Chapter 5
Water quality: The crucial factor in sustaining marine life

SUSTENANCE TO MARINE LIFE

In the three preceding chapters we have analyzed the trends, condition and economic values of coral reefs, mangroves and fisheries for the Philippines. There is one crucial link binding all of these together and affecting their conditions and economic usefulness to humans. This, of course, is *water*. Water and its transport role is crucial in the maintenance of all coastal ecosystems because these ecosystems and their numerous organisms are dependent on the incubation and movement of larvae which provide new recruits of fish, invertebrates and plants to all coastal systems. Water quality directly affects the viability of these minute living organisms to survive and be successfully transported to their eventual home where they reproduce. Most kinds of pollution are carried by water and affect all living coastal resources and their ability to grow and reproduce naturally. As the sea becomes more polluted, we will lose living coastal resources at an increasing cost to society.

The vulnerability of coral reefs to pollution is well-documented. In Chapter 2, we noted an example from Jakarta Bay where the average depth of coral growth decreased from about 10 to 1 m in the last 70 years as a result of the increasing pollution. Other studies have shown that coral growth rates decrease significantly with increases in phosphates, nitrates, other nutrients, petroleum products, silt and some heavy metals (Table 5.1). Since corals need adequate light, any substance which blocks light will slow their growth rates. In addition, certain chemicals affect their metabolism and ability to grow and reproduce. Many other coral reef organisms follow a similar pattern for corals and are adversely affected by pollution.

Table 5.1. Influence of three water quality parameters factor increases over ambient (normal) for various proportions of coral growth inhibition[56].

Water quality parameter	% Growth decrease of coral		
	90%	50%	10%
Suspended particulate matter (silt)	x 4.23	x 1.94	x 1.13
Chlorophyll-*a*	x 4.88	x 2.48	x 1.22
Reactive phosphate concentration	x 2.25	x 1.61	x 1.11

Note that if reactive phosphate concentration increases by 2.25 times normal, coral growth decreases by 90%.

Mangrove plants are less vulnerable to pollution in a general sense than corals. Yet, many of the aquatic organisms which live in or depend on a mangrove system are highly vulnerable to increasing pollutant levels. Crustaceans, an important member of the mangrove food chain, accumulate herbicides and heavy metals which affect both their long-term reproductive capacity and their quality for human consumption.

Marine fisheries are extremely vulnerable to the effects of certain pollutants because of their high metabolism rates and because their larval life cycle exposes them to wide areas of marine waters at a time when they are affected by relatively small quantities of pollutants. Fisheries, the ultimate product we associate with the sea because of their food value, are already under increasing scrutiny for the potential impact of the pollutants they pass on to humans. The obvious case is the increasing incidence of red tides, transmitted through some crustaceans and fish, which can kill humans if the concentrations are high enough. Red tides are increasingly associated with levels of certain pollutants in relatively closed bays or areas without adequate water circulation.

POLLUTION SOURCES AND TRENDS IN COASTAL WATER QUALITY

Marine pollution has been defined as the "anthropogenic input of substances into the marine environment resulting in harm to marine life, human health, marine activities and a reduction in the quality and usefulness of sea-water"[49]. The types of pollution common in Philippine coastal waters are numerous but there are a few sources which are pervasive and are causing increasing harm to coastal ecosystems and fisheries production[31, 51, 63, 107]. These are:

a. Domestic sewage liquid waste with high nutrient loads, some toxic chemicals and biological contaminants from coastal cities and municipalities, and ships, most of which go into the sea;

b. Domestic solid waste from coastal cities and municipalities, and ships, much of which is dumped into shoreline areas or rivers and ends up in the sea;

c. Sediments from upland and coastal erosion, construction sites, deforestation, poor agriculture practices which flow through rivers or directly into the sea;

d. Mine tailings and sediments from quarrying and mining both in the coastal and upland areas, much of which flows to the sea through streams and rivers;

e. Industrial organic and toxic wastes (heavy metals), which although often treated or restricted, end up being dumped into rivers and eventually the sea;

f. Agriculture chemicals such nitrates, phosphorous and pesticides which mostly pollute nearby rivers, streams and ground waters, some of which go to the coastal waters;

g. Aquaculture development which causes increasing acid levels in soil and water and releases nutrients from fertilizers and pesticides into nearby coastal waters; and

h. Oil and fuel leaks and spills from ships.

Broadly separated, the three categories of pollutants are distinguished by those that are organic in nature, e.g. nutrients and oils; inorganic substances including metals and radionuclides; and the persistent organic pollutants (POPs) made up of pesticides or herbicides, polyaromatic hydrocarbons, polychlorinated biphenyls and other synthetic organics commonly called plastics. Of these, POPs rank highest both in terms of environmental impact and difficulty of measurement. The organics are more easily detected but are known to have a high impact as shown in Figure 5.1.

About 50% of the coastal and marine pollution in the Philippines comes from runoff and land-based discharges. A sizable, but undetermined amount, comes through the atmosphere from land-based sources. Maritime transportation and dumping may

Figure 5.1. Impact versus difficulty of measurement for contaminants[51].

Impact

Difficulty of measurement

account for about 20% of the pollution if world trends are reflected in the Philippines as shown in Table 5.2.

Table 5.2. Sources of pollution in the marine environment worldwide[50].

Sources	% of all potential pollutants
Runoff and land-based discharges	44
Atmosphere (largely land-based)	33
Maritime transportation	12
Dumping	10
Offshore production	1

The trends in coastal and marine pollution in the Philippines are not encouraging, with the incidence of pollution-related problems increasing dramatically over 20 years ago. There are more records of ecosystem failure due to pollution in areas close to urban development or areas near human settlements of any size because of domestic waste. Algal blooms are occurring more frequently and causing red tide events that kill or make shellfish and some fish species toxic. Heavy metals are being implicated in fish and human poisoning in some bays where mining occurs or did in the past. We see increasing amounts of plastics on beaches. Endocrine-disrupting chemicals from aquaculture, agriculture and other land-based activities are increasingly being detected in marine sediments. These chemicals can affect the reproduction of certain marine organisms and can be transmitted to humans[63, 105]. The result of all this will be an increasing drain from societal welfare and economies.

WHAT IS BEING LOST FROM COASTAL AND MARINE WATER POLLUTION?

Pollution in coastal and marine waters has a major impact on estuaries, mangroves, coral reefs, seagrass beds, soft-bottom benthic communities, as well as adjacent waters that support important fisheries. We have shown the vulnerability of these systems to various kinds of pollutants and cited studies which indicate long-term effects of pollutants on endocrine systems, reproductive health of marine organisms and humans as well as the effects on growth rates of corals and other more physical impacts of pollution. The linkages between lowered productivity of these systems and lowered economic value are not difficult to make. The three major economically valuable resources of most concern that are affected by pollution are fisheries, recreation and tourism industries and biodiversity.

One way to quantify the losses caused by water pollution would be to measure the decline in productivity of the marine ecosystems of concern. The losses to fisheries, tourism, recreation uses and biodiversity as a result of pollution can all be quantified as done in Chapters 2, 3 and 4 from the impacts of habitat destruction for coral reefs and mangroves and overfishing for fisheries. The losses from these economic sectors resulting from pollution will be proportional to the severity of the pollution and size of resource economy affected. If a coral reef is destroyed from urban runoff or fresh water flooding, the losses will be equal to the original productivity of that reef plus whatever other benefits derived from it such as coastal protection. We indicated in Chapter 2 that 1 km^2 of healthy coral reef can easily generate US$50,000/year from fishing and tourism. Thus, the cost of pollution destroying such a reef can be equated to this value. Similar computations can be done for mangroves, fisheries and other marine resource systems. The decrease in fish recruitment caused by polluted water could also be measured in reduced productivity.

Another way to quantify the cost of pollution is to value the environment's services as a receptor of waste. The amount that polluters, such as factories, households and others, are willing to pay for discharging wastes into the environment is a direct method of measuring environmental waste disposal services (EWDS). This willingness-to-pay may be the maximum amount that the polluting firm is willing to incur should it be denied the privilege to dispose of its wastes into the environment or the prospective cost of reducing pollution to a non-damaging level[83].

Lingayen Gulf and its river basins have been studied for EWDS provided as receptors of pollutants. The value of these EWDS in terms of the control costs for the manufacturing sector alone was P9.9 million in 1995[83]. The average annual value of EWDS by source of pollution from 1986 to 1995 is shown in Table 5.3. The overall average annual value of P366 (US$14.1 million) of EWDS provided by the Gulf represents what polluters should be willing to pay to prevent the dumping of their wastes. This substantial amount undoubtedly underestimates what is being lost every year in the Gulf in terms of lowered fish catch, reduced aquaculture potential, lowered tourism potential and others. One obvious example of this loss is the reduced interest in diving and swimming in and around the over 60-year old Hundred Islands National Park because of deteriorated water quality.

Table 5.3. Average annual value of environmental waste disposal services by source of pollution in Lingayen Gulf (1986-1995)[83].

Source of waste	Value (in US$'000)	% share
Domestic	3,065	23.0
Agriculture	1,472	10.0
Manufacturing	427	2.7
Mining	5.2	0.04
Non-point sources	9,135	64.0
Total	**14,104** (P366 million)	**100.0**

US$1 = 28.5 pesos in 1995

An important implication of this analysis is that we note that the largest source and value of pollution is from non-point sources. Non-point sources represent soil erosion from deforestation and poor land use practices, flood waters, general urban runoff and others. These sources are difficult to control and yet have the largest single impact on the Gulf. This realization that pollution is not only costly but emanates from many different sources highlights the need for integrated management approaches in coastal areas. Integrated coastal management is the topic of the next and last chapter of this book.