Ecology

Ecology (from Greek: οἶ κος, "house"; -λογία, "study of") is the scientific study of the relation of living organisms to each other and their surroundings. Ecosystems are defined by a web, community, or network of individuals that arrange into a self-organized and complex hierarchy of pattern and process. Ecosystems create a biophysical feedback between living (biotic) and nonliving (abiotic) components of an environment that generates and regulates the biogeochemical cycles of the planet. Ecosystems provide goods and services that sustain human societies and general well-being. Ecosystems are sustained by biodiversity within them. Biodiversity is the full-scale of life and its processes, including genes, species and ecosystems forming lineages that integrate into a complex and regenerative spatial arrangement of types, forms, and interactions.

Ecology is a sub-discipline of biology, the study of life. The word "ecology" ("oekologie") was coined in 1866 by the German scientist Ernst Haeckel (1834–1919). Haeckel was a zoologist, artist, writer, and later in life a professor of comparative anatomy. Ancient philosophers of Greece, including Hippocrates and Aristotle, were among the earliest to record notes and observations on the natural history of plants and animals; the early rudiments of modern ecology. Modern ecology mostly branched out of natural history science that flourished in the late 19th century. Charles Darwin's evolutionary treatise and the concept of adaptation as it was introduced in 1859 is a pivotal cornerstone in modern ecological theory.

Ecology is not synonymous with environment, environmentalism, natural history or environmental science. Ecology is closely related to the biological disciplines of physiology, evolution, genetics and behavior. An understanding of how biodiversity affects ecological function is an important focus area in ecological studies. Ecosystems sustain every life-supporting function on the planet, including climate regulation, water filtration, soil formation (Pedogenesis), food, fibers, medicines, erosion control, and many other natural features of historical, spiritual or scientific value.

Estuarine ecosystem

The Sundarbans in West Bengal is the estuarine segment of the Ganges as well as Brahmaputra river systems. This littoral forest is the only ecological habitat of its kind for the tiger not only in India but also in the world except in Bangladesh. The typical littoral forests of Sundarbans comprise a host of trees species adopted to the peculiar estuarine condition of high salinity, lack of soil erosion and daily inundation by high tides. The tidal forms and the mangrove vegetation in Sundarban are responsible for dynamic eco-system vigorous nutrient cycling both terrestrial and aquatic. The whole eco-system is sensitive to changes in salinity and the continuous cycle of erosion and deposition is affecting the plant communities giving rise to dynamic floristic changes. The plant communities are continuously adjusting to the new conditions.

Cheetal, wild boar, rhesus macaque are the main prey species of tiger. Aquatic animals like the crabs and fishes are also eaten by Sundarban tiger which occupies the pinnacle of both terrestrial as well as aquatic food-web.

Sundarbans mangrove is the home of a number of endangered and globally threatened species. The Bengal Tiger and the fishing cat are getting effective protection here. The creeks of Sundarbans form the home of Estuarine Crocodile, Salvator Lizard (Water Monitor), River Terrapin and Horse Shoe or King Crab. This area serves as the nesting ground for endangered marine turtles like Olive Ridley, Green Turtle and Hawk’s Bill Turtles. The aquatic endangered mammals like Genetic Dolphins thrive within mangrove creeks close to the sea. Number of heronries form here during monsoon as well as during winter. It is home for Trans-Himalayan migratory birds.

Management

Practices, achievements and shortfalls: The Reserve has received effective protection under Project Tiger since its creation. The core area is free from all human disturbances like fishing, collection of wood, honey and other forest produces while in buffer fishing, honey collection and wood cutting are permitted to a limited extent. Protection against poaching and theft of forest produce has been ensured through intensive patrolling by staff in motorboats and launches. The offices and camps are located at strategic points to keep a watch over the area. There exists an effective communication network for protection. Furthermore, the staff is well armed.

Intensive management takes care of the maintenance and improvement of the habitat through eco-conservation, eco-development, education, training and research. Mud-flats on the periphery of the reserve are artificially regenerated with mangrove plants to meet local fuel wood demand and reduce the pressure on buffer. Non-mangrove plantations are also raised along roads and embankments of the fringe area to cater the need of the fringe people.

Soil conservation is taken up to stabilize the vulnerable sites. To facilitate the availability of sweet water for animals, ponds have been dug at several places in the forest.

Conservation history

The Sundarbans Tiger Reserve, created in 1973, was the part of the then 24-Pargans Division. Subsequently the area comprising of the present tiger reserve was constituted as Reserve Forest in 1978. The total area of the Sunderbans is 9630 sq. km. out of which 4264 sq. km. bears mangrove forest. The area of the Reserve is 2585 sq. km. covering land area of 1600 sq. km. and water body over 985 sq. km.

Forest types: Tidal swamp forests, saline water type mixed forests, brackish water type mixed forests palm swamp type

Major flora

There are 64 plant species in Sundarbans and they have the capacity to withstand estuarine conditions and saline inundation on account of tidal effects.

Major fauna

Main species: Tiger, fishing cat, chital, wild boar, water monitor, estuarine crocodile.

Endangered species

Tiger, Estuarine Crocodile, River Terrapin (Batagur baska), Olive Ridley Turtle, Gangetic Dolphin, Ground Turtle, Hawks Bill Turtle, King Crabs (Horse shoe)

Special projects

The Reserve has successfully launched a special programme to conserve the highly endangered Olive Ridley Turtles. Hatching of Olive Ridley Turtles and River Terrapin is done at Sajnekhali to replenish their population.

Eco-development

Co-operation of fringe people in the conservation of the tiger habitat, as it could gradually be felt, has been possible through constant motivation and awareness building of the people as well as increased public liaison and their involvement in the planning process for implementation of eco-development programme. Participatory Management has already been introduced in Sundarbans Tiger Reserve and 10 Forest Protection Committees and 14 Eco-development Committees have been formed in the fringe of Sundarbans Tiger Reserve and the response is positive.

Mangrove eco-system is very fragile and people's sustenance in the area, again, mainly depends on the maintenance and sustainable use of the eco-system. At the same time this eco-system is the most productive eco-system on the planet guiding the benefit of the nutrient cycling of both terrestrial as well as marine system

Protection Squads / Patrolling: Anti-poaching camps are manned by 2-3 knowledgeable labourers and supervised by concerned beat guard/Forester/Range officer.

Constraints

There is no denying the fact that the mangrove zone is vulnerable to various threats like poaching of animals and pilferage of woods because of its difficult geographic situation and hostile terrain criss-crossed by a network of turbulent streams and having long stretch of international border with Bangladesh and fishing arena in the sea for thousands of trawlers and mechanized boats. Compared to the size of this protected area and the proportion of problems which is encountered here the logistic support in terms of staff strength, infrastructure facilities and availability of fund is inadequate.

Conflicts

Man and animal: Man-eating propensity of Sundarban tiger has been a great problem. This happens with either attack on villagers entering the forest or by tiger straying into the habitation. Numerous steps taken by the management have helped mitigated this problem to a large extent.

Man and forest

Dire poverty urges the people of Sundarbans to frequent the forest in search of livelihood. Some of them take the risk of cyclone for fishing and other enter the forest to collect honey and fuel wood. The vulnerable mangrove eco-system is under stress due to such interference.

Marine ecosystems

Waterborne infection, from marine or freshwater sources, is the leading cause of illness worldwide, and fish provide more animal protein for human consumption than poultry or meat. Today the health of large marine ecosystems--their diversity, productivity, and resilience--is threatened by a "global epidemic" of coastal algal blooms. This overgrowth of algae has profound implications for water and food safety because vibrios adhere to phytoplankton (algae) and zooplankton, and "red tides" bear biotoxins responsible for fish and shellfish poisoning. Furthermore nutrient-rich effluents stimulate algal growth and warmer sea surface temperatures shift marine ecosystems towards more toxic species.

Dormant *V cholerae* and algal blooms

Cholera becomes endemic when water and sanitation systems are not kept apart, but other environmental factors affect both the inoculum and persistence of this ancient pathogen. In 1991 cholera struck Peru from Chancay (Lima's port city) to the port of Chimbote 400 km north, the next day. Cholera soon surfaced all along the 2000 km Peruvian coast. It then spread rapidly to ports in Ecuador, Colombia, and Chile, and then to Brazil, Venezuela, and Bolivia, following rivers and streams. Over 15 months, more than half a million people fell ill and almost 5000 died in nineteen Latin American nations.

The Peruvian coast is prolific in phytoplankton and their chief consumers, anchovies. Human activities are enhancing the blooms. From March to August, 1991, *Vibrio cholerae* O1, biotype El Tor, serotype Inaba was isolated from marine plankton near Lima; *V cholerae* O1 has been recovered from the bilge of Latin American vessels docked in US Caribbean ports, and seems to have crossed the Pacific as a "stowaway" from Bangladesh.

Since 1960 researchers in Bangladesh have related the seasonality of cholera to coastal algal blooms, but the reservoir remained a mystery. Applying fluorescent antibody and polymerase chain reaction techniques, Colwell and colleagues have identified a viable, but non-culturable "quiescent" form of *V cholerae*, associated with a wide range of surface marine life. Under adverse conditions they contract 15-300 fold and reduce their metabolic rates, "hibernating" to tolerate shifts in pH, temperature, salinity, and nutrients. Under favourable conditions of nitrogen, phosphorus, and warming (also conducive to algal blooms), *V cholerae* reverts to a culturable and infectious state. Chitinases and mucinases facilitate attachment to aquatic organisms, while algal surface films and slimes enhance growth by creating turbulence-free havens. Prolonged survival of vibrios has been associated with cyano (blue-green) bacteria, silicated diatoms, drifting dinoflagellates, seaweed, large algae, water hyacinths, and duckweed but the key commensal and/or symbiotic association is with zooplankton. Up to a million bacteria have been detected on copepod (zooplankton) egg sacs. *V cholerae* is also found in molluscs and in fish skin and intestines.

Harmful algal blooms

In biblical times "red tides" were seen as the blood of sparring whales or as menstrua. Today toxic phytoplankton blooms are associated with paralytic, diarrhoeal, and amnesic shellfish poisoning and with histamine (Scromboid), pufferfish, and ciguatera fish poisoning. The 1972 New England outbreak of red tide paralytic shellfish poisoning, a 1978 outbreak of ciguatera poisoning in Florida (there are now 200 000 cases annually worldwide), and a rash of reports in 1985 on diarrhoeal shellfish poisoning aroused concern, and in 1987 the International Oceanographic Commission (IOC) and UN Food and Agricultural Organization combined to set up an intergovernmental panel on harmful algae blooms.

Algal blooms (red, green, golden, brown, bioluminescent), covering vast expanses of marine, estuarine, and inland water have now been described from points as diverse as California, North Carolina, Guatemala, Iceland, Japan, Thailand, and the Tasman Sea. The global distribution of coastal blooms is visualised on a composite image from a satellite no longer collecting data (figure 1); the sea-viewing wide field sensor is scheduled for launching in 1994. This increase in blooms is a direct consequence of human activities, some local and some impacting on global climate systems. The following is just a sample of reports of the consequences for human health, tourism, and food production. In 1973 and 1974 blooms of brevetoxin-producing Gymnodinium breve blanketed Florida beaches; in 1976 G catenatum bloomed off the Spanish coast causing hundreds of cases of poisoning from contaminated mussels; Pyrodinium blooms off the Philippines in 1983 and 1987 caused 1127 cases and 34 deaths and also 26 deaths on the Pacific coast of Costa Rica and Guatemala in 1987. In the 1980s, diarrhoeal shellfish poisoning associated with dinoflagellates spread from Japan and the Americas to previously uncontaminated areas of Ireland, Portugal, Italy, India, Thailand.

Environmental factors

An outbreak of waterborne disease may be thought of as an inevitable consequence of specific environmental changes amplifying plankton and associated bacterial proliferation. Sunlight, pH, currents, winds, and river runoffs govern the location and timing of plankton blooms. The major anthropogenic influences, global warming apart, are:

Pollution

Excess nutrient from sewage and fertiliser effluents is a primary cause of marine eutrophication; soil erosion and acid rain add additional nitrogen and phosphorus. Freshwater lacks dissolved carbonates so an increase in atmospheric CO_2 can "fertilise" algal growth on ponds and sewage lagoons. Other pollutants upset the balance of marine ecosystems. Toxins, such as polychlorinated biphenyls, heavy metals, and pesticides, accumulate in food chains, causing damage to marine organisms, altering the ecosystem's equilibrium. Oil slicks and solid plastics harm sea mammals and birds, altering predation pressures.

Over-harvesting

The over-harvesting of fish and shellfish reinforces algal growth also by reducing algivorous grazing. Nine of the world's seventeen major fisheries are in serious decline.

Loss of habitat

The wetlands ("nature's kidneys") filter nitrogen and phosphorus, store carbon, and support fish and seabirds. They are disappearing. Salt marshes, sea grasses, and mangroves are suffering from coastal urbanisation; and California has now lost most of its wetland area. Coral reefs (the "oceans' rainforests") that protect coasts and cradle marine life are being widely mined for road and housing construction. Warming directly harms reefs, causing the algal symbiont to sprout flagella and swim off, leaving bleached polyps behind.

Warming and algal growth

Ship recordings ("sea truth") since 1850 demonstrate ocean warming, and Maskell and colleagues illustrated this in the first article in the series. Confirmation comes from Yan and colleagues' time-series studies in the Western Pacific in the mid-1980s (figure 2) but the pattern since then has not been consistent. Global warming probably has contributed to recent variations in sea surface temperature but it is not the only possible explanation. The climate phenomenon known as El Niño (see below) also raises sea temperatures. Figure 3 shows this for the Eastern Pacific.

Warming reduces dissolved oxygen and, within limits, stimulates photosynthesis and metabolism (figure 4), favouring cyanobacteria and dinoflagellates. The 1980s saw several "natural experiments". In 1982/83 a strong El Niño (see below) warmed the North Atlantic, altering zooplankton, fish, seal, and seabird communities throughout the decade. In the Pacific raised surface temperatures overwhelmed the cool, rich, upwelling Humboldt current, altering Peruvian sardine and anchovy yields for years.

In 1986/87 warming supported new growths of species in higher northern and southern latitudes. Since 1987 the dinoflagellate G breve, previously blooming in the Gulf of Mexico, has persisted off North Carolina, following a shoreward intrusion of the Gulf Stream onto the Continental Shelf. In 1987, local factors combined with warm eddies of the Gulf Stream that swept unusually close to Prince Edward Island, and the pennate diatom (Nitzschia pungens) produced domoic acid, killing 5 Canadian mussel consumers and causing 156 cases of amnesic shellfish poisoning. Hundreds of dolphins and whales died that year and there were reverberations throughout the fish and marine mammal populations. In September, 1991, domoic acid appeared in Monterey Bay, California, and hundreds of birds were poisoned. In 1992, massive blooms of Pseudonitzschia pseudodelicatissima occurred in Scandinavian waters; and in 1991/1992 saxotoxins appeared for the first time as far south as the Straits of Magellan.

In the austral summer the sun beats down on the Pacific to generate an eastward-flowing warming centre known as El Niño. Long cycles in earth's tilt are now bringing the Southern Hemisphere closer to the sun so ever more heat permeates this thermal "sink". Ocean-atmospheric modelling predicts stronger and more frequent El Niños, with rising

CO_2.[11,12] The pace and the duration of strong El Niños, which are associated with extreme weather events worldwide, have accelerated. In 1987/88, 1990/91, and 1992/93 and well into 1993 (and persisting). There have been 2-3deg.C anomalous sea surface temperature rises associated with floods and droughts. The sea is a global thermostat, absorbing atmospheric heat for worldwide distribution through broad surface "streams" coursing north and grand submarine "rivers" returning to the equator. Might this conveyor belt have stalled or even reversed direction to produce the rapid climate swings disclosed in Greenland ice-core records?

Plankton and climate

Plankton interact with climate by taking in CO_2, by absorbing and scattering solar heat, and by emitting dimethylsulphide that seeds clouds, which cool the earth's surface through precipitation and sunlight reflection. These biotic feedbacks help to modulate the earth's temperature, the salinity of its oceans, and the composition of its atmosphere.

By harnessing photosynthetically active radiation marine microflora produce twice as much carbohydrate (60 billion tonnes annually) as terrestrial plants. Phytoplankton produce 70% of atmospheric oxygen, that in turn generates protective ozone in the stratosphere. Having evolved before the ozone shield appeared, phytoplankton can produce auxiliary protective pigments, while small increases in the dose of ultraviolet may harm zooplankton (eg, krill).

Emerging diseases and novel strains

New clinical conditions (or their potential) involving algae include diarrhoea associated with Cyclospora-like bodies (CLB) and as yet unidentified toxins off the French coast.

While pollution-related stress can increase the susceptibility of sea mammals to infections such as phocine distemper in Mediterranean dolphins it is now clear that vast numbers of viruses exist in marine waters and estuaries. They could be involved in the exchange of genetic information. The role of environmental changes in increasing pathogenicity of marine viruses, or creating conditions for the survival of known pathogenic viruses introduced through sewage may become a crucial question for the health of large marine ecosystems.

In 1992 a modified vibrio known as V cholerae O139 emerged, first in coastal communities of India and now rapidly spreading in Asia; and in sewage lagoons near Lima chlorine-resistant vibrios have been isolated. These developments may not seem easily linked to global climate change but they represent altered biodiversity and stability within large marine ecosystems. Extensive monsoon flooding of Bangladesh in July, 1993, has enhanced the dissemination of the "Bangladesh strains".

Conclusion

Climate is controlled by the interaction of oceans, atmosphere, land systems, ice cover, and biota; and a change in any one will destabilise the entire system. The transformation in biomass and community structures of key elements in the marine food web is a result of human activities and a byproduct of the ocean's role in the global thermal budget.

The costs in human health and yields are mounting. The degradation of marine ecosystems increases the risk of diseases emerging, and an enhanced plankton reservoir may help explain the rapid invasion of cholera in the Americas. Changes along coastlines are contributing to public health hazards, and are causing hypoxia in the breeding grounds of marine animals and plants. Physicians may see the remedial actions--a reduction in inputs, protection of wetlands, and preservation of species diversity in the oceans--too remote from their clinical practice. Our contribution, and the Lancet series as a whole, is aimed at closing that gap in perception.

Ocean Dumping

Recent studies suggest that the deep ocean bottom supports habitats as diverse as any community on land or in shallow water. The discovery that the deep sea may be every bit as rich as a tropical rainforest comes at a time when land use is at a premium. In the 21st Century, we will have to decide what to do with the vast amount of waste that a growing population -- projected to double from five billion to 10 billion in the next century -- will produce. The oceans, which cover 70 percent of the Earth's surface, are likely to receive consideration as a waste-management option.

Currently, ocean dumping is generally banned worldwide. The motivation for banning ocean dumping gained momentum when contaminated wastes from sewage-derived microorganisms were discovered at public beaches, shellfish beds were contaminated with toxic metals, and fish were infected by lesion-causing parasites. Coastal areas continually impacted by nutrients in waste products (primarily nitrogen) that run off the land eventually suffer from increases in toxic algal blooms and decreased oxygen levels, both of which can kill fish populations.

To some, the deep-sea floor may seem safe from the human disturbances that threaten terrestrial and coastal ocean environments. Yet, most natural and artificial wastes -- such as sewage sludge, mining tailings, fly ash from power stations, dredged spoils from harbors and estuaries, dangerous synthetic organic compounds and packaged goods -- make their way to the sea floor over time.

Studying Deep-sea Biodiversity and Dumping

To determine the impact of waste disposal on bottom-living animals, the National Undersea Research Program (NURP) recently supported numerous research projects in the oceans and Great Lakes. Scientists examined the effects of dumping on living organisms and deep-sea biodiversity, as well as the transmission of contaminants back to the human population.

In the most detailed study ever conducted related to the impacts of ocean dumping, NURP-funded scientists documented the impact of 42 million tons of wet sewage sludge dumped 2,500 m (8,000 ft) off the Mid-Atlantic coast between 1986 and 1992. One of the most significant environmental impacts detected at the 106-mile Dumpsite, so named because it lies 106 nautical miles southeast of New York Harbor, was the restructuring of a deep-sea community.

In a series of 233 core samples taken along a 176-kilometer track off the coast of New Jersey and Delaware, Drs. Fred Grassle and Nancy Maciolek found an incredible diversity of animals, most of which were previously unknown. They identified 798 different species, 171 families, and 14 phyla at around 2,100 m (6,720 ft) -- a sampling that revealed much richer life at those depths than earlier samples had suggested.

As they sampled sites to the north and south, the number of new species doubled, suggesting that species diversity was much richer than ever imagined. The researchers generalized that nearly 10 million species could be found in every sq km of the sea floor beneath depths greater than 1,000 m, excluding the abyssal depths (3,000-6,000m).

Fate and Effects of Sewage Sludge

For six years, the NURP-sponsored studies attempted to determine the fate and effects of sewage sludge on the sea floor. All of the evidence indicated that the sludge material dumped by barges significantly effected the metabolism, diet, and composition of the organisms living there.

Chemist Michael Bothner, of the U.S. Geological Survey, confirmed the presence of sludge in sediments, as well as silver levels 20 times higher at the dumpsite than at an unaffected area. To make this determination, Bothner and his colleagues used the submersible Alvin to collect the silver samples in sediment cores. They also were able to observe how contaminants penetrated to a depth of 5 cm below the sea floor as organisms living in the sediments burrowed through them. During a 10-month sampling period, however, researchers noted seven occasions where the currents were strong enough to resuspend the contaminated sediments. During the same period, chemist Hideshige Takada, of Tokyo University, and Bothner, reported elevated levels of linear alkylbenzenes (LABs), which are widely used as surfactants in synthetic detergents, and coprostanols, a substance found in animal feces, at the dumpsite.

The increased flux of sludge caused measurable changes in the benthic (sea floor) ecology near the dumpsite. Drs. Van Dover, Grassle, and other colleagues observed a tenfold increase in the abundance of urchins, starfish and sea cucumbers at the dumpsite, and observed the sea urchins' ingestion of sludge-derived organic matter. The researchers believed that a long-term disposal program that introduced sludge into the food web would result in the restructuring of the sea-floor community, favoring species able to exploit the organic material available in sewage sludge.

An eel pout, about 0.5 m long, seen from Alvin's starboard viewing port while collecting re-suspended sediment at the 106-Mile Dump site. Click on image for a larger view.

Sludge disposal at the 106-Mile Dumpsite was curtailed in July 1992. This provided additional opportunities to examine the long-term dispersal and effects of waste material in the deep-sea environment, Bothner said. He found that silver levels in sediment samples had begun to decline after the dumping stopped. In subsequent studies, Bothner, and chemical oceanographers Elizabeth Lamoureux and Bruce Brownawell of the State University of New York at Stony Brook, found that while LABs had tapered off, elevated levels of organic contaminants, including PCBs and PAHs in surface sediments, could still be detected around the dumpsite. Dr. Van Dover found that the density of benthic communities at the dumpsite was decreasing and that the ingestion of sewage-derived organic matter was also subsiding at the dumpsite.

The Future of Ocean Dumping

While the effects of sludge dumping appeared to be abating in the vicinity of the 106-Mile Dumpsite, an additional chapter of the story remains to be written. Levels of silver appeared to be on the increase 50 nautical miles south of the dumpsite, as did the densities of sediment-dwelling organisms. According to a 1993 study by Dr. Grassle, Paul Snelgrove, associate chair in fisheries conservation at Memorial University of Newfoundland, and Rosemarie Petrecca, a senior marine scientist at Rutgers University, this suggests that the recovery of the dumpsite led to changes in other habitats, as resuspended materials were transported south.

While deep-sea dumping has been banned, there are many other ways that waste makes its way into water bodies. In Lake Ontario, for example, an average of one ton of waste material discharged from every ship that leaves port is deposited on the lake bottom, according to a recent NURP study. This legal practice, called cargo sweeping, which involves removing from the deck such wastes as iron ore pellets, coal, slag, limestone, construction aggregate, and possibly ash, is leaving a "footprint" on the bottom of the lake. The problem is likely to be even more serious in the Great Lakes with more shipping traffic than Lake Ontario.

In a study led by Brownawell, NURP-funded researchers used a remotely operated vehicle to collect sediment samples at the bottom of Lake Ontario. Their work confirmed that cargo sweeping left waste materials in plots along the bottom, and that these wastes could pose adverse effects on benthic invertebrates. Amphipods, benthic crustaceans at the base of the food chain, appear to be in decline in shipping lanes. Whether this will have an impact on predatory fish in the Great Lakes is unknown, but the observation prompted the U.S. Coast Guard to move shipping lanes away from critical fish spawning areas throughout the Great Lakes where cargo sweeping is a common practice.

Many questions remain about the potential short- and long-term effects of toxic compounds accumulating in deep-water sediments. Some argue in favor of deep-ocean dumping, because the material is diluted as it sinks, and reamins stable on the sea floor. The present body of research, however, suggests that dilution does not completely abate the effects of dumping, nor does the waste sit still once it gets to the bottom. By establishing a long-term observatory at the 106-Mile Dumpsite, Dr. Grassle hopes future research will provide a clear picture of the effects of deep-sea dumping.

Life history theory

Life history theory posits that the schedule and duration of key events in an organism's lifetime are shaped by natural selection to produce the largest possible number of surviving offspring. These events, notably juvenile development, age of sexual maturity, first reproduction, number of offspring and level of parental investment, senescence and death, depend on the physical and ecological environment of the organism. Organisms have evolved a great variety of life histories, from Pacific salmon, which produce thousands of eggs at one time and then die, to human beings, which produce a few offspring over the course of decades. The theory depends on principles of evolutionary biology and ecology and is widely used in other areas of science.

Life history characteristics

Life history characteristics are traits that affect the life table of an organism, and can be imagined as various investments in growth, reproduction, and survivorship.

The goal of life history theory is to understand the variation in such life history strategies. This knowledge can be used to construct models to predict what kinds of traits will be favored in different environments. Without constraints, the highest fitness would belong to a Darwinian Demon, a hypothetical organism for whom such trade-offs do not exist. The key to life history theory is that there are limited resources available, and focusing on only a few life history characteristics is necessary.

Examples of some major life history characteristics include:

- Age at first reproductive event
- Reproductive lifespan and aging
- Number and size of offspring

Variations in these characteristics reflect different allocations of an individual's resources (i.e., time, effort, and energy expenditure) to competing life functions. For any given individual, available resources in any particular environment are finite. Time, effort, and energy used for one purpose diminishes the time, effort, and energy available for another.

For example, birds with larger broods are unable to afford more prominent secondary sexual characteristics . Life history characteristics will, in some cases, change according to the population density, since genotypes with the highest fitness at high population densities will not have the highest fitness at low population densities. Other conditions, such as the stability of the environment, will lead to selection for certain life history traits. Experiments by Michael R. Rose and Brian Charlesworth showed that unstable environments selected for flies with both shorter lifespans and higher fecundity.

Reproductive value and costs of reproduction

Reproductive value models the tradeoffs between reproduction, growth, and survivorship. An organism's reproductive value (RV) is defined as its expected contribution to the population through both current and future reproduction:

RV = Current Reproduction + Residual Reproductive Value (RRV)

The residual reproductive value represents an organism's future reproduction through its investment in growth and survivorship. The cost-of-reproduction hypothesis predicts that higher investment in current reproduction hinders growth and survivorship and reduces future reproduction, while investments in growth will pay off with higher fecundity (number of offspring produced) and reproductive episodes in the future. This cost-of-reproduction tradeoff influences major life history characteristics. For example, a 2009 study by J. Creighton, N. Heflin, and M. Belk on burying beetles provided "unconfounded support" for the costs of reproduction. The study found that beetles that had allocated too many resources to current reproduction also had the shortest lifespans. In their lifetimes, they also had the fewest reproductive events and offspring, reflecting how over-investment in current reproduction lowers residual reproductive value.

The related terminal investment hypothesis describes a shift to current reproduction with higher age. At early ages, RRV is typically high, and organisms should invest in growth to increase reproduction at a later age. As organisms age, this investment in growth gradually increases current reproduction. However, when an organism grows old and begins losing physiological function, mortality increases while fecundity decreases. This senescence shifts the reproduction tradeoff towards current reproduction: the effects of aging and higher risk of death make current reproduction more favorable. The burying beetle study also supported the terminal investment hypothesis: the authors found beetles that bred later in life also had increased brood sizes, reflecting greater investment in those reproductive events.

r/K selection theory

The selection pressures that determine the reproductive strategy, and therefore much of the life history, of an organism can be understood in terms of r/K selection theory. The central trade-off to life history theory is the number of offspring vs. the timing of reproduction. Organisms that are r-selected have a high growth rate (r) and tend to produce a high number of offspring with minimal parental care; their lifespans also tend to be shorter. R-selected organisms are suited to life in an unstable environment, because they reproduce early and abundantly and allow for a low survival rate of offspring. K-selected organisms subsist near the carrying capacity of their environment (K), produce a relatively low number of offspring over a longer span of time, and have high parental investment. They are more suited to life in a stable environment in which they can rely on a long lifespan and a low mortality rate that will allow them to reproduce multiple times with a high offspring survival rate.

Some organisms that are very r-selected are semelparous, only reproducing once before they die. Semelparous organisms may be short-lived, like annual crops. However, some semelparous organisms are relatively long-lived, such as the African flowering plant Lobelia telekii which spends up to several decades growing an inflorescence that blooms only once before the plant dies, or the periodical cicada which spends 17 years as a larva before emerging as an adult. Organisms with longer lifespans are usually iteroparous, reproducing more than once in a lifetime. However, iteroparous organisms can be more r-selected than K-selected, such as a sparrow, which gives birth to several chicks per year but lives only a few years, as compared to a wandering albatross, which first gives birth at ten years old and breeds every other year during its 40 year lifespan.

r-selected organisms usually:

- ⇨ mature rapidly and have an early age of first reproduction
- ⇨ have a relatively short lifespan
- ⇨ have a large number of offspring at a time, and few reproductive events, or are semelparous
- ⇨ have a high mortality rate and a low offspring survival rate
- ⇨ have minimal parental care/investment

K-selected organisms usually:

- mature more slowly and have a later age of first reproduction
- have a longer lifespan
- have few offspring at a time and more reproductive events spread out over a longer span of time
- have a low mortality rate and a high offspring survival rate
- have high parental investment

Determinants of Life History

Many factors can determine the evolution of an organism's life history, especially the unpredictability of the environment. Organisms that live in a very unpredictable environment—one in which resources, hazards, and competitors may fluctuate rapidly—selects for organisms that produce more offspring earlier in their lives, because it is never certain whether they will survive to reproduce again. Mortality rate may be the best indicator of a species' life history: organisms with high mortality rate—the usual result of an unpredictable environment—typically mature earlier than those species with low mortality rates, and give birth to more offspring at a time. A highly unpredictable environment can also lead to plasticity, in which individual organisms can shift along the spectrum of r-selected vs. K-selected life histories to suit the environment.

Perspectives

Life history theory has provided new perspectives in understanding many aspects of human reproductive behavior, such as the relationship between poverty and fertility. A number of statistical predictions have been confirmed by social data and there is a large body of scientific literature from studies in experimental animal models, and naturalistic studies among many organisms.

Aquatic communities are the world's major water habitats. Like land biomes, aquatic communities can also be subdivided based on common characteristics. Two common designations are: freshwater and marine communities.

Freshwater Communities

Rivers and Streams are bodies of water that continuously move in a single direction. Both are rapidly changing communities. The source of the river or stream usually differs significantly from the point at which the river or steam empties. A variety of plants and animals can be found in these freshwater communities, including trout, algae, cyanobacteria, fungi, and of course, various species of fish.

Estuaries are the areas where freshwater streams or rivers meet the ocean. These highly productive regions contain widely diverse plant and animal life. The river or stream usually carries many nutrients from inland sources, making estuaries capable of supporting this rich diversity and high productivity. Estuaries are feeding and breeding grounds for a variety of animals, including: waterfowl, reptiles, mammals, and amphibians.

Lakes and Ponds are standing bodies of water. Many streams and rivers end in lakes and ponds. Phytoplankton are usually found in the upper layers. Because light is absorbed only to certain depths, photosynthesis is common only in the upper layers. Lakes and ponds also support a variety of plant and animal life, including: small fish, aquatic insects, and numerous plant species.

Marine Communities

Oceans cover approximately 70% of the earth's surface. Marine communities are difficult to divide into distinct types, but can be classified based on the degree of light penetration. The simplest classification consists of two distinct zones: the photic and aphotic zones. As with the other communities, a variety of organisms live in the ocean: fungi, sponges, sea anemones, fish, crabs, etc.