Literature Review of No Discharge Zones

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Summary of Findings

A No Discharge Zone (NDZ) is an area where boats cannot discharge any sewage, raw or treated. In most waters within three miles of the coast, boats are allowed to discharge sewage treated with a Marine Sanitation Device, which grinds the sewage, and lowers bacteria counts, but does not reduce nutrient pollution or biological oxygen demand, and can still have higher than safe bacteria levels and introduce dangerous chemicals from the treatment process. In an NDZ, boats must use a Type III Marine Sanitation Device which is a holding tank where all sewage is pumped out at pumpout facilities, then treated more thoroughly. An NDZ helps reduce nutrient pollution because sewage contains nitrogen and phosphorous. Since sewage is organic matter, the bacteria that break it down use oxygen from the water, which lowers the dissolved oxygen available for other organisms. Although fecal coliform bacteria levels are reduced, they are still higher than otherwise found in the water, and can transmit diseases such as hookworm, tapeworm, diarrhea, salmonella infections, and more. Boat sewage is a contributing factor in beach closings caused by fecal coliform bacteria levels being deemed dangerous for swimmers. Filter feeders living in the water such as oysters can be infected with these pathogens and pass them on to those who eat them. The deodorizers and treatment chemicals such as chlorine, formaldehyde and quaternary ammonia used in marine sanitation devices can be toxic to marine life.

According to the EPA, 86% of boaters support No Discharge Zones. In many places that have already established NDZs, there has been notable success. In Avalon Harbor in California, bacteria counts dropped from 16,000 to 23 organisms per 100 milliliter by a strong enforcement effort that included putting dye in marine toilets to alert officials if anything was discharged. Within 3 years of Rhode Island's Great Salt Pond being an NDZ, officials were able to reopen shellfish beds that had been closed from high bacteria levels for over a decade. Other places that have NDZs say that they saw an increase in stewardship from boaters and marinas, and also cleaner water has helped local businesses and raised property values.

Introduction

A No Discharge Zone (NDZ) is "an area in which both treated and untreated sewage discharges from vessels are prohibited" (EPA No Discharge Zones, 2012). In areas without NDZs, boats can treat their sewage using a Marine Sanitation Device (MSD) and discharge the treated sewage into the water. NDZs, also referred to as No Discharge Area in some regions, are set up under section 312 of the Clean Water Act. There are three circumstances where a state can apply to create an NDZ. Under 312(f)(3) the state determines the body of water requires extra environmental

protection, and the EPA determines that there are adequate pumpout stations for the amount of boats using the area. The second way to apply is through 312(f)(4)(A) which gives added protection despite inadequate pumpout facilities on the grounds of a high need of environmental protection to sensitive ecosystems. The final NDZ qualification is if a region does not have adequate pumpout stations, but the water in question is part of the drinking water intake zone (EPA No Discharge Zone, 2012).

There are three types of MSD. Type I is a flow through device that treats the sewage with chlorine or heat to disinfect, then grinds up solid waste. Type I can only be used on vessels less than 65 feet long, and the effluent it produces must have no visible floating solids and the fecal coliform bacteria count must be under 1000 per 100 milliliters (mL) (EPA Marine Sanitation Devices, 2012). Type II is a more thorough treatment that can be used on boats of any size. It involves a flow through biological disinfection treatment, and requires total suspended solids to be under 150 milligrams per liter, and fecal coliform bacteria counts to be under 200 per 100 mL (EPA Marine Sanitation Devices, 2012). Type III is a holding tank used by vessels of any length. The contents of it can either be dumped out at sea if the boat is beyond three miles from the shore, or at designated pumpout stations (EPA Marine Sanitation Devices, 2012).

A pumpout station can be on the shore side at a marina or dock or it can be mobile on a boat. Pumpout stations remove the waste from the boat's holding tank, then treat it through the municipal sewage treatment facility, an on-site sewage treatment facility, have it hauled off in a honey-dipper, or a treat it at a septic system.

Effect of Sewage Discharge from Boats

A: Health Effects

Dumping boat sewage is an issue because human sewage is known to have many different disease causing organisms, especially of sewage from ill persons. Between 5 and 10% of the population are carriers of Endamoeba histolytica, which causes amoebic dysentery, and 25% of the population are carriers of hookworm, ascarid, or tapeworms. Organisms found in excreta can cause diarrhea, infectious hepatitis, salmonella infection, bacillary dysentery and many more diseases (Sealand Technologies, 2001).

Since it would impractical to test for each disease carrying organism in every sample, scientists and officials usually test for indicator organisms such as fecal coliform bacteria which are found in the intestines of warm blooded animals, but not species like fish or shellfish. Humans produce millions of coliform bacteria each day (Sealand Technologies, 2001). Urine does not increase fecal coliform counts because it does not have microbes. Although not common, urine of a diseased individual can transmit an infection, for example typhoid (Sealand Technologies, 2001).

Since there are lots of potentially harmful bacteria associated with sewage, different water activities have different fecal coliform or other bacteria standards to abide by. Beaches are closed to swimming if there is an enterococci test with 104 colony forming units (CFU) per 100 mL on any single test, or if the mean of the past five tests is greater than 35 CFU /100 mL (Warren,

2005). Before enterococci, fecal coliform used to be used as the measure for dangerous bacteria levels. Beaches closed when levels were over 200 CFU/100mL. Shell fish harvesting areas have even stricter regulations, requiring water quality to have 14 CFU/100 mL or less (Warren, 2005). Flushing a holding tank treated with a Type I or Type II MSD could potentially close a beach or shellfish bed if testing is done shortly after or if there is poor flow.

B: Ecological Effects

Biological oxygen demand (BOD) is a serious problem related to sewage in water. BOD is how much dissolved oxygen is consumed by the bacteria breaking down sewage. A high BOD means that there is a high demand for oxygen by the decomposers so there is less oxygen available for other aquatic animals. Both raw and treated sewage have a high BOD. The contents of a boat's holding tank have a BOD of 1,700-3,500 parts per million (ppm). In comparison treated municipal sewage has a BOD of 5-100 ppm, and raw municipal sewage has one of 110-400 ppm (Sealand Technologies, 2001). This shows that the relative impact of dumping raw sewage overboard is effects the BOD of the water significantly more than an equivalent amount of municipal sewage.

In addition to BOD, oxygen can be depleted indirectly through the high levels of nutrients such as nitrogen and phosphorous found in both raw and treated sewage. Plants need these nutrients to grow, but excess nutrients can cause ecological problems such as algal blooms. When algae die they are broken down by decomposers that use dissolved oxygen which means less oxygen remains for other organisms. When there are excess algae on the surface, they block out sunlight from reaching underwater plants. Plants produce oxygen as a byproduct of photosynthesis, so if there are fewer plants, less oxygen is produced. This whole system can lead to dead zones which are parts of a body of water that have too little dissolved oxygen to support life.

When water is warmer, it can dissolve less oxygen. Peak boating season occurs during the summer when the water is warmest. Several studies show that marinas often have lower dissolved oxygen levels than nearby waters (Sealand Technologies, 2001). The Chesapeake Bay is particularly at risk since in the deep channel in the middle of the Bay that becomes a dead zone in the summer.

In addition to sewage, boat toilets often contain deodorizers and other chemicals that can be harmful to marine life. MSD often produce byproducts of chlorine, quaternary ammonia and formaldehyde from the sewage treatment (EPA protecting coastal waters, 1994).

C: Shellfish

Shellfish such as oysters, clams, and mussels filter particles in the water including bacteria. This means that they are susceptible to absorbing bacteria. Oysters can filter up to 100 gallons per day, so the bacteria from sewage can accumulate in the oysters (Sealand Technologies, 2001). A study by for Maryland Department of the Environment found that areas with high boat concentration and low tidal flushing often were where the highest levels of fecal coliform bacteria were found (Sealand Technologies, 2001).

The bacteria that contaminate shellfish can be passed on to people eating them. This puts consumers at risk of the diseases. The shellfish farmers are struggling to keep their shellfish clean and safe. Especially in the Chesapeake Bay region where shellfish was once such an economically and culturally important industry, it is important to protect the shellfish.

D: Other Effects

Sewage causes aesthetic degradation. Larger pieces of sewage are more obvious to people using the water, and take away from the aesthetic appeal. In addition, larger sewage pieces take longer to break down because they have a smaller surface area to volume ratio.

Marine Sanitation Devices

Since 1980, all boats with installed toilets must have a Coast Guard approved Marine Sanitation Device (MSD). If the boat is over 65 feet in length, it must have either a Type II or III MSD (Warren, 2005).

In 2010, the EPA did an analysis of two of the Coast Guard approved Type I MSDs. Performance tests were done on the Electro Scan™ device and the Thermopure-2 device on their effectiveness at treating bacteria, and reducing total suspended solids (TSS), nutrients, and BOD. The Electro Scan device uses chlorine generated from salt water to disinfect the wastewater. When tested, fecal coliform bacteria levels of treated effluent ranged between non-detect and over 1,600 with an average of 82 as the Most Probable Number (MPN) per 100 milliliters of water. The Thermopure-2 device uses heat to kill bacteria, and its effluent produces a range from non-detect to 30,000,000 fecal coliform bacteria MPN (Fredrick, 2010). Thermopure-2 was ineffective because temperatures were supposed to be between 61 and 85^{o}C, but only reached between 38 and 49^{o}C during tests. In terms of visible floating solids Electro Scan device produced between 0 and 5,500 mg/L with a mean of 190 mg/L, and Thermopure-2 produced 0-1,600 mg/L with a mean of 66 mg/L (Fredrick, 2010).

The coast guard standards for Type I MSDs do not currently include *E. coli* or enterococci performance standards. *E. coli* and enterococci are subgroups of fecal coliforms that often indicates pathogens and according to epidemiological studies, there is a positive association between high concentrations of *E. coli* and enterococci in ambient waters and cases of gastrointestinal illnesses associated with swimming. In tests conducted by the EPA, effluent of the Thermorpure-2 was found to have an MPN/100 mL of millions for *E. coli*, and hundreds of thousands for enterococci. The Electron Scan was usually found to have safe levels of indicator bacteria (Fredrick, 2010).

Figure 1 (Fredrick, 2010):

BOD_5 Comparison of Effluent from Type I MSDs to Secondary Treatment Standards

Analyte	Average Effluent Concentration From Type I MSDs		EPA Secondary Treatment Standards *
	Electro Scan	Thermopure-2	
BOD_5 (mg/L)	780	920	45
TSS (mg/L)	1,000	1,000	45

* 40 CFR 133.102 Secondary Treatment Regulations, 7-day average.

As seen by figure 1, both Type I MSDs are significantly higher in BOD and TSS than the EPA secondary treatment standards that are applied to wastewater treatment plants. BOD and TSS are also not included in the coast guard standards.

Also not included in the coast guard standards for MSD are nutrients. Ammonia can be an indicator of human waste in water because it is an inorganic form of nitrogen that is produced when humans digest proteins. Excess ammonia is excreted via urine (Fredrick, 2010). Other forms of nitrogen and phosphorous are also excreted in human waste.

In effluent treated by the Electro-Scan, there was residual chlorine averaging 2.7 mg/L. High levels of chlorine can be toxic to aquatic organisms. Other types of MSD not tested in the EPA study can also treat waste with formaldehyde which is also released into the water (Sealand Technologies, 2001).

There is significant doubt about the effectiveness of chlorination from wastewater treatment on pathogenic viruses. Boats can discharge anywhere so there is no buffer zone like there is after a municipal treatment plant to prevent direct discharge into shellfish harvesting waters. Type II MSDs are more effective than Type I at reducing coliform counts and suspended solids, but still do not significantly reduce nutrients or BOD. Since Type III is a holding tank, it is most effective at reducing all parameters because it has to be discharged at a pumpout or dump station. Type III can reduce bacteria to less than 100 organisms per 100 mL and reduce BOD by 90% (Sealand Technologies, 2001).

Establishing a No Discharge Zone

The EPA Clean Water Act gives three options for establishing an NDZ. Under Criteria (f)(3), there are adequate facilities in the proposed area to handle the removal and treatment of sewage. Criteria (f)(4)(A) is used when there are not adequate facilities to handle the sewage, but there is a need of extra protection for the ecology or for recreational use of the water. Criteria (f)(4)(B) is used when there are not adequate facilities to handle the sewage, but there is a threat to drinking water from boat sewage.

To establish an NDZ when there are enough pumpout facilities, applicants must show a certification of why there needs to be higher protection than Federal standards for the body of water, a map of all pumpout facilities, a schedule of their operating hours, draught restrictions,

form of waste treatment (ex. does the pumpout facility go directly into municipal sewage or get removed hauled away periodically), and information on vessel population and usage. It also is recommended that applicants have a strategy for outreach and enforcement. The application is first sent to the state Department of Natural Resources and the state Department of the Environment. The Department of Environment will hold a meeting to see if there is local support, and then both organizations will review the application and either return it with comments or pass it on the EPA Regional Administrator. Within 90 days the EPA will determine if the area should become an NDZ. If there is no public oppositions, then the NDZ will be implemented (EPA Protecting Coastal Waters, 1994)

No Discharge Zone Effectiveness

It is often difficult to quantify the effectiveness of an NDZ. However, around the country, EPA, state, and local officials have reported that not only water quality improved, but there was also an environmental stewardship from boaters and marina owners increased after the creation of an NDZ (Stephenson, 2004).

An example of an effective, well researched NDZ is in Avalon Harbor, California which is a pleasure boat harbor that once had fecal coliform counts of 16,000 organisms per 100 mL. After establishing an NDZ the counts dropped to 23 organisms per 100 mL. They had very strict enforcement which included a dye tablet dropped into the on-board toilet by representatives of the Harbormaster's Office. When sewage is discharged the fluorescent dye shows up in the water, and a fine is issued to the violator.

Another study was conducted in Rhode Island's Great Salt Pond which was designated as a NDZ in 1993. Within three years of no sewage discharge, shellfish beds were able to reopened after over a decade of being closed for high fecal coliform bacteria counts during the peak boating season (Stephenson, 2004). Lower nutrients also meant there were fewer algal blooms (Stephenson, 2004).

A marina owner in Herring Bay, Maryland said that having an NDZ has resulted in cleaner water which has helped the marina's business (Stephenson, 2004). In Newport Bay in California, officials report significant economic value of the cleaner water saying that clean water has helped property values, encouraged tourism, and sport and commercial fishing (Stephenson, 2004). Rhode Island officials say that an NDZ has helped their offshore clamming industry (Stephenson, 2004).

In addition to the physical benefits of an NDZ, there are is also a major fringe benefit of improved environmental stewardship. Reports by local, state and EPA officials all cite an increase in awareness and care for the environment from boaters and marina owners. This often comes from peer pressuring from between boaters to make sure that others do not discharge.

One of the biggest factors that the EPA has found in the success of NDZs at improving water quality is the availability of pumpout facilities. There is no time limit given to NDZs, so if they are expected to exist in perpetuity, it is important that pumpouts are maintained, and are able keep up with boating needs over time (Stephenson, 2004).

Opinions about No Discharge Zones:

In 2003 the EPA surveyed over 1000 boaters and marina owners throughout the US about their experience with NDZs. Awareness of NDZs was high, with 93% of boaters knowing that they were boating in a No Discharge Zone, and 97% of boaters knowing that they were prohibited from dumping any kind of sewage into the water. During 2003, 93% of boaters said that they never had a time when they looked for, but did not find an active pumpout station, and 91% never experienced trouble with the pumpout facilities throughout the year (EPA final NDZ evaluation, 2004).

During the same time frame, 63% of marinas reported that their pumpouts were functional 100% of the time. An additional 33% said there facilities were functional 75-99% of the time, and only 23% of marina's said that boats ever had to wait more than 15 minutes to use a pumpout (EPA final NDZ evaluation, 2004).

An anonymous study of nearly 1000 boaters in Salem Sound, Massachusetts in 2005 showed that 70% of boaters do not dump any sewage overboard, 13% dump treated waste, and 17% dump untreated waste. Of those who dump overboard, 88% do it more than three miles off the coast where it is legal to dump untreated waste, 14% dump within three miles of the coast, and 3% discharge where they are moored (Warren, 2005). Various reasons were given for why boaters discharge untreated waste instead of getting it pumped out; the most common reasons were 'unavailability of pumpout facilities', 'equipment malfunctions' and 'holding tank overflows while out while at sea' (Warren, 2005).

In the Salem Sound, there was a decent awareness of pumpout facilities with 90% of respondents knowing of at least one pumpout facility, 36% knowing at least two, and 14% knowing three or more (Warren, 2005). Many of the respondents who did not know of any pumpout facilities were ones who did not have a head on their boat.

In terms of boaters opinion, 86% of survey respondents in supported making the Salem Sound and NDZ (Warren, 2005). Boaters are generally aware of the effects of sewage and MSD treatments. In the Salem Sound survey, 81% of boaters believe sewage may cause problems at beaches, 83% think it increases human health risks to disease and parasites and 62% say that the disinfectants and deodorizers from MSDs increase toxins in the water (Warren, 2005). Also, 6% of boaters are under the impression that sewage provides food for fish, and 11% feel that sewage has no affect because it gets diluted and biodegrades (Warren, 2005). Most boaters (79%) would report it if they saw another vessel illegally discharging, however there is some confusion about who to report this to (Warren, 2005). For more extensive commentary on boaters opinions, see *Salem Sound Marine Sanitation Needs Assessment* which was published by the Massachusetts of Coastal Zone Management, and written by B. Warren in 2005.

A: Enforcement/Outreach

Strong applications applying for creating an NDZ include enforcement and outreach effort plans. Many successful applicants for NDZ said that outreach and accessibility were a stronger motivator for compliance because although enforcement is important it is difficult when there are many boats and few enforcers (Herrera Environmental Consultants, 2012). Outreach can include making sure that pumpout facilities are well advertised, easily accessible, and close to where boaters will be. For commercial boaters there is a direct monetary cost related to the time and inconvenience of going to the pumpout.

An interview with an NDZ petition coordinator in Massachusetts said that a good strategy to gain public support is to "bring it back to the poop" and make people, especially boaters think about what they are discharging into the water that people swim and fish in (Herrera Environmental Consultants, 2012).

The Galveston Bay Foundation had a successful education campaign for the NDZ in Clear Lake that included a webpage with a guide and map of local pumpout facilities, an explanation of the dangers of sewage, and a video on how to properly pumpout a boat. Also they branded their campaign with a catchy slogan of 'pump don't dump' that included a logo of a boat and fish (Galveston Bay Foundation, 2010).

B: Other Considerations

When considering designating an NDZ, it is important to consider the capabilities of boats to have holding tanks to pumpout. In an EPA survey of boats in NDZs, 78% had an installed toilet on board, 15% had a portable toilet, and 9% had no toilet (EPA final NDZ evaluation, 2004). Most boats under 16 feet do not have toilets on board. Of the boats with installed toilets, 99% had a holding tank (EPA final NDZ evaluation, 2004). A similar study done in the Salem Sound of Massachusetts reported similar results saying that 81% of the boats they surveyed had an onboard head, and of those 39% have Type III MSD, 24% have portapotties, 2% have Type II, and 12% have Type I MSD (Warren, 2005).

Also, it is important to consider how distributed pumpout facilities are because according to interviews done in Massachusetts, boaters are only willing to go about 15 minutes out of the way to find a pumpout facility (Herrera Environmental Consultants, 2012). It helps for pumpout facilities to be spread across the NDZ, and to correspond with where there is the most boat traffic.

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