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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 Initiativ (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 th 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/cfr/cfr%20o/part%20159.htm

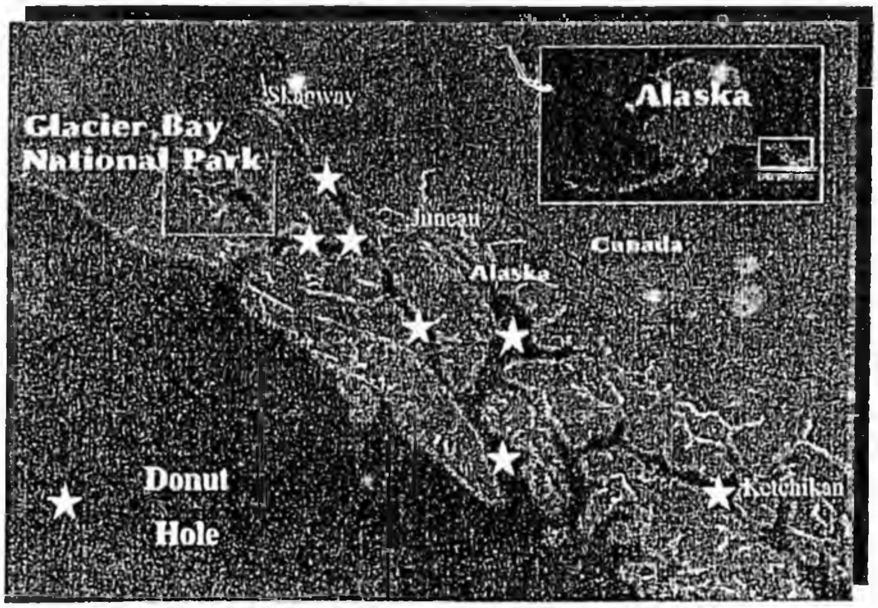
[12] The geometric mean of fecal coliform samples was 1?,824 for blackwater and 1,163,188 for graywater. See Appendix B Large Ship Sampling Data Tables 47B & 51

[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

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

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.

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[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 snip 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

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[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)
[30]

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.[13] ADEC took a conservative approach and applied the more stringent chronic rather than acute water quality standards.

[13] 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.

Table 5. 2000 Large Ship Conventional Pollutant Data

The values for all pollutants, except fecal coliforms, are medians. Fecal coliform information is represented as a geometric mean.

Water Type (# samples) Large Ship Appendix _ Table #	Collected from	Fecal Coliform (MPN/100 ml)	TSS mg/l	BOD mg/l	COD mg/l	Ammonia mg/l	pH	Total Cl mg/l	Free Cl mg/l
	AK WQS	14	n/a	n/a	n/a	17.00[35]	6.5-8.5	0.0075*	0.0075*
	MDL	2	1.3	2	3.0	0.03	0.1	0.10	0.10
GW - Accommodations & Laundry (3) Table 51.	CT	6	138.7	61	240.0	25.12	6.8	0.37	0.26
GW – Accommodations (3) Table 52.	CT	104	455.0	355	1,340.0	24.94	8.4	0.78	ND
GW - Laundry (10) Table 53.	CT	8	39.0	86	300.0	0.39	9.2	0.23	ND
GW – Galley (11) Table 54	CT	13,750	223.5	850	940.0	2.19	6.9	ND	ND
Mixed GW (24) Table 55	CT	118,052	92.0	170	405.0	1.40	6.8	ND	ND
Mixed GW (13) Table 56.	DB	1,163,188	250.0	450	940	0.20	5.95	ND	ND
BW&GW (11) Table 60.	DB	12,824	110.0	130	395.0	8.50	7.0	ND	ND
BW (22) Table 61	MSD	18,213	407.0	130	1,210.0	100.00	7.6	0.33	ND

MPN = Most Probable Number MDL = Method Detection Limit GW = Graywater BW = Blackwater
CT= Collecting Tank DB =Double Bottom Tank
MSD = Marine Sanitation Device ND= Non Detect
*Note that the MDL for chlorine is higher than the chronic water quality standard

The graywater sampled from accommodations & laundry, accommodations only, and laundry only had low fecal coliform counts. Galley graywater and mixed graywater had very high levels of fecal coliforms. Graywater sampled from double bottom tanks had higher fecal coliform results than the corresponding wastewater type sampled from collecting tanks. This is illustrated in Table 7.

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[35] The ammonia Water Quality Standard is for unionized ammonia. All samples were analyzed for total ammonia. Salinity, temperature, and pH affect the unionized portion of total ammonia. ADEC used TABLE IX. TOTAL AMMONIA CHRONIC CRITERIA FOR SALTWATER AQUATIC LIFE to calculate the total ammonia that corresponds to the unionized ammonia Water Quality Standard. Southeast Alaska port conditions were used for this calculation: 10 psu salinity; pH of 7.0; and temperature of 12.5 degrees Celsius. Using these ambient conditions, the total ammonia equivalency to the unionized Water Quality Standard is 17 mg/L.

The treated blackwater results included two samples that had been treated with a reverse osmosis treatment system before being stored in the double bottom tank. These samples had res lts below the limit of detection for fecal coliforms, which lowered the geometric mean substantially. Even with the addition of these two samples, the treated blackwater had a high geometric mean of fecal coliform, 18,213 MPN/100ml, as well as a high median of ammonia, 100.0 mg/l, and COD, 1,210.0 mg/l. These results indicate that the blackwater treatment systems were not functioning properly.

2001 Sampling Data

The state cruise ship law was effective in the summer of 2001. From this year forward, blackwater samples were taken primarily to ensure compliance with effluent standards. (When blackwater and graywater are mixed, it is considered blackwater.) Graywater was phased into the state program. Any graywater discharged in the state needed to be sampled as of 2001 but was not subject to the effluent standards until 2003. This is the cause of the disparity between the graywater effluent samples and the blackwater effluent samples presented in Table 6.

The low fecal coliform and TSS level of the mixed black and graywater occurred because 12 of the 16 samples were taken from advanced wastewater treatment systems on the Celebrity *Mercury* and Holland America *Statendam*. No fecal coliforms or TSS were detected in the effluent from those systems. The other ship that sampled its mixed black and graywater discharged outside Alaska water and was sampled voluntarily.

Table 6. 2001 Large Ship Conventional Pollutant Data

The values for all pollutants, except fecal coliforms, are medians. Fecal coliform information is represented as a geometric mean.

Water Type (# samples) Large Ship Appendix B Table #	Collected from	Fecal Coliform (MPN/ 100 ml)	TSS mg/l	BOD mg/l	COD mg/l	Ammonia mg/L	pH	Total Cl mg/L	Free Cl mg/l
	AK WQS	14	n/a	n/a	n/a	17.00	6.5-8.5	0.0075*	0.0075*
	MDL	2	1.3	2	3.0	0.03	0.1	0.10	0.10
GW – Accommodations (15) Table 32	DB	10,896	66.0	217	460.0	0.11	6.8	ND	ND
GW – Accommodations (15) Table 33	CT	2,189	55.5	170	300.0	0.99	7.6	3.00	0.30
GW – Galley (10) Table 34	DB	784,072	383.0	1,300	1,707.0	0.65	4.4	ND	ND
GW – Galley (23) Table 35.	CT	402**	766.0	740	1,410.0	1.00	7.0	4.00	1.30
Mixed GW (4) Table 36.	DB	649,994	151.3	194	289.0	0.32	6.5	ND	ND
Mixed GW (13) Table 37.	CT	38,933	76.5	220	520.0	0.48	7.2	ND	ND
GW - Laundry (7) Table 38.	DB	651,460	43.0	160	410.0	0.40	8.3	0.20	ND
GW - Laundry (2) Table 39.	CT	30	22.0	100	650.0	Not taken	8.4	1.03	1.03
Mixed BW&GW (16) Table 46.	MSD	2	0.7	3	11.5	0.63	7.1	ND	ND

*Note that the MDL for chlorine is higher than the chronic water quality standard.

** Some samples did not meet the fecal coliform 6 hour holding time and were not analyzed

Water Type (# samples) Large Ship Appendix B Table #	Alkalinity mg/l	Conductivity (Umhos/cm	Oil &Grease mg/l	Phosphorous Total mg/l	Nitrate as N mg/l	TOC mg/l	Total Kjeldahl Nitrogen mg/l	Settleable Solids mg/l
AK WQS								
MDL	0.5	1	1.5	0.01	1.0	1.0	1.0	0.1
GW (15) Table 40.	59.6	883	47.0	5.54	0.0	305.0	12.0	0.2
BW (5) Table 47.	125.4	3,590	0.2	9.05	0.6	100.0	27.8	4.5

MPN = Most Probable Number MDL = Method Detection Limit GW = Graywater BW = Blackwater
CT= Collecting Tank DB =Double Bottom Tank
MSD = Marine Sanitation Device ND= Non Detect

Table 7 compares 2000 and 2001 samples of wastewater that were held for up to 20 hours in double bottom (DB) tanks with wastewater collected and discharged immediately from collecting tanks (CT). The concentration of fecal coliform, TSS, and BOD increased when wastewater was stored in the double bottom tanks indicating a degradation of the effluent quality.

Table 7. Comparison of 2000 and 2001 Large Ship Wastewater Samples Held in Double Bottom vs. Collecting Tanks

# Samples	Sample Date	Sample From	Waste Type	Fecal[36]	TSS	BOD	COD	Ammonia	pH	Total Cl	Free Cl
			Units	MPN/100ml	mg/l	mg/l	mg/l	mg/l			mg/l
			AK WQS	14	n/a	n/a	n/a	17.00	6.5-8.5	0.0075	0.0075
			MDL	2	1.3	2	3.0	0.03	0.1	0.10	0.10
13	2000	DB	Mixed Graywater	1,163,188	250.0	450	940	0.20	5.95	ND	ND
15	2001	DB	GW accommodation	10,896	66.0	217	460.0	0.11	6.8	ND	ND
10	2001	DB	GW Galley	784,072	383.0	1,300	1,707.0	0.65	4.4	ND	ND
4	2001	DB	Mixed GW	649,994	151.3	194	289.0	0.32	6.5	ND	ND
7	2001	DB	GW laundry	651,460	43.0	160	410.0	0.40	8.3	0.20	ND
11	2000	DB	BW&GW	12,824	110.0	130	395.0	8.50	7.0	ND	ND
3	2000	CT	GW Accommodation and Laundry	6	138.7	61	240.0	25.12	6.8	0.37	0.26
3	2000	CT	GW accommodation	104	455.0	355	1,340.00	24.94	8.4	0.78	ND
10	2000	CT	GW laundry	8	39.0	86	300.0	0.39	9.2	0.28	ND
11	2000	CT	GW galley	13,750	223.5	850	940.0	2.19	6.9	ND	ND
24	2000	CT	Mixed GW	118,052	92.0	170	405.0	1.40	6.8	ND	ND
15	2001	CT	GW Accommodation	2,189	55.5	170	300.0	0.99	7.6	3.00	0.30
23	2001	CT	GW Galley	402	266.0	740	1,410.0	1.00	7.0	4.00	1.30
13	2001	CT	Mixed GW	38,933	76.5	220	520.0	0.48	7.2	ND	ND
2	2001	CT	GW laundry	30	22.0	100	650.0	Not taken	8.4	1.03	1.03
			Median DB	**194,343**	**130.7**	**206**	**435.0**	**0.36**	**6.7**	**ND**	**ND**
			Median CT	**587**	**92.0**	**170**	**520.0**	**1.20**	**7.2**	**.37**	**ND**

2002 Sampling Data

In 2002, the graywater from large ships was still exempt from the fecal coliform and total suspended solids standards. The graywater effluent quality that year was still quite poor. The median and geometric mean values of both the 2002 graywater and blackwater are presented in Table 8.

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36 This value is geometric mean not median

Table 8. 2002 Large Ship Conventional Pollutant Data

The values for all pollutants, except fecal coliforms, are medians. Fecal coliform information is represented as a geometric mean.

Water Type (# samples) Large Ship Appendix B Table #	Collected from	Fecal Coliform (MPN/100 ml)	TSS mg/l	BOD mg/l	COD mg/l	Ammonia mg/L	pH	Total Cl mg/l	Free Cl mg/l
	AK WQS	14	n/a	n/a	n/a	17.00	6.5-8.5	0.0075*	0.0075*
	MDL	2	1.3	2	3.0	0.03	0.1	0.10	0.10
GW - Galley (7) Table 21.	DB or CT	6,279	1,320.0	2,790	5,110.0	2.66	4.11	ND	ND
GW - Accom & Laundry (12) Table 23	DB or CT	47,357	130.5	367	615.0	1.07	6.72	ND	ND
Mixed GW (19) Table 25.	CT or DB	38,603	190.0	328	621.0	1.00	6.14	ND	ND
BW (21) Table 15	Various	5	0.1	3	61.6	18.80	7.5	ND	ND

Water Type (# samples) Large Ship Appendix B Table #	Collected From	Alkalinity mg/l	Conductivity (Umhos/cm	Oil &Grease mg/l	Phosphorous Total mg/l	Nitrate as N mg/l	TKN mg/L	TOC mg/l	Settleable Solids mg/l
	AK WQS								
	MDL	0.5	1	1.5	0.01	1.0	1.0	1.0	0.1
GW - Galley (7) Table 22	DB or CT	0.25	1,810	520.0	14.10	0.2	0.2	1,600.0	44.0
Accom. & Laundry (12) Table 24	DB or CT	73.5	5,090	140.0	5.50	0.2	0.2	209.5	0.1
Mixed GW (19) Table 26.	CT or DB	53.4	1,920	95.0	3.99	0.2	0.2	162.5	0.5
BW (21) Table 15	DB, CT, or MSD	135.0	685	0.9	3.21	0.1	0.1	23.0	0.1

MPN = Most Probable Number MDL = Method Detection Limit GW = Graywater BW = Blackwater
CT= Collecting Tank DB =Double Bottom Tank
MSD = Marine Sanitation Device ND= Non Detect
*Note that the MDL for chlorine is higher than the chronic water quality standard

Galley graywater showed lower levels of fecal coliform bacteria than the accommodations or mixed graywater but the levels of BOD, COD, and TSS are much higher. Galley graywater is a more complex wastewater to treat than laundry or domestic wastewater because of the high amount of oil, grease, and solids.

The conventional pollutant results for blackwater were much lower than the graywater results with the exception of a high ammonia median of 18.80 mg/l. The seven ships that discharged blackwater in Alaska had advanced wastewater treatment systems,[37] which resulted in a low fecal coliform geometric mean of 5 MPN/100ml and median TSS of 0.1 mg/l

2003 Sampling Data

In 2003, large cruise ship graywater and blackwater were subject to the fecal coliform and total suspended solids standards. The median and geometric mean values of pollutants detected in graywater and blackwater are presented in Table 9.

[37] 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.

Table 9. 2003 Large Ship Conventional Pollutant Data

The values for all pollutants, except fecal coliforms, are medians. Fecal coliform information is represented as a geometric mean.

Water Type (# samples) Large Ship Appendix B Table #	Fecal Coliform (MPN/100 ml)	TSS mg/l	BOD mg/l	COD mg/l	Ammonia mg/l	pH	Total Cl mg/l	Free Cl mg/l
AK WQS	14	n/a	n/a	n/a	17.00	6.5-8.5	0.0075*	0.0075*
MDL	2	1.3	2	3.0	0.03	0.1	0.10	0.10
Graywater (3) Table 3.	7	0.0	23	67.0	1.30	7.3	ND	ND
Blackwater (57) Table 1.	1	0.0	4	72.0	25.10	7.4	ND	ND

Water Type (# samples) Large Ship Appendix B Table #	Alkalinity mg/l	Conductivity (Umhos/cm	Oil &Grease mg/l	Phosphorous Total mg/l	Nitrate as N mg/l	TOC mg/l	Total Kjeldahl Nitrogen mg/l	Settleable Solids mg/l
AK WQS								
MDL	0.5	1	1.5	0.01	1.0	1.0	1.0	0.1
Graywater (3) Table 4.	34.1	199	6.2	0.23	0.0	12.7	4.8	0.0
Blackwater (57) Table 2	219.5	987	0.0	3.60	0.0	19.4	29.0	0.0

MPN = Most Probable Number MDL = Method Detection Limit GW = Graywater BW = Blackwater

CT = Collecting Tank DB =Double Bottom Tank

MSD = Marine Sanitation Device ND= Non Detect

*Note that the MDL for chlorine is higher than the chronic water quality standard.

Only one ship, the Carnival *Spirit*, discharged graywater in Alaska. The graywater from this ship was treated through a reverse osmosis advanced wastewater treatment system. This was the cause of the dramatic improvement in the 2003 graywater quality. It should be noted, however, that the COD level was still high.

In 2003, the number of ships with advanced wastewater treatment systems increased to 18.[38] These ships discharged their wastewater in Alaska. Most of these ships mixed their graywater

[38] Princess - *Star Princess, Sun Princess, 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*

and blackwater together resulting in blackwater. The blackwater effluent was of high quality but still had elevated levels of ammonia and COD.

4.3. Pollutants in Effluent that Exceed Alaska Water Quality Standards

The medians of most pollutants in effluent were below Alaska Water Quality Standards. Table 10 draws upon Table 5 – 9 for conventional pollutants and Appendix C. Summary of Large Ship Sampling for Priority Pollutants to highlight the medians that do not meet Alaska Water Quality Standards at the end of pipe. A shaded cell indicates that the concentration in effluent was below the standard.

Table 10. End of Pipe - Large Ship Pollutant Medians that Do Not Meet Alaska Water Quality Standards

			Blackwater				Graywater			
Pollutant	Units	AWQS	2003	2002	2001	2000	2003	2002	2001	2000
Ammonia	mg/l	17.00	25.10	18.80		100.00				25.12
Free Chlorine	mg/l	0.0075							1.30	0.26
Fecal Coliform	MPN/100 ml	14.0				18,213		47,357	784,072	1,163,188
Copper, dissolved	ug/l	3.1	10.70	7.72	133.85	225.00		31.65	255	31.01
Nickel, dissolved	ug/l	8.2	12.60	16.70	20.50			12.70	15.0	
Zinc, dissolved	ug/l	81.0	109.5	195.5	169.5	425.0		262.0	270.0	

Note: Fecal coliform information is a geometric mean.

4.4. Pollutants that Exceed Alaska Water Quality Standards in Receiving Water

The Science Advisory Panel concluded in their November 2002 *The Impact of Cruise Ship Wastewater Discharge on Alaska Waters* report that even the wastewater discharged in 2000 from vessels moving at a minimum of 6 knots, 1 mile from shore, met Alaska Water Quality Standards in the receiving water.[39] For large ships, this is due to a minimum underway dilution factor of 50,000.[40]

ADEC therefore focused on the impact that cruise ship wastewater effluent has on the receiving waters during stationary discharge. ADEC modeled the dilution of large cruise ship effluent during stationary discharge during a very conservative scenario, a neap tide[41] in Skagway, using the EPA approved Visual Plumes model and information provided by operators in their Vessel Specific Sampling Plans. ADEC calculated a dilution factor for each ship's discharge. (More detailed information on the model used to calculate the dilution factor is included in Appendix D. Cruise Ship Stationary Discharge Modeling.) The lowest dilution factor calculated by the model was 8 for blackwater and 5 for graywater. The concentration of a pollutant in Table 10 was divided by these factors to arrive at the pollutant concentration that is expected in the receiving waters (Table 11). If the pollutant concentration met the Alaska Water Quality Standards in receiving water after applying the dilution factor, the cell is shaded.

Table 11. Modeled Large Ship Median Pollutant Concentrations in Receiving Waters during Stationary Discharge (Fecal coliform information is a geometric mean.)

			Blackwater				Graywater			
Pollutant	Units	AWQS	2003	2002	2001	2000	2003	2002	2001	2000
Free Chlorine	mg/l	0.0075							0.26	0.052
Fecal Coliform	MPN/100 ml	14.0				2,276.63		9,471	156,814	232,638
Copper, dissolved	ug/l	3.1			16.73	28.13		6.33	51.0	6.2

Of the many (176) pollutants that were tested in effluent during 2003, none are expected to exceed Alaska Water Quality Standards in the receiving water during stationary discharge.

4.5. Whole Effluent Toxicity Testing

Whole Effluent Toxicity (WET) testing is an alternative to directly analyzing environmental samples for individual constituents. WET testing addresses the effect that simultaneous exposure to a mixture of pollutants has on an organism.

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[39] Science Advisory Panel "The Impact of Cruise Ship Wastewater Discharge on Alaska Waters", November 2002 http://www.state.ak.us/dec/press/cruise/documents/impact/executivesummary.htm

[40] Large Cruise Ship Dilution factor = 4 x (ship width x ship draft x ship speed)/(volume discharge rate)4x (30 m x 8 m x 3.10 m sec-1)/(0.06 m3sec-1) = 50,000

[41] A tide of minimum range occurring at the first and the third quarters of the moon.

There are two ways to perform the WET test: static non-renewal and static renewal. In a static non-renewal test, organisms are exposed to a single portion of the solution for the duration of the test. In a static renewal test, organisms are exposed to fresh changes of the test water every day. This testing method is more conservative because the organisms are exposed to the effluent at the same strength for a longer time period. ADEC conducted WET testing using the static renewal method on commercial passenger vessels in 2002[42] and again in 2003.[43]

2002 Testing

This test was designed to simulate exposure to the concentration of pollutants that could be found in the receiving waters behind a moving cruise ship. Because of the high dilution rates associated with moving cruise ships, the dilution series started at 50% effluent and increased by a factor of 10 such that the percent effluent progressively decreased. The concentrations tested were 50%, 5%, 0.5%, 0.05%, 0.005%, and 0.0005% effluent. The dilution series represented concentrations that are attained in receiving waters with dilution factors (df) of 2, 20, 200, 2,000, 20,000, and 200,000. A typical large cruise ship discharging 200 cubic meters per hour while traveling at 6 knots (11 km/hour) would have a dilution factor of about 50,000.[44]

WET results are presented in Table 12. The percentages represent the highest effluent concentration at which the tests exhibited no observable acute or chronic effects. Values in parentheses show dilution factors associated with the no observed effect concentrations (NOEC).

Table 12. Large Ship 2002 No Observed Effect Concentration (NOEC) and Dilution Factor (df)

Vessel	Treatment System	Mysid Acute NOEC	Topsmelt Acute NOEC	Bivalve Larvae NOEC	Echinoderm Fertilization NOEC
Dawn Princess Graywater	Chlorine added to collection tanks	5% (df=20)	5% (df=20)	0.5% (df=200)	0.5% (df=200)
Mercury Mixed Effluent	Reverse Osmosis	50% (df=2)	50% (df=2)	50% (df=2)	50% (df=2)
Volendam Mixed Effluent	Aerated Membrane (Ultrafiltration)	50% (df=2)	5% (df=20)	5% (df=20)	5% (df=20)

The *Dawn Princess* graywater demonstrated some effect at 50% concentration (one part sea water to one part wastewater) in the acute test and some effect at 5% wastewater concentration in the chronic tests. This limited toxicity occurred despite the fact that no residual chlorine was found in the sample. However, the ammonia concentration was 10 mg/L. Samples from the *Mercury* did not demonstrate any toxicity, even at a 1:2 dilution. The *Volendam* sample

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[42] Science Advisory Panel "Review and Comment Regarding Whole Effluent Toxicity Test Results for Five Commercial Passenger Vessels in Alaska July 2002" http://www.state.ak.us/dec/press/cruise/documents/wetfinal.htm and "Lab results for Whole Effluent Toxicity test (WET) – August 2002" http://www.state.ak.us/dec/press/cruise/documents/wetreport.htm

[43] ADEC "2003 Whole Effluent Toxicity Results for Commercial Passenger Vessels in Alaska" http://www.state.ak.us/dec/press/cruise/documents/wet/2003%20Whole%20Effluent%20Toxicity%20(WET)%20Test%20Discussion.pdf

[44] The Panel has developed a formula for predicting dilution/dispersion in the wake of large cruise ships.
Dilution factor = 4 x (ship width x ship draft x ship speed)/(volume discharge rate)

demonstrated an effect at 50% for the Topsmelt acute test and on both chronic test species but had no effect on the Mysid acute test with as little as a 1:2 dilution.

The observed WET values would not be of concern during underway discharge because dilution factors of greater than 1:200 would be easily achieved in the receiving water. During 2002, *Dawn Princess* discharged its graywater underway a minimum one nautical mile from shore going at least 6 knots. The vessel held its blackwater until it was outside Alaska waters. As of 2003, this vessel mixes its accommodations graywater with its blackwater and then treats it through an advanced wastewater treatment system that meets the stringent standards for continuous discharge. (See Table 2.) Wastewater from the *Mercury* and *Volendam* continue to be discharged in port. *Mercury* effluent is diluted by a factor of 18 and *Volendam* effluent is diluted by a factor of 60, even during stationary discharge during a neap tide. (See Appendix D. Cruise Ship Stationary Discharge Modeling Table 4.) Therefore, the effluent from these three ships is not expected to cause toxicity to marine organisms.

<u>2003 Testing</u>

From the period of June through September 2003, ADEC conducted WET testing on the following large vessels: *Norwegian Wind, Sun Princess, Carnival Spirit,* and *Ryndam*. These ships represented all four of the advanced treatment systems operated on cruise ships in Alaska. These large vessels had obtained U.S. Coast Guard certification to discharge wastewater any time anywhere, including in port.

ADEC designed the 2003 WET test to determine if there are any negative effects to the marine environment during stationary discharges when dilution factor will be low. Therefore, the dilution series only increased by a factor of 2 instead of 10. The dilution series was 50%, 25%, 12.5%, 6.25%, 3.125%, and 1.5% effluent. This series represented concentrations that are attained in receiving waters with dilution factors (df) of 2, 4, 8, 16, 32, and 66.7.

ADEC calculated the ship specific dilution factors during a worst case scenario, a stationary discharge during a neap tide in Skagway, using the Visual Plumes model.[45] (See Appendix D. Cruise Ship Stationary Discharge Modeling.) When the ship specific dilution factor calculated by the Visual Plumes model is greater than the No Observed Effect Concentration dilution factor (df), no toxicity is expected.

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[45] ADEC used the Visual Plumes mode UM3 with the Brooks far field solution. For more information on this model go to http://www.epa.gov/ceampubl/swater/vplume/

Table 13. Large Ship 2003 Whole Effluent Toxicity Test Results & Ship Specific Dilution Factor during Neap Tide

No Observed Effect Concentration (NOEC) and Dilution Factor (df)

Vessel	Treatment System	Ship Specific Dilution Factor from Visual Plumes model	Mysid Acute NOEC	Topsmelt Acute NOEC	Bivalve Larvae NOEC		Echinoderm Fertilization NOEC
					Normality[46]	Survival	
Norwegian Wind Mixed Effluent	Scanship Bioreactor/ultra-filtration	24	>50% (df=2)	12.5% (df=8)	6.25% (df=16)	50% (df=2)	25% (df=4)
Ryndam Mixed Effluent	Aerated Membrane (Ultrafiltration)	60	>50% (df=2)	50% (df=2)	12.5% (df=8)	50% (df=2)	50% (df=2)
Sun Princess Mixed Effluent	Hamworthy Bioreactor and Ultrafiltration	15	12.5% (df=8)	12.5% (df=8)	<1.5%[47] (unknown)	50% (df=2)	<1.5% (unknown)
Spirit Graywater	Reverse Osmosis	5	>50% (df=2)	50% (df=2)	25% (df=4)	50% (df=2)	Unable to run[48]

These results indicate that **large ships' wastewater effluent will not cause toxicity in receiving waters, even during periods of minimal tidal flux**.

4.6. Summary of Large Ship Data 2000 – 2003

Wastewater production volumes depend primarily on the number of passengers and crew on a vessel. The volumes are also affected by ship waste management practices and configuration. The average large cruise ship with 2,300 people (including crew) produces 800 cubic meters or 211,200 gallons of wastewater per day. Between 90-95% of that wastewater is graywater.

Before the passage of the state cruise ship law, blackwater and/or graywater from large cruise ship samples taken at the end of pipe did not meet Alaska Water Quality Standards for ammonia, free chlorine, fecal coliform, copper, and zinc (Table 10). Wastewater effluent is diluted by a small factor during stationary discharge. If large ships discharged while stationary, the Water Quality Standards would have been exceeded for free chlorine, fecal coliform, and copper in the receiving water. However due to substantial dilution, all Alaska Water Quality Standards, except fecal coliform, were met in the receiving water while ships discharged underway.

[46] Normality measures the normal development of the bivalve larvae.
[47] S. propuratus gametes is not a bivalve but was substituted because the mussels and oysters would not spawn due to elevated summer temperatures.
[48] The organisms were not available when the sample arrived in September.

The state cruise ship law, effective in July 2001, allowed large cruise ships to seek interim protective measures that extended the time for compliance with the graywater standards until January 1, 2003.[49] All ships that discharged graywater in state water from 2000 through 2002 sought and were granted this extension. Under the interim protective measures, the ships could only discharge graywater while underway. In contrast, the blackwater discharged from large ships was subject to the state effluent standards in July 2001. This is the cause of the drastic difference in the effluent quality of the gray and blackwater until 2003 when the standards applied to both wastewater types.

In 2001, the data reflect that 21 of the 24 large ships stopped discharging blackwater into Alaska water. The fecal coliform levels in blackwater fall drastically because the two ships[50] that continued to discharge blackwater in Alaska waters had advanced wastewater treatment technology. The other ship[51] treated blackwater through a traditional macerator chlorination system. The graywater results, especially the galley water, continued to indicate poor effluent quality.

The 2000 and 2001 data also indicate that holding water in double bottom tanks for later discharge increases the concentration of fecal coliform, TSS, and BOD. It is possible that the double bottom tanks were contaminated with blackwater and that fecal coliform multiplied in the warm holding environment.

In 2002, the overall quality of the graywater was still poor. Seven ships[52] had advai[illegible]l wastewater treatment systems and discharged blackwater in Alaska. The blackwate[illegible]uality was dramatically better than the graywater but still had elevated levels of ammonia.

In 2003, the only large ships that discharged wastewater in Alaska had advanced wastewater treatment systems. Most of these systems treated blackwater but one system treated graywater. Most tested pollutants met Water Quality Standards at the end of pipe without dilution. Even considering the minimal dilution that occurs during stationary discharge during a neap tide, the concentration of tested pollutants met all Alaska Water Quality Standards in receiving water. (See Table 11.)

The quality of large cruise ship wastewater reflected the continued increase in the number of vessels that installed advanced treatment technology, from two of 24 (8%) in 2001 to seven of 25 (28%) in 2002 to eighteen[53] of 32 (56%) in 2003.

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[49] AS 46.03.465(c)

[50] Celebrity *Mercury* and Holland America *Statendam*

[51] Universe Explorer

[52] 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, Zaandam. The Radisson *Seven Seas Mariner* had an advanced system, but it was not approved for continuous discharge.

[53] 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

Risk Characterization

ADEC expects that only large cruise ships with advanced wastewater treatment systems will discharge wastewater in Alaska in the future. WET testing results and a comparison of sample results with Alaska Water Quality Standards indicate that the effluent from these advanced systems is not expected to cause toxicity to the marine environment. No human health risk is posed by the low concentration of tested pollutants found in wastewater samples.

The wastewater samples indicate that hazardous materials are not being discharged through these wastewater treatment systems.

5. WASTEWATER CHARACTERISTICS – SMALL SHIPS

5.1. Statistics

Since 2001, 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. 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:

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

5.2. Summary of Conventional Pollutant Data

There were only three small ship wastewater samples taken in 2000, too few to analyze. Only a short list of conventional pollutants was sampled during 2001. In 2002 and 2003, small ship wastewater samples were analyzed for the expanded list of conventional pollutants as well as for priority pollutants.

Small vessel conventional pollutant data taken in 2001 through 2003 is summarized according to wastewater effluent type in Table 14. Detailed sampling results from individual ships can be found in Appendix E: Small Ship Sampling Data.

Table 14. Small Ship Conventional Pollutants

The values for all pollutants, except fecal coliform, are medians. Fecal coliform information is represented as a geometric mean.

	Number of Samples	Ammonia total (as N)	pH	BOD5	COD	TSS	Total Chlorine Residual	Fecal Coliform	Free Chlorine Residual
Year Wastewater Type Small Ship Appendix E Table #		mg/l		mg/l	mg/l	mg/l	mg/l	MPN/100	Mg/l
MDL		0.03	0.10	2	3.0	1.3	0.10	2	0.10
AK WQS		17.00	6.5 – 8.5	n/a	n/a	n/a	0.0075*	14	0.0075*
2001 GW Table 30	25	1.03	7.5	212	525.0	49.6	ND	103	ND
2002 GW Table 16	11	0.31	7.2	175	400.0	54.1	0.65	222[54]	ND
2003 GW Table 1	23	0.46	7.3	199	330.0	55.6	0.70	48	ND
2001 BW Table 32	16	3.30	7.8	60	863.0	115.8	0.03	10,561	ND
2002 BW Table 20	12	16.15	7.5	137	805.5	133.0	ND	11,582	ND
2003 BW Table 5	21	11.50	7.9	39	625.0	87.1	ND	500	ND
2001 BW&GW Mixed Table 31	10	7.72	7.3	130	814.0	108.0	1.00	3,720	0.10
2002 BW&GW Mixed (Table 18)	17	16.80	7.5	154	835.0	77.0	0.25	5,487	1.10[55]
2003 BW&GW Mixed Table 3	18	29.[illegible]	7.0	346	545.0	128.5	ND	56,513	ND

*Note that the MDL for chlorine is higher than the chronic water quality standard.

MPN = Most Probable Number MDL = Method Detection Limit GW = Graywater BW = Blackwater

ND= Non Detect

[54] Results skewed by one result of 16,000,000.

[55] In several instances only free chlorine was tested. This resulted in higher medians for free than total chlorine.

	Number of Samples	Conductivity	Oil & Grease	Total Organic carbon	Alkalinity	Total Nitrate and Nitrite as N	Total Phosphorus	Total Kjeldahl Nitrogen	Total Settleable Solids
		umhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
MDL		1.0	1.5	1.0	0.5	1.0	0.01	1.0	0.1
WQS		n/a							
2002 GW (Table 17)	1	369	52.0	352.0	61.0	0.5	0.86	0.4	0.1
2003 GW (Table 2)	23	429	15.0	68.9	76.3	0.0	1.60	6.3	0.0
2002 BW (Table 21)	1	34,500	8.5	299.0	116.0	0.5	2.33	5.7	0.1
2003 BW (Table 6)	21	28,800	7.3	29.7	125.0	0.0	3.30	39.0	2.0
2002 BW&GW Mixed (Table 19)	4	29,750[56]	20.0	305.0	77.9	0.5	1.36	23.2	0.1
2003 BW&GW (Table 4)	18	17,900	62.0	158.5	204.5	0.0	3.50	35.0	2.4

MPN = Most Probable Number MDL = Method Detection Limit GW = Graywater BW = Blackwater
ND= Non Detect

Fecal coliform was at its lowest level in graywater and blackwater during 2003.

In the mixed black and graywater, there is a substantial increase in the concentration of fecal coliform from 3,720 MPN/100 ml in 2001 to 56,513 MPN/100 ml in 2003.

5.3. Pollutants in Effluent that Exceed Alaska Water Quality Standards

The medians of most pollutants in effluent were below Alaska Water Quality Standards. Table 15 draws from Table 14 for conventional pollutants and Appendix F. Summary of Small Ship Sampling for Priority Pollutants to highlight the pollutant medians that do not meet Alaska Water Quality Standards at the end of pipe. A shaded cell indicates that the concentration in the effluent was below the standard.

[56] Eight samples were analyzed for conductivity

Table 15. End of Pipe - Small Ship Pollutants Medians that Do Not Meet Alaska Water Quality Standards

			Graywater		Treated Blackwater		Treated Blackwater & Graywater Mixed	
Pollutant	Units	AWQS	2003	2002	2003	2002	2003	2002
Ammonia	mg/l	17.00					29.00	
Free Chlorine	mg/l	0.0075	ND	ND				1.10
Fecal Coliform	MPN/100 ml	14	48	222	500	11,582	56.513	5,487
Arsenic	ug/l	36.0			42.8	44.9		
Copper	ug/l	3.1	74.8	27.4	6.4	11.1	22.0	76.3
Nickel	ug/l	8.2			13.0	14.9	12.2	16.6
Selenium	ug/l	71.0			171.0	170.0	98.2	134.0
Zinc	ug/l	81.0	150.0	86.9			98.5	165.0

Note: Fecal coliform information is a geometric mean.

5.4. Pollutants that Exceed Alaska Water Quality Standards in Receiving Water

The Science Advisory Panel concluded in *The Impact of Cruise Ship Wastewater Discharge on Alaska Waters* report that the wastewater discharges from vessels moving at a minimum of 6 knots, 1 mile from shore, would meet Alaska Water Quality Standards in the receiving water.[57]

ADEC therefore focused on the impact that cruise ship wastewater effluent has on receiving waters during stationary discharge. ADEC modeled the dilution of small ship effluent during stationary discharge during a very conservative scenario, a neap tide[58] in Skagway, using the EPA approved Visual Plumes model and the information provided by operators in their Vessel Specific Sampling Plans. ADEC calculated a dilution factor for each ship's discharge. (More detailed information on the model used to calculate the dilution factor can be found in Appendix D Cruise Ship Stationary Discharge Modeling.) The lowest dilution factor calculated by the model was 1.5 for graywater, 38 for blackwater, and 8 for mixed wastewater. The concentration of a pollutant in Table 15 was divided by these factors to arrive at the pollutant concentration that is expected in the receiving waters (Table 16). If the predicted pollutant concentration met the Alaska Water Quality Standards in receiving water after applying the dilution factor, the cell is shaded.

[57] Science Advisory Panel "The Impact of Cruise Ship Wastewater Discharge on Alaska Waters," November 2002 http://www.state.ak.us/dec/press/cruise/documents/impact/executivesummary.htm

[58] A tide of minimum range occurring at the first and the third quarters of the moon.

Table 16. Modeled Small Ship Median Pollutant Concentrations in Receiving Waters during Stationary Discharge

			Graywater		Treated Blackwater		Mixed Blackwater & Graywater	
Pollutant	Units	AKWQS	2003	2002	2003	2002	2003	2002
Free Chlorine	mg/l	.0075						0.14
Fecal Coliform	MPN/100 ml	14	32	148		305	7,064	686
Copper	ug/l	3.1	49.8	18.3				9.5
Zinc	ug/l	81.0	100.0					

Note: Fecal coliform information is a geometric mean

In 2003, of all the pollutants that were tested (176), only three pollutants are expected to regularly exceed Water Quality Standards during stationary discharge.

5.5. Whole Effluent Toxicity Testing

Whole Effluent Toxicity (WET) testing is an alternative to directly analyzing environmental samples for individual constituents. WET testing addresses the effect that simultaneous exposure to a mixture of pollutants has on an organism.

There are two ways to perform the WET test: static non-renewal and static renewal. In a static non-renewal test, test organisms are exposed to a single portion of the solution for the duration of the test. In a static renewal test, test organisms are exposed to fresh changes of water every day for the duration of the test. Static renewal testing is more conservative because the test organisms are exposed to the effluent at the same strength for a longer time period. ADEC conducted WET testing using the static renewal method on commercial passenger vessels in 2002[59] and again in 2003.[60]

<u>2002</u>

This test was designed to simulate exposure to the concentration of pollutants that would likely be found in the receiving waters behind a moving ship. Because of the high dilution rates associated with moving ships, the dilution series started at 50% effluent and increased by a factor of 10 such that the percent effluent tested progressively decreased. The concentrations tested were 50%, 5%, 0.5%, 0.05%, 0.005%, and 0.0005% effluent. The dilution series represented

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[59] Science Advisory Panel "Review and Comment Regarding Whole Effluent Toxicity Test Results for Five Commercial Passenger Vessels in Alaska July 2002" http://www.state.ak.us/dec/press/cruise/documents/wetfinal.htm and "Lab results for Whole Effluent Toxicity test (WET) – August 2002" http://www.state.ak.us/dec/press/cruise/documents/wetreport.htm

[60] ADEC "2003 Whole Effluent Toxicity Results for Commercial Passenger Vessels in Alaska" http://www.state.ak.us/dec/press/cruise/documents/wet/2003%20Whole%20Effluent%20Toxicity%20(WET)%20Test%20Discussion.pdf

concentrations that are attained in receiving waters with dilution factors (df) of 2, 20, 200, 2,000, 20,000, and 200,000. For comparison, a small cruise ship with a width of 10 meters and a draft of 1 meter, discharging 0.4 cubic meters per hour (0.0001 cubic meters per second) while traveling at 6 knots (3.09 m/s) multiplied by the small ship factor of 3 would give a dilution factor of about 927,000.[61]

WET test results are presented in Table 17. The percentages represent the highest effluent concentration at which the tests exhibited no observable acute or chronic effects. Values in parentheses show dilution factors associated with the no observed effect concentrations (NOEC).

Table 17. Small Ship 2002 No Observed Effect Concentration (NOEC) and Dilution Factor (df)

Vessel	Treatment System	Mysid Acute NOEC	Topsmelt Acute NOEC	Bivalve Larvae NOEC	Echinoderm Fertilization NOEC
Kennicott Mixed Effluent	Macerator/ Chlorinator	5% (df=20)	5% (df=20)	5% (df=20)	0.5% (df=200)
Yorktown Clipper Blackwater	Macerator/ Chlorinator	50% (df=2)	50% (df=2)	50% (df=2)	50% (df=2)
Yorktown Clipper Graywater	Chlorine injection	0.5% (df=200)	0.5% (df=200)	0.5% (df=200)	0.05% (df=2,000)

The WET tests indicated that acute or chronic toxic effects on marine organisms are not expected to occur in receiving water when vessels discharge underway. However, the *Kennicott* mixed effluent could cause chronic effects (echinoderm fertilization) during stationary discharge, even when considering the ship specific dilution factor of 23 calculated by the Visual Plumes model. The *Yorktown Clipper* blackwater effluent would not cause toxicity even during stationary discharge. The *Yorktown Clipper* graywater effluent could cause both chronic and acute toxicity during stationary discharge, even when ship specific dilution factor of 1.5 is applied. (See Appendix D. Cruise Ship Stationary Discharge Modeling Table 5 for ship specific dilution factors.) The chronic toxicity of the *Kennicott* mixed effluent and the *Yorktown Clipper* graywater may be explained by the excessive chlorination of the effluent. Alaska's Water Quality Standard for total residual chlorine is 7.5 ug/l. The total residual chlorine in the *Kennicott* mixed effluent and the *Yorktown Clipper* graywater was 30,300 ug/l and 16,200 ug/l respectively.

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[61] The Science Panel has developed a formula for predicting dilution/dispersion in the wake of small cruise ships.
Dilution factor = 3 x (ship width x ship draft x ship speed)/(volume discharge rate);
http://www.state.ak.us/dec/press/cruise/documents/impact/dilutionwastewater.htm
The dilution factor is large for small ships compared to large ships because of the much smaller volume discharge rate.

2003

ADEC designed the 2003 WET test to determine the likelihood of negative effects to the marine environment during stationary discharges when dilution factor will be low. Therefore, the dilution series only increased by a factor of 2 instead of 10. The dilution series was 50%, 25%, 12.5%, 6.25%, 3.125%, and 1.5% effluent. This series represented concentrations that are attained in receiving waters with dilution factors of 2, 4, 8, 16, 32, and 66.7.

ADEC calculated the dilution factors during a worst case scenario, a stationary discharge during a neap tide in Skagway, using the Visual Plumes model.[62] (See Appendix D. Cruise Ship Stationary Discharge Modeling.) When the ship specific dilution factor calculated by the Visual Plumes model is greater than the No Observed Effect Concentration dilution factor (df), no toxicity is expected.

Table 18. Small Ship 2003 Whole Effluent Toxicity Test Results & Dilution Factor during Neap Tide

No Observed Effect Concentration (NOEC) and Dilution Factor (df)

Vessel	Treatment System	Ship Specific Dilution Factor from Visual Plumes model	Mysid Acute NOEC	Topsmelt Acute NOEC	Bivalve Larvae NOEC		Echinoderm Fertilization NOEC
					Normality[63]	Survival	
Spirit of Oceanus Mixed Effluent	BW Biological GW untreated	8	25% (df=4)	12.5% (df=8)	<1.5% (unknown)	12.5% (df=8)	<1.5% (unknown)
Spirit of Columbia Blackwater	Macerator/ Chlorinator	50[64]	>50% (df=2)	50% (df=2)	50% (df=2)	50% (df=2)	25% (df=4)
Spirit of Columbia Graywater	Untreated	2.5[65]	12.5% (df=8)	25% (df=4)	6.25% (df=16)	25% (df=4)	<1.5% (unknown)

On the *Spirit of Oceanus*, the blackwater is treated with a biological system and the graywater is untreated. The effluent is mixed before it is discharged. The mixed effluent is only expected to receive a dilution factor of 8 in the receiving water during stationary discharge. We do not expect the mixed effluent would cause acute toxicity even at this small dilution factor. The tests show that the effluent exhibits some chronic toxicity (bivalve larvae normality and echinoderm

[62] ADEC used the Visual Plumes mode UM3 with the Brooks far field solution. For more information on this model go to http://www.epa.gov/ceampubl/swater/vplume/

[63] Normality is the normal development of the bivalve larvae.

[64] *Spirit of Columbia*'s blackwater is discharged from a pump under the waterline, which increases dilution.

[65] *Spirit of Columbia*'s graywater is discharged directly from drains by means of gravity, which decreases dilution.

fertilization) at this dilution rate. However, in practice this vessel only discharges while underway when the effluent is expected to be diluted by a factor of approximately 100,000.[66] Therefore no toxicity to marine organisms is expected to result under normal operating procedures.

The *Spirit of Columbia* blackwater should not cause acute or chronic effects to marine organisms in receiving waters, even during stationary discharge.

The *Spirit of Columbia* graywater may cause acute and chronic effects on marine organisms while discharging in port. There is little dilution of its graywater because it is discharged above waterline. Graywater from this vessel is not expected to cause toxicity in receiving water during underway discharge because of the high dilution factor experienced while underway.

5.6. Summary of Small Ship Data 2001 – 2003

The state defines small ships as vessels that carry between 50 and 249 overnight passengers for hire. The average small cruise ship with 100 people (including crew) produces 9.5 cubic meters or 2,500 gallons of waste water per day. Of that amount 830 gallons is seawater used for toilets. There is roughly 16.7 gallons of graywater used per person or 1,670 gallons total.[67]

Small cruise ships and Alaska Marine Highway System (AMHS) ferries treat their blackwater with marine sanitation device (MSD). Some mix their blackwater and graywater together and then treat the wastewater through a MSD. Some vessels treat their graywater with chlorine before discharge while others discharge untreated graywater.

In 2001, small ships were only sampled for a short list of conventional pollutants. In 2002 and 2003, small ships sampled for the expanded list of conventional pollutants as well as for priority pollutants. Graywater effluent usually met the fecal coliform and total suspended solids effluent standards established by the state law. Blackwater and mixed black and graywater usually met the total suspended solids standards but exceeded the fecal coliform standard.

Risk Characterization

The wastewater samples indicate that hazardous chemicals are not being discharged through these wastewater systems. However, small ship effluent may not meet Alaska Water Quality Standards for free chlorine, fecal coliform, copper, and zinc in receiving water during stationary discharge.

The 2003 WET results were less toxic than those of 2002. In both years, the level of toxicity did not present a concern during underway discharge but graywater would, in all likelihood, cause marine toxicity during stationary discharge.

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[66] Dilution calculation for small ships Dilution factor = 3 x (ship width x ship draft x ship speed)/(volume discharge rate) =3 x (_____m x _____m x _____m sec^{-1})/(_____m^3sec^{-1}), the vessel's width is 15.3 m with a maximum draft of 4.15 m. ADEC assumed ship speed at 6 knots (3.09 m sec^{-1}) and the discharge rate of .0057 m^3sec^{-1}
Science Advisory Panel "The Impact of Cruise Ship Wastewater Discharge on Alaska Waters" November 2002, Section I located at http://www.state.ak.us/dec/press/cruise/documents/impact/dilutionwastewater.htm

[67] Figures taken from Wilderness Discoverer 2003 VSSP. Small ship water production varies with ship capacity and configuration.

During stationary discharge, small ship effluent may pose a risk to human health in areas where aquatic life is harvested for raw consumption due to the high concentration of fecal coliform.

6. EVALUATION OF WASTEWATER TREATMENT TECHNOLOGY

6.1. TRADITIONAL TREATMENT SYSTEMS

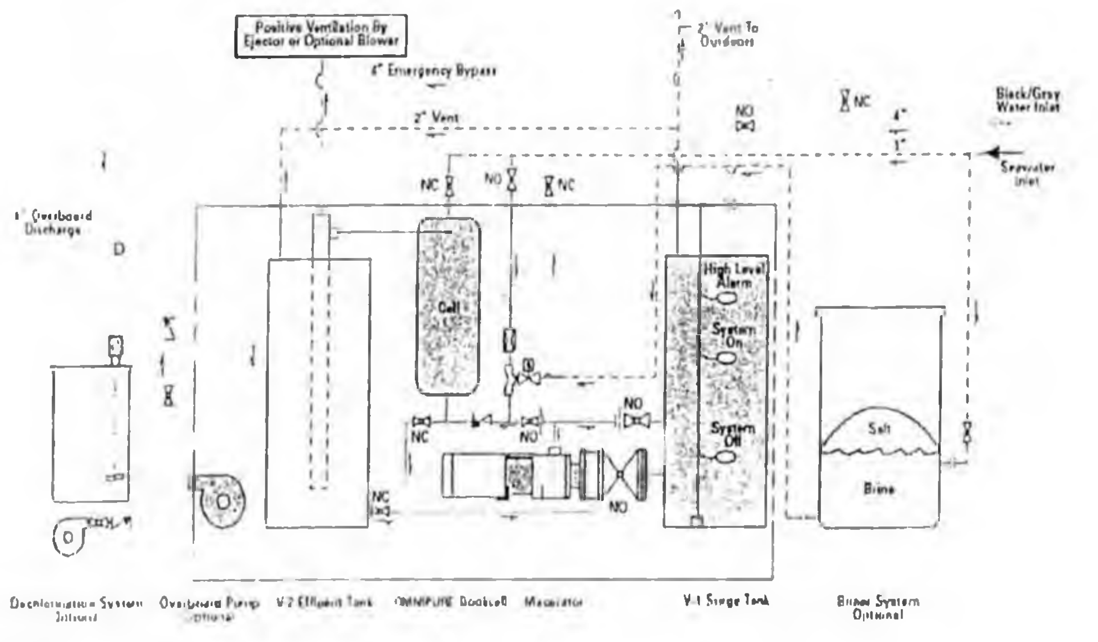
Prior to 2001, vessels used one of two marine sanitation devices (MSDs) to treat sewage on ships: maceration-chlorination or biological-chemical disinfection systems.

Maceration-chlorination systems

Maceration-chlorination systems are installed on most of the small cruise ships and ferries that ply Alaska waters.[68] This system reduces bio-solids through maceration, internal dilution, oxidation, and chlorine disinfection. The macerator pump breaks up solids in the sewage influent to a maximum particle size of 1.5 mm. The wastewater is then mixed with ambient seawater and passed between charged cell plates where a number of reactions occur simultaneously. The reactions cause the electrolytic breakdown of organic molecules. The electrocatalytic process also produces sodium hypochlorite from the salt in the seawater. This disinfectant continues to oxidize the waste stream in a contact tank with a 90-95% oxidation rate that kills total bacterial within minutes.[69] The treated water remains in the contact tank, usually for a minimum of 30 minutes. In low salt brackish water, some operators add chlorine to the tank to ensure disinfection is complete or add salt to the waste stream. Material that is not oxidized (i.e. cellulose) is returned for further treatment. No sludge is produced. Gases produced from reactions are mixed with ambient air and exhausted. (Figure 3.)

Figure 3. Maceration-Chlorination System

Engineering Flow Diagram



[68] ADEC, 2003 Small Commercial Passenger Vessel Wastewater Treatment Table, http://www.state.ak.us/dec/press/cruise/documents/2003smallshiptable.htm
[69] Information from Exceltech website http://www.21mainstreet.com/alpha/exceltec.asp

Maceration-chlorination systems often produce effluent that does not meet the Alaska commercial passenger vessel fecal coliform standard. (See Section 4 "Wastewater Characteristics - Small Ships.") Another disadvantage of this system is that operators tend to chlorinate in excess of the manufacturer's recommendations in order to meet this standard. Marine life is very sensitive to chlorine. The chlorine concentration in ambient water must be less than 7.5 ug/l to protect aquatic life.[70] Whole Effluent Toxicity (WET) Testing conducted in July 2002 demonstrated that chlorine level in wastewater effluent can be toxic to marine life.[71]

Alaska Marine Highway System (AMHS) ferries present an interesting case study on the importance of properly operating maceration-chlorination systems as well as sampling in the proper location in the treatment cycle. In April 2002, AMHS engineers discovered that their wastewater had been sampled before it had sufficient chlorine contact time, and subsequently began sampling in the correct location. This explains the high geometric mean of fecal coliform in samples taken prior to May 1, 2002 (4,212 MPN/100 ml) versus those samples taken during the remainder of 2002 (94 MPN/100 ml).[72] (See Table 19.) Samples taken from May through December 2002 also had lower chemical oxygen demand (COD) and total suspended solids (TSS) and higher chlorine residual.

In 2003 however, wastewater samples had the highest level of fecal coliform and lowest level of chlorine of all three years. ADEC audited the samplers during a July 29, 2003 sampling event. The sampler took the sample 15 minutes into the pumping cycle and the fecal coliform result was 11,000 MPN/100 ml. This seems to suggest that the timing of the sample did not make any difference as was suggested comparing the 2001 with the 2002 data. The AMHS information indicates that maceration-chlorination treatment systems are sensitive devices that produce variable results depending upon operation. However, the 2002 data demonstrated that maceration-chlorination systems can achieve fecal coliform levels that are in compliance with the state cruise ship law.

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[70] ADEC Saltwater Aquatic Life Criteria Comparison
http://www.state.ak.us/dec/dawq/wqs/documents/saltwateraquatichlfecriteria.htm

[71] The Science Panel interpretation of the WET test is located at http://www.state.ak.us/dec/press/cruise/documents/wetfinal.htm The laboratory results for the WET test are located at http://www.state.ak.us/dec/press/cruise/documents/wetreport.htm.

[72] This number is different than the number in Section 9 of "The Impact of Cruise Ship Wastewater Discharge on Alaska Waters" November 2002 by Science Advisory Panel. ADEC wrote Section 9 with all sampling data received by September 30, 2002. This report includes additional data points for 2002.

Table 19. Alaska Marine Highway System Samples

All values are medians except fecal coliform which is expressed as a geometric me...

Date (Table in Appendix E)	Number of Samples	Total Ammonia as N	BOD 5-Day	COD	Fecal coliform	Free chlorine	pH	Total chlorine	TSS
		mg/L	mg/L	mg/L	MPN/100 ml	mg/L		mg/L	mg/L
	MDL	0.03	2.0	3.0	2	0.10	0.1	0.10	1.3
January 2001 - April 2002 (Table 38)	8	7.61	99	765.0	4,212	0.55	7.5	1.10	89.4
May 2002 - December 2002 (Table 37)	10	9.50	102	557.0	94	2.25	7.5	1.78	64.8
January – December 2003 (Table 36)	9	11.00	185	365.0	13,990	0.00	7.2	0.00	99.2

Biological And Chemical Disinfecting Systems

Marine biological treatment systems are similar to land based municipal treatment systems. A marine biological treatment system has three steps: (1) aeration; (2) clarification & filtration; and (3) final chemical disinfecting.[73] All sludge is re-circulated to the activated sludge aeration section.[74]

The raw sewage passes through a screen, which removes grit, then enters the marine sanitation devic ISD) aeration chamber. The raw sewage mixes with a large concentration of active aerobic bacteria that consume the organic waste in the sewage. The chamber contains air diffusers that provide oxygen to keep the aerobic bacteria healthy.

The wastewater flows from the aeration chamber into the clarification and filtration chambers. The filter media removes larger pieces of organic waste not consumed by bacteria in the aeration chamber. The aerobic bacteria also consume the biomass on the filter. After clarification and filtration, wastewater flows into the chlorine contact chamber. The wastewater stays in this chamber until virtually all bacteria are killed resulting in a chlorine residual of 1 – 2 mg/l (ppm).

Unlike a land based biological system, marine systems process a concentrated blackwater stream without dilution from graywater or storm water. Biological systems thrive on a constant, even flow of nutrients and constant pH. This constant flow is difficult to achieve since the demand on a ship's treatment system is intermittent with periods of low or no flow.

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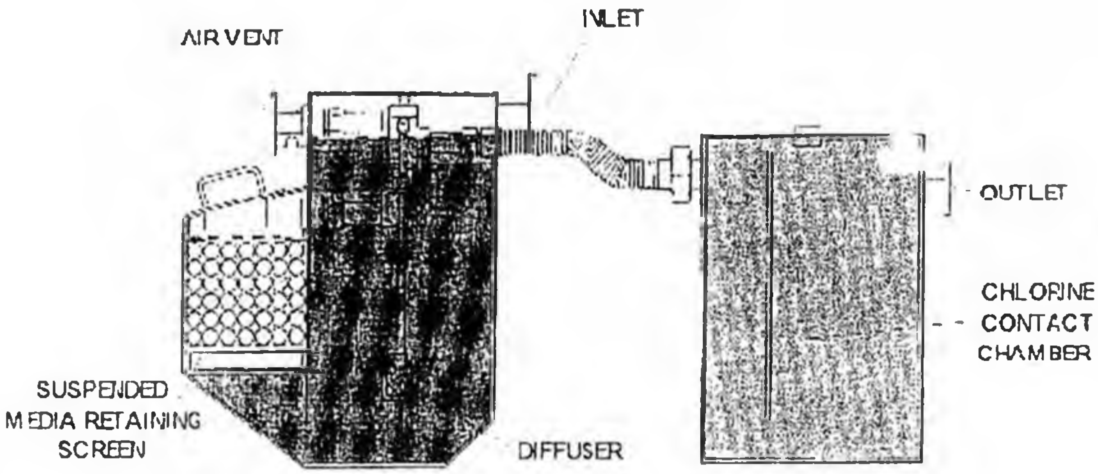
[73] Fox-Pac MSD home page http://www.redfoxenviro.com/foxpacmarinemsd.html
[74] Waste treatment systems: http://www.hamworthykse.com/docGallery/29.PDF

Figure 4. Biological and Chemical Disinfection System[75]



6.2. Advanced Treatment Systems

The fecal coliform and total suspended solids standards in the state and federal cruise ship laws have prompted large ships to either install advanced treatment systems that meet secondary treatment standards or to hold all of their wastewater for discharge outside of Alaska. Large cruise ship operators have evaluated several advanced wastewater treatment designs. These include chemical treatment and mechanical decanting; activated oxidation and oxidant disinfection; reverse osmosis filtration, and bio-reactor/filtration. The overall value and efficiency of each system, which includes evaluation of the installation cost, maintenance, operator training and monitoring, continues to be a subject of research by the cruise lines.

Generally, cruise ships using advanced technology have combined enhanced aerobic digestion with filtration to clean shipboard wastewater. These treatment systems do not use chlorine in the normal treatment process; however, some ships may use chlorine to control fecal re-growth that occurs in the discharge piping.

These treatment systems all produce solid sludge, which is discharged 12 miles from shore, incinerated, or offloaded it to land based disposal sites.

<u>Chemical treatment and mechanical decanting</u>

This system uses chemical treatment and a mechanical decanter, followed up by a UV purifier. The design is used successfully in shore-based applications and showed promise in large-scale laboratory tests. However, the pilot program on a cruise ship indicated that modifications were necessary for a fully operational treatment system.[76] No additional information is available to ADEC on this system.

[75] Fox-Pac MSD home page http://www.redfoxenviro.com/foxpacmarinemsd.html
[76] From a wastewater technology paper prepared by David Eley for the Governor's Briefing Papers and Alaska Regional Response Team updated June 2002. For more information contact Mr. Eley at 907-586-2685 or capedee@alaska.com

Activated Oxidation Process

This treatment process is currently operated on ten small ferries in British Columbia.[77] It has four major components: (1) a primary screening system, (2) a primary solids separation and oxidizing system, (3) a secondary oxidation tank, and (4) oxidant generation equipment, which eliminate the need for chlorine disinfection. Ozone disinfection presents fewer known environmental and health effects than chlorine and its byproducts.[78] It is more effective than chlorine at killing bacteria and viruses. In addition, ozone is unstable in the environment and decomposes to oxygen in a short period of time.[79]

An enhanced system with a biological oxidation component has been installed on Royal Caribbean's *Vision of the Seas*.[80] A polymer is also added to the preliminary stage to cause the solids to clump together and for a sludge "mat". The process removes the mat before the effluent enters the treatment system.[81] The treatment system is comprised of six main system components: (1) primary solids separation/oxidation tank; (2) bioreactors (Hydroxyl-F³R); (3) secondary solids separation; (4) oxidation/disinfection tank; (5) controls and oxidant generation equipment; and (6) sludge dewatering and drying equipment.

The sludge is dewatered and incineration onboard or offloaded to shore. No discharge at sea is necessary. The system manufacturer is conducting tests on the *Vision of the Seas* to ensure that it meets U. S. Coast Guard discharge standards for stationary discharge in Alaska. ADEC has not yet received wastewater effluent data from this system.

Reverse Osmosis Filtration

Osmotic theory dictates that pure water will move across a semi-permeable membrane into wastewater until the contaminant concentrations of both liquids are equal. However, if external pressure is exerted on the contaminant solution, water will flow in the reverse direction from the wastewater into the pure water. This phenomenon is known as reverse osmosis (RO). Reverse osmosis treatment systems have been installed on two ships[82] operating in Alaska. Both systems use ultraviolet (UV) disinfection after the RO unit and were approved by the U.S. Coast Guard for stationary discharge during 2003. The effluent from both systems has a slightly low pH which requires some buffering. *Mercury's* treatment system includes a final run through activated charcoal canisters before discharge. The sample points are both ships are less than 50 feet from the overboard discharge point.

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[77] Hydroxyl Systems B.C Ferry Services Inc. case study website: http://www.hydroxyl.com/marine/index.html
[78] EPA/625/1-86/021 EPA Design Manual Municipal Wastewater Disinfection
[79] EPA 832F99063, EPA Ozone Fact Sheet, September 1999 http://www.epa.gov/npdes/pubs/ozon.pdf
[80] Hydroxyl Systems *Vision of the Seas* case study website: http://www.hydroxyl.com/marine/index.html
[81] Hydroxyl system described on website http://www.hydroxyl.com/index.html
[82] Celebrity *Mercury* blackwater and Carnival *Spirit* graywater

Table 20. Samples Taken after RO/UV Treatment Unit (2003)

	pH	BOD5	TSS	total chlorine residual	free chlorine residual	fecal coliform
Number of Samples = 21		mg/L	mg/L	Mg/L	mg/L	MPN/100
Minimum	6.6	0	0.0	0.00	0.00	0
Median	7.3	15	0.0	0.00	0.00	0
Maximum	9.1	27	0.0	0.00	0.00	4

Large Ship Sampling Data Appendix B, Table 5

Bio-reactor/filtration

These units employ an integrated system of enhanced aerobic digestion and low-pressure membrane filtration to treat blackwater and graywater. Currently, sixteen large cruise ships operating in Alaska have installed this process using Zenon, Scanship, or Hamworthy systems.[83]

After only a brief holding period in the bio-reactor, the Zenon system passes the influent through membrane filtration modules that have very large surface area and an extremely small pore size (0.035 micron or 0.035 X 10^{-6} meters).[84] Wastewater then passes through a UV disinfection unit. Samples are taken immediately after the UV unit. The distance from the UV unit to the discharge point varies from vessel to vessel.

Table 21. Zenon/UV Treatment System (2003)[85]

Number of Samples = 24	pH	BOD5	TSS	Total Chlorine Residual	Free Chlorine Residual	Fecal Coliform
Units		Mg/L	mg/L	mg/L	mg/L	MPN/100
Minimum	7.2	0	0.0	0.00	0.00	0
Median	7.6	0	0.0	0.00	0.00	0
Maximum	8.4	5	0.0	0.00	0.00	0

Large Ship Sampling Data Appendix B, Table 6

The Scanship system relies more heavily on biological digestion. This unit enhances the capacity and effectiveness of the bio-reactor with plastic carrier elements (biofilm) suspended in the wastewater to increase reactor surface area with eventual polishing microfiltration and UV

[83] ADEC, 2003 Large Commercial Passenger Vessels Discharge Status and Wastewater Treatment, http://www.state.ak.us/dec/press/cruise/documents/2003largeshipswwtable.htm

[84] From a wastewater technology paper prepared by David Eley for the Governor's Briefing Papers and Alaska Regional Response Team, updated June 2002 and discussions with Rick Softye former VP of Holland America. For more information contact Mr. Eley at 907-586-2685 or capedec@alaska.com

[85] Holland America *Maasdam, Ryndam, Statendam, Veendam, Volendam,* and *Zaandam*

disinfection.[86] At the beginning of the season, samples were taken after the UV. By mid-season, the samples were taken at the end of the discharge line before the overboard port.

Table 22. Scanship/UV (2003)[87]

Number of Samples = 18	pH	BOD5	TSS	Total Chlorine Residual	Free Chlorine Residual	Fecal Coliform
Units		mg/L	mg/L	mg/L	mg/L	MPN/100
Minimum	6.3	5	0.0	0.00	0.00	0
Median	6.9	11	7.0	0.00	0.00	0
Maximum	7.6	26	28 6	0.00	0.00	240

Large Ship Sampling Data Appendix B, Table 7

In a Hamworthy system, wastewater is passed through an aerobic biological treatment system and ultrafiltration units. It is then chlorinated to kill remaining bacteria. The chlorine levels in the effluent were occasionally over the 10 mg/l limit for continuous discharge allowed by the U.S. Coast Guard and the Alaska Water Quality Standard of 7.5 ug/l. Princess has installed UV on two of their ships with the Hamworthy system and is considering substituting UV for chlorine disinfection on all ships in the future. Samples of this system were taken on the discharge line near the overboard port. Some samples indicated that there was fecal contamination within the discharge line.

Hamworthy (2003)[88]

Number of Samples = 53	pH	BOD5	TSS	Total Chlorine Residual	Free Chlorine Residual	Fecal Coliform
Units		mg/L	mg/L	mg/L	mg/L	MPN/100
Minimum	6.6	0	0.0	0.00	0.00	0
Median	7.3	2	0.0	0.00	0.00	0
Maximum	8.1	86	19.1	55.00	50.00	220

Large Ship Sampling Data Appendix B, Table 8

All four of the treatment systems listed above regularly satisfy the requirements necessary to maintain U.S. Coast Guard continuous discharge certification. (See Table 2.)

[86] Scanship Environmental website: http://www.scanship.no/
[87] Norwegian *Sky*, *Sun*, and *Wind*
[88] Princess *Dawn*, *Island*, *Pacific*, *Star* and *Sun*; Radisson *Seven Seas Mariner*

Table 23. Comparison of Advanced Treatment System Medians

Number of Samples = 58	pH	BOD5	TSS	Total Chlorine Residual	Free Chlorine Residual	Fecal Coliform
Units		mg/L	mg/L	mg/L	mg/L	MPN/100
RO (21)	7.28	14.9	0.0	0.00	0.00	0
Zenon (24)	7.64	0.0	0.0	0.00	0.00	0
Scanship (18)	6.94	10.9	7.0	0.00	0.00	0
Hamworthy (58)	7.33	2.2	0.0	0.00	0.00	0

Sample data demonstrated that fecal coliform contamination of the effluent sometimes occurred in the discharge pipe. The probability of fecal contamination increased as the pipe length increased. ADEC will therefore require that samples be taken within 50 feet of the overboard discharge location in the future.

7. RISK CHARACTERIZATION

7.1. Toxicological Profile of Detected Pollutants

Sections 3 and 4 discuss the large ship and small ship wastewater data. Table 11 and Table 16 list the pollutants that exceed water quality standards in receiving water. This section will discuss those pollutants in greater detail.

CONVENTIONAL POLLUTANTS

Ammonia

Ammonia is present in two forms in saltwater: un-ionized ammonia (NH_3) and the ammonium ion (NH_4+). The un-ionized ammonia form has been demonstrated to be the more toxic form of ammonia.[89] Ammonia affects the life cycle as well as survival of some species.[90] Water quality parameters, particularly pH and temperature, but also salinity, affect the proportion of un-ionized ammonia.

Ammonia at concentrations slightly less than those chronically toxic to animals may stimulate growth and reduce reproduction of a red macroalgal species.[91]

Ammonia has a strong and suffocating odor. Ammonia's short term human health effects include lung irritation, causing coughing and/or shortness of breath. Higher exposures cause fluid buildup in the lungs (pulmonary edema), which can cause death. In addition, ammonia is a corrosive chemical, which can severely burn the eyes and skin. Repeated exposure to ammonia can cause chronic irritation of the eyes, nose, mouth, and throat.

Chlorine

Free residual chlorine is described as the portion of the chlorine injected into water that remains as molecular chlorine, hypochlorous acid, or hypochlorite ions after the solution has reached a state of equilibrium. Combined residual chlorine is described as the portion of chlorine injected into water that remains combined with ammonia or nitrogenous compounds after the equilibrium has been reached. Both free and residual chlorine have a very short half-life in marine waters, therefore, it is difficult to assess the effects of chlorine on aquatic life.[92] ADEC saltwater criteria for chlorine are 13 μg/L (acute criterion) and 7.5 μg/L (chronic criterion).[93]

In humans, ingestion of large doses of chlorine may cause gastrointestinal irritation, including vomiting and nausea. If dehydration occurs, body temperature increases and circulatory and central nervous system damage may result. Exposure of the eyes to sodium chl[illegible] le may cause

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[89] EPA 440/5-88-004 Ambient Aquatic Life Water Quality Criteria page 7

[90] Details of the testing results is located in EPA 440/5-88-004 located at http://www.epa.gov/waterscience/pc/ambientwqc/ammoniasalt1989.pdf

[91] EPA 1989, Ambient Water Quality Criteria for Ammonia (Saltwater)-1989, EPA Office of Water, Regulations and Standards Division, Washington DC. EPA 440/5-88-004

[92] EPA January 1985, Ambient Water Quality Criteria for Chlorine, Office of Water, EPA 440/5-84-030

[93] ADEC, Alaska Water Quality Criteria Manual for Toxic and other Deleterious Organic & Inorganic Substances, May 15, 2003, Table IV or V available at http://www.state.ak.us/local/akpages/ENV.CONSERV/dawq/wqs/pdf/70wqsmanual.pdf

stinging while exposure to other forms of chlorine, including free and residual chlorine, may cause stinging or irritation of the skin.

Fecal Coliform

Bacteria water quality standards are set to protect human health from diseases associated with water that has been contaminated with feces. The presence of fecal coliforms usually indicates the presence of pathogens. Shellfish concentrate fecal coliform bacteria and other pathogens that may be present with coliform bacteria. Shellfish beds are closed to harvesting when the geometric mean of fecal coliform bacteria exceeds 14 colonies per 100 milliliters of water. While most fecal coliform bacteria are harmless to humans, exposure to some may cause short-term adverse effects, including rash, ear infections, gastrointestinal pain, nausea, diarrhea, vomiting, and fever.[94]

PRIORITY POLLUTANTS

Copper

Copper is highly toxic in aquatic environments. Copper will bio-concentrate in many different organs in fish and mollusks. Copper is an effective algaecide. Free ions of copper are the lethal agent. Single cell and filamentous algae and cyanobacteria are more susceptible to the acute effects, which include reductions in photosynthesis and growth, loss of photosynthetic pigments, disruption of potassium regulation, and mortality. Mammals are not as sensitive to copper as are other aquatic organisms. The predominant mammalian effects include hepatic and renal toxicity, and fetal mortality.[95] However, high doses are usually required to elicit these effects in mammals.

Alaska has a water quality standard of 3.1 µg/L dissolved copper in saltwater based on chronic effects to aquatic life.

Low levels of copper are essential for humans. Exposure to high levels of copper may cause mouth and eye irritation and may induce vomiting, nausea, and intestinal pain.[96]

Zinc

Zinc is very soluble in water and is almost never found free in nature. It is one of the most mobile of the heavy metals. Most of the zinc introduced into the aquatic environment is partitioned into the sediments by sorption onto hydrous iron, manganese oxides, clay, and organic materials.[97] Variables affecting the mobility of zinc include the concentration and composition of suspended and bed sediments, dissolved and particulate iron and manganese concentrations, pH, salinity, concentration of ions or molecules that bind to transition-metal ions, and the concentration of zinc.

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[94] Washington State Department of Ecology, March 2002, *Focus: Fecal coliform bacteria and Washington's water quality standards*, Publication No. 02-10-010

[95] EPA, 2002a. National Recommended Water Quality Criteria – Correction, EPA Office of Water, Washington, DC. EPA 822-Z-99-001

[96] Agency for Toxic Substances and Disease Registry (ATSDR), United States Department of Health and Human Services, Center for Disease Control, September 2002, ToxFAQs for Copper.

[97] EPA 440/5-87-003 EPA Ambient Water Quality Criteria for Zinc February 1987.

Most organisms need some minimum concentration of zinc to function properly. Toxicity of zinc to an organism depends on feeding habits. Plants and most fish would not be adversely affected, but many invertebrates could be affected by ingestion of sufficient quality of particulates containing zinc. The toxicity of zinc, as well as other metals, is reported to be influenced by a number of chemical factors including cadmium, magnesium, hardness, pH, and ionic strength. These factors appear to affect the toxicity of zinc by influencing the proportion of available zinc or by inhibiting the sorption or binding available by biological tissues. Alaska has a water quality standard of 81.0 µg/L of dissolved zinc in saltwater based on chronic effects to aquatic life.

As with copper, zinc is an essential element in humans at low doses. Human ingestion of zinc is generally not a concern. The Recommended Daily Allowances for adults is 15 mg/day.[98]

7.2. Cumulative Impact

Large Ships

Since the passage of the Alaska cruise ship laws, large cruise ships installed advanced wastewater treatment systems that meet the stringent U.S. Coast Guard requirements for continuous discharge. The quality of the wastewater on large ships has therefore improved dramatically. During 2003, all the large cruise ships that discharged wastewater in Alaska had these advanced systems. Ships that did not have advanced systems discharged outside 3 nautical miles. The 2003 data is the most representative of the wastewater quality that ADEC expects in the future. Therefore, we will focus on the risks presented by the 2003 data.

In 2003, ships were sampled for 16 conventional pollutants and 160 priority pollutants. **The vast majority of these pollutants were not detected.** Only ammonia, copper, nickel, and zinc did not regularly meet Alaska Water Quality Standards at the end of pipe (Table 10).

The Science Advisory Panel concluded in *The Impact of Cruise Ship Wastewater Discharge on Alaska Waters* that effluent from a typical large ship will be diluted by a factor of at least 50,000 during underway discharge.[99] By applying this dilution factor, the concentration of all pollutants would meet Alaska Water Quality Standards in the receiving water during underway discharge.

ADEC was concerned about the impacts on the receiving water caused by stationary wastewater discharge. In order to address this issue, ADEC calculated the dilution factor during stationary discharge for each large ship during a worst case scenario. (See Appendix D Cruise Ship Stationary Discharge Modeling for more information.) The lowest dilution value for each effluent type was then used to calculate the anticipated concentration of each pollutant in receiving water during stationary discharge (Table 11). After applying the dilution factor, no tested pollutant would exceed Water Quality Standards.

Whole Effluent Toxicity (WET) testing was done in 2003 on 4 of the 18 large ships that discharged in Alaska. Test results indicate that **wastewater effluent from large ships with advanced wastewater treatment systems does not pose a risk to aquatic organisms, even**

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[98] EPA 440/5-80-079 October 1980 Ambient Water Quality Criteria for Zinc.

[99] Science Advisory Panel "The Impact of Cruise Ship Wastewater Discharge on Alaska Waters." November 2002 http://www.state.ak.us/dec/press/cruise/documents/impactdilutionwastewater.htm

during stationary discharges. ADEC will continue WET testing on the advanced wastewater treatment systems during 2004. This test gives insight into the wastewater's effect on marine organisms. This test indicates that exceedances of ammonia, copper, nickel and zinc Water Quality Standards at the end of pipe are not harming aquatic life.

None of the pollutants mentioned above are present in concentrations should cause risks to human health.

Small Ships

ADEC reviewed data collected from small commercial passenger vessels from 2001 through 2003. These ships have not installed new wastewater treatment systems on their vessels and the effluent quality has remained relatively consistent.

During the evolution of the sampling protocol, pollutants have been added and deleted as appropriate. In 2003, ships were sampled for 16 conventional pollutants and 160 priority pollutants. **The vast majority of these pollutants were not detected**. The eight (8) pollutants that did not regularly meet Alaska Water Quality Standards at the end of pipe are included in Table 15.

The Science Advisory Panel concluded that the dilution factor caused by the underway discharge by a small ship would be based on the width, draft, and speed of the vessel divided by the discharge rate and multiplied by a factor of 3.[100] With the aid of this dilution, we would expect all pollutants to meet Alaska Water Quality Standards during underway discharge.

ADEC was concerned about the impacts on the receiving water caused by stationary wastewater discharge. In order to address this issue, ADEC calculated the dilution factor caused by stationary discharge for each small ship during a worst case scenario. (See Appendix D Cruise Ship Stationary Discharge Modeling for more information.) The lowest dilution value for each effluent type was then used to calculate the expected concentration of each pollutant in receiving water during stationary discharge (Table 16). Even with the benefit of dilution, we predict the stationary discharge of wastewater from small ships contain concentrations of free chlorine, fecal coliform, copper, and zinc that exceed Alaska Water Quality Standards.

The marine environment is very sensitive to the concentrations of free chlorine. In fact the water quality standards are below the methods of detection for chlorine. The concentration of chlorine in mixed blackwater and graywater during 2002 was found in excess of 100 times the Alaska Water Quality Standards. The predicted concentration of chlorine from this discharge was 10 times the standard in receiving water and therefore did pose a risk to aquatic life during stationary discharges.

The fecal coliform concentrations in receiving water indicate that it is important for these ships to avoid anchoring in areas used for shellfish aquaculture or areas frequently used for subsistence and recreational shellfish harvesting. Most of the shellfish farms in Southeast Alaska are located between Ketchikan and Petersburg. ADEC evaluated the small ship routes and the location of

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[100] The Science Panel has developed a formula for predicting dilution/dispersion in the wake of small cruise ships.
Dilution factor = 3 x (ship width x ship draft x ship speed)/(volume discharge rate);
http://www.state.ak.us/dec/press/cruise/documents/impact/dilutionwastewater.htm

registered commercial shell fish beds and found that small ships do not currently moor or dock near these sites.

Copper is highly toxic in aquatic environments. This toxicity is reflected in the low Alaska Water Quality Standard of 3.1 µg/L dissolved copper in saltwater. The predicted concentration of copper in receiving water during small ship stationary discharge can be as high as 10 times this standard and therefore does pose a likely risk to aquatic life.

Most organisms need a minimum concentration of zinc to function properly. Alaska has a water quality standard of 81.0 µg/L for dissolved zinc in saltwater based on chronic effects to aquatic life. In 2003, the level of dissolved zinc found in receiving water during graywater discharge slightly exceeds Water Quality Standards, and therefore poses some risk to aquatic life.

The Whole Effluent Toxicity (WET) testing done in 2002 and 2003 in conjunction with the information above indicates that **the wastewater effluent from small ships poses some risk to the marine environment during stationary discharges.**

The concentration of fecal coliform in the effluent during stationary discharge would pose a risk to human health in areas where aquatic life is harvested for raw consumption.

7.3. Comparison to other Marine Discharges

Cruise ship's wastewater systems can be compared to municipal treatment systems that serve small Alaskan cities. Cruise ships are excluded from obtaining permits under the Clean Water Act. However, their marine sanitation devices (MSDs) must meet effluent standards set in Section 312. This section set the Type II MSD standards for blackwater at 200 fecal coliform/100 ml and 150 mg/L total suspended solids (TSS). In Alaska, cruise ships must also adhere to state and federal wastewater effluent standards and discharge conditions (Table 2).

Municipalities must obtain permits under the Clean Water Act before discharging wastewater. The Act uses both water quality effluent standards and technology based limits to protect water quality [iii] It has been termed a technology-forcing statute because of the rigorous demands placed on the regulated community to improve effluent quality through treatment technology. The Act required municipalities to upgrade systems to secondary treatment, (85% removal of biological oxygen demand (BOD) and total suspended solids (TSS)), by July 1, 1988. Eighty-six percent (86%) of municipalities met that date. Cities that discharged wastes into the marine environment were eligible for case-by-case EPA waivers of the secondary treatment requirement. These waivers, referred to as 301(h) waivers, require 30% removal of BOD and TSS. In order to be eligible for these waivers, natural factors such as tides and currents must provide significant elimination of traditional forms of pollution, protect shell fish, fish, and other aquatic life, and comply with water quality standards. Waivers were only granted, with certain exceptions, if a waiver application was filed by December 29, 1982.

Juneau and most other Alaskan cities adhere to secondary treatment standards and have limits that do not allow the exceedance of a monthly geometric mean of 200 fecal coliforms per 100 ml if chlorine is used for disinfection and a monthly geometric mean of 400 fecal coliform bacteria if ultraviolet light is used for disinfection. However, many communities in Southeast Alaska including the popular cruise ship ports of Ketchikan, Skagway, and Sitka have waivers from

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[iii] Copeland, Claudia. CRS Report for Congress, Clean Water Act, A Summary of the Law, January 20, 1999

secondary treatment. These treatment systems have been assigned very large mixing zones to allow for dilution in the receiving water. These cities have effluent limits with a daily maximum of 1.5 million fecal coliforms/100 ml and a monthly geometric mean of 1 million fecal coliforms/100 ml These are the highest limits that have been allowed in Alaska.

Domestic and industrial discharges in Alaska usually exceed water quality standards at the end of pipe. Under the State of Alaska and the National Pollutant Discharge Elimination System (NPDES) permit systems, these entities are granted mixing zones - areas where they may legally exceed water quality standards while dilution and decay or die-off occur. Outside of the mixing zone, water quality standards must be met. ADEC uses information from the discharge source such as wastewater volume, velocity, temperature, and salinity as well as pipe diameter and depth, and receiving water uses and sensitivity to determine the size of the mixing zone. These Dischargers must monitor at the edge of mixing zone specified in their permit to ensure that they are meeting the water quality standards. Because other dischargers are typically granted a mixing zone, ADEC considered the effect of dilution on cruise ship effluent to assess its impact on water quality.

There are numerous potential sources of pollution that impact the Alaska marine environment. They include private vessels, commercial fishing vessels, day trip charter vessels, commercial passenger vessels that have less than 50 overnight passengers for hire, yachts, residential shore based dischargers, runoff and wildlife, (including marine animals). The effects of these other sources have not yet been quantified.

8. ADEC RECOMMENDATIONS

8.1. Recommendations for future study

Sampling

At the recommendation of the Science Advisory Panel, ADEC tested vessel wastewater for commonly used organophosphorus pesticides at the end of 2003 season. No pesticides were detected in the four samples. The ADEC will continue organophosphorus testing during the 2004 season.

Cyanide was dropped from the Quality Assurance/Quality Control (QAQC) Plan after 2000 even though there were high concentrations in some of the 2000 samples. We believe the exclusion from the sampling protocol was premature. ADEC will resume sampling for cyanide in 2004 when the state goes on board and samples the ship wastewater discharges.

In general, fecal coliforms survive for shorter periods than other enteric microorganisms in marine water. The absence of fecal coliform bacteria does not guarantee the absence of viruses and other pathogens.[102] EPA recommends using enterococci for bacteria monitoring in marine waters.[103] ADEC will sample vessel wastewater for *Escherichia coli* (E. *coli*) and enterococci, in 2004.

The current method detection limits (MDL) for chlorine exceeds Alaska Water Quality Standards. As part of the QAQC Plan for 2004, ADEC will require using a more sensitive test that can measure as low as 20 ug/l, instead of the current MDL of 100 ug/l. This sensitive method, however, will still not be able to detect the Alaska Water Quality chronic standard of 7.5 ug/l.

During 2003, some large ship samples were taken from the sampling port right after the treatment system but at a distance between 50 to 400 feet from the overboard discharge port. The 2003 data indicated that fecal contamination and growth occasionally occurs during the transit from the treatment system to the overboard port. In 2004, ADEC will only approve Vessel Specific Sampling Plans where samples are taken from sample ports located within 50 feet of the overboard discharge port.

State cruise ship regulations,[104] effective November 2002, allowed small ships to have a qualified crew member sample the vessel's wastewater. ADEC will encourage small vessel operators to use their own staff to sample their vessel as it comes into port. These samples will be more representative since ships will still be full with passengers and the treatment system will be operating normally. ADEC can provide sampling training to operators upon request. ADEC would audit the vessel samplers.

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[102] Commission on Geosciences, Environment and Resources, 1993 "Managing Wastewater in Coastal Urban Areas" pg. 67 http://books.nap.edu/books/0309048265/html/67.html

[103] EPA 440/5-88/007 Bacteria Water Quality Standards Criteria Summaries: A Compilation of State/Federal Criteria. September 1988.

[104] 18 AAC 69.090, http://www.state.ak.us/dec/title18/wpfiles/69mas.pdf

Section 5.1 discusses traditional treatment systems. The sampling results from the Alaska Marine Highway System (AMHS) ferries' macerator chlorinating systems were extremely variable from 2001 through 2003. ADEC recommends that AMHS sample for fecal coliform, total suspended solids (TSS) and chlorine at timed intervals such as: 1) at the discharge pump start; 2) 5 minutes into the pumping cycle; 3) 10 minutes into the pumping cycle; 4) 15 minutes into the pumping cycle; and 5) at the end of the discharge cycle. This experiment would check the fecal coliform variability throughout the pumping cycle. This information may indicate the correct location for the sample port in the treatment cycle.

New Studies

ADEC made assumptions about ambient water quality for the dilution model. It is important to check these assumptions with real data. ADEC will conduct ambient marine monitoring in Southeast Alaska in coordination with the Western States Coastal Environmental Monitoring and Assessment Program (EMAP) project during the summer of 2004.[105] The EMAP project will also include sediment and fish tissue sampling for heavy metals and PCBs. ADEC will use this information in future modeling efforts.

After applying the dilution factor calculated by the Visual Plumes model to effluent data, small ships exceed four Alaska Water Quality Standards (free chlorine, fecal coliform, copper, and zinc) in receiving water during stationary discharge. When a ship discharges above the waterline, the dilution factor is decreased, exacerbating the problem. The Visual Plumes model that is used to estimate the dilution factors in this report was not designed to model discharges from vessels. ADEC may perform a dye study in the future to determine the dilution factor caused by small ships during stationary discharge.

8.2. Recommendations for Best Management Practices

When large and small vessels discharge wastewater underway, they are able to meet all Alaska Water Quality Standards. The 2003 data indicates that large vessels with advanced wastewater treatment systems meet Alaska Water Quality Standards for all tested pollutants in receiving water during stationary discharges. Large vessels should use discharge ports that are less than 12 inches in diameter to create a jet like propulsion that will increase dilution. Large vessels should avoid discharging above the water line because this decreases dilution. ADEC also wants to encourage the continued use of ultraviolet light instead of chlorine as a disinfectant on large ships. It is also important that the discharge port be located within 50 feet of the wastewater treatment system to decrease the likelihood of fecal coliform contamination in the discharge line.

Small ships regularly exceed four Alaska Water Quality Standards in receiving water during stationary discharge. Vessels that have holding capacity should not discharge while stationary. Holding water while in port is ideal. Most small ships can hold their blackwater and mixed blackwater and graywater for up to 24 hours while stationary (Table 24). This is important since blackwater and mixed blackwater and graywater have the highest fecal coliform counts.

However, only one ship can hold their graywater, the majority of wastewater volume, for even 12 hours while stationary (Table 24). According to the Vessel Specific Sampling Plans,

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[105] For more information on EMAP, visit the EPA EMAP Research Strategy Report, July 2002 at http://www.epa.gov/emf/ulie/html/pubs/docs/resdocs/EMAP_Research_Strategy.pdf

graywater is not plumbed to blackwater holding tanks. Therefore, excess blackwater holding capacity can not be used to store graywater.

Small ships need to develop strategies to limit their graywater discharge while stationary. Small vessels should not do laundry to minimize their waste water production. Small vessels could also schedule to arrive in port or at anchor after the morning high water usage periods (8-10 a.m.) or leave before the evening high water usage (6 [illegible] pm).

Table 24. Small Ship Holding Tank Capacity

Company	Ship Name	Number of passengers and crew	Blackwater (gallons per day) Produced	Blackwater Holding capacity	Blackwater Hold 24hr	Blackwater Hold 12 hr	Graywater (gallons per day) Produced	Graywater Holding capacity	Graywater Hold 24hr	Graywater Hold 12 hr
AMHS	Columbia	223	6,690	23,800	Yes	Yes	GW is mixed with BW. See BW.			
AMHS	Kennicott	204	6,120	8,800	Yes	Yes	GW is mixed with BW. See BW.			
AMHS	Malaspina	188	5,640	8,006	Yes	Yes	GW is mixed with BW. See BW.			
AMHS	Matanuska	186	5,580	8,281	Yes	Yes	GW is mixed with BW. See BW.			
AMHS	Taku	97	2,910	3,360	Yes	Yes	GW is mixed with BW. See BW.			
Glacier Bay	Wilderness Adventurer	95	2,920	2,400	No	Yes	GW is mixed with BW. See BW.			
Glacier Bay	Wilderness Discoverer	120	3,130	2,400	No	Yes	GW is mixed with BW. See BW.			
America West Steamship	Empress of the North	320	8,730	[illegible]6,8[illegible]	Yes	Yes	GW is mixed with BW. See BW.			
CruiseWest	Spirit of Discovery	105	500	1,700	Yes	Yes	2,500	30	No	No
CruiseWest	Spirit of Alaska	99	495	334	No	Yes	2,250	182	No	No
CruiseWest	Spirit of Columbia	99	400	3,600	Yes	Yes	2,260	478	No	No
CruiseWest	Spirit of Endeavour	130	600	934	Yes	Yes	3,600	934	No	No
CruiseWest	Spirit of 98	120	3,600	12,700	Yes	Yes	3,000	0	No	No
CruiseWest	Spirit of Oceanus	178	19,875	14,460	No	Yes	GW is mixed with BW. See BW.			
Lindblad	Sea Bird	96	3,000[106]	1,150	No	No	2,100	735	No	No
Lindblad	Sea Lion	98	3,000[107]	1,255	No	No	2,100	735	No	No
New World Ship Management	Clipper Odyssey	204	612	606	Yes	Yes	16,500	28,800	Yes	Yes
New World Ship Management	Yorktown Clipper	175	2,728[108]	2,996	Yes	Yes	12,000[109]	2,996	No	No

Source: Table created from information submitted by small ship owner and operators in their 2003 Vessel Specific Sampling Plans

[106] Includes saltwater for flushing.
[107] Includes saltwater for flushing.
[108] Includes saltwater for flushing.
[109] This vessel does laundry which accounts for 2,000 gallons per day. This vessel should not do laundry in port.

8.3. Evaluation of Whether Small Ships Should Remain in the Program

Based on the wastewater testing results, ADEC recommends that small ships remain in the Commercial Passenger Vessel Environmental Compliance program. The Science Advisory Panel recommended in their November 2002 report that these ships should avoid stationary discharge, particularly in small fjords and embayments where the movement or flux of water is limited, because of the high levels of fecal coliform and suspended solids in their wastewater.[110] ADEC WET test results in conjunction with conventional and priority pollutant testing indicate that these small ships pose some risk to the marine environment during stationary discharge. Small ships that discharge blackwater or blackwater and graywater mixed while stationary may pose a risk to human health in areas where people collect shellfish for raw consumption.

Small vessels were granted three years to come into compliance with the state cruise ship law wastewater effluent standards.[111] As of March 1, 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 should include a description of Best Management Practices, such as avoiding stationary discharges in areas of limited water movement, that the operator is undertaking to limit the adverse impacts of their discharges.[112] Violations and fines could be levied against ships that are found violating the terms of their approved plan.

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[110] Science Advisory Panel, November 2002, "The Impact of Cruise Ship Wastewater Discharge on Alaska Waters," Executive Summary, http://www.state.ak.us/dec/press/cruise/documents/impact/executivesummary.htm

[111] Alaska Statute 46.03.460 – 490 Section 7

[112] 18 AAC 69.045 Interim Protective Measures Plan, http://www.state.ak.us/local/akpages/ENV.CONSERV/title18/wpfiles/69mas.pdf

Date: July 11, 2006 **Time:** 09:30-11:00
Vessel: Norwegian Sun **Port:** Juneau
Written by: Moana Leirer (ADEC Inspector)

OBSERVATIONS:

On Tuesday July 11, 2006 09:30, I met David Wetzel and Tessina Davidson with Admiralty Environmental at the AJ dock in Juneau Alaska. My purpose was to observe the sampling procedures used for large passenger vessels under Alaska's Commercial Passenger Vessel Environmental Compliance Program. I also took additional samples for enterococcus, cya. de and PCBs. David and Tessina were sampling for conventional and priority pollutants from a mixed blackwater and graywater treatment system for the Norwegian Sun's second random unannounced sampling event.

David and Tessina arrived with one medium sized cooler and one small cooler which were used to haul sample bottles grouped together within a clear plastic garbage bag. The coolers did not have ice in them at this time.

David, Tessina and I stopped at ship security and stated our purpose. The vessel took our Alaska ID's and replaced them with visitor passes. The security officials called the engine control room, and we were met by the environme .al officer (EO) Karl Hergeselle. At this time David verified verbally that the vessel was currently discharging overboard. The EO brought us to the galley area for ice where David took the sample bottles out of the clear plastic bag and filled the bag with ice for the medium cooler. Tessina filled the small cooler ¾ full with ice and added some water to create an ice water bath for the fecal coliform sample. I filled my cooler with ice at this time as well.

Mixed Blackwater and Graywater Sampling Event:

The USCG certified this system to discharge continuously.

The EO escorted us to the overboard sampling port, which is located with two feet from the ov rboard hull penetration. The sample port was sterilized and flushed (Figure 1) with an adequate amount of effluent from the discharge line.

The sampling began at 10:15
David and Tessina donned safety gear, including:

- Protective lab coat
- Ear protection
- Safety glasses
- Latex gloves

Figure 1: Norwegian Sun overboard sample port being flushed with treated effluent.

While the port was flushing, David removed the ice bag from the cooler and began labeling the sample bottles with the date, analyses, and sampler initials. At this time, Tessina prepared the field test kit and began filling out the chain of custody. Prior to sampling, David filled the test vial used to detect free chlorine and passed it on to Tessina. David put the sample time on the bottles and filled (Figure 2) them in the following order:

- Settable Solids (1 liter)
- Field Test Bottle (120 ml)
- Fecal Coliform- 100 ml
- Wet Chemistry- BOD, Alkalinity, pH, conductivity, TSS (1 liter)
- Metals (1 liter)
- Preserved Wet chemistry-NO_2/NO_3, Ammonia, COD, and Total Phosphorus (250 ml)
- TKN (500 ml)
- Oil and Grease (1 liter-glass)
- BNA
- TOC (250 ml-glass)
- VOC (4 40ml vials glass)

After filling the sample bottle for Fecal Coliform, David put the bottle in a plastic "Ziploc" and immediately put sample in the ice water bath along with the 120 ml temperature blank. After all the bottles were filled David transferred the bottles to the medium cooler and emptied the bag of ice over the sample bottles. The large temperature blank was added to the cooler at this time as well. Once David had filled all of his bottles, I proceeded to fill my bottles.

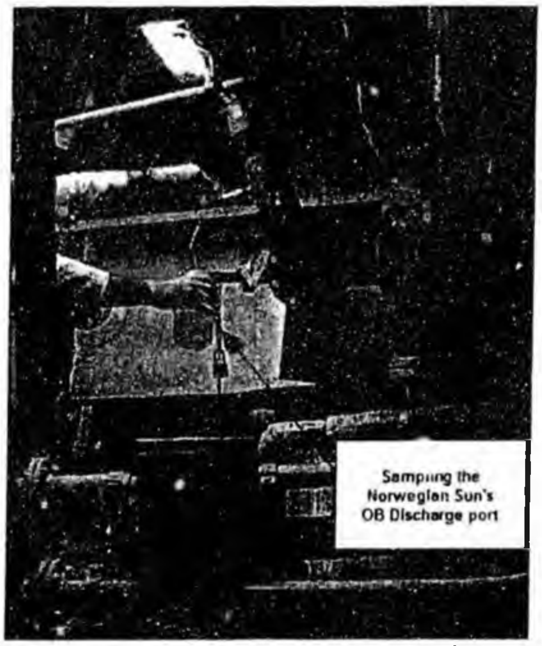

Figure 2: David Wetzel taking a sample from the Norwegian Sun's overboard discharge port.

Tessina tested the sample (test vial) to check for free chlorine. When the reagent was added to the test vial it appeared to have a slight pink color to it indicating a small amount of free chlorine. However, the chlorine meter gave a reading of zero free chlorine. Tessina dumped the sample and added new sample and reagent to the test vial. The second time the chlorine meter gave a reading of 0.05 mg/L. The amount of free chlorine is not enough to affect the VOC analysis. Therefore, David rinsed the ascorbic acid out of the decanting bottle before he used it to fill the VOC bottles. Ascorbic acid was not added to the BNA sample bottle.

Tessina began field tests immediately after David filled field test bottle. Tessina took the temperature of the large and small temperature blanks before they were placed in the cooler with ice. Tessina then measured the temperature of the sample in the field test bottle immediately after it was filled and recorded the information in her field notes. The final field tests conducted was pH and total chlorine. Tessina entered the field results into her notebook, and then proceeded to take pictures of the sample port.

Results of Field tests & method included:

Mixed Blackwater and Graywater	
Time	10:15
Temperature C°	32.2
Total Chlorine	0.08
Free Chlorine	0.05
pH	6.43

Tessina used a *HACH* Pocket Colorimeter to detect total and free chlorine. Tessina rinsed the test vials for the *HACH* equipment with water and replaced into test kit. Liquid wastes were dumped into a 1 liter container retained by the samplers. The pH field test was conducted using a calibrated *Oakton Instruments pH Tester 2*, and was wiped clean with a *Kimwipes* tissue after use.

All debris, including used gloves and tissues were placed in the 1 liter waste container and taken off the ship. David acquired the signature of the EO in the field notes and on the chain of custody form, and secured the documents in the sample kit Pelican case. We then proceeded to the engine control room where David retrieved a copy of the discharge log from the EO.

I accompanied Tessina to the lab for sample delivery. Tessina relinquished the samples to Robin Jung of Analytica at 11:25 am. Robin unloaded the coolers and measured the temperature blank of both coolers and recorded them on the chain of custody. The temperature of the medium cooler was 4.2°C and the small cooler's temperature was 1.4°C. Robin then proceeded to check for bubbles in the VOC vials; there were no bubbles present. Robin moved all samples to the receiving refrigerator and made a copy of the chain of custody for Tessina's records.

Recommendations

This was an excellent sample event and I can only think of a one improvement:

- **Alcohol or some kind of bactericide should be used to clean equipment after field tests are conducted for each sampling event.**

Commercial Passenger Vessel Environmental Program
ADEC Oversight Checklist

During Water Sample Collection

- ☐ Were the samples collected from appropriate and representative locations at appropriate times? **Yes.**
- ☐ Was the sample collection time representative of the maximum usage of the wastewater treatment and discharge system? **Yes**
- ☐ Did the sampler collect the required ship records and logs, particularly the Graywater & Sewage Discharge Record Book which identifies tanks, estimates volumes and calculates discharge rates (if any) at the time the sample was drawn? **Yes**
- ☐ Did the ship representative indicate any problems with the wastewater treatment system? **No.**
- ☐ Did the samplers work in twos to assure that proper sampling techniques and note-taking? **Yes**
- ☐ Did the sampler/s use sanitary techniques? **Yes, but equipment should be sterilized with a bactericide after each sampling event.**
- ☐ Did the sampler/s wear disposable gloves, safety eye gear, tie-back suit and proper foot gear? **Yes**
- ☐ Did the sampler/s remain aware of potential safety and biohazards present? **Yes.**
- ☐ Were sample bottles all co. ctly prepared? **Yes.**
- ☐ Were the samples identified clearly on the sample bottles and the chain of custody form? **Yes.**
- ☐ Were the specified field measurements taken (pH, temperature, chlorine residual)? **Yes.**
- ☐ Were priority pollutant samples taken? **Yes**
- ☐ Was a volume of water equal to at least ten times the volume of the sample discharge line first discharged into a bucket or similar container, to clear the line of standing water and possible contamination? **Yes.**
- ☐ Were the sample bottles filled and sealed correctly? **Yes.**

- Were sample bottles cooled immediately in an ice-water bath to 4° degrees C, and placed into a cooler containing frozen blue ice to maintain a sample temperature of 2-6 degrees C? **Yes**

- Except for the VOC bottles, were the sample bottles filled to the shoulder of the bottle, leaving a small space for expansion and mixing? **Yes**

- Did the sample bottles for ammonia, COD, fecal coliform, oil and grease, TOC, nitrogen and phosphorus have the appropriate preservative added in the laboratory? **Yes.**

- If chlorine residual is detected during field measurement of chlorine did the sampler add the sodium thiosulfate to the BNA, PCB and pesticide sample bottles until no chlorine is detected? **N/A**; chlorine was not detected in significant amount

- Was the chain of custody form correctly completed? **Yes.** Were any collection anomalies noted? **N/A**

- Did the sampler use a field log book? **Yes.** Note any sampling anomalies? **N/A**

- Did the sampler transcribe or receive copies of the required documents from the ship sewage and graywater discharge record book (recording times, volumes, and vessel location where the waste is discharged for each graywater and treated sewage discharge port)? **Yes,**

- Were the sample holding times met? (See QAQC) **Yes.**

- Did the sampler dispose of liquid and solid waste correctly? **Yes**

- Was sample custody maintained until delivery to lab? **Yes.**

- Latitude/longitude and speed at time of discharge being sampled, **Yes**

Date: June 12. 2006 **Time:** 04:00-05:30
Vessel: Seven Seas Mariner **Port:** Underway from Skagway to Sitka
Written by: Moana Leirer (ADEC Inspector)

OBSERVATIONS:

On Sunday June 11, 2006 I flew to Skagway via Skagway Air with David Wetzel of Admiralty Environmental. My purpose was to observe the underway sampling procedures used for large passenger vessels under the Commercial Passenger Vessel Environmental Compliance program. David and I planned on sailing with the ship from Skagway to Sitka. David was sampling for conventional pollutants from a mixed blackwater and graywater treatment system for the Seven Seas Mariner's first unannounced sampling event.

Since this sampling event was conducted while the ship was in route to Sitka, the sample bottles were flown back to Juneau for analyses except for the fecal coliform (FC) sample. The FC sample was dropped off at the Sitka Wastewater Treatment plant for analysis in their certified laboratory. David carried a medium sized cooler in which he used to haul the sample bottles to the laboratory in Juneau. David also carried a small Pelican case that held his field testing equipment.

David and I stopped at ship security and stated our purpose. The security officials contacted the engine control room, and we were met by the Environmental Engineer (EE) Stephane Billy. At this time the EE assigned cabins for both David and I to stay in while on board the vessel. Once our accommodations were taken care of we proceeded to the engine control room and met with the Chief Engineer Germain Bouver and the EE to arrange the sampling location and time. We agreed to meet at 4:00am to conduct the sampling at the overboard discharge sampling port. David placed his gel packs in the freezer that would be used later when the samples were shipped back to Juneau.

Mixed Blackwater and Graywater Sampling Event:

At approximately 04:15 am I met with David, and the EE in the engine control room. At this time David verified with the EE that the ship was discharging overboard. David asked the EE for a small bag of ice for the FC sample to be placed in after sampling.
While the EE retrieved the ice David labeled the sample bottles with ship name, sample point, and date. We then proceeded to the overboard discharge port to begin sampling. The overboard sample port is located approximately 12 feet from the overboard hull penetration.

The sample port was sterilized with a propane heat gun and then flushed (Figure 1) with an adequate amount of wastewater. While the sample port was being sterilized David began filling out his field notes. David then took the required picture of the sample port that included a sign with vessel name, date, and sampling event (Figure 2).

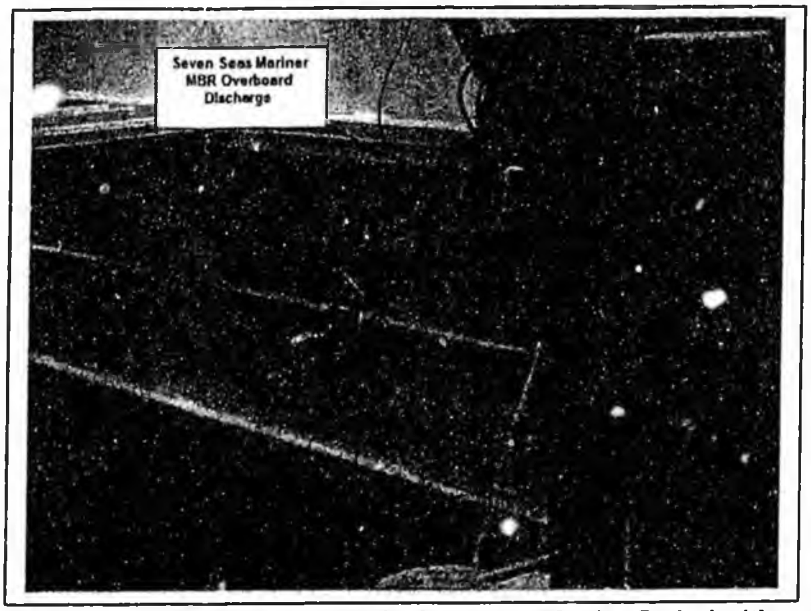

Figure 1: Overboard sample port in the process of being flushed with wast water prior to sampling.

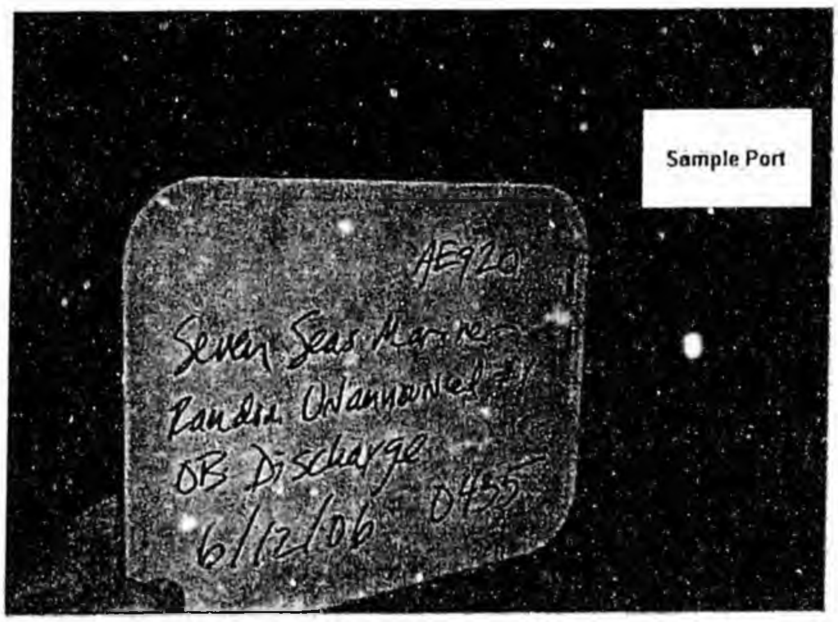

Figure 2: Required sampling event photo taken by David Wetzel.

The sampling began at 04:35 am
David donned safety gear, including:

- Laboratory Coat
- Ear Plugs
- Latex gloves

David recorded the time sampling began on each bottle and then filled the sample bottles (Figure 3) in the following order:

- Field Test Bottle (120 ml)
- Preser   d Wet chemistry-NO_2/NO_3, Am nonia, COD and Total Phosphorus (250 ml)
- Wet Chemistry- BOD, Alkalinity, pH, conductivity, TSS (1 liter)
- TKN (500 ml)
- Settable Solids (1 liter)
- Oil and Grease (1 liter-glass)
- TOC (250 ml-glass)
- Fecal Coliform- 100 ml

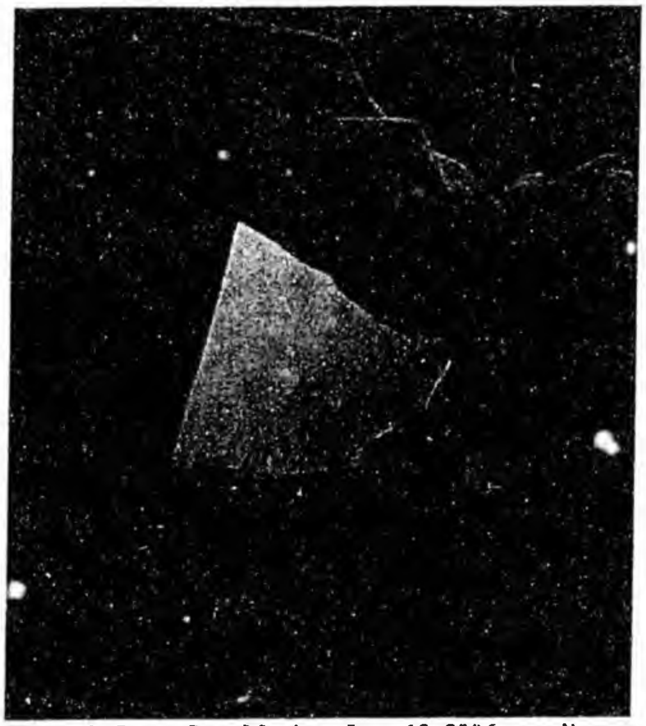

Figure 3: Seven Seas Mariner June 12. 2006 sampling event.
David Wetzel filling the sample bottle for Oil & Grease analyses.

Sample bottles were placed in the empty cooler without ice except for the FC sample which was placed in the bag of ice provided by the EE. David then proceeded with the field tests. He first took the sample temperature, which was conducted approximately 8 minutes after the filed bottle was filled with sample. Chlorine and pH were then tested for following the proper procedures per the equipment manufacturer's guidelines. The field test results were recorded in David's field notes.

Results of Field tests:

Mixed Blackwater & Graywater	
Time	04:35
Temperature	32.8
Total Chlorine	Non-detect
Free Chlorine	Non-detect
pH	7.18

David used a *HACH Pocket Colorimeter* to detect total and free chlorine. Free chlorine was tested for first with the idea that the residual may dissipate more quickly than the total chlorine. After the chlorine tests were conducted, David wiped the *HACH* equipment with *Kimwipes* lab tissue. Liquid wastes were dumped into wastewater bucket used to flush sample port. The pH field test was conducted using a calibrated *Oakton Instruments pH Tester 2* and was also wiped clean with a *Kimwipes* tissue after use.

David acquired the signature of the EE in his field notes and on the chain of custody form, and secured the documents in the sample kit Pelican case. We then proceeded to the engine control room and David immediately put samples on gel ice in the sample cooler. David then obtained a copy of the discharge log from the EE and recorded the ships position when the sampling began.

All debris except for David's gloves was placed in the cooler with the sample bottles. We disembarked in Sitka and I did not accompany David to the lab.

Recommendations

This was an excellent sample event and I can only think of a few improvements:

- **The samples taken on this event were shipped back to Juneau via airplane in a cooler with gel ice packs; can't use wet ice on commercial flights. Although the FC sample was immediately placed on ice, the remaining samples were not. Not until we returned to the engine control room did the sampler add gel ice to the cooler. The sampler should put all of the samples immediately on wet ice to bring the temperature down and then replace the wet ice with gel ice upon shipping. Wet ice will bring the sample temperature down faster than gel ice and keep the samples cooler overall.**

- **The FC sample was placed immediately in a bag of ice, but the FC sample should be placed in an ice water bath to bring the temperature down to 4°C.**

- **Sampler should take the temperature of the sample with a thermometer immediately after the sample bottle (field test bottle) is filled. Typically the field test bottle is filled last and the temperature is taken right away.**

- **Alcohol or some kind of bactericide should be used to clean equipment after field tests are conducted for each sampling event.**

Commercial Passenger Vessel Environmental Program
ADEC Oversight Checklist

During Water Sample Collection

- ❑ Were the samples collected from appropriate and representative locations at appropriate times? **Yes.**
- ❑ Was the sample collection time representative of the maximum usage of the wastewater treatment and discharge system? **Yes**
- ❑ Did the sampler collect the required ship records and logs, particularly the Graywater & Sewage Discharge Record Book which identifies tanks estimates volumes and calculates discharge rates (if any) at the time the sample was drawn? **Yes**
- ❑ Did the ship representative indicate any problems with the wastewater treatment system? **No.**
- ❑ Did the samplers work in twos to assure that proper sampling techniques and note-taking? **No, ADEC approved the sampling of the Seven Seas Mariner with only one sampler.**
- ❑ Did the sampler/s use sanitary techniques? **Yes, but equipment should be sterilized with a bactericide after each sampling event.**
- ❑ Did the sampler/s wear disposable gloves, safety eye gear, tie-back suit and proper foot gear? **Yes**
- ❑ Did the sampler/s remain aware of potential safety and biohazards present? **Yes.**
- ❑ Were sample bottles all correctly prepared? **Yes.**
- ❑ Were the samples identified clearly on the sample bottles and the chain of custody form? **Yes.**
- ❑ Were the specified field measurements taken (pH, temperature, chlorine residual)? **Yes.**
- ❑ Were priority pollutant samples taken? **No**
- ❑ Was a volume of water equal to at least ten times the volume of the sample discharge line first discharged into a bucket or similar container, to clear the line of standing water and possible contamination? **Yes.**
- ❑ Were the sample bottles filled and sealed correctly? **Yes.**
- ❑ Were sample bottles cooled immediately in an ice-water bath to 4° degrees C, and placed into a cooler containing frozen blue ice to maintain a sample temperature of 2-6 degrees C? **Yes/NO, only the FC sample was cooled immediately.**
- ❑ Except for the VOC bottles, were the sample bottles filled to the shoulder of the bottle, leaving a small space for expansion and mixing? **Yes**

- Did the sample bottles for ammonia, COD, fecal coliform, oil and grease, TOC, nitrogen and phosphorus have the appropriate preservative added in the laboratory? **Yes.**

- If chlorine residual is detected during field measurement of chlorine, did the sampler add the sodium thiosulfate to the BNA, PCB and pesticide sample bottles until no chlorine is detected? **N/A**

- Was the chain of custody form correctly completed? **Yes.** Were any collection anomalies noted? **N/A**

- Did the sampler use a field log book? **Yes.** Note any sampling anomalies? **N/A**

- Did the sampler transcribe or receive copies of the required documents from the ship sewage and graywater discharge record book (recording times, volumes, and vessel location where the waste is discharged for each graywater and treated sewage discharge port)? **Yes,**

- Were the sample holding times met? (See QAQC) **Yes.**

- Did the sampler dispose of liquid and solid waste correctly? **Yes**

- Was sample custody maintained until delivery to lab? **Yes.**

- Latitude/longitude and speed at time of discharge being sampled, **Yes**

Date: July 19, 2006 Time: 09:45-11:00
Vessel: Westerdam Port: Juneau
Written by: Moana Leirer (ADEC Inspector)

OBSERVATIONS:

On Wednesday July 19, 2006 09:45, Albert Faure and I met David Wetzel and Ryan Kubota with Admiralty Environmental at the Cruiseship Terminal in Juneau Alaska. My purpose was to observe the sampling procedures used for large passenger vessels under Alaska's Commercial Passenger Vessel Environmental Compliance Program. I also took additional samples for enterococcus, cyanide and PCBs. David and Ryan wc sampling for conventional and priority pollutants from a mixed blackwater and gray. ater treatment system for the Westerdam's second random unannounced sampling event.

David and Ryan arrived with a three coolers; a large, medium, and small cooler which were used to haul sample bottles grouped together within clear plastic garbage bags. The coolers did not have ice in them at this time. David and Ryan were using the extra large cooler for additional on board sampling requested by the vessel. Albert and I did not audit that portion of the sampling as it was an internal event and not for compliance purposes.

We stopped at ship security and stated our purpose. The vessel took our Alaska ID's and replaced them with visitor passes. The security officials called the engine control room, and we were met by the environmental officer (EO) Roy Powell. The EO brought us to the engine control room (ECR) where we met with the Environmental Engineer (EE) Danny Van Dijk to coordinate the sampling event. At this time the EE brought David and I to the crew mess area to get ice; Ryan and Albert waited in the ECR. David took the sample bottles out of the clear plastic bag and filled the bag with ice for the medium cooler. I filled my cooler with ice and during this time David labeled the sample bottles with sample name, vessel name, analyses and sampler identification. Once I was finished filling my cooler with ice, David prepared an ice water bath in the small cooler for the fecal coliform sample.

David and I returned to the ECR to meet up with Ryan and Albert. The EE then escorted us to the sample port. The large cooler was left in the ECR for later sampling.

Mixed Blackwater and Graywater Sampling Event:

The USCG certified this system to discharge continuously.

The EO escorted us to the overboard sampling port, which is located within 1 meter from the overboard hull penetration. The sample port was sterilized and flushed with an adequate amount of effluent from the discharge line.

David and Ryan donned safety gear, including:

- Protective lab coat
- Ear protection
- Safety glasses
- Latex gloves

While the port was flushing, David removed the ice bag from the cooler staged the bottles for sampling. At this time Ryan, prepared the field test kit and recorded the temperature of the 1 liter and 120ml temperature blanks for the large and small cooler respectively. Prior to sampling, David filled the test vial used to detect free chlorine and passed it on to Ryan.

The sampling began at 10:15am.
David put the sample time on the bottles and filled them with effluent in the following order:

- Settable Solids (1 liter)
- Wet Chemistry- BOD, Alkalinity, pH, conductivity, TSS (1 liter)
- Preserved Wet chemistry-TKN, NO_2/NO_3, Ammonia, COD, and Total Phosphorus (1 liter)
- Metals (1 liter)
- BNA
- Oil and Grease (1 liter-glass)
- TOC (250 ml-glass)
- VOC (4 40ml vials glass)
- Fecal Coliform- 100 ml
- Field Test Bottle (120 ml)

After filling the sample bottle for Fecal Coliform, David put the bottle in a plastic "Ziploc" and immediately put the sample bottle in the ice water bath along with the 120 ml temperature blank. After all the bottles were filled David transferred the bottles to the medium cooler and emptied the bag of ice over the sample bottles. The large temperature blank was added to the cooler at this time as well. Once David had filled all of his bottles, I proceeded to fill my bottles.

Ryan tested the sample (test vial) to check for free chlorine. The result for free chlorine was 0.0 mg/L. Therefore, David rinsed the ascorbic acid out of the decanting bottle before he used it to fill the VOC bottles. Ascorbic acid was not added to the BNA sample bottle.

Ryan began the field tests immediately after David filled the field test bottle. Temperature was measured immediately after the field test bottle was filled. Ryan then proceeded with the remaining tests for pH and total chlorine. Ryan recorded the field results into his notebook, and then proceeded to take get signatures from the EE, Albert and myself.

Results of Field tests & method included:

Mixed Blackwater and Graywater	
Time	10:15
Temperature C°	29.0
Total Chlorine	0.00
Free Chlorine	0.00
pH	7.34

Ryan used a *HACH Pocket Colorimeter* to detect total and free chlorine. Liquid wastes were dumped into a 1 liter container retained by the samplers. The pH field test was conducted using a calibrated *Oakton Instruments pH Tester 2.* All field test equipment was rinsed with deionized water and sterilized with alcohol after use. All debris, including used gloves and tissues were placed in the 1 liter waste container and taken off the ship.

David took a picture of the sampling port with a sign identifying the sample port, sampling event and date. We then proceeded to the engine control room where David retrieved a copy of the discharge log from the EO.

Recommendations

This was an excellent sample event and I can't think of any improvements.

Commercial Passenger Vessel Environmental Program
ADEC Oversight Checklist

<u>During Water Sample Collection</u>

- ❑ Were the samples collected from appropriate and representative locations at appropriate times? **Yes.**
- ❑ Was the sample collection time representative of the maximum usage of the wastewater treatment and discharge system? **Yes**
- ❑ Did the sampler collect the required ship records and logs, particularly the Graywater & Sewage Discharge Record Book which identifies tanks, estimates volumes and calculates discharge rates (if any) at the time the sample was drawn? **Yes**
- ❑ Did the ship representative indicate any problems with the wastewater treatment system? **No.**
- ❑ Did the samplers work in twos to assure that proper sampling techniques and note-taking? **Yes**
- ❑ Did the sampler/s use sanitary techniques? **Yes**
- ❑ Did the sampler/s wear disposable gloves, safety eye gear, tie-back suit and proper foot gear? **Yes**
- ❑ Did the sampler/s remain aware of potential safety and biohazards present? **Yes.**
- ❑ Were sample bottles all correctly prepared? **Yes.**
- ❑ Were the samples identified clearly on the sample bottles and the chain of custody form? **Yes.**
- ❑ Were the specified field measurements taken (pH, temperature, chlorine residual)? **Yes.**
- ❑ Were priority pollutant samples taken? **Yes**
- ❑ Was a volume of water equal to at least ten times the volume of the sample discharge line first discharged into a bucket or similar container, to clear the line of standing water and possible contamination? **Yes.**
- ❑ Were the sample bottles filled and sealed correctly? **Yes.**

- Were sample bottles cooled immediately in an ice-water bath to 4° degrees C, and placed into a cooler containing frozen blue ice to maintain a sample temperature of 2-6 degrees C? **Yes**

- Except for the VOC bottles, were the sample bottles filled to the shoulder of the bottle, leaving a small space for expansion and mixing? **Yes**

- Did the sample bottles for ammonia, COD, fecal coliform, oil and grease, TOC, nitrogen and phosphorus have the appropriate preservative added in the laboratory? **Yes.**

- If chlorine residual is detected during field measurement of chlorine, did the sampler add the sodium thiosulfate to the BNA, PCB and pesticide sample bottles until no chlorine is detected? **N/A;** chlorine was not detected

- Was the chain of custody form correctly completed? **Yes.** Were any collection anomalies noted? **N/A**

- Did the sampler use a field log book? **Yes.** Note any sampling anomalies? **N/A**

- Did the sampler transcribe or receive copies of the required documents from the ship sewage and graywater discharge record book (recording times, volumes, and vessel location where the waste is discharged for each graywater and treated sewage discharge port)? **Yes,**

- Were the sample holding times met? (See QAQC) **Yes.**

- Did the sampler dispose of liquid and solid waste correctly? **Yes**

- Was sample custody maintained until delivery to lab? **Yes.**

- Latitude/longitude and speed at time of discharge being sampled, **Yes**

Date: July 21, 2006 **Time:** 14:15-15:45
Vessel: Silver Shadow **Port:** Juneau
Written by: Moana Leirer (ADEC Inspector)

OBSERVATIONS:

On Friday July 21, 2006 14:15 I met David Wetzel and Diana Cote with Admiralty Environmental at the Alaska Steamship Dock in Juneau Alaska. My purpose was to observe the sampling procedures used for large passenger vessels under Alaska's Commercial Passenger Vessel Environmental Compliance Program. David and Diana were sampling for conventional and priority pollutants from a mixed blackwater and graywater treatment system for the Silver Shadow's second random unannounced sampling event. David and Diana arrived with a medium and small cooler which were used to haul sample bottles grouped together within a clear plastic garbage bag. The coolers did not have ice in them at this time.

I was already on board the vessel conducting an ADEC vessel inspection so the Environmental Officer (EO) Marco Taccarelli escorted me to the security gate to meet with David and Diana. David and Diana cleared vessel security and we all proceeded to the engine control room (ECR). The EO then escorted us to get ice. David took the sample bottles out of the clear plastic bag and filled the bag with ice for the medium cooler. David then prepared an ice water bath in the small cooler for the fecal coliform sample.

Mixed Blackwater and Graywater Sampling Event:

The ADEC has approved this vessel to discharge continuously under AS 46.063.462(c).

The EO escorted us to the overboard sampling port, which is located within 3 feet from the overboard hull penetration. The sample port was sterilized and flushed with an adequate amount of effluent from the discharge line.

David and Diana donned safety gear, including:

- Protective lab coat
- Ear protection
- Safety glasses
- Latex gloves

While the port was flushing, David removed the ice bag from the cooler and staged the bottles for sampling. Prior to sampling, David filled the test vial used to detect free chlorine and passed it on to Diana. At this time Diana prepared the field test kit and recorded the temperature of the 1 liter and 120ml temperature blanks for the large and small cooler respectively.

The sampling began at 14:45. David put the sample time on the bottles and filled them with effluent in the following order:

- Settable Solids (1 liter)
- Preserved Wet chemistry-TKN, NO_2/NO_3, Ammonia, COD, and Total Phosphorus (1 liter)
- Oil and Grease (1 liter-glass)
- Wet Chemistry- BOD, Alkalinity, pH, conductivity, TSS (1 liter)
- BNA
- Metals (1 liter)
- TOC (250 ml-glass)
- Fecal Coliform- 100 ml
- VOC (6- 40ml vials glass)
- Field Test Bottle (120 ml)

After filling the sample bottle for Fecal Coliform, David put the sample bottle in a plastic "Ziploc" and immediately put it in the ice water bath along with the 120 ml temperature blank. After all the bottles were filled except for the VOC vials, David transferred the bottles to the medium cooler and emptied the bag of ice over the sample bottles. The large temperature blank was added to the cooler at this time as well. David then filled the VOC vials (Figure1), ensured no bubbles were present and put them in the cooler with ice. David took a picture (Figure 2) of the sampling port with a sign identifying the sample port, sampling event, and date.

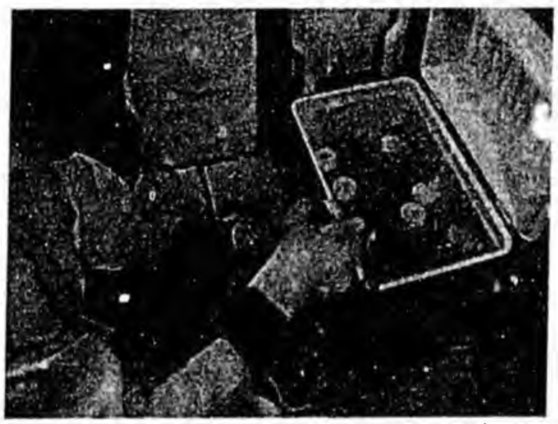

Figure 1: David Wetzel filling the VOC vials.

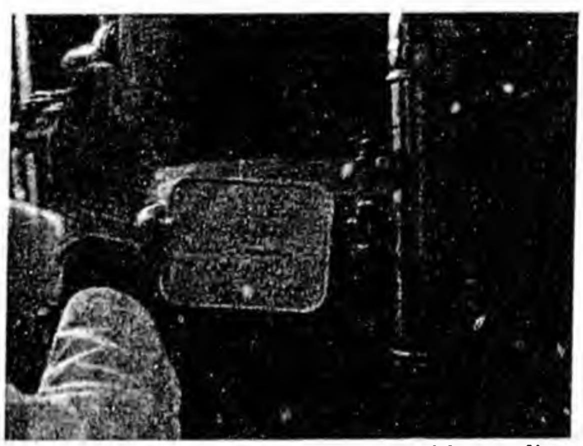

Figure 2: Picture of the sample port with sampling event information.

Diana tested the sample (test vial) to check for free chlorine prior to sampling. The result for free chlorine was 0.02 mg/L. Therefore, David rinsed the ascorbic acid out of the decanting bottle before he used it to fill the VOC bottles. Ascorbic acid was not added to the BNA sample bottle.

Diana began the field tests immediately after David filled the field test bottle (Figure 3). Temperature was measured immediately after the field test bottle was filled. Diana then proceeded with the remaining tests for pH and total chlorine. Diana recorded the field results into her notebook and on the chain of custody.

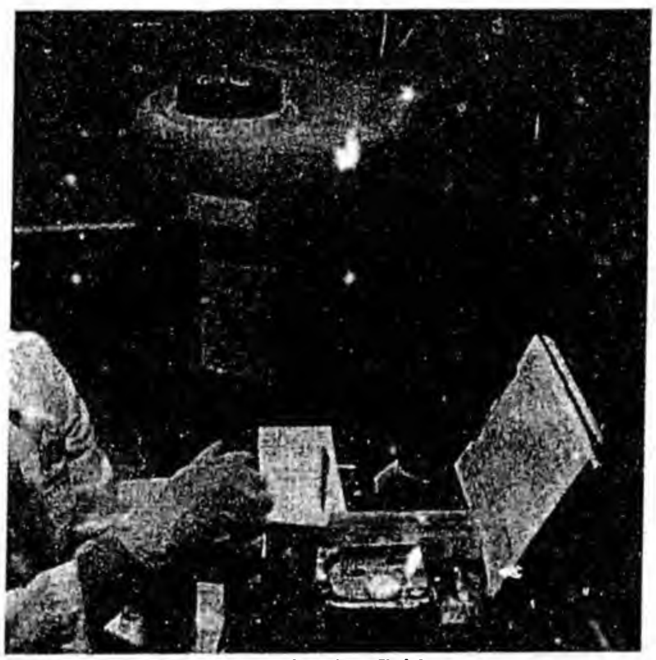

Figure 3: Diana Cote conducting field tests.

Results of Field tests included:

Mixed Blackwater and Graywater	
Time	14:45
Temperature C°	14.7
Total Chlorine	0.02
Free Chlorine	0.02
pH	6.92

Diana used a *HACH Pocket Colorimeter* to detect total and free chlorine. Liquid wastes were dumped into a 1 liter container retained by the samplers. The pH field test was conducted using a calibrated *Oakton Instruments pH Tester 2*. All field test equipment was rinsed with deionized water and sterilized with alcohol after use. All debris, including used gloves and tissues were placed in the 1 liter waste container and taken off the ship.

After the sampling was complete we proceeded to the engine control room where David retrieved a copy of the discharge log from the EO and the necessary signatures to complete the documentation.

I did not accompany David and Diana to the lab.

Recommendations

This was an excellent sample event and I can't think of any improvements.

Commercial Passenger Vessel Environmental Program
ADEC Oversight Checklist

<u>During Water Sample Collection</u>

- ❑ Were the samples collected from appropriate and representative locations at appropriate times? **Yes.**
- ❑ Was the sample collection time representative of the maximum usage of the wastewater treatment and discharge system? **Yes**
- ❑ Did the sampler collect the required ship records and logs, particularly the Graywater & Sewage Discharge Record Book which identifies tanks, estimates volumes and calculates discharge rates (if any) at the time the sample was drawn? Yes
- ❑ Did the ship representative indicate any problems with the wastewater treatment system? No.
- ❑ Did the samplers work in twos to assure that proper sampling techniques and note-taking? **Yes**
- ❑ Did the sampler/s use sanitary techniques? **Yes**
- ❑ Did the sampler/s wear disposable gloves, safety eye gear, tie-back suit and proper foot gear? **Yes**
- ❑ Did the sampler/s remain aware of potential safety and biohazards present? **Yes.**
- ❑ Were sample bottles all correctly prepared? **Yes.**
- ❑ Were the samples identified clearly on the sample bottles and the chain of custody form? **Yes.**
- ❑ Were the specified field measurements taken (pH, temperature, chlorine residual)? **Yes.**
- ❑ Were priority pollutant samples taken? **Yes**
- ❑ Was a volume of water equal to at least ten times the volume of the sample discharge line first discharged into a bucket or similar container, to clear the line of standing water and possible contamination? **Yes.**
- ❑ Were the sample bottles filled and sealed correctly? **Yes.**

- Were sample bottles cooled immediately in an ice-water bath to 4° degrees C, and placed into a cooler containing frozen blue ice to maintain a sample temperature of 2-6 degrees C? **Yes**

- Except for the VOC bottles, were the sample bottles filled to the shoulder of the bottle, leaving a small space for expansion and mixing? **Yes**

- Did the sample bottles for ammonia, COD, fecal coliform, oil and grease, TOC, nitrogen and phosphorus have the appropriate preservative added in the laboratory? **Yes.**

- If chlorine residual is detected during field measurement of chlorine, did the sampler add the sodium thiosulfate to the BNA, PCB and pesticide sample bottles until no chlorine is detected? **N/A;** chlorine was not detected at a significant amount.

- Was the chain of custody form correctly completed? **Yes.** Were any collection anomalies noted? **N/A**

- Did the sampler use a field log book? **Yes.** Note any sampling anomalies? **N/A**

- Did the sampler transcribe or receive copies of the required documents from the ship sewage and graywater discharge record book (recording times, volumes, and vessel location where the waste is discharged for each graywater and treated sewage discharge port)? **Yes,**

- Were the sample holding times met? (See QAQC) **Yes.**

- Did the sampler dispose of liquid and solid waste correctly? **Yes**

- Was sample custody maintained until delivery to lab? **Yes.**

- Latitude/longitude and speed at time of discharge being sampled. **Yes**

Date: July 27, 2006 Time: 09:30-2:00
Vessel: Ryndam Port: Juneau
Written by: Moana Leirer (ADEC Inspector)

OBSERVATIONS:

O Thursday July 27, 2006 09:30, Albert Faure and I met David Wetzel and Tessina Davidson of Admiralty Environmental at the Alaska Steamship Dock in Juneau Alaska. Our purpose was to observe the sampling procedures used for large passenger vessels under Alaska's Commercial Passenger Vessel Environmental Compliance Program. David and Tessina were sampling for conventional and priority pollutants from a mixed blackwater and graywater treatment system for the Ryndam's second random unannounced sampling event. They were took a blind duplicate sample as per the 2006 Northwest Cruise Association's (NWCA) Quality Assurance Quality Control Plan (QAQCP).

David and Tessina arrived with one large cooler and one small cooler. The large cooler was used to haul sample bottles grouped together within clear plastic garbage bags. The large and small cooler also contained a 1 liter and 120 ml liter temperature blank respectively. The cooler did not have ice in it at the time. They also had a 10 liter cubitainer to use for the duplicate sampling.

We stopped at ship security and stated our purpose. The vessel took our Alaska ID's and re ced them with visitor passes. The security officials called the engine control room, and we were met by the environmental officer (EO) Eddy Swift. The EO brought us to the galley to get ice. David took the sample bottles out of the clear plastic bags and filled the bags with ice for the large cooler. At this time Tessina removed the temperature blanks from the coolers and put them in her lab coat pocket. David prepared an ice water bath in the small cooler for the fecal coliform samples. The bags of ice and sample bottles were them placed into the cooler for transport.

We then proceeded to the engine control room (ECR) and on to the overboard discharge sample port.

Mixed Blackwater and Graywater Sam ling Event:

The USCG certified this system to discharge continuously.

The EO escorted us to the overboard sampling port post UV at Frame 151. The sampling port is located within 11.5 meters (~37 feet) from the overboard hull penetration. The sample port was flushed for approximately 45 seconds draining an adequate amount of effluent from the discharge line.

David and Tessina donned safety gear, including:

- Protective lab coat
- Ear protection
- Safety glasses
- Latex gloves

David first filled the small test vial for Free chlorine testing and handed it over to Tessina; Tessina then tested the effluent for Free chlorine. David verified with the EO that the ship was actually discharging and began to stage out the sample bottles to be filled.

The sampling began at 10:16am.
David began to fill the 10 liter cubitainer, which he would use to fill the Conventional Pollutant sample bottles. Once the cubitainer was filled David shook the container to mix the effluent within.

The Ryndam's sample bottles were pre-labeled with vessel name, date, sampling event and sampler names. Prior to sampling, David put the time on the Ryndam's sample bottles. The blind duplicate sample bottles did not include the vessel name or the sample time. David did include the sample time for both sample sets within the field notes. David then filled the sample bottles from the 10 liter cubitainer in the following order:

- Field Test Bottle (120 ml)
- Field Test Bottle (120 ml)-**DUPLICATE**
- Wet Chemistry- BOD, Alkalinity, pH, conductivity, TSS (1 liter)
- Wet Chemistry- BOD, Alkalinity, pH, conductivity, TSS (1 liter)- **DUPLICATE**
- Preserved Wet Chem. -TKN, NO_2/NO_3, Ammonia, COD, & T Phosphorus (1 liter)
- Preserved Wet Chem-TKN, NO_2/NO_3, Ammonia, COD, &T Phosphorus (1 liter)- **DUPLICATE**
- Oil and Grease (1 liter-glass)
- Oil and Grease (1 liter-glass)- **DUPLICATE**
- TOC (250 ml-glass)
- TOC (250 ml-glass)- **DUPLICATE**
- Settable Solids (1 liter)
- Settable Solids (1 liter) **DUPLICATE**
- Fecal Coliform- 100 ml
- Fecal Coliform- 100 ml **DUPLICATE**

Note: the fecal coliform sample bottles were filled directly from the sample port.

David then filled the 10 liter cubitainer a second time to fill the Priority Pollutant bottles. David shook the effluent within the 10 liter cubitainer and filled the sample bottles in the following order:

- Metals (1 liter)
- Metals (1 liter) **DUPLICATE**
- BNA
- BNA **DUPLICATE**
- VOC (4 40ml vials glass)

- VOC (4 40ml vials glass) **DUPLICATE**

After filling the sample bottles for fecal coliform, David put the bottles in a plastic "Ziploc" and immediately put them in the ice water bath along with the 120 ml temperature blank. After all the bottles were filled David transferred the bottles to the large cooler and emptied the bag of ice over the sample bottles. The large temperature blank was added to the cooler at this time as well.

Tessina tested the sample (test vial) to check for free chlorine. The result for free chlorine was 0.03 mg/L. Therefore, David rinsed the ascorbic acid out of the decanting bottle before he used it to fill the VOC bottles. Ascorbic acid was not added to the BNA sample bottle.

Tessina began the field tests immediately after David filled the field test bottles. Temperature was measured immediately after the field test bottle was filled. Tessina then proceeded with the remaining tests for pH and total chlorine. Tessina recorded the field results into their notebook, and proceeded to take get signatures from the EO.

Prior to placing the temperature blanks in the coolers, Tessina recorded the ambient temperatures of the 1 liter and 120ml temperature blanks, which were 22.0°C and 23.3°C respectively.

Results of Ryndam sample field tests included:

Mixed Blackwater and Graywater Ryndam Sample	
Time	10:16
Temperature C°	31.6
Total Chlorine	0.00
Free Chlorine	0.03
pH	7.82

Results of Duplicate sample field tests included:

Mixed Blackwater and Graywater Duplicate Sample	
Time	10:16
Temperature C°	31.4
Total Chlorine	0.00
Free Chlorine	0.03
pH	7.78

Tessina used a *HACH Pocket Colorimeter* to detect total and free chlorine. Liquid wastes were dumped into a 1 liter container retained by the samplers. The pH field test was conducted using a calibrated *Oakton Instruments pH Tester 2.* All field test equipment was rinsed with deionized water and sterilized with alcohol after use. All debris, including used gloves and tissues were placed in the 1 liter waste container and taken off the ship.

Tessina took a picture of the sampling port with a sign identifying the sample port, sampling event and date. We then proceeded to the engine control room where David retrieved a copy of the discharge log from the EO.

In order for the blind duplicates to remain unknown to the laboratory, David and Tessina sampled the m/v Infinity for Conventional and Priority Pollutants immediately after the Ryndam event. The idea is that when the samplers arrive at the lab they will have three sets of Conventional and Priority Pollutant sample bottles. One set for the Infinity, one for the Ryndam and one for the blind duplicate.

The chain of custody (COC) for the blind duplicate sample did not include the sample time or field test results. Therefore, the laboratory can not determine whether the blind duplicate samples belong to the Infinity or the Ryndam. The samplers retain the blind duplicate information in their field notes for reference.

I met up with Tessina after the Infinity sampling event and accompanied her to the lab for sample delivery. Tessina relinquished the samples to Sally Wanstall of Analytica at 14:00. The Ryndam and the Infinity samples were in the same cooler (large cooler) and the blind duplicate samples were in a cooler alone. All of the fecal coliform samples were in the small cooler together. Sally unloaded the coolers and measured the temperature blank of all three coolers and recorded them on the chain of custody's. The temperature of the large cooler was 0.5°C. The blind duplicate cooler temperature was 6.0°C, and the fecal coliform cooler's temperature was 1.0°C.

Sally checked the pH level in the preserved sample containers to ensure proper preservation. All samples had a pH less than 2. Sally also checked the VOC vials for bubbles; there were no bubbles present. Sally moved all samples to the receiving refrigerator and made a copy of the chain of custody for Tessina's records.

Recommendations

This was an excellent sample event and I can't think of any improvements.

Commercial Passenger Vessel Environmental Program
ADEC Oversight Checklist

<u>During Water Sample Collection</u>

- ☐ Were the samples collected from appropriate and representative locations at appropriate times? Yes.
- ☐ Was the sample collection time representative of the maximum usage of the wastewater treatment and discharge system? Yes
- ☐ Did the sampler collect the required ship records and logs, particularly the Graywater & Sewage Discharge Record Book which identifies tanks, estimates volumes and calculates discharge rates (if any) at the time the sample was drawn? Yes
- ☐ Did the ship representative indicate any problems with the wastewater treatment system? No.
- ☐ Did the samplers work in twos to assure that proper sampling techniques and note-taking? Yes
- ☐ Did the sampler/s use sanitary techniques? Yes
- ☐ Did the sampler/s wear disposable gloves, safety eye gear, tie-back suit and proper foot gear? Yes
- ☐ Did the sampler/s remain aware of potential safety and biohazards present? Yes.
- ☐ Were sample bottles all correctly prepared? Yes.
- ☐ Were the samples identified clearly on the sample bottles and the chain of custody form? Yes.
- ☐ Were the specified field measurements taken (pH, temperature, chlorine residual)? Yes.
- ☐ Were priority pollutant samples taken? Yes
- ☐ Was a volume of water equal to at least ten times the volume of the sample discharge line first discharged into a bucket or similar container, to clear the line of standing water and possible contamination? Yes.
- ☐ Were the sample bottles filled and sealed correctly? Yes.

- Were sample bottles cooled immediately in an ice-water bath to 4° degrees C, and placed into a cooler containing frozen blue ice to maintain a sample temperature of 2-6 degrees C? **Yes**

- Except for the VOC bottles, were the sample bottles filled to the shoulder of the bottle, leaving a small space for expansion and mixing? Yes

- Did the sample bottles for ammonia, COD, fecal coliform, oil and grease, TOC, nitrogen and phosphorus have the appropriate preservative added in the laboratory? **Yes.**

- If chlorine residual is detected during field measurement of chlorine, did the sampler add the sodium thiosulfate to the BNA, PCB and pesticide sample bottles until no chlorine is detected? **N/A**; chlorine was not detected

- Was the chain of custody form correctly completed? Yes. Were any collection anomalies noted? N/A

- Did the sampler use a field log book? Yes. Note any sampling anomalies? N/A

- Did the sampler transcribe or receive copies of the required documents from the ship sewage and graywater discharge record book (recording times, volumes, and vessel location where the waste is discharged for each graywater and treated sewage discharge port)? Yes,

- Were the sample holding times met? (See QAQC) Yes.

- Did the sampler dispose of liquid and solid waste correctly? Yes

- Was sample custody maintained until delivery to lab? Yes.

- Latitude/longitude and speed at time of discharge being sampled, Yes

Responsibilities outlined in NWCA 2006 QAQC Plan

The sampler

- notified the ADEC of its intent to sample at least 36 hours prior to sample collection. YES
- identified sample name clearly on the chain of custody and sample bottles. YES
- Collected field notes in bound field notebooks with numbered pages. YES
- On-board staff will witness the sampling and will initial the field notes. YES

Passenger Vessel Wastewater Sampling Procedures Inspection Review for Priority Pollutants

For the

Volendam @ Juneau Dock

Conducted May 19,2006, 3:35 PM

Observations and Concerns

Passenger Vessel Wastewater Sample Login Procedures Inspection Review for Priority Pollutants

For the

Norwegian Sun *and* Norwegian Star @ Juneau Dock

Conducted May 23,2006, 4:00 PM

Observations and Concerns

Submitted by

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May 28, 2006

Attachments:

Completed "2006 Cruise Ship Wastewater Discharge Monitoring Program Quality Assurance/Quality Control Sampling Audit Checklist" and "Sample Check-in Audit Checklist"

Note: The Sampling Audit (Volendam) and the Sample Login Audit (Norwegian Sun and Norwegian Star) were completed on different dates. Reference to each specific audit is clearly indicated within the body of this report.

Observations:

Sampling Audit of M/S Volendam on 5/19/06

At 3:00 PM, Friday, May 17, 2005, the QA/QC officer arrived at the Juneau, AK docking point of the M/V Volendam. At 3:25 PM sampling personnel Tessina Davidson and Ryan Kubota of Admiralty Environmental Inc joined me at the gangway with the sampling containers and equipment. We boarded the ship, were issued identification cards and were then met by David Carlisle, engineering assistant for the Volendam. The group then proceeded to a galley area to secure ice for the sampling coolers. It was noted that the main sampling cooler was charged with ice while the smaller cooler (for fecal coliform sample) was charged with ice and a small amount of water. After charging the coolers with ice the entire group proceeded below deck to the sampling port. Mr. Kubota confirmed that the ship was currently discharging. At this point Mr. Carlisle produced discharge logs and Mrl. Kubota reviewed them. Sampling personnel donned the following safety gear:

- TYVEK suit
- safety glasses
- latex gloves
- hearing protection

The sampling port was opened and allowed to purge. After adequate purge, a sample was collected by Mr. Kubota and passed to Ms. Davidson. As Ms. Davidson began shipboard measurements of temperature, pH and chlorine with this sample, Mr. Kubota proceeded to collect samples for off-site testing purposes. Ms. Davidson began the collection of shipboard notes, recording temperature, pH, residual and free chlorine as she completed these tests. It was noted that all waste was collected in an appropriately labeled polyethylene bottle and removed from the ship by the sampling team.

Field Tests:

A 120 mL polypropylene bottle was used for onsite measurement of pH, temperature and residual chlorine. The following tests were conducted onboard with a waste-stream sample and the results entered into the field notebook and onto the Chain of Custody form:

pH – handheld meter

pH = 7.78

residual Cl_2 – test kit.

residual/total Cl_2 = 0.06/0.03

temperature – handheld electronic probe

The calibration date on the pH meter, the visible spectrometer used in Cl_2 determinations and the temperature probe was requested. Calibration dates (5/01/06) were in agreement with the 2006 QA/QC Plan.

The QA/QC officer did not specifically hear either of the sampling personnel verify the location of the sampling port relative to the UV treatment and discharge point (within 50 ft). When asked about the location of the sampling port by the QA/QC officer, Mr. Carlisle pointed to a sign located above the sampling port indicating that port to be the one specified in the Volendam VSSP.

Sampling containers used in sample collection had been previously labeled with date and nature of sample. The type of sampling container, headspace and the presence of the appropriate preservative was verified (see attached audit checklist). It was noted that the preservative for the TOC sample differed from that listed in the 2006 QA/QC Plan. Once samples were collected, Mr. Kubota placed temperature blanks into both coolers followed by the filled sample bottles.

Treated wastewater sampling (points of interest are indicated by ✱):

- BOD/TSS/pH/EC/Alkalinity
  - ♦ The bottle was properly labeled.
  - ♦ The proper headspace and preservative requirements were verified.
- COD/NH_3/N_2/NO_3/P(total)
  - ♦ The bottle was properly labeled.
  - ♦ The proper headspace and preservative requirements were verified.
- TKN
  - ♦ The bottle was properly labeled.
  - ♦ The proper headspace and preservative requirements were verified.
- TOC
  - ♦ A 125 mL amber bottle was properly labeled.
  - ♦ The proper headspace was verified.
  - ✱ Ascorbic acid was used as preservative.
- Settleable Solids
  - ♦ The bottle was properly labeled.
  - ♦ The proper headspace and preservative requirements were verified.

- Oil and Grease
  - The bottle was properly labeled.
  - The proper headspace and preservative requirements were verified.

- Fecal Coliforms
  - The bottle was properly labeled.
  - The proper headspace and preservative requirements were verified.
  - ✱ The temperature blank for this sample was not checked prior to introduction of the sample.

After completing sample collection, a placard containing appropriate sampling information was placed in front of the sampling port and Mr. Kubota photographed the sampling port. Mr. Kubota then began the Chain of Custody form for this sampling event with the appropriate reference information and collected the appropriate signatures (from shipboard assistant) for the CoC form and the shipboard notes. The samplers then removed sampling safety apparel, collected coolers and any waste and followed Mr. Carlisle back to the entry gangway where we returned identification cards and exited the ship.

Circumstances did not allow the QA/QC officer to follow the samplers to the contracting laboratory for the sample check-in audit so it was agreed that sampling events scheduled for 5/23/06 would be used for the sample check-in audit.

Recommendations:

- The preservative for the TOC sample listed in the 2006 QA/QC Plan should be amended from H_2SO_4 to ascorbic acid.
- The temperature blanks for both receiving coolers should be installed immediately upon charging the coolers with ice.
- The temperatures of the receiving coolers should be verified prior to placing samples into the coolers.

Sample Login Audit for samples collected from M/V Norwegian Sun and Norwegian Star on 5/23/06

On 5/23/06 at 4:00 PM, the QA/QC officer met Admiralty Environmental Inc. sampling personnel Tessina Davidson and Ryan Kubota at Analytica Alaska Inc, Juneau, AK. Ms. Davidson and Mr. Kubota had just completed conventional sampling of the M/V Norwegian Star and had earlier that day completed conventional sampling of the M/V Norwegian Sun and were submitting the samples from both of these events to the contracting laboratory for testing. In total there were 3 coolers containing samples and the QA/QC officer observed Ms. Davidson and Mr. Kubota relinquish custody of these three coolers to Analytica Inc. sample custodian Sally Wanstall at approximately 4:05 PM. None of the coolers were sealed with custody tape. Upon relinquishing the coolers Mr. Kubota informed Ms. Wanstall that there were three sets of samples and that one of those sets was a duplicate sample. Mr. Kubota did not reveal which of the conventional sampling events was duplicated and nowhere on the duplicate bottle's labeling was it apparent which of the two ship's samples had been duplicated. Mr. Kubota gave the Chain of Custody forms to Ms. Wanstall and signatures were checked.

Upon receiving the coolers Ms. Wanstall, assisted by Levi Wanstall proceeded to check temperature blanks, check pH on the samples preserved with acid and complete the chain of custody forms. Temperature blanks on all coolers were within the limits defined in the 2006 QA/QC Plan. Clean techniques were followed during pH verification. The temperature blank data was entered onto the relevant Chain of Custody form and dates and other relevant information completed. The samples were logged and fecal coliform samples were promptly refrigerated. The temperatures of the refrigerators used for sample storage were within the limits defined in the 2006 QA/QC Plan (F.C. = 4.2°C, other = 5°C). It was noted that the remaining samples requiring refrigeration would be further processed and if required, cooled within the hour.

Recommendations:

- When more than one ship is sampled and it is necessary to delay delivery of the first set of samples to the contracting laboratory, custody tape should be used to seal coolers containing this first set of samples given that this cooler will most likely not remain within the sampler's line of sight at all times prior to submission to the contracting laboratory.
- As per the 2006 QA/QC Plan, Chain of Custody forms are to be placed into the cooler containing the relevant samples.

The Admiralty Environmental Inc. sampling team works together very efficiently and shows great care and attention in performing the sampling tasks. Analytica Alaska Inc. personnel demonstrate very professional and efficient processing of field samples.

Clarification on any portion of this report may be directed to:

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