NOTES

CHAPTER 10

ENVIRONMENTAL STRESS: HUMAN EFFECTS

"It is only in the most recent and brief period of their tenure, that human beings have developed in sufficient numbers, and acquired enough power, to become one of the most potentially dangerous organisms that the planet has ever hosted."

– John McHale

Humans have always regarded the marine environment as their domain to exploit. However, since World War II, urbanized countries have looked to technology both as a means to harvest resources more quickly and efficiently and as a panacea for the undesirable side effects. Many governments still foolishly believe that no matter how dramatically we deplete the earth's resources and allow world population to multiply, technology will always bail us out.

Many of the human-induced stresses discussed in this chapter, such as sophisticated industrial pollutants, acid rain, and radioactive waste, are relatively new to the natural landscape. Their effects, however, are far-reaching, and very possibly impervious to technological curative efforts.

POLLUTION

Most wastes we discharge into the air, water, and land eventually wind up in the ocean. Twenty-two billion tons of pollutants are dumped into the oceans every year, mostly from land-based and atmospheric sources. The global circulation of ocean currents, the longevity of many pollutants, and the continuity of marine life means that no part of the ocean is exempt from pollution. Additionally, we have to consider the cumulative effects of contaminants, whether DDT, PCBs, or trace metals, and their synergistic interactions. For example–siltation can interact with pollutants, changing their form so that they can be more readily ingested.

The United Nations Group of Experts on Scientific Aspects of Marine Pollution estimates that forty-four percent of marine pollution

Point source pollution. Pictured: Industrial waste spewed through a pipe.

–Photo: Soil Conservation Service

originates as land-based runoff and discharges, thirty-three percent is from atmospheric sources, twelve percent is from boat discharges and spills, ten percent is from deliberately dumped wastes, and one percent is from offshore mineral mining. There are three basic types of land-based pollutants found in the ocean: dissolved nutrients, dissolved toxins, and suspended toxic or non-toxic particles transported by rivers and streams into the ocean. Each of these can be disastrous to marine environmental health and viability.

Scientists and regulators classify water pollution into two broad categories: "point" and "non point" sources. Point sources come from a single point, the mouth of the pipe, for instance, or from a distinct location, such as a factory, ditch, well, vessel, ship yard, or container. Non-point source pollution is indirect, such as storm runoff drains carrying pollutants from streets, construction sites, car exhausts, and farmlands.

SEWAGE

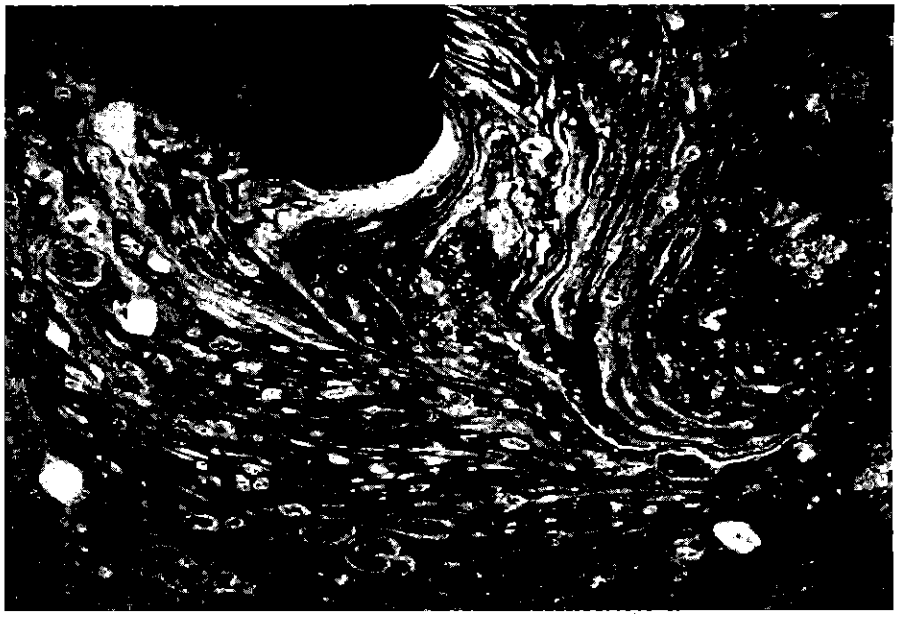
Sewage is a problem wherever there are dense human populations. Sewage can be point or non-point (runoff) pollution. Point pollution occurs in channels such as ditches, canals, and pipes, which release sewage in a specific area. Even in cities and municipalities that have sewage treatment facilities, treated sewage "sludge" may be pumped directly into the sea, dumped from barges, or carried through storm sewers into rivers and streams and then into the ocean. Sewage adds phosphates and nitrates to the water, which cause explosive algae blooms. As these nutrients decompose, they use up the oxygen supply which marine organisms need. Ultimately, when the oxygen is depleted, the result is an anoxic, or "dead zone."

NOTE: Marine creatures also produce a large amount and variety of excrement, but the sea can deal with these natural wastes because they are widely dispersed. On the contrary, human waste materials are usually dumped in high concentrations in small areas, such as from municipal sewage systems.

A dramatic example of water which became anoxic was seen in the New York-New Jersey area in the late 1970s and early 1980s, where nine million metric tons of sludge were being dumped every

Sewage pollution

Photo: EPA–



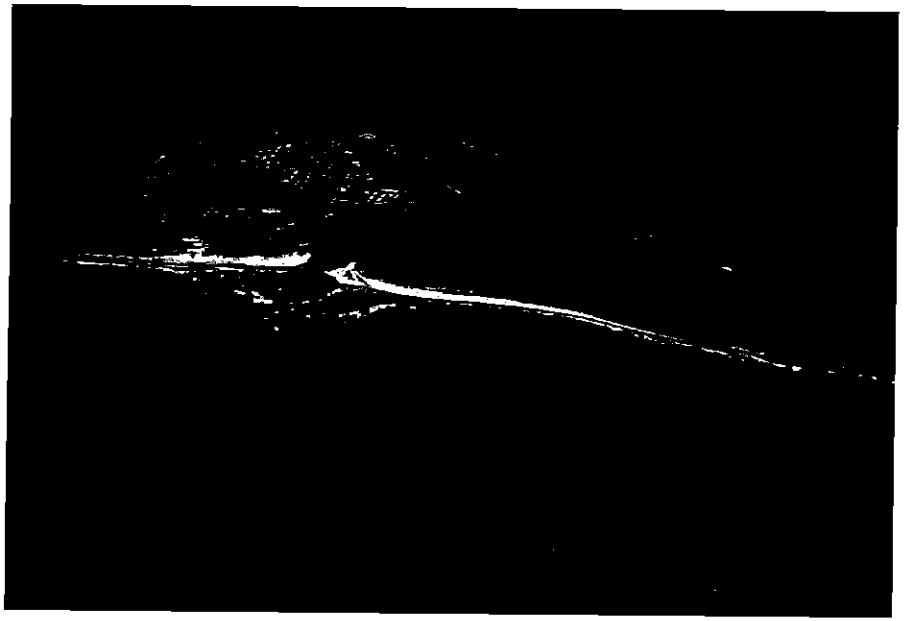


Photo: Mort and Alese Pechter–

Non-point source pollution. Pictured: Run-off in Puerto Rico

year in an area of twelve thousand square kilometers. Lack of oxygen so totally decimated bottom dwelling organisms in the New York Bight (an area stretching sixty-five hundred square kilometers) that recreational divers began noticing abnormally high mortality amongst scallop, lobster, and quahog populations. Scuba divers and fishers also reported that some species of fish which normally inhabit sand and rock bottoms had migrated to surface waters in a desperate attempt to survive.

Although a long standing affliction, sewage only captures world headlines when it encroaches upon human comfort and safety. Such was the response in the 1980s when the public was alarmed and outraged because beaches in Long island and New Jersey were suddenly inundated with dead and diseased fish and bottlenose dolphins, dirty syringes, and other hazardous medical waste, resulting in beach closings and quarantines.

Industrial Waste

Industrial pollution, which can emanate from both point sources and non-point sources (such as fallout of gaseous pollutants spewn into the atmosphere from industrial smokestacks), is one of

the most destructive and widespread environmental impacts of the twentieth century.

Industrial waste, which includes poisonous metals such as mercury, tin, and lead, is primarily from factories, mines, and to a lesser extent, boats. These "heavy metals" and "high tech" chemical compounds (synthetic organics) not only kill some species outright, but also contaminate survivors and the food chain. This contamination causes chronic problems like disease, deformities, and lesions; it also weakens the immune systems of marine inhabitants and impairs their ability to resist their natural enemies.

Scientific evidence indicates chlorine as a common link in many of the world's most notorious environmental toxins; dioxin, DDT, Agent Orange, PCBs (poisonous chemicals used to cool machinery), and the ozone-destroying chloroflourocarbons (CFCs) are all based on chlorine.

Organochlorines, synthetic chlorine substances, are used in many industries because they are highly resistant to natural breakdown. But this same stability allows them to remain in the environment for decades or centuries. As a result, the entire planet has become blanketed with chlorine-based poisons. From the North Pole to the deep oceans, organochlorines can be found in the water, air, and food chain. Because these synthetic poisons concentrate in

Photo: Michigan Sea Grant–

Industrial pollution

–Photo: NOAA

Sea birds soaked with oil cannot maintain body heat or fly to forage for food. Pictured: Oil soaked bird after the Exxon Valdez spill.

fat, they multiply as they move up the food chain. Beluga whales in the St. Lawrence River, which are at the top of the food chain, have accumulated such high levels of PCBs that dead whales are classified as legally hazardous waste.

PCBs have been banned in many countries, but still are widely in evidence. Scientists have found that animals with PCBs in their bodies sicken more easily. In 1988, for example, over eighteen thousand common seals in the North Sea died of disease. Autopsies revealed that most of these seals had PCBs in their bodies.

Experts predict that industrial pollution will continue to be a problem in the future, and in fact, will probably increase as industrial development increases and coastal populations grow. The Environmental Protection Agency (EPA) regulates the amount of pollutants that may be discharged into the marine environment through the National Pollutant Discharge Elimination System. This system requires polluters to obtain permits which fix limitations on the quantities of pollutants that may be discharged, prohibits the discharge of others, and requires the polluter to file periodic reports on their operations, among other requirements.

Oil and Hazardous Materials Spillage

Petroleum compounds and their by-products are also sources of marine pollution. Whereas some oil naturally seeps from the sea bed, most is from human activities. Experts estimate that each year between three and six million metric tons of oil are discharged into the ocean from atmospheric, land, and sea-based sources.

When oil spills into the sea, it forms a large pool, called a *slick*, on the surface of the water. The slick can drift to shore, foul beaches, kill wildlife, and alter marine ecosystems. Unfortunately, public awareness of the damage wrought by oil pollution is often limited to dramatic and large scale oil disasters, such as the *Exxon Valdez*.

In March 1989, when the huge oil tanker *Exxon Valdez* ran aground in Prince William Sound, Alaska, 250,000 barrels (45 million liters) of oil poured into the sea. The death toll from this one spill alone included 150 rare bald eagles, 1,000 sea otters and hundreds of thousands of fish, seals, and shellfish. Over 100,000 sea birds died of hypothermia and related causes as their feathers became clogged with oil and tar balls and lost their insulative ability. The attendant damage to other sea life and the vital fisheries in the area is still being studied, but juvenile populations are clearly depressed and fewer healthy offspring are surviving despite massive cleanup efforts. Furthermore, cleanups often cause more damage than the oil itself.

In 1991, during the Gulf War, up to two million barrels of crude oil were deliberately pumped into the Persian Gulf from wells in Kuwait, killing acres of sea bottom and marine life. Although these major environmental catastrophes grab the headlines and raise world consciousness, there are actually thousands of less spectacular tanker accidents and other incidents every year. Additionally, a large percentage of oil enters the ocean from oil rigs, cars, machinery and dredging operations, as well as from routine boat operations such as cleaning of boat ballasts and bilges.

The number of vessels legitimately moving petroleum and hazardous substances, both tankers and tank barges, and the number of port calls and other movements are large. The latest available figures show that there are more than 25,000 ships of over 1,000 gross registered tons in world's merchant fleet. About 5,500 of these are tankers, including 265 U.S. flag tankers.[1]

A concurrent unresolved environmental problem related to the transport of oil is that of floating tar. Floating tar generally comes from tankers flushing out their ballast tanks before entering port to take on new cargoes of petroleum. This poses a serious hazard for

Newark, New Jersey. In 1990, NOAA reported that 25% of the 47,500 barrels of atomic waste which had been dumped in the gulf of the Farallones National Marine Sanctuary, had ruptured, and posed an unmitigated threat to many of the valuable commercial fish stock, sea birds, and marine mammals in the area. Once considered the richest marine habitat in the West, since 1991, it has cost the U.S. government almost a billion dollars to conduct a study to assess the extent of the damage from radioactive material.

The Partial Test Ban of 1963 stopped atmospheric testing in the U.S. and England and was followed by a similar ban in France in 1974. Unfortunately, even today, some underground testing still takes place in other parts of the world.

In 1983, a global agreement (an annex to the London Dumping Convention of 1975) was reached which banned dumping of radioactive waste at sea. However, hazardous radioactive waste is still transported by ship. The potential for a large-scale, virtually irreversible disaster, is thus unallayed. The former Soviet Union, for example, recently admitted to having dumped seventeen nuclear reactors and thousands of tons of liquid and solid nuclear waste into the Kara and Barents Seas throughout the "Cold War," even after the global ban on radioactive dumping was enacted. Russia still has nuclear submarines afloat, which although officially decommissioned, are housing reactors which may not be dismantled for many years.

Nor has the problem of eventual leakage of previously discarded containers of nuclear waste been adequately addressed. Lake Karachy in central Russia, long used as a dump for a nuclear weapons plant, now holds radioactive material equal to twenty-four times the amount of the total fallout from the Chernobyl disaster, and scientists fear a high risk of a catastrophic washout. Nor do the mistakes of the past always shape the wisdom of the present. Much to the chagrin of environmentalists and world leaders, in the spring of 1995, France announced that it plans to resume nuclear testing in the far Pacific.

Atmospheric Pollution

"Damage already done to the ozone layer will be with us, our children, and our grandchildren throughout the twenty-first century."

– Former British Prime Minister Margaret Thatcher

Air pollution is an insidious problem. Every day, enormous amounts of combustion exhaust fumes from petroleum which is

used for many forms of transportation and power production are spewn into the atmosphere. The EPA reports that U.S. industries pump at least 2.4 billion pounds of chemicals into the air every year. Large quantities of these airborne toxins wind up in the marine environment. Some marine chemists estimate that sixty to eighty percent of the contaminants in highly urbanized areas, such as the New York Bight, comes from atmospheric inputs. Airborne and land-based pollutants travel significant distances, and as they make their way up the food chain, they contaminate a wide spectrum of marine organisms and fish, and ultimately, humans.

"Acid Rain"

"Acid rain spares nothing. What has taken humankind decades to build and nature millennia to evolve is being impoverished and destroyed in a matter of a few years–a mere blink in geologic time." ***– Don Hinrichsen***

Few environmental issues have generated so much controversy as acid rain (also called acid deposition). ACID RAIN is produced from the burning of fossil fuels by power plants, industry, and motor vehicles, whose smokestacks and tail pipes release millions

Acid rain is created when noxious compounds are created by the combustion of fossil fuels and are spewed into the air, such as from smokestacks, combine with water vapor.

Photo: EPA –

effects in humans, animals, and plants. Other types of genetic mutation and defects are also attributable to increases in background radiation and climactic change.

These abstract environmental phenomena thus have real consequences for all earth's inhabitants. Perhaps the most serious consequence of such damage, from the standpoint of the marine environment, is the projected rise in sea level due to thermal expansion of the oceans and the melting of the polar ice caps. One of the most compelling and often asked questions about the marine environment is: "is the world sea already rising and if so, by how much?" Researchers at Scripps Oceanographic Institution have been attempting to answer that question by analyzing statistics in several different regions of the oceans, where sea level data recorded by tide gauges appears to be relatively homogenous. The conclusions so far show that the average sea level in the world ocean may indeed be rising by a few millimeters a year.

A by-product of this process is an expected massive sediment and nutrient runoff. The results may include damage to and loss of low-lying coastal regions such as the eastern U.S., coral reefs, mangroves, salt marshes, and dependent marine species which would unlikely be able to adapt to the concurrent rise in sea level, the reduction in salinity, and the increase in turbidity.

In effect, the consequences from the greenhouse effect are not understood, as there are many feedback systems, such as increased cloud cover, which may result in net increases or decreases in temperature. Further, anthropogenic emissions may very well lead to a global cooling. The main point is that these emissions are changing the atmospheric composition of our planet at alarming rates, and we as yet do not know what the consequences will be. Many scientists are more concerned over the cumulative indirect effects of this type of industrial pollution and concomitant world-wide deforestation and resulting erosion than over any isolated accidents and incursions of whatever magnitude. The bottom line is that causing significant global climactic modifications will have serious effects on us all.

Marine Debris

Marine debris is not new. As far back as the era of the ancient mariners, the sea has always been used as a garbage dump. What is particularly troublesome today is the *massive amount* of garbage being generated and the *type* of garbage. The world's population and industrial growth of the last hundred years has produced a quantity of marine debris unrivaled in history. Exactly how much

debris has actually accumulated in our oceans and waterways? Unfortunately we do not know, as there are no current quantitative studies. In 1975, however, the National Academy of Sciences estimated that the ocean was being bombarded with 14 billion pounds of litter a year, or almost three times the weight of the entire annual catch of fish and shellfish in the United States. A more recent study estimated that the world merchant fleet alone dumps more than five and a half million metal, glass and plastic containers into the ocean every day.

It has also been reported that at least 160 species of marine vertebrates and two species of invertebrates ingest marine debris, and up to a million sea creatures are killed every year by debris thrown into the sea. As the world's population continues to grow, more and more debris will be generated, and that debris will kill growing numbers of marine wildlife.

Historically, trash that ended up in the ocean was made of paper and cloth which decayed, or metal and glass which sank and disappeared from view, making it easy for offenders to ignore the problem. The NIMBY (Not In My Back Yard) principle gave many people a false sense of security. As a result of modern technology, however, our oceans and waterways have been inundated with a material which gives marine debris not only high visibility, but also longevity, *plastic.*

The very characteristics which make plastic a household and industrial wonder make it a disaster in the ocean. Plastic is strong, it is lightweight, it does not rot, it does not rust, it is resistant to ozone, and it is not biodegradable. It can literally last up to hundreds of years. Plastic debris is in evidence everywhere. In coastal cleanups in the Gulf Of Mexico, for example, volunteers routinely collect plastic debris which originates in twenty-eight different countries, including locations as distant as Japan, Bulgaria, and Antarctica.

The Center for Marine Conservation estimates that at least half of all marine debris today consists of manufactured plastic items and plastic resin pellets (plastic resin pellets are the raw form of plastic, typically in the shape of spherules or beads, that have been synthesized from petrochemicals). The plastic items most commonly found are fishing gear, packaging materials, plastic bags and bottles, balloons, and syringes.

Widespread use of plastics has only been in effect for 40 years. In just the last ten years, the use of plastics in packaging has more than doubled. In 1975, nearly 5.6 billion pounds of plastics were used in packaging. In 1987 this figure soared to 15.2 billion pounds. In this relatively short space of time, some of the most remote and

Photo: Jill Townsend/CMC –

The Center for Marine Conservation estimates that up to 80% of all marine debris today is made of plastic and other synthetic materials.

pristine oases on earth, such as Antarctica, have be-come visibly despoiled with debris.

Plastic and other types of marine debris originate from many sources. In addition to merchant ships, Navy vessels, which typically hold thousands of military personnel, generate about 1,000 pounds of trash for every 5,000 people. Commercial fishing boats abandon or lose over 100,000 tons of "ghost" fishing gear (netting, traps, monofilament line, buoys, and cyalume sticks) every year. Recreational vessels are also responsible for marine debris. The U.S. Coast Guard estimates that fifty-two percent of the trash dumped into U.S. waters is from recreational vessels. Even though waste disposal from offshore oil operations is strictly regulated, marine debris associated with petroleum activities is routinely sighted.

Problems with Plastic Debris

I. Entanglement

Plastic lines, nets, traps, and packaging materials entangle and kill untold numbers of fish, marine mammals, and sea birds. Fishing gear made of synthetic materials, which is purposely or unintentionally abandoned, may drift near the surface or remain on the ocean floor. This is referred to as GHOST FISHING. Ghost fishing gear can continue to entrap marine life indefinitely. Large plastic items such as diapers and bags can smother corals. Monofilament line can entangle and tear soft sponges and sea fans.

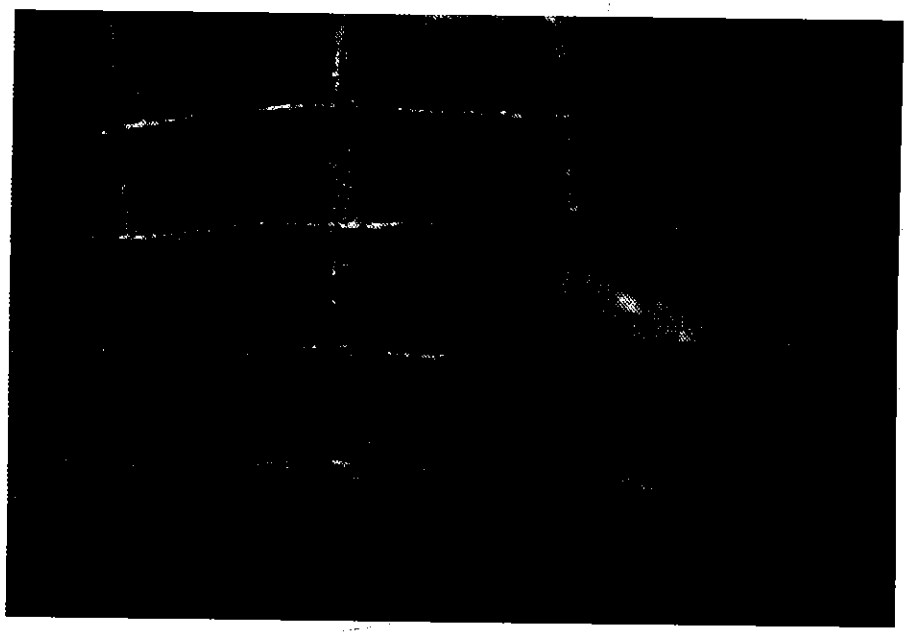
II. Ingestion

Plastic items are also ingested by marine creatures. Whales and turtles in particular may swallow plastic bags or balloons, mistaking them for jellyfish. Ingestion of plastic bags is particularly dangerous for sea turtles, since the plastic may get stuck in the turtle's throat and asphyxiate it, or block the turtle's digestive tract and cause death from starvation. Researchers have also found that approximately fifty of the world's two hundred and eighty species of sea birds are known to eat plastic and feed plastic to their young, especially Styrofoam pellets, which they mistake for fish eggs and plankton.

For recreational user groups, garbage in and around the water poses immediate and serious problems. Broken glass, rusty metal, and contaminated waste can cause infection and

Synthetic fishing gear kills over a million marine creatures a year.

Photo: Stephen Frink–



disease if it penetrates into the body. Divers and swimmers who become entangled in monofilament fishing line can drown. Marine debris can damage and incapacitate recreational boats and other vessels by fouling propeller shafts and blocking water intake ports for propulsion or cooling systems. Vessels have even been sunk as a result of collisions with especially large debris items.

Human Population Growth

"The real issue is how many footprints will fit on the earth?"

– U.S. Senator Alan Simpson

Population growth and the world capacity for food production are increasing constraints to the marine environment. Demographic analysis shows that it took hundreds of thousands of years for the human race to reach a population level of 10 million, only 10,000 years ago. This number grew to 100 million people about 2,000 years ago and to 2.5 billion by 1950. Within less than the span of a single lifetime the population has more than doubled to 5.5 billion in 1993, and that number is expected to double again by the middle of the twenty-first century. In the last decade, food production from both land and sea declined relative to world population growth.

This accelerated population growth resulted from rapidly lowered death rates combined with sustained high birth rates. This was possible because of increases in food production and distribution, improvements in medical technology and public health, and gains in education and standards of living in many developing nations.

The relationships among human population, economic development, and natural environment are complex and not fully understood. Nonetheless, there is no doubt that the threat to the biosphere is linked to population size and resource use. Increasing greenhouse gas emissions, ozone depletion, acid rain, loss of biodiversity, habitat destruction, excessive mining of minerals, fossil fuel consumption, and shortages of water, food, and fuel indicate how natural ecosystems are being pushed ever closer to their limits.

Habitat Alteration and Destruction

"An unnatural decoupling of humans and nature is one of the unfortunate results of high population density and urbanization." ***– Eugene Odum***

Major Pollutants Affecting U.S. Coastal Waters

POLLUTANT	SOURCE	EFFECTS
Nutrients, including nitrogen compounds	Fertilizers, sewage, acid rain from motor vehicles and power plants	Creates algae blooms, destroys marine life
Chlorinated hydrocarbons; pesticides, DDT, PCBs	Agricultural runoff, industrial waste	Contaminates and harms fish and shellfish
Petroleum hydrocarbons	Oil spills, industrial discharge, urban runoff	Kills or harms marine life, damages ecosystems
Heavy metals; arsenic, cadmium, copper, lead, zinc, mercury	Industrial waste, mining	Contaminates and harms fish
Soil and other particulate matter	Soil erosion from construction and farming; dredging	Smothers shellfish beds, blocks light needed by marine plants
Plastics	Ship dumping, household waste, litter	Strangles, mutilates wildlife, damages natural habitats

Source: *Newsweek*, August 1, 1988.

Photo: Doris Alcorn/CMC –

A monk seal with its mouth sealed shut by a plastic packing ring dies of starvation.

In conjunction with population expansion, one of the greatest environmental problems we face today is habitat alteration and destruction. Although some natural events (erosion, subsidence, and storms) alter habitats and ecosystems, human activities are the major culprit in habitat degradation. Deforestation, coastal construction, mining, land fill and dredging operations, the building of roads and drainage ditches, year-round grazing of ranges, and the cultivation of easily eroded lands are destroying valuable terrestrial, marine, and coastal ecosystems.

In addition to eliminating habitats, these activities may result in excessive runoff of rainwater, which can cause floods. They may also lead to drought, which occurs when too little water is stored underground. Moreover, runoff strips soil from the land and deposits it in reservoirs, ship channels, and other bodies of water. These silt-laden bodies must then be dredged or abandoned.

Destruction of habitats, direct and indirect, occurs daily. In many parts of the world, coastal, marine and freshwater habitats are regularly dynamited and bulldozed to create housing, industrial facilities, airports, ports, and resorts for burgeoning populations. In Southeast Asia, live coral is dug up, pulverized, and used as construction material. Other poor developing nations build urban and industrial complexes literally on top of living reefs. Indirect damage

–Photo: Stephen Frink

A sea fan infested with algae from pollutants in the water.

Dredging operations cause silt and toxins to run off into the ocean.

Photo: EPA–

to aquatic habitats is perpetuated by the effects of construction–uprooting and runoff of sediments and toxic chemicals, siltation of reefs which depend on clear water and sunlight, and alterations in water salinity, flow, and temperature. Coral reefs in Southern Florida are declining from being inundated with excessively salty water as a consequence of the diversion of fresh water from the Everglades. Instead of flowing into Florida Bay, the water is being used for agriculture and to supply the growing population along the Florida coast.

Wetlands have been systematicly destroyed, with the blessing of the federal government, since the days of colonial America. In 1764, the Virginia Assembly chartered the Dismal Swamp Company (of which George Washington was a member) to drain 40,000 acres of the Great Dismal Swamp for logging. In the mid-1980s, the U.S. Congress allocated 65 million acres of wetlands for the states to sell to increase their revenues. Between 1940 and 1960, the U.S. Department of Agriculture subsidized the drainage of another 60 million acres of wetlands for agriculture.

Habitat destruction often goes hand in hand with tourism, and specifically the tourist market which brings in the most revenue. In 1994, for example, the governor of the state of Quintana Roo in Cozumel, Mexico, approved a proposal to build a cruise ship dock to cover Paradise Reef, a mile and a half of living reef and one of Cozumel's most popular and prolific dive sites. Even though local dive operators and other groups lobbied against the construction project (which was originally canceled after the President of Mexico was sent a petition with 5,000 signatures), government officials reversed their position and gave approval to build the pier because they believed tourism was more important than protecting the ecology.

The total impact of habitat destruction is sometimes underestimated. By zeroing in on the most obvious and immediate problems, we sometimes overlook the subtle but equally or more insidious ones. For example, one of the worst effects of logging, dredging, dumping, and mining operations is not the felling of trees or removal of minerals and coral, but the construction of dirt roads, camps, piers, and other infrastructures that support these enterprises (especially where the activity takes place on steep slopes), not to mention the energy used up and the waste generated by the construction crews and equipment.

Solutions to habitat degradation are by no means simple. Competition between humans and the environment is an extremely difficult dilemma, with economic and political, as well as scientific,

ramifications. In the U.S., for example, over half the population lives within fifty miles of the sea. Roughly two thirds of the world's people live along coastlines and rivers draining into coastal waters. And it is the coastal areas within 200 miles of land that contain the most productive ecosystems. These areas account for more than half the ocean's biological productivity and supply nearly all the world's catch of fish.

The destruction of wetland habitats is particularly harmful to the biosphere. Wetlands (bays, estuaries, mangroves, and marshes) which are spawning grounds for seventy-five percent of commercial seafood species, are routinely drained and bulldozed to make way for farmlands and industrial, municipal, and recreational development. Because of human activities, by the mid 1970s, the U.S. had lost 50% of all its wetlands, and it continues to lose another 371,000 acres each year.[2] Only nine percent of California's original 3.5 million acres of coastal wetlands remains today. Wetland destruction is financially as well as ecologically costly. The federal government estimates that ongoing wetland losses cost the nation's fisheries more than $200 million annually in reduced catches.

Pollution is also a widespread cause of habitat degradation. Coastal waters are heavily polluted throughout heavy urban areas from New York and New Jersey to California. Beyond the United States, contamination of coastal waters is highly evident in Japan, Brazil, the Baltic Sea, the North Sea, the Mediterranean, and elsewhere. Runoff from dredging, filling, and building associated with coastal development operations can affect water temperatures and salinity, and inundate the marine environment with organic and inorganic toxins and sediment, at the same time smothering the seagrasses which would normally filter out these harmful materials. Sediment promotes the growth algae blooms, including toxic "red tides." Dredged material may also contain PCBs, heavy metals, oil and grease, pesticides and pathogens which contaminate the food chain.

Human-induced alterations in habitats caused by the construction of dams and sea walls can also be highly destructive. Species such as salmon, for example, need cool river water, but dams allow the water to become warmer. Other, less useful species then dominate the water and prey upon small migrating salmon that must pass downstream through the reservoir. Modern engineering works, such as dams, are also responsible for a reduction of nutrient and sediment supplies which rivers carry to estuarine and coastal ecosystems, resulting in declining fish populations.

Diseased coral in the Florida Keys as a result of pollution.

Photo: Stephen Frink

Damage from Collisions

Marine habitats are damaged and destroyed by physical impacts. In particular, coral reefs are degraded by boat groundings and improper anchoring of boats. Large cruise ships head the list of offenders in this category, but commercial and recreational vessels of all sizes routinely contribute to the problem as well. As recently as August, 1994, a 170-foot research vessel owned by the University of Miami ran aground at Looe Key National Marine Sanctuary in Florida, reducing some of the coral reefs in the area to rubble. Scientists fear that the damaged corals may take years to regrow, if they regrow at all.

Anchors dropped directly on coral can annihilate innumerable living marine resources. As the anchor chain drags across a coral reef and is later retrieved, dozens of feet of coral can be slashed and crushed, destroying the coral outright, or leaving it defenseless against marauding bacteria and algae. Dragging anchor chains also stirs up clouds of silt which smother living coral polyps. (See Chapter 15 for correct anchoring techniques.)

On a much lesser scale, incidental damage to reefs can be caused by unwary or poorly trained divers and snorkelers. In a study done recently in Looe Key, Florida, it was observed that 26% of the divers and 61% of the snorkelers touched coral at least once in a 30 minute period. Five percent of the divers touched coral 20 times or more in 30 minutes.

Valuable wetlands being drained and bulldozed for agriculture.

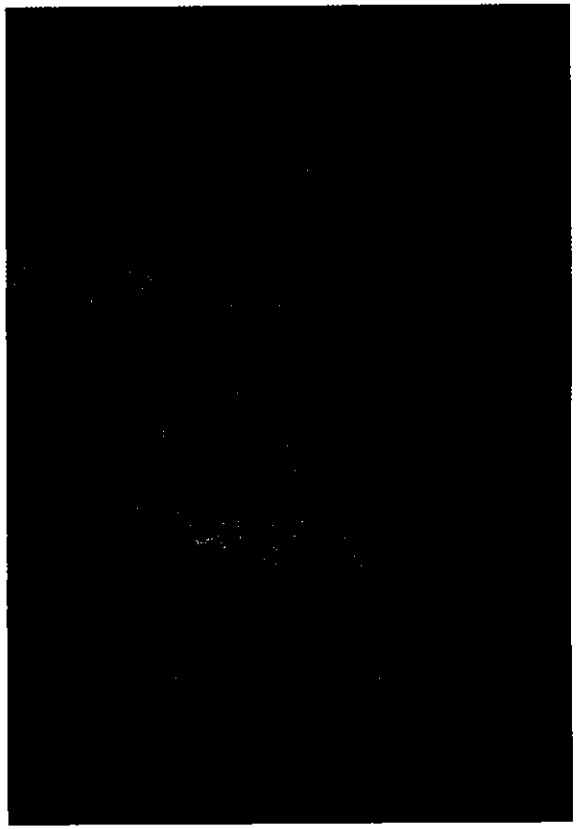


Photo: Raymond Gehrman

The ongoing groundings of commercial and recreational vessels in the Florida Keys, events which were damaging miles of valuable living coral reef, finally prompted legislators to designate the area a National Marine Sanctuary in 1992. However, successfully protecting an environment, even one which is under formal jurisdiction, requires ongoing funding, effective management, monitoring and research, and cooperation among resource managers and user groups.

Tourism and Recreation

Tourism, one of the largest and fastest growing industries in the world today, is a double-edged sword. In some small countries like Belize, for example, tourists outnumber the local population. On the one hand, tourism provides jobs and financial support in developing nations. Many small islands, such as the Turks and Caicos, derive the majority of their gross national product from tourism. On the downside, tourism puts pressure upon natural habitats and

may infringe upon local culture. Mass tourism began in the 1950s with the advent of widely available and affordable transportation. Many places that were once serene wildlife habitats, priceless historic monuments, and fragile ecosystems have become bustling holiday resorts, overrun by millions of travelers whose main concern is their own immediate pleasure.

Tropical marine and coastal settings, with balmy weather, picturesque scenery and facilities for water sports are prime tourist attractions. In Florida, reef tourism brings in approximately $1.6 billion a year, with over 2 million people a year visiting John Pennecamp Coral Reef State Park and Key Largo National Marine Sanctuary. Unfortunately, many of these tropical havens are extremely vulnerable to the effects of tourism and recreational activities. Bright lights, crowds, and collisions with boats, or their anchors and propellers, can harm and scare marine creatures. The intrusion of loud noises, such as from overhead aircraft, boats, water skis, and jet skis, has been shown to interfere with creatures who rely on acoustic sounds as their primary means of communication. Loud noise can also cause seabirds to abandon their eggs or chicks and cause marine mammals and fish to deviate from their normal behavior.

Traditionally, many marine areas have allowed tourists to feed fish and other wildlife. In fact, tour guides and divemasters are often tipped extra by their paying customers for luring fish into public view with Cheez Whiz, bread, eggs, and other artificial delicacies. This "food" disrupts the natural food chain and fish eating habits and can be detrimental to the fish's digestive system. Cutting up and feeding fish "natural" food items, such as sea urchins, is also a habit which should be discouraged because it removes integral links in the reef ecosystem. Feeding fish may also provoke aggressive behavior. There have been reported incidents of divers injured by fish that are conditioned to bite an open hand underwater, whether or not it contains food.

Because divers interface directly with the underwater environment, they are often blamed unfairly for environmental damage. Other than the very limited aforementioned study at Looe Key, we have almost no data to determine to what extent skin and scuba divers actually contribute negative effects.

We do know, however, that dive travel is increasing and that most divers travel to tropical reefs. According to *Skin Diver Magazine*'s Diver Survey, the average diver takes 3.7 trips and stays eight days per trip. The survey also reports that in the last three years, 66% of *Skin Diver Magazine* subscribers traveled outside the

continental U.S. on diving trips. Seventy-one percent of dive travelers went to the Caribbean, 51.7% to Mexico, 30% to the Bahamas, and 27% to Micronesia, the Red Sea, and the Great Barrier reef of Australia. Of those who dived in the U.S., 64.7% traveled to Florida. These numbers verify that divers are flocking to areas which are vulnerable to human impacts.

In addition to divers and snorkelers, participants in other recreations such as fishing, boating, water skiing, and jet skiing, frighten marine creatures from their habitats and alter nesting, feeding, and mating patterns. Large numbers of tourists can also result in additional marine debris, sewage pollution, and the removal of living marine resources for souvenirs. However, there is no data which can quantify the amount of damage caused by people vacationing and participating in recreational activities in these environments. Until research can show otherwise, therefore, we must assume that the recreation industry is not the source of major alterations and destruction in the marine environment. Nevertheless, the conservation ethic must be strongly promoted among recreational users. Proper education, training, and orientation at resort areas help prevent accidental damage.

Decline of Biodiversity

The earth contains between three and forty million species, but only 1.4 million of these species have been classified. We are presently on a course in which we are losing nature much faster than we can learn about it. The loss of biodiversity is a crucial concern in marine conservation and is a common theme throughout this book. The term BIODIVERSITY (biological diversity) refers to the diversity of life, and is often divided into three distinct categories:

1. genetic biodiversity (diversity within a species);
2. species biodiversity (diversity among species); and
3. ecosystem biodiversity (diversity among ecosystems).

All three areas of biodiversity are critical. One of the most immediate questions in environmental conservation today is, "How can we best resolve the complex problem of declining species populations and biodiversity before supplies become exhausted?" Scientists estimate that 36,500 species of plants and animals are becoming extinct every year, mostly because of human activities. If terrestrial as well as aquatic habitats continue to be altered and

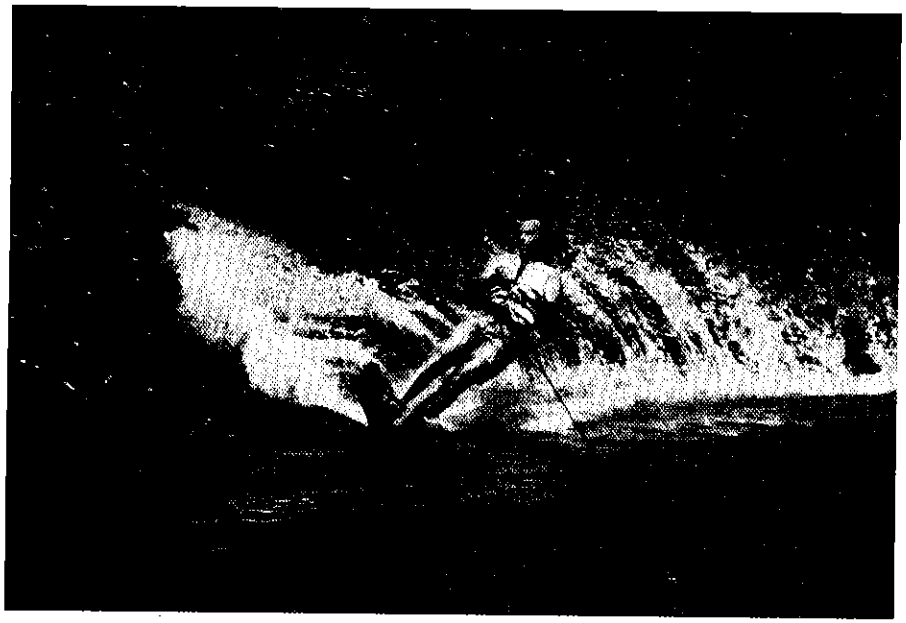


Photo: Reef Relief–

Loud noises disturb marine wildlife and disrupt their activities. Pictured: A waterskier disturbing a mangrove.

destroyed at the current rate, at least 500,000 and perhaps 1 million species will become extinct over the next twenty years.[3]

Until recently, however, most environmental attention has focused on the loss of biodiversity in terrestrial ecosystems, especially tropical rain forests. But scientists, economists and legislators, as well as industrial, commercial, and recreational entities, and concerned citizens, are beginning to realize that the threats to the living resources of our world's marine and coastal ecosystems are equally significant, and that loss of aquatic life can depreciate the entire biosphere. Scientists fear that the alarming decline in populations of fish, for example, may set off a chain of ecological disasters affecting not only the fish, but also the animals and humans that feed on fish, and the species on which the fish prey.

Additionally, as scientists continue to validate the ecological principle that earth is a biosphere, collaborative efforts are now underway to gain greater insight into the relationship between the biological, chemical, and physical nature of marine ecosystems. Scientists are starting to take a holistic approach to the problems of the marine environment, considering both the effects of natural disturbances and human interventions on marine communities and the effects of the changes in species populations on the entire ecosystem. As opposed to the traditional single-species focus, now

ecosystem-wide surveys are being conducted, such as one sponsored jointly by NOAA and the EPA. These surveys are providing important quantitative data on the key ecosystem components, including phytoplankton, zooplankton, nutrients, and hydrography.

The protection and preservation of biodiversity in habitats, from rain forests to coral reefs, is a global and compelling challenge. Whereas we still do not have a solution that is universal, at least there is increasing agreement that the *problem is universal* and that something must be done soon. If a solution is at all possible, therefore, it will have to be predicated on an unprecedented alliance among citizens, industry, and government.

Live Rock Harvesting and Fish Collecting

Since prehistoric times, shells and coral have been harvested from the sea for many purposes: decoration, jewelry, tools, even currency. The fascination with these items continues to grow. In coral reef communities throughout the world, thousands of tons of corals and shells, as well as fish for aquariums, are taken from the ocean by amateur and commercial collectors, resulting in a lucrative billion dollar a year trade.

The large aquarium trade is one of the markets that demands tropical marine animals and living reef rocks. Several hundred fresh water and marine species are currently collected, and most of the marine species are taken from reefs. The U.S. is the largest importer of tropical fish in the world, and it obtains about eighty percent of its supplies from the Philippines.

Since the aquarium trade does not pose an immediate danger of extinction to fish or invertebrates, it is not formally regulated. However, fish collecting should only be done by individuals trained in ecologically sound procedures. Poisons, such as sodium cyanide, used in the Philippines to extract fish from their habitat, should be condemned. This toxic chemical damages the liver, kidneys and reproductive organs of the fish (which die within weeks), and it indiscriminately kills corals and other reef inhabitants.

Fish collection may also exact a high death toll due to poor handling and transport. Amateurs who attempt to remove fish from the ocean can injure or kill them. Certain species, for example, must be brought to the surface extremely slowly, or their gas bladders will burst from the change in pressure. Some species should not be removed under any circumstances because they cannot survive outside the reef environment. Half of all butterfly fish, for example, die within two months after capture.

The removal of live coral for aquariums and jewelry is a widespread problem. About 250,000 pieces of live coral were imported into the U.S. in 1991 for the aquarium industry. Most commercially valuable precious coral, which is used for jewelry and statues, comes from the Mediterranean or from deep seamounts in the Pacific.

In many of these countries, the coral grounds are over-exploited, and restrictions on the taking of rare and endangered species are poorly enforced or non-existent. Historically, coral was harvested selectively by divers who would choose from coral colonies according to size and quality. Modern coral harvesting is much more destructive because it often involves non-selective dredging devices such as the "Italian Bar" and the "St. Andrew's Cross," which strip large tracts of the seabed along with its inhabitants.

The countries dealing most heavily in ornamental shells are Indonesia, the Philippines, India, Mexico, Haiti, and Kenya. Often countries which ban the removal of shells and coral from its own reefs, such as the U.S., allow these items to be imported from the Philippines for resale to local collectors. Mother-of-pearl, the thick iridescent layers found inside the shells of several mollusk species, has been prized by collectors for centuries. The best mother-of-pearl comes from reefs in the Indian and Pacific Oceans, and the main suppliers are Indonesia, the Philippines, Australia, the Solomon Islands, New Caledonia, and Papua New Guinea.

Although pressure from coral, shell, and aquarium fish collection are stressful to marine habitats, responsible regulation of these industries can decrease the damage as well as bolster the economy and provide jobs for local artisans in developing countries. In the Philippines, training courses have been set up to teach local collectors alternative and less invasive methods of catching aquarium fish. In some nations, shell collectors are beginning to work with governments to become more selective in what they remove and sell, avoiding endangered species. The CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) is observed in over a hundred countries. This law classifies species into two categories, Appendix I of the CITES deals with species which are most threatened and prohibited for trade, and Appendix II deals with species which are allowed to be traded, but are regulated and require documentation.

Another case study of conservation efforts can be seen in Fiji, where the Fisheries Division has issued a set of guidelines for the exploitation of reefs for use other than food harvesting. The guidelines require an exploratory survey before any new coral reef area is harvested. However, smuggling and long-standing exploitation practices still undermine these and other conservation efforts.

Decline and Depletion of Fish Populations

Ninety-six million metric tons of fishes, shellfish, and algae are taken out of the world's oceans every year by commercial and sport fishers. One hundred million metric tons is the limit of maximum sustainable yield advised by the United Nations Food and Agriculture Organization (FAO). SUSTAINABLE YIELD refers to the optimum annual catch that can be derived indefinitely from harvested species, without causing a stock failure. In addition to the fact that we are almost beyond that limit, almost thirty percent of the catch is never even used for human consumption. An enormous amount of fish is wasted because of poor fishing methods or because it is used in products other than food.

Of the nearly 20,000 known species of fish, about 9,000 are currently harvested, but only 22 species are regularly caught in significant quantities. Just six groups, herrings, cods, jacks, redfishes, mackerels, and tunas, account for nearly two thirds of the total annual catch. Studies by the National Fish and Wildlife Service (NFWS) indicate that 85% of the species currently fished in American waters are now overexploited. At least 14 species of oceangoing fish, including Atlantic salmon, yellowtail flounder, grouper, Spanish mackerel, bluefin tuna, swordfish, and Pacific perch, have been so seriously depleted that it could take them twenty years to recover, even if all fishing were to stop tomorrow.

Dwindling fish supplies present immediate and long-term problems having scientific, political, and economic repercussions. Over half the population of developing nations depends on fish as its primary source of dietary protein. In highly industrialized countries, as well as in developing nations, fishing contributes significantly to economic stability. In the U.S. alone, where one third of the population fishes recreationally, it has been estimated that the indirect and direct impact of just recreational fisheries (not including commercial fishing) adds up to about $50 billion a year and generates 600,000 full-time jobs.

Part of the problem can be attributed to natural causes such as oceanic and weather fluctuations like El Nino-warmed waters which result in reduced food supplies. But experts feel that the most detrimental toll is imposed by human activities–man-made pollution, coastal construction, and excessive and abusive fishing practices.

Many researchers feel that the primary reason that fish populations are declining is that too many people are taking too many fish too quickly. Unlike terrestrial wildlife preserves and parks, living marine resources have historically been free to the public, with little

Bycatch is a serious problem. Pictured: A live loggerhead turtle captured by accident in a fishing net.

–Photo: Mike Weber/CMC

or no restrictions over those who might abuse and exploit these resources. Many countries of the world, particularly those desperate for food and economic survival, employ wanton and wasteful fishing practices, such as ghost fishing, dynamiting coral reefs, and the use of poisons to extract fish from their habitats. These methods cause chronic damage to entire marine ecosystems.

In industrialized countries, sophisticated fishing devices, such as computers, radar, electronic depth finders, spotter planes, and helicopters, allow commercial fishing boats to locate large schools of fish with speed and accuracy. Another modern invention, immense gill nets (some are 40 miles long and 300 to 500 feet deep) sweep everything in their path, including turtles, dolphins, sharks, and sailfish.

TRAWLS, nets with a wide mouth tapering to a small, pointed end, are towed behind a vessel at any depth in the water column. Gillnets have been outlawed in many countries of the world

because of their huge bycatch, in which species other than the target species, and juveniles, are incidentally trapped and wasted. The magnitude of the bycatch problem can be seen in shrimp trawling in the U.S. Gulf of Mexico shrimp fishery, where trawl mesh is so small that for every pound of shrimp taken, an average of ten pounds of bycatch is caught as well.

It is also important to understand that biotic impoverishment goes beyond the loss of individual species. Fish are a keystone, or critical link, in the food chain of a marine ecosystem. Excessive removals of fish can have dramatic effects which reach up the food chain to marine mammals and cascade down to plankton. So, although there are still habitats that contain few or no endangered fish species, they may contain so few representatives of each species present that the functioning of an entire ecosystem can be impaired.

There is yet another problem confronting fish populations, one which is not as well understood, but is equally serious, the alteration of the gene pool in fish species. By selectively fishing out the larger, more desirable members of certain species, we may create inferior breeds, dominated by younger, smaller fish which mature and reproduce earlier and with fewer offspring, and have a shorter life span. We may also unwittingly replace commercially prized species with commercially useless species possessing superior survival adaptability.

The decline and depletion of fish populations is a dramatic example of what the American ecologist Garrett Hardin referred to as THE TRAGEDY OF THE COMMONS, the irresponsible plundering of a public resource by individuals interested only in short-term financial profit.