Clean Water Notebook

Ecological Impact Of Boat Sewage Discharge

Volume 1

Updated January, 2001

How much of a problem does sewage from boats pose to the environment?

A boat cruising well offshore at five knots, discharging a 20-gallon holding tank using a three gallon per minute pump rate, poses little risk of health hazard or environmental harm. Several hundred boats, on the other hand, segregated in a small harbor for a sailboat regatta or boating festival, that dump toilet waste directly overboard can present a definite problem.

What harm does the discharge of raw or inadequately treated sewage have on our waterways?

The impact of sewage on our waterways falls into three categories:

- **aesthetic degradation**
- **health hazard**
- **oxygen depletion**

Although the first is most noticeable, it has the least impact from an ecological point of view. The absence of floating waste, however, does not mean that the surrounding waters are safe from other negative effects of sewage discharge.

What scientific proof exists that links boat sewage and health hazards?

From a scientific point of view, the link between boat waste discharge and harm to the general population's health has not been proven. Circumstantial evidence, however, is convincing and has led many state regulatory agencies to believe that boats directly contribute to the degradation of shellfish beds and swimming beaches. Furthermore, studies by the U.S. Environmental Protection Agency (USEPA) and by state water quality agencies have identified numerous sources of "non-point" pollution, such as urban storm water runoff, failing septic tank systems and agriculturally-applied chemicals. Boat wastewater is just one of these, but together, non-point sources represent the major cause of the pollution entering our waterways. Boats are no longer being singled out, but are being treated as part of the overall problem – a problem which is likely to become more regulated.[1]

In the absence of scientific proof, why do officials heavily regulate disposal?

The following quotation from Environmental Engineering and Sanitation explains the reasoning for stringent controls of all human waste.[2]

> The improper disposal of human excreta and sewage is one of the major factors threatening the health and comfort of individuals in areas where satisfactory sewage systems are not available. This is so because very large numbers of different disease-producing organisms can be found in the fecal discharges of ill and apparently healthy persons. Surveys show that 5 to 10 percent of the population are carriers of Endamoeba histolytica, causing amoebic dysentery,[1] and 25 percent of the population are carriers of ascarid, hookworm, or tape-worm.[2] Studies in an American city showed that 9.1 percent of the local population harbored Endamoeba histolytica and that 23.1 percent harbored parasites.[3] Knowing that other

In the absence of scientific proof, why do officials heavily regulate disposal? (continued)

> organisms causing various types of diarrhea, bacillary dysentery, infectious hepatitis, salmonella infection, and many other illnesses are found in excreta, it becomes obvious that all sewage should be considered presumably contaminated, beyond any reasonable doubt, with disease-producing organisms.

(Salvato, 1972, p.259)

How is contamination from boats or other sources detected and measured?

The key weapon in the public health official's arsenal of determining if food or water has been contaminated with human or animal waste is by the use of indicator organisms. This is not the same as determining the existence of disease-causing organisms. There are numerous disease-causing organisms, and each requires separate detection procedures. Further, it is unrealistic to examine a water sample for each potential pathogen. While pathogenic micro-organisms may be present in water in numbers sufficient to cause disease, the chances of capturing them in a highly diluted water sample are minimal.

Environmental scientists use indicator organisms to measure water quality, and to predict the presence of harmful organisms. The most common indicator organism is coliform bacteria, which is found in the intestines of all warm-blooded animals, but is not produced by shellfish. Coliform organisms are plentiful (human beings produce millions of these bacteria per day). They are easy to detect through a simple laboratory examination, and generally survive longer than most disease-causing organisms per 100ml (100ml=3.4 oz.) Fecal coliform, including E. coli bacteria, are a subclassification of total coliform bacteria.

Consider the impact of one boat on a small harbor or marina. A human lower digestive tract, as one author puts it, is a "seething cauldron of microbial activity."[3] A single E. coli bacterium can increase to over 10 million organisms in 12-18 hours. (On average, 25% of the total fecal mass produced is bacteria.)

What is the relationship between fecal coliform and contamination of shellfish beds?

Mollusks, such as oysters, clams, and mussels filter tiny particles, including bacteria, as they pump water across their gills and into their stomachs. As a result, they have the ability to absorb the bacteria which are floating in surrounding waters and pass them on to unsuspecting consumers. (**Note:** Proper cooking effectively destroys harmful organisms.)

So efficient are the mollusk's filtering capabilities, that one oyster can filter 50 to 100 gallons of water per day.[4] When waste is dispersed over a shellfish bed, it can potentially be concentrated in the underlying shellfish. Under favorable conditions, fecal matter containing coliform organisms can reach the bottom within minutes of discharge. Maceration serves to disperse the organisms over a wider area, but will not diminish their ultimate numbers.

The National Shellfish Sanitation Program (NSSP) of the U.S. Food and Drug Administration was founded in response to a 1925 typhoid epidemic, which killed 150 people and made thousands of others seriously ill. Though the outbreak was not caused by pleasure boating discharge, the NSSP has sought to protect consumers by preventing sewage contamination of shellfish from all possible sources.[5]

What is the relationship between fecal coliform and contamination of shellfish beds? (continued)

One recent study links boating activities and the closure of shellfish beds. The study found high levels of fecal coliform bacteria are most evident in areas with high boat concentration and low tidal flushing. This finding is further supported by study results from Puget Sound, Long Island Sound, Narragansett Bay, North Carolina and Chesapeake Bay; all conducted since 1987.[6]

The economic impact of shellfish sanitation regulation is significant to marina operators. State regulators are held to the guidelines of the NSSP as administered by the U.S. Food and Drug Administration. The potential for sewage discharge may be sufficient cause to block marina expansion.[7] Several states restrict marinas from adding slips as a result of possible condemnation of shellfish beds. Shellfish and boating are often viewed as mutually exclusive activities.

Is urine sterile? Does it contribute to an increased health hazard?

Since the vast majority of people are disease-free, their urinary discharges are sterile (free of microbes). Therefore, urine does not contribute to increased coliform counts. One should not conclude, however, that urine from a diseased individual will not transmit infection. Although rarely found in developed countries, urinary carriers of typhoid have a persistent infection and will regularly discharge typhoid bacilli.[8]

What is BOD and how does it relate to the marine ecosystem?

Biological Oxygen Demand (BOD) is another indicator of pollution by organic materials. According to one authority on marina development and operation, BOD is perhaps the most serious consequence of waste discharge in terms of the natural environments.[9] BOD is the amount of oxygen, expressed in milligrams per liter (mg/l) or part per million (ppm), it takes to oxidize organic matter into carbon dioxide and water. The relative size of a “ppm” is analogous to 5 average footsteps if it takes 1,000,000 footsteps to cross the U.S.A..

In both air and water environments, the oxygen produced by plants is offset by the oxygen consumed by animals, and the reverse is true of carbon dioxide, so an equilibrium is maintained both on land and water between plants and animals. The atmosphere surrounding the earth is maintained at about 21% oxygen at sea level. The oxygen available for respiration by fish or biological activity by microbes in water is that which is dissolved (8 ppm at about 70^0 F). In simplistic terms and for comparative purposes, air contains 21% oxygen and water only 0.0008% oxygen. The free oxygen present in water is referred to as dissolved oxygen (DO).

An ecosystem can go out of balance if an external source of oxygen demand is added (i.e. farm animal wastes, agricultural chemicals, faulty septic tanks, or direct discharge of sewage from boats). These discharges act as fertilizers to microscopic plants such as algae, but the added oxygen from photosynthesis of the increased numbers of aquatic plants is less than the amount of oxygen consumed during their decomposition. Once the oxygen is depleted, the water can become stagnant and can only be inhabited by anaerobic (absence of oxygen) organisms.

Although untreated human waste is a “natural” by-product of our everyday activity, discharge of that waste in significant volume into our waters is not a natural process and can accelerate the process of euthrophication, or the drying up of a water body.

What is the comparitive BOD of boat waste to other sources of sewage discharge?

Oxidizable organic material in the wastewater stream can be measured by determining the BOD level. As with coliform testing, there is more than one method of measurement. The following table provides relative BOD levels for various forms of wastewater discharge.

TABLE 1 – BOD Levels For Various Forms of Wastewater[10]

Source	BOD Level (ppm)
Treated Municipal Sewage	5-100
Raw Municipal Sewage	110-400
Boat Holding Tank Contents	1,700-3,500

Based on this table, one should keep in mind "relative strength" when evaluating the volume of various discharges. Dumping a single 20-gallon waste holding tank has the same impact as discharging several thousand gallons of sewage discharged from an efficiently operated municipal treatment plant or septic tank. A municipal waste treatment plant, however, operates 24 hours per day and often generates millions of gallons of effluent per day. Even though municipal discharge is far less concentrated, the total number of pounds of BOD generated in a given period is considerably greater.

Blackwater sewage from boats can also have a severe impact in warmer water, when peak boating activity coincides with lowered solubilities of oxygen. (As temperature increases, dissolved oxygen decreases.) At least three recent studies have shown lower levels of dissolved oxygen in marina waters compared to ambient DO levels in nearby waters.[11] In light of these studies, it is difficult to escape the conclusion that raw sewage discharge from boats contributes to the overall problem of decreasing oxygen levels. The following statement, taken from a recent National Geographic article, indicates the magnitude of the problem. "Measurements in the [Chesapeake] bay's deep channels reveal that 15 percent of its 15 trillion gallon volume has had little or no oxygen some summers."[12]

What is the impact of sewage which has been treated by a Coast Guard certified MSD?

The EPA has set a standard which requires that Type I MSDs not produce an effluent with greater than 1000 fecal coliform per 100 milliliters and no visible floating solids. Basically, Type I devices macerate waste, then treat it with the addition of chlorine, formaldehyde, or heat. The term "no visible floating solids" was devised by the EPA and Coast Guard to mean no floating materials which could be readily identified as human waste or toilet tissue. (Basically solids must be reduced to less than 1/16 inch in diameter.) No reduction of BOD takes place. A Type I MSD probably reduces the health hazards associated with boat waste discharge, but does little to curb the pollution effects.

Significant doubt exists as to the effectiveness of the wastewater treatment via chlorination on pathogenic viruses. One public health specialist has commented that "at least discharges from municipal treatment plants are fixed and can have a defined bufferzone around their discharge preventing against the harvest of shellfish within the zone. Boats being mobile can discharge anywhere."[13]

Type II MSD's are much more complex and have the capability to reduce coliform counts to less than 200 organisms per 100ml, and suspended solids to less than 150 mg/l or ppm. "Suspended solids" is a measure of solids which are held in suspension in water. The clarity of the effluent from a Type II is equivalent to slightly cloudy water.

What is the impact of sewage which has been treated by a Coast Guard certified MSD? (continued)

Type III MSD's must maintain a no discharge (holding tank) standard.[14] Holding tank wastes treated at a secondary municipal treatment plant will produce a reduction in bacteria (less than 100 organisms per 100ml) and in BOD (about 90%).[15]

TABLE 2 – MSD Definition References

Type I Device	1000 fecal coliform/ 100ml	No Visible Floating Solids
Type II Device	200 fecal coliform/ 100ml	150 mg/l Suspended Solids
Type III Device	No Discharge Standard	Holding Tank Recirculating Toilet Incinerating Toilet

What evidence exists that boats equipped with holding tanks on coastal waters will provide any better level of control?

One pleasure boat harbor has developed an effective program to control fecal coliform levels. In Avalon Harbor, California, every incoming boat is greeted by a representative of the Harbormaster's Office, who deposits a dye tablet in the on-board toilet system. Any discharge from a moored boat will be colored with fluorescent dye, and in such cases the boat must leave from the harbor immediately, and the operator is fined. Before this program began, fecal coliform counts in the harbor exceeded 16,000 organisms per 100ml. After the program was initiated, counts dropped to 23 organisms per 100 ml in the harbor.[16] This experience confirms that coliform levels can be controlled if an effective no-discharge program is implemented.

Which type of device will be most effective at curbing the negative impacts of sewage discharge from boats under 65 feet in length?

This is a complex question without a simple answer. Many variables are involved, such as boat operator behavior, availability of dockside pumps, space and power constraints on smaller craft, and reasonable levels of enforcement. (Certainly, a holding tank which contains all waste is most effective, providing that the tank contents receive treatment via a properly designed and operated on-shore wastewater treatment system). If dockside pumpout stations are lacking, which system is the better choice? A Type I MSD probably reduces the health hazard compared to direct discharge from a marine toilet or a holding tank. On the other hand, a Type I may give the boat owner a false sense of security in dumping sewage in a confined body of water. In the same ways, the responsible boat owner is less likely to discharge the contents of a full holding tank into a marina or near a swimming beach because of the large volume to be discharged. At least a holding tank provides a choice of when the discharge can take place independent of toilet use.

Perspective from the Shellfish Industry

The following is a letter from a shellfish farmer reprinted from the Puget Sound Water Quality Authority newsletter.[23] It offers an interesting perspective on this issue.

> It amazes me, as a manager of a shellfish farm, how little time I actually spend running the farm. It used to be that I would wear out two or three pairs of hip boots each year from working on the beds. Now if I need new boots, it's because the rubber has cracked from age. Instead, I spend my time participating on assorted committees and organizations and attending meetings to preserve the clean water so vital to our survival. This is true of most shellfish farmers I know.
>
> The shellfish we raise are filter feeders. Each individual filters up to 100 gallons of water per day. We raise these animals at the end of the stream. All of the impurities that have been added to the water throughout the watershed are on their dinner plate. Our challenge is to raise an oyster in this environment which is fit to be consumed raw. With the growth and development of the Puget Sound region, this challenge becomes more difficult every year. To survive, the farmer needs to be informed about every activity going on upstream in the watershed. The University of Washington's School of Fisheries should consider changing its shellfish curriculum to include courses about on-site septic system design and maintenance, dairy waste management, hobby farm best management practices, storm water runoff and fecal coliform bacteria.
>
> Shellfish are often referred to as the canary in the mine shaft. They truly are. Shellfish farmers are almost always the first to know when there is a pollution problem in the watershed. The first statistic most environmental groups quote when rallying for support is that 40 percent of the shellfish beds in Puget Sound have been closed due to pollution.
>
> Shellfish farmers are environmentalists committed to producing a wholesome, nutritious food in the water of Puget Sound. Most have similar commitments to mine on their local watershed committees, soil conservation districts, etc. It is a labor of love and I am thankful to have an employer who supports these efforts.
>
> Bill Dewey
> Manager, Taylor United Samish Bay
> Shellfish Farm
> Skagit County, Washington
> (Sound Waves, 1993)

A Final Word

Boatmen, more than any other group, want to protect and preserve the marine environment from pollution. They look to knowledgeable members of the marine industry for guidance in meeting this challenge. Boats and Marinas can coexist with other marine industries, such as shellfishing, if effective control of boat sewage is achieved. This notebook is aimed at helping the marine industry achieve this goal.

Glossary and Abbreviations

Activated Sludge Process: Removes organic matter from sewage by saturating it with air and adding biologically active sludge.

Aerobic: Presence of free oxygen.

Anaerobic: Absence of free oxygen.

BOD: Biological oxygen demand; The amount of oxygen used by microorganisms (and by chemical reactions) in the biodegradation process. BOD is usually measured at 20^0 C for 5 days. Also referred to as Biochemical Oxygen Demand.

Bacteria: Small living organisms which often consume the organic constituents of sewage.

Blackwater: Toilet wastewater.

COD: Chemical Oxygen Demand; The amount of oxygen used in chemically oxidizing a substance.

Coliform: Group of bacteria which produce gas and ferment lactose, some of which are found in the intestinal tracts of warm-blooded animals.

Combined Sewer: Carries sanitary wastes as well as storm water.

DO: Dissolved oxygen.

Detention Time: Average time required to flow through a basin.

Eutrophication: The normally slow aging process by which a lake evolves into a bog or marsh and ultimately assumes a completely terrestrial state and disappears. During eutrophication the lake becomes so rich in nutritive compounds, especially nitrogen and phosphorus, that algae and other microscopic plant life become super-abundant, thereby "choking" the lake, and causing it eventually to dry up. Eutrophication may be accelerated by many human activities.

Fecal Coliform: Coliform specifically originating from the intestines of warm-blooded mammals.

Graywater: Wastewater not originating from toilets, such as from showers, sinks, dishwaters, etc..

MSD: Marine Sanitation Device; any equipment designed to receive, retain, treat or discharge sewage.

MSD, TYPE I: Generally, a maceration/disinfection device meeting a discharge standard where the fecal coliform bacterial count is 1000 organisms per 100 milliliters or less, and there are no visible floating solids.

MSD, TYPE II: A more advanced waste treatment system meeting a discharge standard where the fecal coliform bacterial count is 200 organisms per 100 milliters or less, and the suspended solids level is 150 milligrams per liter or less.

MSD, TYPE III: Generally, a holding tank designed to prevent the overboard discharge of treated or untreated sewage, or any waste derived from sewage.

Microbes: Minute plant or animal life. Some microbes which may cause disease exist in sewage.

Nitrogenous Wastes: Wastes of animal or plant origin that contain a significant concentration of nitrogen.

ppm: Parts per million; weight/weight for water, and volume/volume for air.

Pathogen: Microorganisms which causes disease.

Phosphorus: An element that while essential to life, contributes to the eutrophication of lakes and other bodies of water.

Primary Treatment: The state in basic treatment that removes the material that floats or will settle in sewage. It is accomplished by using screens to catch the floating objects and tanks for the heavy matter to settle in.

Sanitary Sewers: Carry only domestic wastewater.

Secondary Treatment: The second step in most waste treatment systems in which bacteria consume the organic parts of the wastes. It is accomplished by bringing the sewage and bacteria together in trickling filters or in the activated sludge process.

Septic Tank: Underground tanks for treating small flows of domestic wastewater.

Storm Sewers: Carry storm water only.

Suspended Solids: The small particles of solid pollutants which are present in sewage and which resist separation from the water by conventional means.

Tertiary Waste Treatment: Wastewater treatment beyond the secondary or biological stage. It may include the removal of nutrients such as phosphorus and nitrogen or any other potential problems.

Endnotes

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