Assessment of Cruise Ship and Ferry Wastewater Impacts in Alaska

Alaska Department of Environmental Conservation

Commercial Passenger Vessel Environmental Compliance Program

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Executive Summary

Cruise ships by their sheer size and passenger number are a highly visible industry in Alaska. Concerns about cruise ship pollution led to the creation of the Alaska Cruise Ship Initiative (ACSI) in 2000. Wastewater samples taken as part of the ACSI in 2000 indicated that the blackwater[1] treatment systems were not working properly and that graywater[2] quality was similar to blackwater. This information led to state and federal laws that now regulate cruise ship and ferry blackwater and graywater discharge in Alaska.

Before the passage of the state cruise ship law, blackwater and graywater from large cruise ships did not meet Alaska Water Quality Standards for ammonia, free chlorine, fecal coliform, copper, and zinc at the end of pipe. These ships would have exceeded Alaska Water Quality Standards for free chlorine, fecal coliform, and dissolved copper if they discharged while stationary. However, Alaska Water Quality Standards, except fecal coliform, were probably met in the receiving water while ships discharged underway due to substantial dilution.

Since the passage of the state law in 2001 and federal cruise ship law in 2000, most large cruise ships discharging into Alaska waters[3] have installed advanced wastewater treatment systems. The effluent quality produced by the advanced systems has dramatically improved from waste water discharged from most ships in 2000-2002. Therefore, ADEC considered the 2003 data to assess the impact of large cruise ship effluent in receiving waters. In 2003, these systems produced wastewater that met Alaska Water Quality Standards for most tested pollutants at the end of pipe. After applying a conservative dilution factor, Alaska Water Quality Standards were met in receiving water for all tested pollutants. Whole Effluent Toxicity (WET) testing conducted during 2003 in conjunction with dilution estimates indicates that effluent from ships with advanced wastewater treatment systems does not pose a risk to aquatic organisms, even during stationary discharge. No tested pollutant is present in concentrations that cause risks to human health.

Small cruise ships and Alaska Marine Highway System (AMHS) ferries use traditional treatment, not advanced systems to treat their blackwater. The quality of small ship effluent has remained relatively consistent from 2001 to 2003. Therefore, ADEC used all the data available to assess the impact of small vessel effluent on receiving waters. The wastewater produced by small vessels frequently exceeds eight (ammonia, free chlorine, fecal coliform, arsenic, copper, nickel, selenium, and zinc) Alaska Water Quality Standards at the end of pipe. After applying a conservative dilution factor, four (free chlorine, fecal coliform, copper, and zinc) Alaska Water Quality Standards may be exceeded in receiving water during stationary discharge. The discharge met Alaska Water Quality Standards for all tested pollutants in the receiving water during underway discharge due to the large dilution factor. In addition, WET testing conducted on six small vessels in conjunction with the sampling results indicates that small ship stationary effluent does pose some risk to the marine environment. Due to the high concentration of fecal coliform, the effluent from some small ships may pose a risk to human health in areas where aquatic life is harvested for raw consumption.

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[1] Black water is sewage.
[2] Graywater originates from showers, galley, laundry, etc.
[3] Alaska water is defined as 3 nautical miles from shore and the waters of the Alexander Archipelago defined in AS 46.03.490(18).

The wastewater samples taken from large and small vessels to date indicate that hazardous chemicals are not being discharged through these wastewater systems.

ADEC recommends that small vessels remain in the commercial passenger vessel program. Small vessels were granted three years to come into compliance with the cruise ship wastewater effluent standards. Further, in 2004, these vessels may submit an interim protection plan that, if approved by ADEC, extends the time for compliance with the effluent standards. This plan must detail the steps that the owner is taking to comply with the wastewater discharge limits including a description of the practices used to limit the adverse impacts of their discharges. Violations and fines could be levied against ships that are found violating the terms of their approved plan.

1. INTRODUCTION

1.1. Assessment Report

The 2001 state cruise ship legislation directed the Alaska Department of Environmental Conservation (ADEC) to submit a report to the Governor assessing commercial passenger vessels' discharges in Alaska marine waters. Using information from the 2000 – 2003 cruise ship seasons and other sources, this report satisfies the requirements to:

1. Characterize, to the extent possible, the risks to the marine and human environments posed by the discharge of sewage and graywater from commercial passenger vessels;

2. Evaluate the sewage and graywater treatment systems and technologies on the vessels, including an evaluation of whether small commercial passenger vessels should be made subject to the discharge limitations in AS 46.03.463; and

3. Recommend further action by the state in relation to the matters discussed in the report.

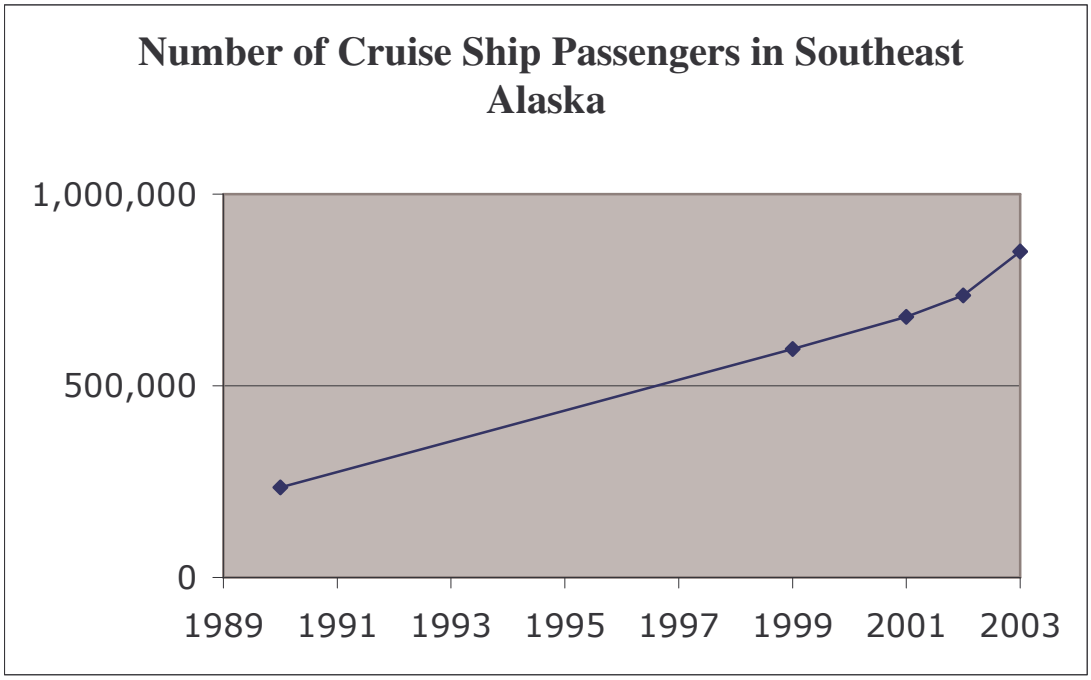
This report also presents general background information and detailed appendices of wastewater sampling data, in response to the numerous requests received by ADEC staff from industry, environmental groups, and other government agencies. Bilge and ballast water issues are a maritime wide concern and are beyond the scope of the 2001 legislation and this report.

1.2. Cruise Ship Industry Trends in Alaska

The first steamships began carrying tourists to Alaska in 1884,[4] making tourism one of Alaska's oldest industries. The number of cruise ship passengers that visit Alaska has increased by almost three and a half times since 1990. In 1990, 235,000 passengers traveled to Southeast Alaska. By 2003, the number of cruise ship passengers in Southeast Alaska increased to roughly 800,000[5] with tens of thousands of crew (Figure 1). By comparison, the state's population is approximately 650,000.[6] Roughly 95% of the current cruise ship traffic is concentrated in Southeast Alaska, a region with a population of approximately 73,000 people.[7] This makes the cruise ship industry extremely visible in the region. For example, Skagway - with a summer population of 1,200 people – often has more than 12,000 people visiting in a day. The other 5% of cruise ship traffic is directed primarily toward Southcentral Alaska, but a few small cruise ships visit Western Alaska.

[4] Alaska Permanent Fund Corporation Alaska History Page http://www.apfc.org/library/AKHistoryD.cfm?s=5
[5] ADEC 2003 registration information
[6] Alaska Department of Labor and Workforce Development, Workforce Info Home Page http://almis.labor.state.ak.us/?PAGEID=67&SUBID=115
[7] Alaska Department of Labor and Workforce Development, Borough & Census Area Estimates 2000 – 2003, http://146.63.75.50/research/pop/estimates/02T2-1.xls

Figure 1. Cruise Ship Passenger Increase in Southeast Alaska



Source: Southeast Conference Report and ADEC Registration Statistics

The three most popular large cruise ship ports are Juneau, Ketchikan, and Skagway. Large ships tend to stop at the main Southeast Alaska ports and a large tidewater glacier (Glacier Bay or Hubbard). Some large cruise lines have trips that start in Southcentral Alaska (Seward) travel through southeast Alaska and end in Vancouver. The next voyage is reversed.

Alaska Marine Highway System (AMHS) ferries travel between Southeastern Alaska communities including Ketchikan, Juneau, and Skagway. These calls generally only last an hour or two. Small cruise lines explore remote bays and channels. They call on smaller Alaska ports and Native villages as well as the larger ports for most of a day. The small ships may venture from Alaska ports across the Bering Sea to the Russian Far East. The most popular ports for small ships are Sitka, Bartlett Cove, Skagway, Ketchikan, and Juneau.

Table 1 shows the number of cruise ship visits per port per year in 2003.[8] There are often multiple ships in a port in a single day.

[8] These numbers are derived from the 2003 Cruise Line Agencies of Alaska ship schedule. The actual visits may have varied slightly.

Table 1. Cruise Ship Visits Per Port in 2003

Place Name	Description	Number of small ship visits per year	Number of large ship visits per year
Adak	Port in Aleutian Islands	1	0
Anchorage	Port in Southcentral Alaska	8	0
Attu	Port in the Aleutian Islands	5	
Baranof Warm Springs	Port in Southeast Alaska	1	0
Bartlett Cove	Port inside Glacier Bay National Park	122	0
Cold Bay	Remote site	1	0
College Fiord	Tidewater Glacier in South central Alaska	7	147
Cordova	Port in Southcentral Alaska	16	0
Dutch Harbor	Unalaska Island (one of the Fox Is.) in the Aleutian Is.	7	3
Elfin Cove	Port in Southeast Alaska	25	0
Glacier Bay	Tidewater Glaciers, National Park in SE AK	See Bartlett Cove	207
Haines	Port in Southeast Alaska (Northern Lynn Canal)	67	13
Homer	Port in Southcentral (western Kenai Peninsula)	10	2
Hubbard Glacier	Tidewater Glacier near Yakutat on Gulf of Alaska	0	151
Icy Bay	Tidewater Glacier near Yakutat on Gulf of Alaska	0	2
Juneau	Port in Southeast Alaska	96	448
Ketchikan	Port in Southeast Alaska	100	408
Kodiak	Port in Kodiak Island (South central Alaska)	4	3
Misty Fiords	National Monument near Ketchikan	50	33
Nome	Western Alaska	2	3
Petersburg	Port in Southeast Alaska	96	0
Seward	Port in South Kenai Peninsula	0	98
Sitka	Port in Southeast Alaska (outside coast)	140	140
Skagway	Port in Southeast Alaska (Northern Lynn Canal)	100	328

Place Name	Description	Number of small ship visits per year	Number of large ship visits per year
St. Matthew	Island in the Bering Sea	9	0
St. Paul	Island in the Bering Sea	9	0
Tracy Arm	Tidewater Glacier in Southeast Alaska (between Juneau& Wrangell)	100	128
Valdez	Port in South central Alaska	16	0
Whittier	Port in South central Alaska	32	0
Wrangell	Port in Southeast Alaska	32	8

1.3. Concern about Cruise Ship Industry Environmental Practices

Tourism shares the rich marine environment with commercial fisheries, one of Alaska's largest private employers. Over 50% of America's seafood (5.1 billion of 9.4 billion pounds) is harvested from Alaska's waters.[9] The commercial fishing industry depends on the perception and actuality that Alaskan fish come from uncontaminated waters.

Alaska's Native peoples subsist off the bounty of the sea, relying heavily upon marine resources for nutrition, sustenance, cultural integrity, and spiritual well being. Alaska Natives were alarmed over potential cruise ship pollution and the fouling of especially vulnerable food items such as filter feeding mollusks.

In July 1999, Royal Caribbean Cruise Lines (RCCL) entered a federal criminal plea agreement involving total penalties of $6,500,000 for 1994 and 1995 environmental violations in Alaska including knowingly discharging oil and hazardous substances (dry-cleaning and photo processing chemicals) and making false entries in federally required Oil Record Books. RCCL admitted to a "fleet-wide practice of discharging oil contaminated bilge waste" and to submitting false statements in numerous jurisdictions. The $6,500,000 for Alaska violations was part of a larger $18,000,000 total federal plea agreement. In January 2000, RCCL entered into a state civil settlement for the Alaska violations. The state settlement required RCCL expenditures of over $3,325,000. This illegal discharge outraged many Alaskans, who began to question whether cruise ships met Alaska Water Quality Standards enforced by the Alaska Department of Environmental Conservation (ADEC).

Because of its international nature, the cruise industry was excluded from many of the U.S. environmental laws and regulations that land-based industries are required to meet. EPA did not issue a permit under the federal Clean Water Act for cruise ship wastewater discharges because of a marine vessels exemption that dates from the 1970s. The U.S. Coast Guard certifies marine sanitation devices (MSDs) for American flagged ships and checks to ensure that all applicable vessels have certified MSDs during ship inspections. They did not, however, monitor the wastewater effluent quality.

Large cruise ships operate under MARPOL (International Convention for the Prevention of Pollution from Ships), an environmental treaty drafted by the International Maritime

[9] "Fisheries of the United States 2002." September 2003. National Marine Fisheries Service, NOAA, U.S. Dept. of Commerce.

Organization (IMO), an agency of the United Nations. Annex IV of MARPOL addresses the disposal of sewage. Since the United States did not sign Annex IV, it is not mandatory, that ships follow Annex IV in the United States.[10]

1.4. Alaska Cruise Ship Initiative (ACSI)

In December 1999, ADEC responded to public concern and convened a forum to review and discuss the cruise industry's waste management and disposal practices in Alaska. The participants included the U.S. Coast Guard, the U.S. Environmental Protection Agency (EPA), Southeast Alaska communities, industry, Tribes, environmental groups, and concerned Alaskans. This effort became known as the Alaska Cruise Ship Initiative (ACSI). Goals of the ACSI included:

(1) identifying cruise ship waste streams,

(2) developing pollution prevention and waste management solutions,

(3) assessing and verifying compliance of volunteer wastewater sampling, and

(4) keeping the Alaskan public informed.

Voluntary sampling of large cruise ships in 2000 indicated that the marine sanitation devices (MSD) on most ships did not function well. U.S. Coast Guard regulations require that effluent from the type II MSD treatment systems installed on cruise ships contain no more than 200 fecal coliforms per 100 ml and 150 mg/l total suspended solids at installation.[11] Surprisingly, the fecal coliform results were as high as 16 million[12] in blackwater and 32 million in graywater.[13]

1.5. Alaska Specific Legislation

As a result of the ACSI efforts, the U.S. Congress enacted Title XIV – Certain Alaskan Cruise Ship Operations on December 21, 2000.[14] The law creates wastewater standards for vessels with 500 or more overnight passengers, and prohibits cruise ships from discharging raw sewage in areas that are more than 3 nautical miles from shore but still within the Inside Passage. These "donut holes" are now closed to discharge. (See Figure 2.) The regulations to implement the law became effective in July 2001[15] and are enforced by the U.S. Coast Guard.

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[10] EPA MARPOL 73/78 overview http://www.epa.gov/OWOW/OCPD/marpol.html
[11] 33 CFR Part 159 – Marine Sanitation Devices
http://www.uscg.mil/d14/units/msohono/references/cfrs/sub%20o/part%20159.htm
[12] The geometric mean of fecal coliform samples was 12,824 for blackwater and 1,163,188 for graywater. See Appendix B. Large Ship Sampling Data Tables 47B & 51.
[13] Blackwater originates in toilets. Graywater comes from showers, sinks, kitchens, and laundry.
[14] "Title XIV—Certain Alaskan Cruise Ship Operations" of the Miscellaneous Appropriations Bill (H.R. 5666) on December 21, 2000 in the Consolidated Appropriations Act of 2001 (P.L. 106-554).
[15] 33 CFR Part 159 Subpart E – Discharge of Effluents in Certain Alaskan Waters by Cruise Vessel Operations.

Figure 2. Donut Holes Closed by Federal Cruise Ship Legislation

Under the federal legislation, large cruise ships may discharge blackwater and graywater in Alaska while underway.[16] During an underway discharge, blackwater effluent must contain no more than 200 fecal coliforms per 100 ml and no more than 150 mg/l total suspended solids. There are currently no federal effluent standards for underway graywater discharges.[17] Ships that discharge blackwater in Alaska while underway must take at least two blackwater samples per cruise ship season. The federal law allows continuous discharge of blackwater and graywater that meet more stringent standards (Table 2). A ship approved by the U.S. Coast Guard to discharge continuously must sample their wastewater twice per month

State of Alaska cruise ship legislation, AS 46.03.460 – AS 46.03.490,[18] was passed during a 2001 special session of the Alaska Legislature and became effective on July 1, 2001. The legislation establishes the Commercial Passenger Vessel Environmental Compliance (CPVEC) program in the ADEC. The regulations to implement the program, 18 AAC 69, were effective November 15, 2002.[19]

The state law sets standards and sampling requirements for the underway discharge of blackwater in Alaska that are identical to the blackwater standards in the federal law (Table 2). Because of the high fecal coliform counts detected in graywater during 2000, the state law also set graywater standards (Table 2). It also has provisions regarding the disclosure of solid waste and hazardous waste disposal information.

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[16] Traveling at least 6 knots while at least 1 nautical mile from shore.

[17] The Administrator of the EPA may promulgate different wastewater effluent standards in the future. EPA recently began the process of evaluating whether the current federal standards are consistent with Alaska Water Quality Standards.

[18] Available at: http://old-www.legis.state.ak.us/cgi-bin/folioisa.dll/stattx01/query=as+46!2E03!2E460/doc/{@17677}?

[19] Regulations were drafted by stakeholder committee and brought through formal rule making process. They are available at http://www.state.ak.us/dec/title18/wpfiles/69mas.doc

The CPVEC program applies to both large and small commercial passenger vessels. A small commercial passenger vessel provides overnight accommodations for 50 to 249 passengers. State law defines a large commercial passenger vessel as one that provides overnight accommodations for 250 or more passengers.[20] Several key aspects of the CPVEC program, such as payment of environmental compliance fees and compliance with wastewater discharge standards, did not apply to small commercial passenger vessels until January 1, 2004.[21] These vessels did, however, have to adhere to the wastewater sampling, record keeping, and reporting requirements as soon as the law was effective.

Table 2. Comparison of State and Federal Laws

<table>
<tr><th>Law</th><th>State</th><th>Federal</th></tr>
<tr><td># Overnight Passengers</td><td>50+</td><td>500+</td></tr>
<tr><td>Discharge Limits</td><td colspan="2">At Least 1 mile from shore @ min. 6 knots</td></tr>
<tr><td></td><td>BW & GW</td><td>BW only</td></tr>
<tr><td>Fecal Coliform/100 ml</td><td>Geometric Mean of 200</td><td>200</td></tr>
<tr><td>Total Suspended Solids (mg/l)</td><td>150</td><td>150</td></tr>
<tr><td>Discharge Limits</td><td colspan="2">Continuous Discharge (at anchor)</td></tr>
<tr><td></td><td>BW & GW</td><td>BW & GW</td></tr>
<tr><td>Fecal Coliform/100 ml</td><td rowspan="3">Refers to Fed Law</td><td>Geometric Mean of 20</td></tr>
<tr><td>Chlorine (mg/l)</td><td>10</td></tr>
<tr><td>Total Suspended Solids (mg/l)</td><td>30</td></tr>
</table>

1.6. Science Advisory Panel

During the ACSI, a Science Advisory Panel was organized to independently address the scientific questions surrounding the impact of cruise ship waste in Alaska. The Science Advisory Panel is a group of scientists and engineers whose work and conclusions are not subject to government or industry approval. The nine core members of the Panel include an oceanography professor, NOAA physical oceanographer, ADEC environmental engineer, civil engineering professor, oceanographer for a law firm, microbiologist, NOAA senior staff scientist, chemistry professor, and an EPA senior toxicologist. While Panel members were not compensated, a paid facilitator, who is a retired U.S. Coast Guard Captain-of-the-Port and industrial toxicologist, supported the Panel's work.

[20] AS 46.03.490

[21] Small ship owners/operators may obtain an extension of time for compliance with AS 46.03.463(a) - (d) by submitting an approved plan for interim protective measures. See 18 AAC 69.045 for details.

The North West Cruiseship Association funded the facilitator and travel expenses for non-governmental panel members in 2000 - 2001. ADEC funded the facilitator and travel expenses for non-governmental panel members in 2002. The efforts of the Science Advisory Panel culminated in the publication of *The Impact of Cruise Ship Wastewater Discharge on Alaska Waters*[22] in November 2002 and several other papers available on the following website: http://www.state.ak.us/dec/press/cruise/documents/sciencepanel.htm Science Advisory Panel work is referenced throughout this report.

[22] http://www.state.ak.us/dec/press/cruise/documents/impactcruise.htm

2. WASTEWATER SAMPLING DESIGN, RATIONALE, and STATISTICS

2.1. Data Reliability and Representative Nature

It is crucial that wastewater sample data is reliable[23] and representative.[24] This data is used to determine compliance with the cruise ship laws and to conduct scientific analysis. Large vessels that discharge in Alaska take at least two compliance samples per cruise ship season to satisfy both state and federal cruise ship laws. ADEC, U.S. Coast Guard, and the Northwest Cruiseship Association have established a Quality Assurance/Quality Control (QAQC) plan that ensures that the sample results are reliable.[25]

The QAQC plan includes standard sampling and laboratory quality control elements with additional instructions tailored to a maritime facility. It lists all the pollutants to be tested and the EPA analytical methods to be used. The QAQC requirements include duplicate sampling, sampling audits, and a lab technical systems audit. The U.S. Coast Guard cruise ship regulations require third party sampling. ADEC regulations are consistent with other state wastewater programs and allow industry to collect samples using their own staff. However, large cruise ships sample to satisfy the requirements of both the federal and state law. Therefore, a third party sampler takes all required large vessel wastewater samples. Small ship operators are not bound by the federal law but have also chosen to use third party samplers.

ADEC also performs independent compliance sampling and analysis. ADEC tests for pollutants listed in the QAQC plan as well as other pollutants of concern.

Because each ship is configured differently and follows unique wastewater management practices, the state also requires the owner/operator to submit a vessel specific sampling plan (VSSP). The VSSP plan, approved by ADEC before sampling begins, must demonstrate that the sample will be representative of the wastewater discharged from the particular ship.

From 2001 through 2002, wastewater sampling on large cruise ships was dictated by the ability to discharge underway and to get the samples to the laboratory within the EPA mandated six hour holding time for fecal coliform analysis. This frequently meant that wastewater samples were taken in the middle of the night when the volume of wastewater was low. The ideal wastewater sample would have been taken during daytime when the volume of wastewater production was high. These samples did not sample the treatment abilities at normal flow conditions and therefore are not representative. By 2003, only large cruise ships with advanced wastewater treatment systems discharged wastewater in Alaska. These vessels were approved for continuous discharge and were sampled during the day in port while the vessel was discharging into receiving water. These continuous discharge samples should be representative of the wastewater effluent produced by the wastewater treatment systems and discharged into receiving water.

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[23] Reliability reflects the degree of certainty.

[24] The objective of representative sampling is to ensure a sample or group of samples accurately characterizes site conditions. ASTM Method 6044-96 Standard Guide for Representative Sampling for Management of Wastes and Contaminated Media. http://www.astm.org/cgi-bin/SoftCart.exe/DATABASE.CART/PAGES/D6044.htm?L+mystore+nhpu4885

[25] The most current version, "Northwest CruiseShip Association, Discharge of Effluents in Certain Alaska Waters by Cruise Vessel Operations, 2003 Operating Season Quality Assurance/Quality Control Plan For Sampling and Analysis of Treated Sewage and Graywater From Commercial Passenger Vessels," is available at: http://www.state.ak.us/dec/press/cruise/pdf/03qaqc.pdf

Small cruise ships are sampled in port because of the economic hardship it would cause if third party samplers traveled with the vessels. The time spent in Juneau, where small cruise ships do their wastewater sampling, is often used to disembark passengers and to get ready for the next cruise. There is usually little to no wastewater produced during this day. State cruise ship regulations[26] effective November 2002 gave small ships the ability to have their crew sample their wastewater and submit it to a laboratory for analysis. This would enable underway sampling; however, none of the ships have exercised this option. Despite these issues, the data obtained over the last three seasons, when considered in its entirety, does provide a reasonable picture of the pollutants that are present in small cruise ship wastewater discharges.

Alaska Marine Highway System ferries were usually sampled in port; however, there were usually passengers still aboard the vessel. The wastewater samples from the ferries were therefore representative of the wastewater effluent produced by its wastewater treatment system.

2.2. Sampling Program Evolution from 2000 - 2003

The sampling strategy that guided the voluntary sampling program in 2000 differs from the regulatory program existing today. Table 3 and Table 4 highlight the evolution of the sampling program. The pollutants with asterisks are defined as conventional pollutants in 40 CFR Part 401.16 and are typically tested in the effluent of wastewater treatment plants. On the advice of the Science Advisory Panel, ADEC expanded this sampling list. This group is referred to as conventional pollutants throughout this report. Priority pollutants refer to an EPA list of 126 specific pollutants that include heavy metals and specific organic chemicals.

Table 3. Conventional Pollutants

Pollutant	2000	2001	2002	2003
Ammonia	√	√	√	√
pH*	√	√	√	√
Biochemical Oxygen Demand (BOD)*	√	√	√	√
Chemical Oxygen Demand (COD)	√	√	√	√
Total Suspended Solids (TSS)*	√	√	√	√
Total and Free Chlorine	√	√	√	√
Fecal Coliform*	√	√	√	√
Settleable Solids		√	√	√
Oil and Grease*		√	√	√
Total Organic Carbon (TOC)		√	√	√
Conductivity		√	√	√

[26] 18 AAC 69, http://www.state.ak.us/dec/title18/wpfiles/69mas.pdf

Pollutant	2000	2001	2002	2003
Alkalinity		√	√	√
Total Nitrogen[27]		√	√	√
Total Phosphorus		√	√	√

Table 4. Priority Pollutants

Pollutant	2000	2001	2002	2003
Base, Neutral, Acids (BNAs)	√	√	√	√
Pesticides[28]	√			
Polychlorinated Biphenyls (PCBs)	√	√	√	
Volatile Organic Chemicals (VOC)	√	√	√	√
Trace Metals	√	√	√	√
Cyanide	√			

2000 Season's Voluntary Program

The voluntary ACSI program in 2000 applied to large ships only. The goals of the 2000 sampling program were to characterize wastewater quality and to determine if hazardous substances were discharged to receiving water through the wastewater systems. The voluntary program included two samples per season.

2001 Season - Moving from Voluntary Sampling to Compliance Sampling

In 2001, the purpose of the sampling shifted to assess compliance with the laws as well as conducting scientific impact analyses. All ships discharging in Alaska water are required by Alaska statute[29] to sample twice a year. On the advice of the Science Advisory Panel, ADEC increased conventional pollutants monitoring requirements. The pesticides and their metabolites on the 2000 priority pollutant list[30] have not been used in the U.S. for many years and were not detected in any of the 2000 samples. The U.S. Coast Guard and ADEC therefore removed pesticides from the priority pollutant list in 2001.

2002 Season

The sampling strategy for the majority of the large ships was the same as in 2001. However, six of seven large ships, with advanced wastewater treatment systems, had U.S. Coast Guard

[27] Total nitrogen includes ammonia, nitrate, nitrite, and total kjeldahl nitrogen (TKN).
[28] aldrin, chlordane, dieldrin, 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, alpha endosulfan, beta endosulfan, endosulfan sulfate, endrin, endrin aldehyde, heptachlor, heptachlor epoxide, alpha BHC, beta BHC, gamma BHC, delta BHC and toxaphene
[29] AS 46.03.465(d)

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approval for continuous discharge and were sampled in port.[31] Small ships took their first priority pollutant samples in 2002 and began sampling for the expanded list of conventional pollutants.

2003 Season

In 2003, the wastewater data from large ships reflected the continued increase in the number of large vessels with advanced treatment technology, from seven of 25 (28%) in 2002 to eighteen[32] of 32 (56%) in 2003. Small vessels continued to discharge and be sampled in port.

As in previous years, one of the two sampling events included testing for priority pollutants. ADEC and U.S. Coast Guard dropped PCBs from the priority pollutant sampling list for 2003 season because of the 2000 - 2002 history of non-detects. The priority pollutants (Base/Neutrals & Acids, Volatile Organic Chemicals, and Trace Metals) analyzed in 2003 are listed in Appendix A.

At the recommendation of the Science Panel, ADEC also tested vessel wastewater for commonly used organophosphorus pesticides at the end of 2003 season. No pesticides were detected. ADEC will continue to test for organophosphorus during the 2004 cruise ship season.

[31] The following ships had advanced wastewater treatment systems that were approved for continuous discharge by the U.S. Coast Guard: Celebrity *Mercury* and Holland America *Ryndam, Statendam, Volendam, Veendam*, and *Zaandam*. The Radisson *Seven Seas Mariner* had an advanced system, but it was not approved for continuous discharge.

[32] Princess - *Star Princess, Sun Princes, Dawn Princess, Coral Princess, Pacific Princess, Island Princess*
Celebrity - *Mercury*
Holland America – *Ryndam, Statendam, Maasdam, Volendam, Veendam, Zaandam*
Carnival – Carnival *Spirit* (graywater only)
Norwegian – *Norwegian Sun, Norwegian Sky, Norwegian Wind*
Radisson - *Seven Seas Mariner*

3. APPLYING ALASKA WATER QUALITY STANDARDS TO RECEIVING WATER

The State of Alaska has Water Quality Standards adopted in regulation. These standards help protect human health and the environment. ADEC tested for pollutants in samples taken at the discharge point inside the vessel. These effluent samples are also referred to as "end of pipe" samples. Discharges from the ship mix with the receiving water. ADEC, therefore, applied modeled dilution factors to the vessels' end of pipe sample results to determine whether Water Quality Standards were met in receiving waters.

In this document, ADEC refers to the Water Quality Standards located in *ALASKA WATER QUALITY CRITERIA MANUAL FOR TOXIC AND OTHER DELETERIOUS ORGANIC AND INORGANIC SUBSTANCES* amended through May 15, 2003, TABLE IV. AQUATIC LIFE CRITERIA FOR MARINE WATERS.[33] ADEC took a conservative approach and applied the more stringent chronic rather than acute water quality standards.

[33] This document is available at http://www.state.ak.us/dec/dawq/wqs/documents/70wqsmanual.doc

4. WASTEWATER CHARACTERISTICS – LARGE SHIPS

4.1. Statistics

Since 2000, ADEC has collected substantial amounts of wastewater sampling data on cruise ships and ferries subject to the Commercial Passenger Vessel Environmental Compliance Program. In order to characterize the central tendency of the large quantity of data, the median was used. The median is the middle of a distribution: half the scores are above the median and half are below the median. The median is less sensitive to extreme scores than an average and is thus a better measure for skewed distributions. Medians are used to present all pollutant data in this report except for fecal coliform. Much of the fecal coliform data was highly skewed so a geometric mean was used to summarize this data.

Geometric Mean

When distributions are more highly skewed, a geometric mean is used. A geometric mean moderates the effect of a single high value. A geometric mean is computed as follows:

$(X_1X_2..X_n)^{1/n} =$

Example:

$(1 \times 2 \times 10 \times 10{,}000)^{1/4} = 21$

4.2. Summary of Conventional Pollutant Data

2000 Sampling Data

Table 5 compares the median and geometric mean values of conventional pollutants tested in 2000 wastewater samples. Appendix B Large Ship Sampling Data presents the detailed sampling results from individual ships. Table 5 and subsequent tables also present the applicable Alaska Water Quality Standards[34] for comparison.

[34] ADEC, Alaska Water Quality Criteria Manual For Toxic and other Deleterious Organic & Inorganic Substances May 15, 2003, Table IV located at: http://www.state.ak.us/local/akpages/ENV.CONSERV/dawq/wqs/documents/70wqsmanual.doc. Fecal coliform standards and pH standards from ADEC Water Quality Standards, 18 AAC 70, http://www.state.ak.us/dec/title18/wpfiles/70mas.pdf. The most conservative standard is listed.