary- feed on primary consumers
      Carnivores: Meat eaters
      Omnivores: Meat and Plant eaters

3. Decomposers: Break down dead organic matter. Convert complex organic matter to simple inorganic matter. Without decomposers nutrients would not be cycled in an ecosystem.

   a. detritivores / detritus feeders – help begin the decomposition process by physically breaking down larger particles (earthworms, crabs, ants, termites, dung beetles)

   b. saprophytes – secrete enzymes and absorb nutrition (bacteria and fungi)

F. Trophic Relationships

1. Food chain: one way flow of energy through an ecosystem. Starts with Sun and ends with decomposers

2. Food web: complex overlapping set of food chains, shows how energy and matter move through trophic levels

3. Trophic levels: energy levels in an ecosystem

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AP Environmental Science Ecology pg.3

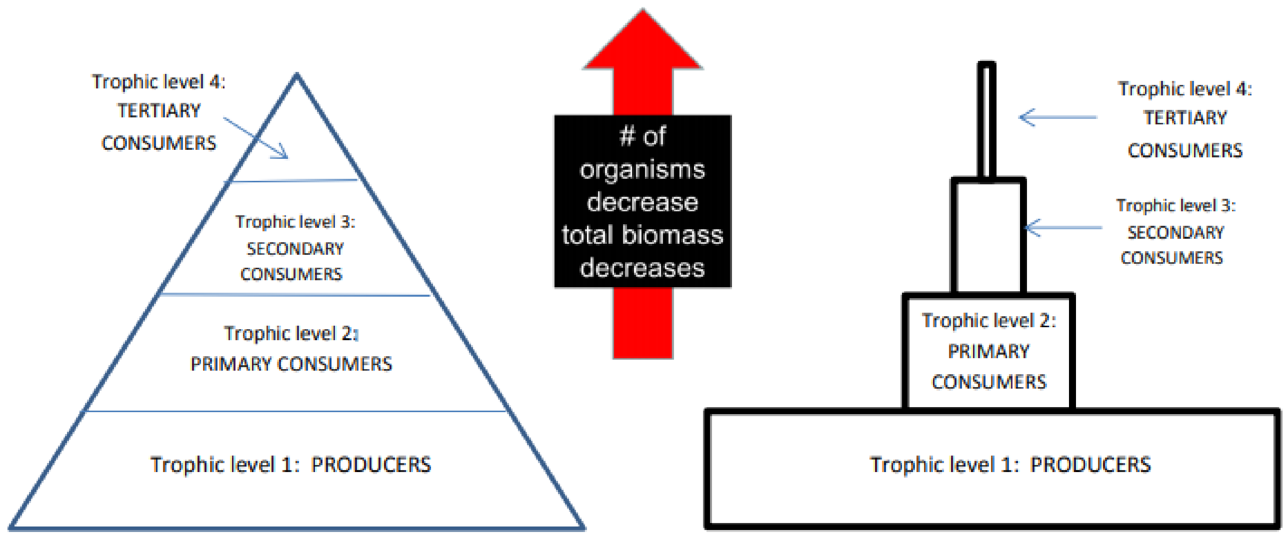
Biomass Pyramid and Energy Flow

How is ecological efficiency related to the 2nd Law of Thermodynamics? What factors contribute to the biomass pyramid shape? How can NPP be calculated given GPP and R?

Biomass: **Total combined mass of all organic matter in an area or trophic (energy/feeding) level**

Biomass can be arranged into a feeding relationship with the producers occupying the first level.

A. Biomass Pyramid:



1. What happens to biomass as trophic level increases?

2. What causes the change in biomass? (3 main reasons)

   a. Heat: energy is lost as heat while maintaining body temperature

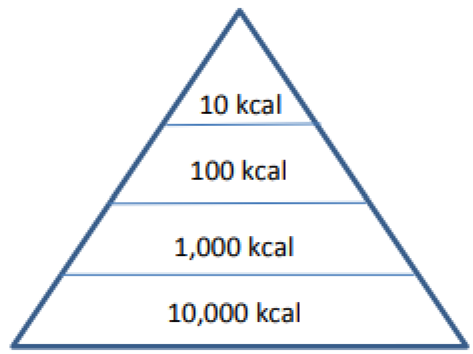
   b. Not all parts are eaten or digested/absorbed
      - Bones
      - Some biomass is passed through the body and expelled
      - Some biomass is never eaten

   c. Life processes
      - Respiration, hunting, reproduction

B. Ecological Efficiency: The amount (in %) of energy that is transferred from one trophic level to the next. Typical ecological efficiency is 10%. 10% of energy from one trophic level is passed onto the next trophic level. Note* Plants are very inefficient using the Sun's energy (1%)

The 10% Rule

1. Typical ecological efficiency

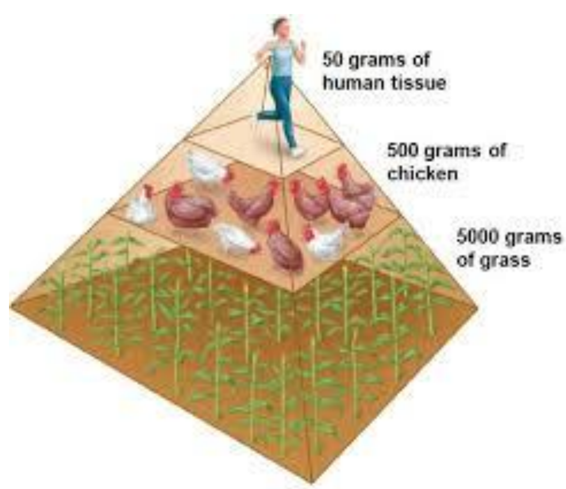


2. 2nd Law of Thermodynamics:
   As energy is transferred, useful energy is lost usually degraded to lower-quality, more dispersed, higher entropy, less useful energy (usually dispersed heat).

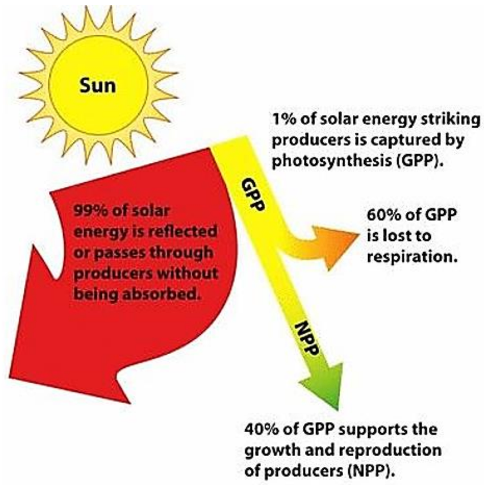
3. Because so little energy can be transferred between trophic levels, it is necessary that the first trophic level contains the greatest biomass to support the higher trophic levels above.

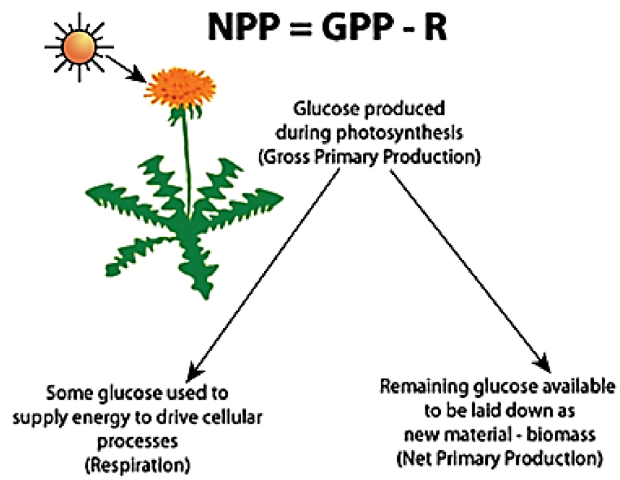
4. The more steps in a food chain (or more trophic levels), the greater the amount of (high quality, useful) energy lost.

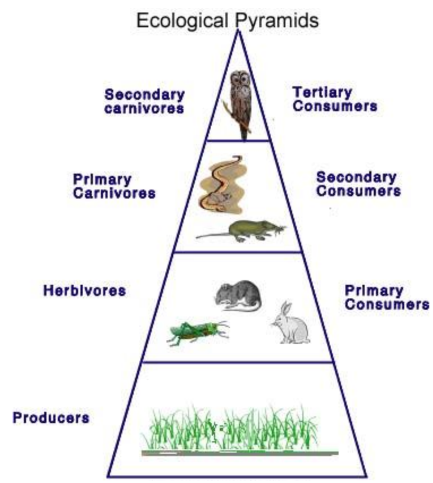
5. How can more individuals be supported by an ecosystem?
   More individuals can be supported if they occupy lower trophic levels
   More herbivores can be supported

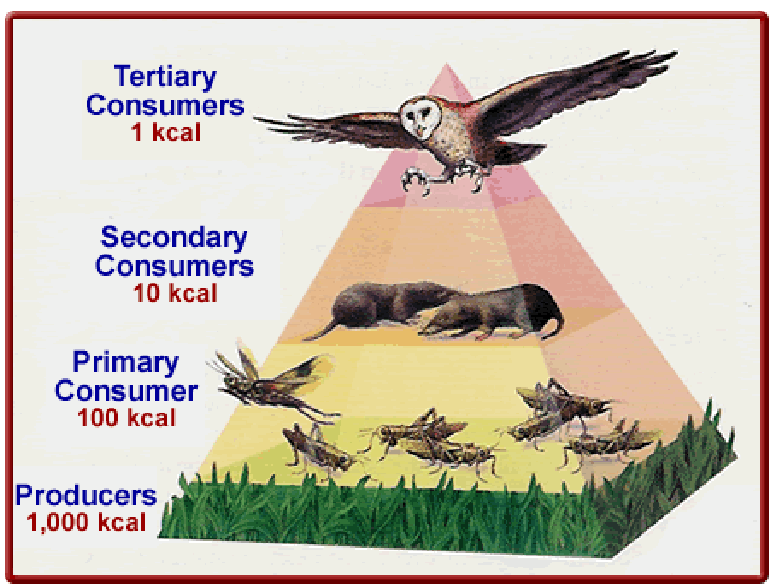


C. Primary Productivity - the degree to which autotrophic organisms (primarily plants and algae) convert solar energy into organic substances through photosynthesis









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Zones of Tolerance and Optimal Zones for organisms within ecosystems

Describe the difference between an organism's optimal range and range of tolerance. How do limiting factors serve to control population size?

List 7 **abiotic** factors that occur in ecosystems in the space provided below.

A. Abiotic conditions vs. abiotic resources
   1. **Conditions**: Not consumed by organisms

   Temperature Wind pH Turbidity Transparency Texture of substrate

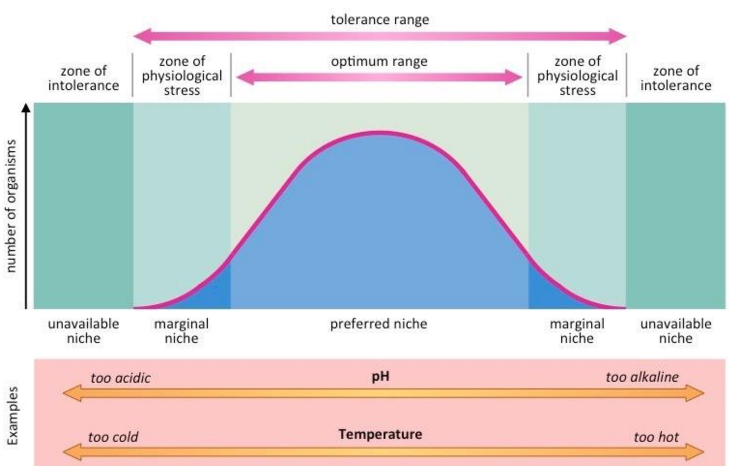
   SalinityFire Bedrock Material Particulate Matter

   2. **Resources**: Consumed by organisms (Sometimes converted into something else. Can be biotic)

   Water Light Oxygen Nutrients (Nitrogen, Phosphorous, Potassium, NPK)

   Space resources (nesting sites, shelter from predators)

B. Optimum zone, zone of stress and limits of tolerance.



1. Different species thrive under varying environmental conditions:
Temperature: warmer vs. colder
Light: bright direct vs. shade
Salinity: low salinity content vs. high salinity content (freshwater vs. saltwater)

2. For every condition there is an optimum: the range or level at which the organism does best or prospers.

3. <u>Optimal range</u>: the range of a factor that supports ideal growth of a species.

4. <u>Range of Tolerance</u>: the entire range that supports *any* growth of a species, this includes the optimal range.

5. Limits of Tolerance: The points or values at the high and low ends of the range of tolerance scale.

6. Zones of Stress: Exists between the optimal range and the limits of tolerance. In the species zone of stress, they may survive but will not thrive. For example they may not reproduce, may have weaker immune systems and be unable to hunt for food efficiently.

7. The population density of a species will be the greatest where all conditions are optimal.

8. Sketch of population size when related to environmental factor.

C. Limiting Factors

1. List 7 limiting factors that can occur in an ecosystem in the space provided below. (they may be biotic or abiotic)

2. Definition: A factor that prevents or inhibits the growth, development, distribution or abundance of a species.

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AP Environmental Science Ecology pg. 8

Species Interactions Shape Biological Communities

When the environment of a species changes, who has a greater chance for survival, specialist or generalist species? Why? Contrast indicator species to keystone species. Describe and give examples of the 3 types of Symbiotic Relationships. Describe the various types of competition.

Define: Habitat: The place where an organism lives

Define: Niche: The role of an organism (what it feeds on, when it feeds, where it feeds, where it finds shelter etc.)

A. Specialist vs. Generalist Species

1. Specialist: narrow niche, adapted to a narrow set of conditions, has very specific requirements. Has a difficult time adjusting to changing conditions.
   Examples: Panda (bamboo) and Koala (eucalyptus)

2. Generalist: broad niche, wider range of tolerance, can adapt to changing situations well
   Examples: Raccoons, Cockroaches

B. Indicator Species: indicates the health of an ecosystem. Natural warning system.

Examples: Trout-indicate clean cold water with high dissolved oxygen (DO)

frogs (and other amphibians, like salamanders) - permeable skin absorbs toxins quickly → limb mutations and other dysfunction

lichens sensitive to heavy metals or acids - good indicators of air pollution (esp. SO_2) if lichen population decreases or is absent

birds (especially birds of prey such as eagles and falcons) - decline in bird populations helped indicate the negative effects of the chemical pesticide DDT (eggshell and beak abnormalities)

macroinvertebrates (mayfly, stonefly, dragonfly, crayfish, snails and beetles) commonly used as indicators of heath of aquatic systems due to the fact that they spend most if not all of their lives in water and are collected easily

C. Keystone Species: a species whose role is absolutely vital for the survival of many other species in an ecosystem. "Umbrella Species" "Critical Link"

Examples: gray wolf of North America (Yellowstone) – Grey wolves were hunted to local extinction in early 1900's. A **trophic cascade** occurred: Elk populations increased → overgrazed territory affecting many other species. After being reintroduced to the park in 1995 – the ecosystem's struggling populations of fish, beaver, willow, and songbirds recovered.

prairie dogs of the Great Plains – Prairie dog colonies aerate and help fertilize and retain water the soil allowing a greater diversity of plants to thrive

fig tree of the tropical rainforests of Peru- Provides food for monkeys and fruit eating birds when no other trees are producing fruit. Without the fig fruit, populations of monkeys and birds would decline

Define Symbiosis: A close physical relationship between two organisms where at least one of them benefit

D. Symbiotic Relationships:

1. Mutualism (+ +) a relationship between two organisms in which both species benefit
   Clownfish and anemone crocodile and Egyptian plover

2. Commensalism (+ 0) a relationship between two organisms in which one species benefits and the other is unaffected Shark and Remora Cattle and Egret

3. Parasitism (+ -) a relationship between two organisms in which one species benefits and the other is harmed Deer and tick Mosquitos and Humans

E. Types of Competition

Distinguish between intraspecific competition and interspecific competition. Describe the difference between interference competition and exploitation competition.

Define *competition:* Fight for resources (food, water, space, mates)

1. Resource Partitioning: sharing of resources to avoid competition
   Bats and Swallows Warblers in Northern coniferous trees
   Woodpeckers (insects) and seed eating birds

2. Intraspecific competition vs. Interspecific competition
   a. *Intra* – between members of the same species. Usually very intense and the most common because the species occupy the same exact niche.

   b. *Inter* - between members of different species. Not as intense as intraspecific competition.

3. Interference competition vs. Exploitation competition
   a. *Interference* – when an organism prevents or blocks use of a resource by another organism

   b. *Exploitation* – when an organism uses up a resource more quickly than others can

Species Interactions: Invading Species

How are invasive species introduced to ecosystems? What causes the success of invasive species? Give several examples of how invading species have disrupted the ecosystems they invade.

A. Invading species: May also be identified as Invading, Alien, Exotic, and Nonindigenous

1. Native species exist in a balanced relationship with their natural ecosystem. (i.e.: predator-prey)
2. Introduced species can disrupt the ecosystems they invade.
   - No natural predators or controls
   - Population grows unchecked
   - Exponential growth of invading species
   - Outcompete native species for resources (exploiting resources not meant for them)
   - Generalist species (can be r selected) High biotic potential
   - Overall decrease in biodiversity

3. As a result of invasive species interactions in the ecosystem, what happens to the population of native species?

B. Examples of Invading Species:

1. Rabbits into Australia - Rabbits were introduced when Europeans first settled in Australia in 1859. They were brought there for two main reasons – the domesticated rabbit was a ready source of meat, and the wild rabbit introduced later for hunting. The rabbit populations exploded because they reproduced much quicker than they were hunted. To control the problem from spreading, an 1833 km fence was built to try to prevent the rabbits from spreading, however it was a failure. Kangaroos and emus were negatively affected as they would get caught in the fence just like dolphins are affected by drifting nets in the ocean. The rabbits are partially blamed for the extinction of almost an eighth of the mammal species in Australia and have caused millions of dollars of agricultural and soil damage a year. To control the problem, a virus was injected into the rabbit population that usually killed the infected rabbit however, some rabbits were naturally immune to the virus and a resurgence of the population occurred.

2. Water Hyacinth into Louisiana - The water hyacinth was first brought from South America to the U.S. in 1884 as part of a World's Fair held in New Orleans. They proved to be popular gifts and were transported to garden ponds around the city. The hyacinths reproduced and quickly spread to neighboring waterways. With no natural controls, such as disease or predators, it soon covered immense areas of Louisiana, clogging canals used for boating and fishing. Water hyacinths have been considerably reduced by the introduction of insects that would feed on the plants, heavy doses of herbicides, and physical removal.

3. Asian Longhorned Beetle into United States - Native to Eastern Asia, the long-horned beetle accidentally made its way to New York in packing material. It was first discovered in Brooklyn in 1996. Spread of the Asian long-horned beetle is accomplished through infested tree-based materials, including live trees, fallen timbers and firewood. This can be difficult to address, due to the larvae being deep within the wood. Larvae develop out of the eggs and chew “galleries” into the inner parts of the tree, on which they will feed during the overwinter process. Adults emerge during the spring through these holes that can be found on various spots on the tree, mainly around the branches and trunk of the tree. There can be thousands of the holes that the adults appear from in an infested tree. By making so many holes, adults cause the tree to lose nutrients to maintain its life needs, such as water and sap. To prevent the spread, tree removal and then quarantines are established which prohibit the movement of infected wood. Surrounding healthy trees are treated with a systemic pesticide.

4. Brown Tree Snakes into Guam - Indigenous to Australia, Indonesia, and the Solomon Islands, the brown tree snake was accidentally transported from its native range in the South Pacific to Guam either as a stowaway in ship cargo or by crawling into the landing gear of Guam-bound aircraft shortly after World War II. Because of the absence of natural predators, brown tree snake populations reached unprecedented numbers. Snakes caused the local extinction of most of the native forest vertebrate species, especially birds (the Guam Rail) and lizards. This, in turn, caused a spike in the spider population. To control the problem, mouse bait injected with Tylenol (which is poisonous to the snakes), was released in the environment. Physical traps have been implemented and a species specific virus was also introduced to the snakes, however some snakes were resistant to the virus.

5. Cane Toads in Australia Cane toads were intentionally introduced in Australia in 1935 to help combat cane beetles that were destroying sugar cane crops. They completely failed at regulating the cane beetles, and instead turned their attention to other native insects. Cane toads will eat just about any insect and they reduced prey for native insectivores which created imbalance in the native food webs. Since the initial release of 3,000 toads, cane toad populations in Australia number in the millions and their range continues to expand. In addition to Australia, they are found in south Florida, throughout the Caribbean, and in other tropical and subtropical locales. Cane toads are also poisonous throughout their lifecycle. Whether they are eggs, tadpoles, or full-grown adults, cane toads can poison and potentially kill anything that ingests then. Cane toad poisoning in household pets, such as dogs, has become quite common in Australia and Hawaii. Manual removal is the main management strategy for cane toads. Although toads can be removed as adults, it is easiest to collect the jelly-like strings of cane toad eggs from local creeks or ponds. Also, mesh fencing is used to stop the spread of the toad, but native fauna can also get caught up in the nets. In Australia especially, there is a widespread education campaign to warn people about the dangers of cane toads and invasive species.

6. <u>Asian Carp in the Mississippi River</u> - Asian carp were brought to the United States in the 1970s to help control algae in catfish farms. The carp escaped into the Mississippi River system during flooding episodes in the early 1990s, established self-sustaining populations in the lower Mississippi River, and then began moving northward. Thus far, the fish have been restricted to the Mississippi River watershed; however, it is feared that they will be able to enter the Great Lakes. They are fierce competitors, capable of pushing aside native fish to obtain food, and their populations grow rapidly, accounting for 90% of the biomass in some stretches of the Mississippi and Illinois rivers. Once in the Great Lakes ecosystem, they could wreak havoc on the foundations of the food chains of the major lakes and adjoining rivers. To deal with this potential menace, two electric fish barriers have been placed within a 1,500-foot stretch of the canal. Electrical pulses emanating from the barriers keep the fish at bay while also allowing barge traffic to move up and down the waterway. This measure, however, is not 100% effective. In addition, rotenone, a biodegradable piscicide (fish poison) is added to the water whenever repairs to the electric barriers are required.