Ganga Curriculum

An Environmental Case Study of the River Ganges

Part III - Ecological, Economic, Spiritual and Cultural Values of Water

Written by Dr. David Black

funded by a grant from the National Science Foundation

Independent Broadcasting Associates, Inc
111 King St Littleton MA 01460
T: 978-486-9180 • ibaradio@gmail.com

Table of Contents

The Ganga Curriculum provides a case study to topics presented in environmental science curricula for high school.

This pdf viewed **on-line** is interactive with the web site..

The three main sections are:

Water Quality,
Water Resource Management and
Ecological, Economic, Spiritual and Cultural Values of Water

This a printable version of the curriculum which is found on the Ganga site. The links refer back to the curriculum site.

Each section begins with reference to specific broadcast segments that provide the introduction for the material and activities that follow. Discussion questions lead the students to consider both the issues associated with the Ganges River itself, and about water resource protection and management in general.

Classroom activities are practical exercises which can be performed in the field, the laboratory or on a computer.

Educational Resources provides links, glossary, articles etc

The list of key concepts covered in the project.

More information about the APES Curriculum and exam can be found at the College Board Website.

The GANGA curriculum can be covered effectively in five class periods, with additional time needed for completion of all activities.

Ecological, Economic, Spiritual and Cultural Values of Water

Ganga's waters provide habitat for endangered species, maintain unique ecosystems and allow for the spiritual purification of those who immerse themselves in them. Ganga is a goddess who came down to Earth to save human soils through purification; does this divine nature suggest that human impurities have little effect on the life of the River? If there exists no true ownership of the River, can humans control the activities that threaten her? In these three segments other values of the River are explored with an emphasis on the changes that are likely with continued deterioration of the quality of the water.

Gangetic Dolphins

Link to Audio Clip of Dolphins sounds

Listen for clicking and whistling in the first section and barking in the second section.

Loss of habitat, pollution, poaching and isolation threaten the Earth's bio diversity and are factors that have led to the Gangetic dolphin being categorized as endangered by the International Union for the Conservation of Nature. Specialists uniquely adapted to their habitats are especially vulnerable to these factors and the Gangetic dolphin is in imminent danger of extinction. The evolutionary history of the species is of great interest, and further understanding of the species may be critical to the success of current efforts to conserve the species.

Sacred Purity and Environmental Pollution

Link to Audio Clip - Sacred Heartland

Most Indians do not believe that the Ganges is polluted. Is this perception an accurate description of the water quality using western standards, a statement of the religious power of the goddess, or a lack of awareness of the conditions that occur in much of the River?

Activities

EA1 Adaptations of Dolphins (research project).

The Gangetic Dolphin

Background

After an intensive six week search by a team of international scientists, the Yangtze River dolphin was declared functionally extinct on January 3, 2007. Despite months of effort, the lack of sightings of the species led the researchers to conclude that although it was possible that a small number of individuals persist, the population can never recover. This represents the first recorded extinction of a cetacean species, but conservation biologists fear that other species face similar threats and may suffer a similar fate. The Gangetic Dolphin faces similar threats to those which devastated the Chinese species, and in the absence of a high level of effort is at risk of imminent extinction.

Discussion Questions

1. In order to categorize a species as endangered or threatened much needs to be known about the natural history of the populations. This information must be evaluated in light of the environmental conditions that occur throughout the range of the species and the factors that render the species most vulnerable to extinction. Is the current status of the species predictable based on these factors?
Response

2. Looking at the information at the Whale and Dolphin Conservation Society (www.wdcs.org), discuss the probability of the sanctuary protecting the dolphin in light of the threats to the species and practices that have proven effective for other species.

Responses

Question 1.

This type of analysis is an important part of understanding endangered species, requiring the student to focus on two key components: characteristics of the species that create vulnerability to extinction and factors in the environment that threaten biodiversity. The lists below are not comprehensive, but provide a basis for beginning the analysis; note that these can be used to assess any species or population.

Characteristics of Endangered Species

- **Initial rarity** - With only 2000 left broken into several populations the Gangetic Dolphin is rare. Certain populations are already vulnerable to inbreeding and stochastic extinction.
- **Large area requirements** - While there is little detailed information available about the species, a large aquatic predator like this certainly requires a large area for foraging.
- **Specialized habitat requirements** - The preference of the species for areas at the confluence of rivers and the requirement for deep waters can be considered specialized habitat requirements for a river species.
- **Higher trophic level species** - As a large predator the dolphin would be considered a high trophic level species. This also increases the vulnerability to the bioaccumulation of toxins in the tissues of the species.
- **Local Endemics** - Although the species does occur in different areas (IUCN, 2005: http://www.redlist.org/search/details.php?species=41758), the restricted distribution of the species significantly increases the probability of extinction.
- **Migratory species** - The species travels the length of the river in a regular migration.
- **Species with poor dispersal abilities** - Limited by the salinity of the waters, species are probably restricted to the rivers in which they are born.
- **Colonial nesting species** - Does not apply.
- **Economic value** - The blubber of the species is economically valuable, and there is evidence that the species is used as a food source.
- **Perceived threat to humans and livestock** - Does not apply
- **Long lived species/low reproductive rate** - Again, natural history information requires additional research but with a predicted maximum longevity of 30 years, and an age of sexual maturity between six and ten year, an expected slow reproductive rate increases the vulnerability of the species to extinction.
- **Other factors**: - The use of sonar in foraging makes the species vulnerable to changes in noise conditions in the habitat area.

Threats to Biodiversity

- **Collection** (including hunting, trapping or poaching) - Although there is evidence to suggest that education and regulations are reducing the harvesting of the species, poaching continues.
- **Habitat destruction or degradation** - Increased siltation reduces the areas of deep water necessary for the species.
- **Habitat fragmentation** - The barrages and dams along Ganga and her tributaries fragment the habitat, preventing migration and isolating smaller populations of dolphins.
- **Introduction of invasive species** - Not a known issue for the species.
- **Pollution** - Ongoing pollution is changing the ecology of the river and threatens the prey base. The introduction of heavy metals and organic toxins to the river has a high probability of harming the populations.

Indirect Effects

- Changes to the environment may disrupt species interactions and the autecology of the species.
- Increased boat noise may affect the success of the species foraging.

Thus the characteristics of the species considered in light of the threats extant in the environment suggest that the current endangered status of the species is predictable.

Question 2:

Possible Response: In-Situ conservation efforts which protect the species in their own habitats are preferred over ex-situ strategies, which rely on zoos, aquaria or botanical gardens to preserve biodiversity in an artificially controlled environment. An evaluation of the feasibility of using in-situ strategies requires the following questions be answered: Is an adequate habitat area available to protect a viable population of the species, and if not is there adequate supporting habitat in the area that is likely to persist despite the lack of formal protection?

More research is probably needed to determine the size of the population than can be supported within the 60 km2 area. The 50/500 rule, which states that at least 500 breeding individuals are needed in a population to prevent the loss of genetic viability and 50 as an absolute minimum population, suggests that the small area is of concern. Is there sufficient connectivity between the conservation area and other suitable habitats to allow for adequate gene flow to prevent inbreeding and serve as a source of colonists should a population go extinct?

The Farakka barrage creates an impenetrable barrier to dolphin movement isolating this population and increasing the probability of extinction.

Can the threats to the species be controlled within the conservation area? Inadequate enforcement funds suggest that poaching within the sanctuary is possible. Pollutant accumulation and habitat degradation associated with siltation are also likely to continue in the sanctuary. Without additional funding, there is concern about the effectiveness of the preserve. While clearly an important step in the preservation of the species, additional efforts will almost certainly be needed to protect the species in Ganga.

Links to Classroom Activities
Predicting Water Quality
Adaptation and the radiation of dolphins.

Sacred Purity and Environmental Pollution

Background

When students in the city of Kanpur, a city which contains one of the most polluted reaches of the Ganges, were asked to define pollution they quickly responded with a variety of definitions from many textbooks. When asked to develop these ideas further, however, it was clear that the easy answers covered much confusion about the nature of the term. Can the sacred be defiled by human actions? The answer to this question must affect a society's response to the discharge of wastes into a river. Children grow up with a greater awareness of the nature and effects of contamination, and yet cleaning the river depends on a consensus among many groups.

Discussion Questions

1. The scientific method ought to be free of the influence of culture: observation, development of hypotheses, design of experiments and testing of each hypothesis should be an objective exercise. And yet, the practice of science is colored by convention, language and cultural values that make the ideal impossible to achieve. Is it possible for eastern and western scientists to reach very different conclusions about the quality of the river when faced with the same data?

Response

2. Any water quality sampling strategy gathers data on a small subset of the total number of pollutants reaching the river. The costs of analysis and sample collection are important factors in the development of a practicable design for a wastewater treatment program. How might a sampling strategy developed for a river in North America or Western Europe bias results and lead to potentially inappropriate conclusions about the health of the river?

Response

3. How can the divine nature of a River affect the way that people treat the waters? The Indian tradition appears to be quite different from that of other cultures. Why do cultures actively work to protect water quality? The links below include sites that discuss other perspectives on water that may assist in this discussion.

Responses

It is possible for different western scientists to reach different conclusions about the quality of the water when faced with the same data. There are few absolutes in the study of water quality making the careful framing of the questions asked critical. Contamination is relative to the uses of the water and the severity of the effect relative to other risks in the community. Coliform bacteria are not harmful in waters not used for drinking or bathing; periodic exposures to heavy metals have a low probability of causing harm. An assessment of water quality thus depends on the considered application of a model based on the principles of risk assessment.

The first step of the risk assessment is hazard identification, which leads to the development of the experimental design for data collection. As discussed in Classroom Activity WQ1, it is impossible to test for all pollutants at all times introducing bias into the results obtained. Past research on the levels of pollution of Ganga assembled for this project show considerable reliance on a small number of pollutants measured irregularly.

As discussed in “The Mysterious Factor X”, different conditions in different systems may make the interpretation of results more difficult. Particularly high levels of bacteriophage activity may lessen the importance of periodic high levels of bacteria to human health.

As discussed above, western rivers are tested for pollutants most commonly associated with regional industries and land uses within the watershed. Rivers are unique in their ability to absorb and detoxify pollutants (see The Mysterious Factor X) and an effective sampling plan must reflect an understanding of both the types and sources of the pollutants and of their behavior once discharged. The Indian government's heavy reliance on dissolved oxygen (DO) levels as a basis for determining water quality exemplifies this issue. While certainly useful as a general indicator of pollution, DO levels fluctuate seasonally, daily and with depth. The amount of oxygen consumed by the life of the river is balanced by the levels of photosynthesis, mixing that occurs at the surface and the levels of oxygen demanding waste that exist at that location. Biochemical Oxygen Demand (BOD) is a better indicator of river conditions, but is more difficult to measure and may provide little indication of the presence of other serious pollutants.

The west has banned the use of many toxins used in developing countries and requires a level of reporting that is unlikely to be found in India. Heavy metals, toxic organic compounds and other pollutants may enter the river at rates vastly higher than those which would occur in the west, requiring an open-minded and well-researched approach to any study.

If a river's waters are sacred, the mundane issues of pollution may be of less importance to those relying on the resource. The divine nature of the Ganga allows many to look beyond the superficial quality of the water as measured in the west to the true nature of the goddess. Certainly she could purify herself were this important, but purity may not be in any way affected by the occurrence of human detritus.

Adaptations of Dolphins
Exploring Evolutionary Principles

Background Information

Freshwater dolphins are threatened wherever they occur, vulnerable because of their high level of specialization and imperiled by habitat alterations, exploitation and the disruption of the aquatic ecosystems on which they depend. The study of the populations is difficult because of the frequently challenging environments in which they live: murky waters in remote locations make the location of individuals challenging and the small populations require that extreme care be taken during the study. Nevertheless, biologists are piecing together the evolutionary history of the dolphin and are working to develop strategies to protect all the species in the habitats in which they occur. They seek to answer the question of the origin of the freshwater dolphin.

The radiation of the whales is a complex story. Appearing in the Eocene, whales diverged into their two modern groups by the late Oligocene (University of California Berkeley, Museum of Paleontology, 2005). The evolutionary history of the four living genera of freshwater dolphins remains one of uncertainty (Table 1). Although all are grouped in the superfamily *Platanistoidae*, the basis of this classification grows largely from similarity in appearance and behavior rather than solid evidence of a common ancestor (Table 2). To answer the questions below, you must look for research to support the various theories proposed to explain the occurrence of similar species in geographically distant parts of the world.

Table 1. River Dolphins of the World

Baiji (Chinese River Dolphin; *Lipotes vexillifer*; declared extinct in 2007)
Boto (Amazon River Dolphin; *Inia geoffrensis*)
Franciscana (La Plata River Dolphin; *Pontoporia blainvillei*)
Ganges River Dolphin (*Platanista gangetica*)
Indus River Dolphin (*Platanista minor*)

Table 2. Taxonomy of the dolphin family

Kingdom Animalia
Phylum Chordata
Class Mammalia
Order: Cetacea
Suborder Odontoceti (toothed whales)
Nine families of dolphins

Research Questions

1. Using on-line resources, describe the features and characteristics of river dolphins (see Table 1 for a species list) that have led to their frequently being placed in a single group. What selective pressures have led to these adaptations?

2. Is a "convergent evolutionary model" appropriate to explain similarities among the different genera, one in which the marine species left the ocean and each evolved similar characteristics in response to the similar conditions found in the rivers in which they settled? Is it possible that once a freshwater dolphin had evolved it slowly migrated to rivers in distant parts of the globe?

3. Discuss how the human uses of the Ganges may threaten the Gangetic Dolphin. Killing of the dolphins for food or because they are seen as competitors for the commercial fish may provide some explanation for the decline, but other factors may indirectly lead to the extinction of the species. What are these and how might they be controlled to allow for the recovery of the dolphin?

4. Describe the factors that led up to the extinction of the Chinese River Dolphin. What steps could be taken to increase the likelihood of survival of the other species faced with similar threats?