MODULE 1

THE MARINE AND COASTAL ENVIRONMENTAL SETTING

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OBJECTIVES:

- To give an overview of the Caribbean marine and coastal environment.
- To help develop basic understanding of the intricate linkages between various marine ecosystems in the Caribbean.

OVERVIEW:

- The Caribbean image of beautiful islands, of blue seas is dependant on its coastal and marine environment.
- High population densities coupled with limited land resources put demands and stress on the natural resources after exceeding their capacities.
- These issues pose threats to the same coastal and marine natural resources on which the important economic activities such as tourism are based.

THE CARIBBEAN'S DILEMMA

The public relations image of the Caribbean, especially for tourism purposes, is one that emphasizes islands strung like green jewels across an azure sea, bathed in sunlight and home to a beautiful, talented and contented people. The reality of course is more complex. Our environment, natural and built, comprises our land, water, air, energy and the natural resources which these support, as well as the communal infrastructure for living, playing and working. The Caribbean comprises a land area of mostly mountainous islands, with relatively shallow marine banks. The Caribbean Basin in total extent is large, but the chain of islands takes up a mere 5 % of the Basin's five million square kilometres. Most notable is that these islands are home to almost 30 million people, on average 155 persons per square kilometer. A region with this kind of population density must be considered crowded.

Land resources determine the extent to which many of the socio-economic activities in the Caribbean can be developed. The land resources of the island States are generally limited. Populations are relatively large, and as mentioned before there are high population densities. Hence stresses on the resources are high, with the possibility of their capacities being exceeded.

The situation in the continental countries contrasts dramatically, as land space is abundant and population densities are comparatively low. Hence these countries have relatively large terrestrial resources to accommodate population growth.

In Caribbean countries, especially island States, the capital city is the focus of economic and service activities. There are usually a few additional important centers where populations are concentrated. In many instances there is also development in the suburban periphery and continuous linear patterns of settlement, especially along the coast. The remainder of the population is found in towns, villages and tenantries of varying size.

In most of the countries there is uneven distribution of inhabitants. There is a tendency for the population to be concentrated on the coastal belt because of the need to be close to port facilities, fishing grounds, manufacturing and tourism activities.

THE MARINE ENVIRONMENT

Some of the most productive and biologically complex ecosystems in the world are found within the Caribbean coastal zone. These include coral reefs, seagrass beds, mangrove forests and coastal lagoons. The economic importance of these systems stems primarily from their linkages to other resources, especially fisheries and coastal tourism, which is the economic mainstay of a majority of the islands. These linkages are often ignored or discounted when considering the monetary value of coastal land for commercial development. The reality is that much of this value is directly related to nearshore marine habitat.

Let's look in more detail at some of these systems.

(a) Coral Reefs

There are approximately sixty species of corals in the Caribbean including about six dominant species that are the primary reef builders. Corals are animals, having a thin layer tissue covering a skeleton of calcium carbonate secreted by the animal tissue during growth. Individual corals grow at rates ranging from 1-30 centimeters (0.394" - 11.811") per year.

Coral reefs, consisting of the consolidated skeletons of corals, accumulate rapidly in geological time. Caribbean coral reefs represent about 10,000 years of coral growth.

Coral reefs are one of our most important coastal resources. They are the basis of many coastal fisheries providing food, shelter and nursery areas for commercially valuable fishes and other species e.g. lobsters. A single reef may contain 3000 species of corals, fish and shellfish. Nearly one third of all fish species live on reefs, while others are dependent on reefs and seagrass beds at various stages in their life cycles.

Reefs form breakwaters which protect harbours and bays, and limit coastal erosion. Coral skeletons are also the principal source of sand and gravel resources. The beaches and visual attractions provided by coral reefs are the focus of much of the tourism in the region. Some of these activities include snorkeling, glass bottom boats and SCUBA diving. More than half of the gross national product (GNP) of the Bahamas comes from people holidaying on its coasts.[1]

Coral reefs require clear clean water and relatively high wave energy to grow and flourish. They do not grow well where they are directly exposed to sun or rain for long periods, or where the water is too salty or muddy.

There are three main groups of coral reefs:

Fringing reefs

These are found close to the shores of land masses where the water is shallow and has two distinct areas. The front area on the ocean side is called the "reef front". The "reef flat" extends all the way to the shore.

Barrier reefs

Barrier reefs are similar to fringing reefs, having both reef front and reef flat, but are formed much farther from shore.

In the region: the Bahamas, Cuba, the Lesser Antilles and Belize are listed as being some of the countries with the world's greatest length of coral reefs.

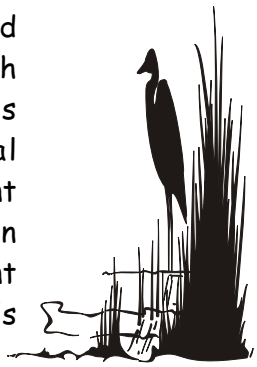
Atolls

Atolls are actually very small islands of coral located in the middle of the ocean. The reef forms a circle, the center of which is a deep lagoon.

(b) Seagrass Beds

Large meadows of seagrasses occur in close association with coral reefs in the Caribbean. Seagrasses are true flowering plants with male and female flowers and seeds borne in fruits, yet the most common form of reproduction is asexual via a rhizome or horizontal root. Seagrasses are very productive. Massive amounts of plant material are consumed directly by grazers (e.g. fishes, turtles, sea urchins), which feed on the plants, or by being channeled into a community of small organisms and bacteria living among the beds and feeding on the plant debris.

The seagrasses covering the bottom of coastal bays trap fine sediments and stabilize the bottom with interwoven rhizomes (underground horizontal roots) beneath the sediment surface. Sediment retention and stabilization is important for adjacent coral reefs



because it prevents abrasion or burial of these reefs during storm conditions. However, their ability to trap sediments also means that they are particularly vulnerable to pollution.

Seagrass blades provide surfaces upon which many organisms attach including a wide variety of algae. These may produce sediment or provide food for grazing organisms. Seagrasses serve as nurseries for juveniles of commercially important species e.g. snappers, grunts and lobsters.

(c) Mangroves

Mangrove forests are a coastal feature of tropical and subtropical regions. These trees develop in low lying coastal areas where freshwater is supplied by rivers or terrestrial runoff. Their prop roots provide a surface for the attachment of marine organisms and reduce tidal and wave energy, thus promoting the deposition of nutrient rich mud and silt. Mangroves provide habitat and shelter for a variety of animals such as small fishes, crabs and birds. By breaking storm waves and dampening tidal currents, mangroves help to maintain the coastline against erosion, and may actually extend coastal lands by trapping and binding sediments. As a result, sediment loads into coastal waters are reduced, and normally there is little if any, resuspension of sediment through shoreline erosion. Decomposed leaves of the mangroves form the base of a food web that extends to large fishes and birds.

In the Caribbean Region, Cuba, Belize and Guyana are listed as having some of the world's largest areas of mangrove forest.

(d) Coastal Lagoons and Salinas

Coastal areas of the Caribbean near major watersheds often contain huge lagoons of fresh or brackish water that provide important sources of organic material and nutrients as well as feeding nesting and nursery areas for various birds and fishes. Large coastal lagoons are most prominent along the mainland and are often the breeding grounds for nearshore shrimp fisheries. Coastal lagoons are buffers controlling terrestrial runoff and providing natural settling basins for suspended sediments.

Salinas, shallow ponds and lakes with limited or only tidal contact with the sea, are characteristic of many dry Caribbean islands. Traditionally, salinas have been used as salt evaporators and are targeted for mariculture or marina construction in more recent development schemes. These ponds also function as sediment traps, and are important to the protection of nearby coral reefs from excessive sediment loading.

To summarise, there are important linkages between these ecosystems. Seagrass beds provide significant energy inputs to the reef systems by serving as feeding grounds for adult reef fishes. Mangroves and seagrass beds also serve important functions in protecting coral reefs by filtering out sediments from land run-off, and reefs in turn protect mangroves, grass beds and beaches from destructive effects of storm-driven waves. In the Caribbean all three of these areas are considered to be under threat.

MODULE 2

SOURCES OF POTENTIAL MARINE POLLUTANTS AND THEIR EFFECTS

SOURCES OF POTENTIAL MARINE POLLUTANTS AND THEIR EFFECTS

OBJECTIVES:

- To identify and define sources of marine pollution in the Caribbean.
- To examine the impacts of marine pollution.
- To examine specific tourism activities contributing to marine pollution and to offer solutions.

OVERVIEW :

- Marine pollution is known as the introduction of substances into the marine environment which has a negative impact on the natural resources, human health and the economies.
- Control and reduction of marine pollution is essential to the well- being of coastal and island dwellers.
- Marine pollution is the result of land-based human activities (coastal or in-land) contributed through point or non-point source categories.

DEFINING MARINE POLLUTION

Marine pollution - we see its consequences in our everyday life. Sometimes you see it in the form of litter and oily substances on the beach or on the surface of the water. Sometimes it sits silently on the seabed in the form of organic and/or inorganic toxins, waiting to become part of the food chain.

What is marine pollution, and why is the control of this pollution so essential to the livelihoods of Caribbean countries?

For close to thirty years, most academics studying the phenomena of marine pollution have adhered to a definition by a United Nations body, the group of experts on the Scientific Aspects of Marine Protection (GESAMP), who define it as the... **"Introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazard to human health, hindrance to marine activities including fishing, impairment of the quality for use of seawater, and reduction of amenities".**

The definition has two important qualities:

First, it is action oriented. Marine pollution is conceptualized as a human activity, thereby omitting all natural activities that could potentially have damaging effects on marine ecosystems. So, for example, earthquakes and volcanic eruptions that emanate from the ocean floor and subsequently damage or change already existing ecosystems would not be considered pollution. However, they could be a potential source of chemicals and substances that because of their nature are classified as pollutants.

Second, the definition is amenable to measurement. Marine pollution is not a hazy, undefined concept. It is very real! It is harmful, and its danger can be identified in a number of ways. Scientists can readily identify various toxic substances found in the marine environment, measure their quantities, and provide estimates of their potential danger to human and marine life.

SIGNIFICANCE OF MARINE POLLUTION

The health, well-being and, in some cases, the very survival of coastal populations depend on the health of coastal ecosystems

The bulk of the world's population lives in coastal areas, and the trend is towards even further concentration in these regions. It has been estimated that the population of coastal dwellers in the Wider Caribbean region will reach between 60 to 65 million persons by the year 2000. The health, well-being and, in some cases, the very survival of coastal populations depend on the health of coastal ecosystems – estuaries, wetlands, associated watersheds, drainage basins, and near shore waters. Ultimately, sustainable human activity in coastal areas depends directly upon a healthy marine environment.

The situation is accentuated in small island Caribbean states where all land-based activities eventually impact on the nearshore marine environment. **Two of the more important socio-economic activities in the region - fisheries and tourism - rely heavily on this environment.**

SOURCES OF MARINE POLLUTION

The major threats to the health and productivity of the marine environment result from human activities on land – both in coastal areas and further inland. Most of the oceanic pollution (more than 75%), including municipal, industrial and agricultural wastes and run-off, as well as deposits from the atmosphere, comes from land-based activities and affects the most productive areas of the marine environment – estuaries and coastal waters. Moreover, contaminants which pose various risks to human health and living resources are transported long distances by various water courses (rivers, streams, canals), ocean currents and atmospheric processes.

Possibly the easiest way to organize one's thinking about marine pollution is to consider it in terms of its source. Although there are many sources of pollution, they are usually divided into two broad source categories:

Point Sources and Non-Point Sources

Point Source Pollution

Point source pollution comes from easily identifiable sources such as pipelines that enter drainage ditches, bays and other bodies of water. It also refers to the intentional release of wastes to marine waters by direct dumping. The major wastes are:

1. Municipal Sewage
2. Dredged Material
3. Industrial Waste

Non-point Source Pollution

This originates from sources that are not so easily identified and are more diffuse in nature. They include:

1. Run-off from
   - cities,
   - industrial sites,
   - agricultural areas, and
   - construction sites.
2. Direct Precipitation.
3. Atmospheric deposition.
4. Underground leaching and seepage.
5. Septic tank systems and sewer overflows.

The major sources of coastal and marine pollution originating from land-based sources vary from country to country, depending on the nature and intensity of specific development activities. Activities related to human settlements, agriculture and industry are the major contributors to the pollutant loads reaching the marine environment.

In order to mitigate and control the impact of pollution originating from land-based sources on coastal marine resources, it is essential that the type and levels of pollutants be identified. This process involves the determination of the sources, localization of the discharges, volume of wastes, concentration of potential pollutants etc.

Pollution of the marine environment results in the input of several classes of contaminants, which vary in toxicity and in their impact on marine and human life. These include:

1. Suspended Solids
2. Pathogens
3. Nutrients

4. Oxygen demanding substances
5. Organic compounds of synthetic and natural origin
6. Heavy metals

From a management perspective it is often easier to identify a specific waste category which may be characterized by one or more contaminants. These include sewage, petroleum hydrocarbons (oil), sediments (suspended solids), agrochemicals (pesticides and fertilizers), solid waste (litter), and industrial (toxic) wastes.

The fate of pollutants in the marine environment and the susceptibility of organisms to them are influenced by the characteristics and composition of the waste, characteristics of discharge site and receiving marine environment and the nature of the organisms concerned. The chemical nature, concentration, toxicity and persistence of individual waste constituents need to be considered. Pollutants are dispersed and diluted by physical processes that transport and mix water. The type, form and amount of waste as well as its discharge characteristics will all influence the dispersal and dilution process. These processes also vary greatly in relation to a water body's degree of enclosure, current, volume and depth. Chemical processes (such as absorption onto sediment), physical features (such as salinity gradients) and biological processes (such as bioaccumulation) all tend to affect the concentration of pollutants after disposal.

IMPACTS OF MARINE POLLUTION

Pollutants effect significant influence on the quality of marine water bodies. In general the major impacts relate to:

Pollutants effect significant influence on the quality of marine water bodies

- Habitat degradation and loss.
- Degraded water and sediment quality.
- Human health risks.
- Wildlife impacts and loss of biodiversity.
- Social and economic impact.

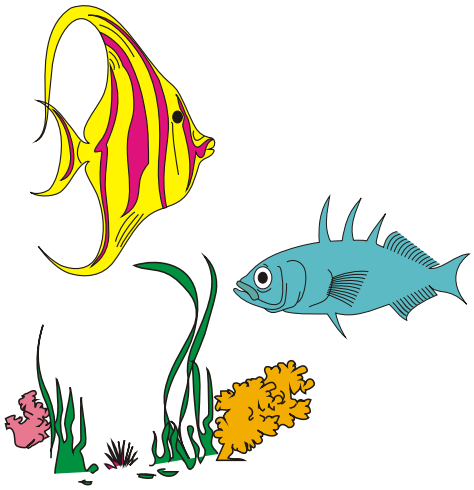
Marine plants and animals of the tropics tend to be more sensitive to certain pollutants than marine life in colder areas. Pollution tends to affect individual organisms by producing lethal effects or structural abnormalities. On a community level, it tends to reduce species diversity and adversely affects food chains or webs. We will now examine some of the individual contaminants, their sources and potential impacts.

SEDIMENTS (SUSPENDED SOLIDS)

Sources

Sediments or suspended solids are eroded soil that is deposited in streams, rivers, drainage ways, estuaries and bays. Several human land-use activities result in soil loss through erosion. The subsequent increase in storm water run-off of solid material results in increased turbidity or suspended solid levels in the coastal environment. Such activities include agriculture and grazing, coastal engineering works, housing and road construction, mineral extraction, deforestation, and beach sand mining. In fact, much of the waste effluent discharged into the marine environment whether it be sewage or industrial has some form of suspended material. An additional source of suspended materials is the practice of waste disposal at sea (ocean dumping).

Effects



Marine water quality is degraded by sediment because the introduction of suspended solids can increase turbidity and block out sunlight. This in turn can reduce the rate of photosynthesis and harm submerged vegetation. Solid particles can settle out of the water column and accumulate on the bottom, which can change the nature of the sediments and associated benthic communities.

In addition, these particles can physically smother and kill many sensitive near-shore coastal habitats such as mangrove stands, seagrass beds and coral reefs. The particles can clog fish gills and filter systems in filter-feeding animals and reduce prey capture for sight feeding predators. Sediments often provide a natural sink for a number of other pollutants such as nutrients, trace metals, organic chemicals and pathogens. These chemicals exacerbate the physical effects of sediment deposition on near-shore habitats, and may lead to the destruction of spawning grounds for important food species in estuarine and marine ecosystems.

Sediment also has direct economic consequences when it reduces recreational use of waters and increases the operating costs of water-treatment facilities.

SEWAGE

Sources

Sewage, also called wastewater has been identified as one of the most significant pollutants affecting the marine environment in the Caribbean. It often contains harmful chemicals, nutrients, pathogens (disease-causing bacteria) and viruses in addition to dissolved material and bits of solid matter such as human waste and garbage. It is estimated that approximately 80% of sewage waste is discharged untreated into the Caribbean Sea (UNEP, 1974). Storm water run-off also contributes to the total composition of sewage with faeces of other mammals and bacteria found naturally in the soil.

Municipal wastewater comes from a variety of sources including households, schools, offices, hospitals, hotels, and commercial and industrial facilities. It enters the marine environment either through pipeline discharges (point sources) or is carried from upstream sources via river systems (non-point sources). In other locations, run-off from streets, parking lots, roofs, lawns, commercial and industrial developments, and construction sites is combined with municipal wastewater through common collection systems. Such run-off may also contain toxic chemical contaminants.

Effects

Wastewater contaminants include the following substances: nutrients, pathogens, organic chemicals, metals, solids, oil and grease, plastics, and floatables. This section will be confined to reviewing the effects of pathogens and viruses as the impacts of organic and inorganic contaminants is covered in subsequent sections. The primary source of microbiological contaminants is from the

discharge of inadequately or untreated sewage and wastewater.

The viability of pathogens depends primarily on their survival after entering the marine environment. Many die quickly after exposure due to various environmental factors (e.g. light). However some can persist especially if absorbed onto suspended matter that provides protection from the surrounding environment.

The major impact of pathogens is on human health. Exposure can occur in two ways:

- Direct: from contact with contaminated coastal waters.
- Indirect: from consumption of contaminated sea-food, particularly shell fish which filter water to obtain food and in the process can ingest and accumulate pathogens to levels where they pose a serious human health risk if consumed.

Some of the more common diseases associated with bathing in contaminated recreational waters or through consumption of contaminated sea food are swimmer's itch, gastroenteritis, dermatitis, viral hepatitis, wound infections, cholera, typhoid fever, bilharzia and dysentery.

NUTRIENTS

Sources

Nutrients such as nitrogen and phosphorus are essential for the proper growth and reproduction of individual organisms and for the general productivity of marine environments. They also represent a potentially damaging pollutant arising primarily from run-off of commercial agricultural fertilizers, animal manure, and from sewage discharge. This sewage discharge may occur from sewage treatment plants or from faulty septic tank systems. Nutrient input may also occur from industrial and urban sources, from the use of commercial detergents, and from the transport of vehicle emissions.

Poor land use practices, including deforestation, urbanization and inappropriate agriculture, can cause soil erosion and increased levels of nutrient flows with the increased level of sediment run off.

The major areas affected by nutrient enhancement are coastal and upstream areas with high population densities.

Effects

The major areas affected by nutrient enhancement are coastal and upstream areas with high population densities. The increase in nutrient levels in a body of water or 'nutrient enrichment' is known as eutrophication. Up to a limit, this can provide beneficial effects by increasing the productivity of marine organisms especially algae or phytoplankton, which leads to corresponding, increases in fish populations in areas where nutrients are lacking.

However if nutrient levels are too high, several adverse impacts can occur.

1. Increased turbidity or cloudiness of the water caused by excessive algae growth blocks sunlight from penetrating the water and submerged vegetation, corals, die from lack of light.
2. Changes in the distribution, abundance and diversity of species, which may have a direct impact on fisheries. Decreased biological diversity is often apparent.

3. Subsequent changes in food chain relationships and the aquatic community structure (also due to increased algae growth).
4. Excessive oxygen depletion when large numbers of algae die and are decomposed by microorganisms. This oxygen depletion can in turn result in extensive fish kills and stunted growth of other marine life.

Some algae can produce toxins which eventually enter the food chain.

OXYGEN DEMANDING SUBSTANCES

Minimum levels of oxygen are critical for maintenance of most life forms. Oxygen levels in water and sediments can decline as a result of several processes.

1. Decomposition or transformation of organic material by microorganisms.
2. Chemical processes which occur independently of microbiological breakdown.
3. Nutrient enrichment.

Waste which has a very high organic content such as solid waste, sewage or effluent from rum-distilleries, food processing plants tend to have a very high BOD (Biological Oxygen Demand) which represents the amount of oxygen required by micro-organisms to break down the waste into compounds such as CO_2, H_2O, and Nitrates. This then results in a reduction in the amount of available dissolved oxygen for respiration by marine organisms. This puts organisms under stress, affecting growth and reproduction, and in severe cases of oxygen depletion resulting in massive fish kills.

ORGANIC CHEMICALS

Chemical pollutants represent a large and varied group of toxic substances. Adverse effects caused by them depend on the interaction of many chemical and biological factors. Some of the more important of these will be discussed in further detail but a few general observations are common to them all.

Only some toxic pollutants are bioavailable to organisms, that is, present in a form to which organisms can actually be exposed. If a pollutant is bioavailable the effects of exposure will vary depending on its concentration, length of exposure and stage in the organism's life cycle. Two important processes determine the ability of many organic chemicals and metals to cause adverse impacts on marine organisms or humans:

Bioaccumulation and Biomagnification

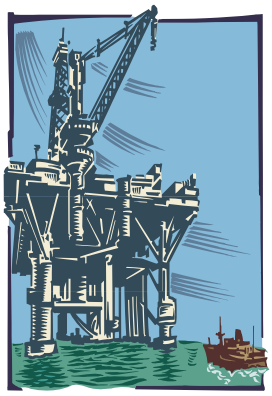
Bioaccumulation is the process whereby a substance enters aquatic organisms, either from the water or from consumed food and is stored within the organism's tissues. Biomagnification refers to increases in the concentration of bioaccumulated substances in the tissues of consumers and predators occupying successive levels of a food chain.

The likelihood of adverse impacts on organisms such as invertebrates, fish or humans is increased if toxic pollutants biomagnify in a food chain. The effects might be immediate as in the case of acute poisoning or may be long term as in development of various cancers. Three of the major sources of organic chemical pollutants are petroleum hydrocarbons (oil), agrochemicals including pesticides, and solid waste.

PETROLEUM HYDROCARBONS

Sources

1. Terrestrial: coastal refineries and storage facilities; Urban, industrial and agricultural run-off; sewage discharge; transport; disposal of used lubricating oils.



2. Atmospheric: Precipitation.
3. Marine: natural seeps; tanker operation and transport; dry-docking; bilge discharge; tanker and non-tanker accidents; oil exploration and exploitation oil terminal operation and off-shore production.

Effects

1. Tar on many beaches that either prevents recreational use or requires extensive clean up operations.
2. Distress and death to marine organisms such as endangered turtles that feed on floating tar.
3. Declines in reproductive success of marine organisms.
4. Taints seafood and contaminates water supplies.

Impacts tend to be regional for the more volatile components of oil, and localized for the more resistant components. The biological effects of marine oil pollution as with other chemical toxic substances is extremely varied and depend on the organisms involved, nature and severity of the oil input and environmental factors. Biological responses may range from immediate mortalities due to smothering and acute toxic effects to long-term and sublethal alterations in physiology, fecundity and community structure. Effects are particularly severe in shallow water and at the air-sea interface and intertidal zone.

Coral reefs and mangroves are two important ecosystems, which are markedly affected by petroleum pollution. Mangroves provide food for growth of young fish, crustaceans etc. while also assisting in the stabilizing of sediments and preventing beach erosion. Coral reefs provide refuge for fish, other animals and seaweeds; protect islands from erosion; make natural harbours; provide materials for construction and handicraft; and often form the basis for tourism and recreational activities.

AGROCHEMICALS (PESTICIDES)

Sources

With rapid residential, agricultural and industrial growth, leaching of pesticides from agricultural land, poor disposal practices and deliberate or accidental dumping into river systems which eventually drain into the sea have all lead to increases in the levels of toxic pesticides reaching the marine environment.

Effects

The impacts of pesticides on marine organisms and ecosystems vary widely from acute and lethal to minor based on their chemical properties and behaviour in the environment. The most obvious impact is from discharge of large quantities of toxic pesticides, which result in acute toxicological effects as seen in massive and immediate kills of marine organisms, in particular fish. The other effect relates to particular groups of pesticides such as organochlorines and polychlorobiphenyls (PCB's) of which DDT is the most famous example. These are extremely persistent and tend to increase in concentration as they are transferred up the food chains, i.e. biomagnify.

Marine birds and mammals including man are particularly susceptible through consumption of contaminated seafood.

Some degree of reproductive impairments has also been observed in mammals/birds studied. Pesticides being used commonly now - organophosphates and carbamates in addition to herbicides such as gramoxone although being less persistent and not being able to biomagnify are acutely toxic and can quickly kill fish and other marine life.

The majority of pesticides - (Organochlorines, PCB's) which pose long-term threats are those which strongly associate with organic matter and sediments thus being readily available to marine organisms. They are very resistant to degradation and because of their high toxicity, high bioaccumulation potential and carcinogenic properties are of major health significance. Pesticides that are toxic, persistent and have some means of reaching humans pose the most serious risks. The consumption of contaminanted seafood is the primary pathway for human exposure to pesticides discharged into the marine environment.

Solid Waste (Litter or Marine Debris)

Sources

Marine debris, also called litter has become a significant problem along shorelines, in coastal waters, estuaries and oceans. Much of this debris consists of persistent synthetic materials such as plastics, which are non-biodegradable and tend to persist in the environment. It has been reported that as much as 80% of marine debris comes from land-based activities. These debris sources include inadequately treated municipal discharges, storm-water discharges, run-off, coastal recreational activities, and inadequate solid waste storage, transport and disposal.

Marine animals die each year by ingesting or becoming entangled with plastic debris. Although the actual plastic may not be toxic, it is indigestible and interferes with feeding and digestion.

Effects

Litter is more than an aesthetic problem in the marine environment. It harms marine life, poses risks to vessels and threatens human health and safety as well as resulting in economic losses.

Marine debris also endangers the safety and livelihood of fishermen and recreational boaters where nets and fishing lines can obstruct propellers and plastic sheeting and

bags block cooling intakes. When deposited on beaches it results in costly clean up efforts and may significantly affect tourist revenue by discouraging beach usage. Beach users can also be injured when they step on broken glass, cans, needles or other litter.

TOXIC METALS

Sources

Most metals that enter the marine environment are naturally occurring and are leached from groundwater or enter surface water as run-off, which is then transported downstream to coastal waters. Toxic metals, for example arsenic, copper, lead, and mercury arise primarily from various point industrial sources such as present or former mining activities, power production, smelting, underground piping and non-point sources such as run-off from pesticide applications, combustion by-products, roadway traffic, and leaching from solid waste dumps. These enter rivers and the marine environment directly or are transported into the atmosphere where they eventually settle into the oceans. Municipal wastewater may also contain trace metals from plumbing systems or from disposal of wastes into sewer systems.

Effects

Metals are chemical elements and as such cannot be destroyed or broken down through treatment or environmental degradation. However, a number of environmental processes can alter the mobility and bioavailability of metals. Regardless of their origin, metals can be toxic under certain conditions to marine organisms and humans. The ability of a metal to affect marine organisms depends primarily on its form (e.g. dissolved or particulate, bound to another substrate or free). Microorganisms in sediments can modify the form of some metals e.g. bacteria convert slightly toxic inorganic mercury to highly toxic and volatile methyl mercury.

Organisms, especially during the early life stages, are sensitive to trace metals and often exhibit high mortality rates. Impaired reproduction in birds and mammals has also been associated with elevated tissue metal levels.

The major concern with respect to discharge of toxic metals in the marine environment is the impact on human health. Four metals are of primary concern: arsenic, cadmium, lead and mercury, because of their known toxicity to humans and their relatively high concentrations in industrial/solid waste. The consumption of contaminated seafood is the major route of human exposure to metals. Toxic metals are capable of inducing a variety of human health effects -lethal and sub lethal, acute and chronic.

OTHERS

The release of heated wastewater can be most stressful to tropical marine life. Tropical marine organisms live at temperatures that are already close to their upper thermal limit. An increase in only a few degrees can be fatal.

THE TOURISM SECTOR AND MARINE POLLUTION

Uncontrolled coastal development poses a number of potential problems.

Increases in population and economic activity in coastal areas is leading to an expansion in urban development along the coast. This includes the construction of tourism facilities, ports, marinas, and coastal protection schemes. This is resulting in significant changes in coral reefs, shorelines, beachfront and the seafloor. Important habitats are being destroyed resulting in long lasting negative impacts on the marine environment.

During the construction phase, clearing of vegetation and grading of land exposes soils to erosion, resulting in increased sedimentation.

Once the land is cleared and buildings are constructed, impervious services such as parking lots and roads cover land that once absorbed pollutants. Impervious surfaces increase rates and volumes of stormwater run-off that may contain several pollutants that reach and contaminate marine waters. Indiscriminate clearing of mangrove forests and destruction of wetlands in the interest of coastal development is significantly impacting on the very resource on which we depend for tourism.

Urban development also results in heavy demands on sewage and solid waste treatment and disposal systems. When septic tanks are located in coastal areas with poor soils, high water tables, or low elevation susceptible to frequent flooding, sewage may be released into surface or ground waters.

Several water and land-based tourism activities generate pollutants that enter the marine environment. Apart from the sewage and solid waste, there is increased potential for oil and heavy metal pollution from the development of the yachting and boating sectors. The use of antifouling paints that contain heavy metals is a serious concern. Tributyl tin is a very highly toxic component of some antifouling paints and although efforts are ongoing to promote the use of less toxic paints, these alternatives are not widely used.

Integrated management programmes are necessary to reduce the problems caused by uncontrolled coastal development. For commercial and recreational establishments situated along the coastline – hotels, guest houses and restaurants - improved solid and wastewater disposal practices, improved landscaping, use of natural pesticides and organic fertilizers, use of non-phosphate detergents in laundries, installation of oil and grease traps in kitchens, promotion of waste minimization and other pollutant reduction strategies, improved maintenance and operation of treatment facilities are just some measures that could be employed. There is a need to highlight the relationships between coastal activities, non-point source pollution and marine degradation. The tourism sector has a key role to play in this education process.

SOLUTIONS

In providing 'solutions' to the issues surrounding the management of coastal resources, two approaches are discussed below. Firstly, non-structutral control - utilising a front end approach, focussing on instituting environmental policies on protection of marine resources through prevention. And secondly, structural control - which involves the construction of structures geared at reducing environmental damage.

Non-structural control focusing on Prevention and Protection

- Watershed management and planning:
  - (a) long-term land use planning
  - (b) siting and development policy and criteria
  - (c) monitoring and long term maintenance
  - (d) erosion and sediment control plans and policies
- Zoning
- Integrated Management Programmes
- Creation of protected habitat areas
- Buffers and setbacks
- Interception and diversion of selected contaminants
- Pre-treatment/removal of selected contaminants
- Establishment of appropriate criteria, guidelines and standards
- Clustering and preservation of open space
- Minimize exposure of bare soil
- Decrease the surface of impermeable areas – roads etc.
- Prevent development on steep slopes
- Improved storage, transport and disposal services
- Construction of appropriate systems and the improved inspection, operation and maintenance of existing systems – e.g. package sewage treatment plants
- Retrofit plans
- Public awareness and education
- Mechanism for testing and evaluation of systems and procedures
- Development of alternative technologies and products (unleaded gasoline for example may reduce the input of lead into the environment)
- Use of environmental audits, environmental impact assessments and modelling tools to aid in more informed decision-making.

Structural Controls

- Ponds
- Infiltration
- Constructed wetlands
- Instream/coastal controls, e.g. gabion baskets/rocks

Erosion and Sediment Control

- Diversions
- Stabilization
- Silt fences
- Sediment traps

MODULE 3

SAVING THE ENVIRONMENT OR SAVING BUSINESS?

SAVING THE ENVIRONMENT OR SAVING BUSINESS?

OBJECTIVE:

- To examine the importance of environmental management on improving business opportunities for Caribbean tourism.

OVERVIEW:

- Travel and Tourism is the largest and fastest growing industry in the world. Tourism generates 25.5% of the GDP for the region.
- The industry in the region depends on the quality product that can be produced by a clean, healthy and safe environment.
- The "greening" of hotels is good business as it means lower operating costs, facilities compliance with legislation and helps protect the long-term investment.

BENEFITS IN 'GREENING' HOTELS

The Travel & Tourism (T&T) industry encompasses transport, accommodation, catering, recreation, and services for travellers. It is the world's largest and fastest growing industry and generator of quality jobs. (Fig. 1)

In 1996, T&T generated US$3.6 trillion of gross output and 255 million jobs worldwide.

The Caribbean Travel & Tourism industry has the following significant economic indicators:

- Employs 2.4 million people, or 1 in every 4 jobs (hotels, taxis, restaurants, recreation).
- Generates 25.5% of the Gross Domestic Product (GDP) for the region.
- Earns US$ 13.2 Billion in export of services and merchandise.
- Pays US$ 6.5 Billion in taxes.
- Spends US$ 15.1 Billion in infrastructure.

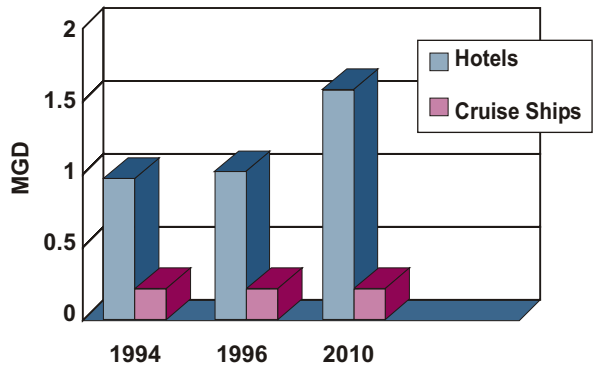
The success of the Caribbean Travel & Tourism industry is dependant upon pristine attractions such as exquisite beaches, healthy coral reefs, lush tropical forest, rare and exotic flora and fauna, warm climate, friendly people, and quality hotels .

For example, scuba diving sites in the Caribbean represent 57% of the dive sites world wide, earning for the region an estimated US$ 1.2 billion.

Several potential environmental impacts are associated with the travel and tourism industry. Namely:

- Large draw on public infrastructure and utilities (electricity, water, sewage) which must be shared with local communities.
- Discharge of untreated effluents into the environment in large quantities.
- Massive import of goods to service the industry- excess packaging and waste.
- Improper land use planning and poor designs of infrastructure systems.

Module 3 - Figure 1



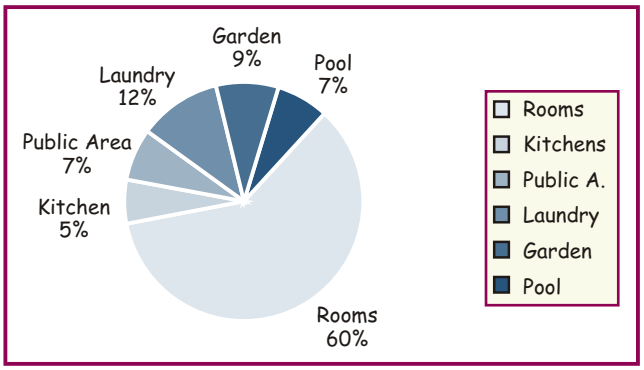
Wastewater Management

- It is assumed that 80% of the water demand reaches the wastewater treatment plant.
- When potable water is used for irrigation, 50% is assumed to reach plant.
- Half of all wastewater treatment plants are operated by the tourism sector (Fig. 4)
- 75% do not comply with selected criteria for good operation.

As an example of distribution of water consumption in a typical tourism establishment such as hotels. Figure 2 illustrates water consumption patterns in hotels audited in Jamaica and Figure 3 the consumption patterns specifically for guest room in Curaçao.

Module 3 - Figure 2

Water Consumption Patterns in Hotels Audited in Jamaica



Module 3 - Figure 3

Estimated Water Consumption in Guest Rooms in Curaçao.

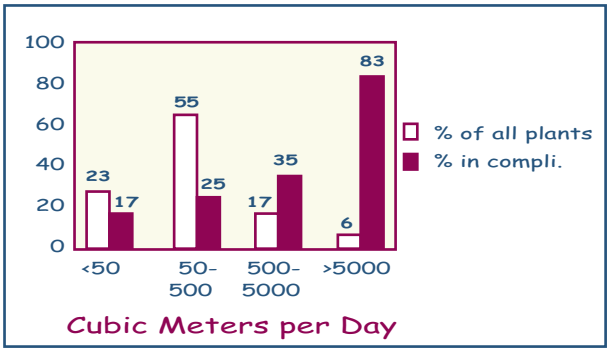
No. of Guestrooms	Water Use Lts/ Guestnight	Desired Consumption
200	889 liters	600-700
66	692	440-500
31	1328	330-380
26	692	330-380
15	912	330-380

Solid Waste Management

- Hotels import many goods to service visitors.
- 40% of all waste brought into a hotel comes in the form of packaging (glass, cardboard, plastic) (Fig. 5)
- Many opportunities to reduce, reuse, recycle exist.
- Few hotels measure or manage their waste costs.

Module 3 - Figure 4

Wastewater Treatment Systems operated by the Tourism Sector.

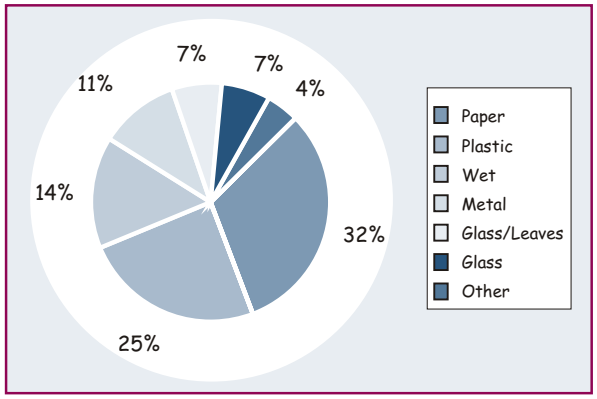


In Conclusion

- Caribbean people depend upon tourism as a principle source of revenue and jobs for the region.
- Caribbean tourism depends upon a healthy, clean, and bountiful environment.
- Measures must be taken now to ensure the prosperity of future generations.

Module 3 - Figure 5

Categories of Solid Waste Generated by Hotels



GREENING OF HOTELS: BOTTOM LINE BENEFITS

Embarking on a programme of greening hotels can lead to the following benefits:

- lower operating costs
- added value for customers
- compliance with legislation
- protection of long-term investment.

Lower Operating Costs

- Linens & Towels Reuse Programme
  - Easy to implement
  - Reduces water, detergents, energy
  - Varying approaches
  - Estimated payback period is less than one month
  - cost: varies, less than $2.00 US per room.
- Low flow showerheads and faucets
  - Easy to install
  - Showerheads reduce water flow from 5 to 7 gallons per minute
  - Aerators reduce water from 2 or 3 gallons per minute to 1.5
- Low flush toilets and dams
- Water reclamation systems
- Operational procedures

Estimated costs and payback period for low flow shower heads may be as follows:

Estimated cost

- Showerheads: $10 to $20 US each
- Faucet aerators: less than $1 US each

Payback

- Showerheads: 3 to 6 months
- Faucets aerators: 1 month

Added Value For Visitors

Implementing or improving existing environmental programmes or operational measures in a tourism facility can provide a number of concrete benefits, particularly to visitors.

- Guests expect companies to do what they can to help the environment.
- Guests feel better when they are at hotels with environmental initiatives.
- 78% of American travellers say that they are concerned about the environment.
- 54% would stay at a hotel because of the efforts made by the hotel.

Obtaining the following awards or working in the following programmes are examples of strategies that can be used in marketing efforts to improve image and identify a tourism facility, such as a hotel, with sound environmental management practices.

- Caribbean Hotel Association, Green Hotelier Award.
- International Hotel and Restaurant Association Environmental Award.
- Green Globe Commendations.
- British Airways Holidays Tourism for Tomorrow.
- Islands Magazine Eco-tourism Award.

Compliance Legislation

Hoteliers should ensure that they are familiar with the local environmental authority's requirements to ensure that their operation is in compliance and benefit from any incentives which may be available.

Protecting Long-Term Investments

The tourism sector requires significant capital investment as well as investment in people. Protecting the environment reduces the risks.

- Protecting natural & cultural resources
  - reefs
  - beaches
  - water supplies
- Full cost analysis:
  - Economic
  - Environmental
  - Social