Afloat Solid Waste Characterization Study

NAVSUP
Naval Supply Systems Command
Naval Inventory Control Point

USS Nimitz (CVN 68) • April 2008

• US NAVY •
P2 POLLUTION PREVENTION

Executive Summary

In April 2008, the Naval Inventory Control Point (NAVICP) 077 team conducted a waste characterization study aboard USS Nimitz (CVN 68) underway during an overseas deployment. Observing shipboard waste handling procedures, while working side by side with ship's personnel, provided the team members with representative data, and insight into the challenges our sailors routinely overcome in order to comply with the International Convention for the Prevention of Pollution from Ships; Maritime Pollution (MARPOL) and mission requirements.

Extensive data was gathered on the type, weight, volume, and source (by location) of the waste generated aboard Nimitz, and comparison was made to data collected during a similar study conducted aboard USS Harry S. Truman (CVN 75) in 2004.

This study revealed the following key data:

- Plastic represented 12.5 percent of total shipboard waste processed in the 2004 Truman study vs. 7.7 percent of total shipboard waste processed in the 2008 Nimitz study. Total plastic waste decreased by 125 pounds in the 2008 study over 2004 levels.
- The galley contributed approximately 65 percent to the ship's waste stream, including 39 percent of the plastic waste generated aboard during the study period.
- 50 percent of the waste processed during the 48-hour period was food waste.
- Cardboard, paper and metals produced a significant percentage of the solid waste stream.

The NAVICP 077 study team makes the following recommendations:

- Conduct a distribution study and a review of items on the 21-day Navy Standard Core Menu (NSCM) to identify the significant contributors of plastic and other packaging waste source reduction efforts.
- Conduct a similar study to evaluate waste reduction opportunities during Replenishment At Sea (RAS) events.
- Accelerate efforts to explore alternatives to plastic packaging that includes marine biodegradable plastic and other environmentally friendly plastic alternatives.
- Initiate a collaborative effort with the Naval Supply Systems Command (NAVSUP) and the Naval Sea Systems Command (NAVSEA) to develop a P2 Solid Waste Awareness Kit to elevate program shipboard awareness, increase knowledge on MARPOL/Navy regulations, and share best practices throughout the fleet.
- Explore recycling and reuse opportunities for solid waste afloat. The NAVICP 077 Team will work to identify programs that maintain sanitary conditions with minimal sailor labor.
- Establish a ship P2 Waste Reduction Afloat Protects the Sea/Plastics Removal In the Marine Environment (WRAPS/PRIME) environmental award to recognize individual ships for their efforts or innovation for promoting solid waste management practices.

1 Introduction

1.1 Purpose

In April 2008, the NAVICP 077 Team conducted a 48-hour Solid Waste Characterization Study aboard USS Nimitz (CVN 68), a fully manned, outfitted, forward deployed aircraft carrier. This study was conducted in support of the Waste Reduction Afloat Protects the Seas (WRAPS) and Plastics Removal In the Marine Environment (PRIME) programs to assess the US Navy's solid waste management practices and recommend possible improvements. Like previous NAVICP studies conducted on USS Truman (2004), USS Essex, USS Fitzgerald and USS Sides (1996), this study collected shipboard real-time data on the types, quantity, and sources of the solid waste streams and how these waste streams were managed from generation to disposal. The purpose of this report is to summarize the findings, compare the results with similar studies, and identify additional P2 opportunities in accordance with pollution prevention principles of source reduction, reuse, recycling, and disposal.

The 2008 study confirms the fleet's adoption of NAVICP recommendations from previous studies, and highlights the continual need for improvement of solid waste management practices afloat. It is realized that solid waste, particularly plastic waste, is still difficult to manage in a shipboard environment to maintain compliance with MARPOL and mission requirements. The objective of the NAVICP Pollution Prevention (P2) Program is to support Navy efforts to identify, expand, and develop processes and procedures to better manage and reduce solid waste afloat.

1.2 Background

The International Convention for the Prevention of Pollution from Ships: Maritime Pollution (MARPOL) Annex V regulates the disposal of solid waste generated during normal vessel operations. Solid waste components include domestic waste (galley waste and food packaging), operational waste, and cargo-related garbage such as dunnage, lining and packing materials. Specifically, Annex V determines where waste discharges are allowed at sea. Under Annex V, it is illegal for any vessel to discharge plastics or garbage containing plastics into any waters worldwide and restrictions are placed on at-sea disposal of other solid waste.

Improper disposal of plastic solid waste creates many environmental problems including entanglement of marine animals, ingestion of plastic solid waste by wildlife, and the littering of shorelines worldwide. A 2007 EPA[1] report estimates that a plastic bottle may take over 450 years to dissolve or degrade in a marine environment compared to cotton cloth that can dissolve in 1 to 5 months.

Although military vessels were previously exempted from MARPOL due to space considerations, the US Congress passed legislation in 1987 which required the Navy to comply with Annex V of the International Treaty. The legislation mandated that the Navy

[1] *Draft Cruise Ship Discharge Assessment Report*, (EPA842-R-07-005), U.S. Environmental Protection Agency, Oceans and Coastal Protection Division Office of Wetlands, Oceans, and Watersheds, December 2007

take action to fully comply with MARPOL Annex V by 1993. The Navy was given an extension to comply until 1998. The US Navy is now bound by these requirements which are included in OPNAVINST 5090.1C (Table 1-1). Additionally, the NAVSEA Solid Waste Management Guide for Surface Ships states that a Solid Waste Management Plan must be in place on all vessels to monitor the sorting, collection and disposal of all waste while underway.

AREA (Distance from Shore)	GARBAGE (Non-Plastics)	GARBAGE (Plastics)
0–3 Nautical Miles	No discharge.	No discharge.
3–12 Nautical Miles	Pulped or contaminated food, pulped paper and cardboard waste may be discharge >3 Nautical Miles.	No discharge.
12–25 Nautical Miles	Bagged, shredded glass and metal waste may be discharged >12 Nautical Miles.	No discharge.
>25 Nautical Miles	Direct discharge permitted.	No discharge.
>50 Nautical Miles & High Seas	Direct discharge permitted.	No discharge.
MARPOL "Special Areas" in Effect	Discharge pulped contaminated food, pulped paper and cardboard waste >3 Nautical Miles. Discharge bagged, shredded glass and metal waste >12 Nautical Miles. Report all non-food pulped, non-shredded garbage discharges to CNO-(N45) upon completion of operations.	No discharge.
Foreign Countries	Discharge pulped or contaminated food, pulped paper and cardboard waste >3 Nautical Miles from foreign coasts. Discharge bagged, shredded glass and metal waste >12 Nautical Miles. Discharge all other garbage >25 Nautical Miles.	No discharge.
Comments	Garbage discharged should be processed to eliminate marine debris. Retain surplus material for shore disposal.	Record keeping requirements for at sea discharge. Minimal discharge authorized if plastic waste processor inoperable and necessary for safety of ships health of crew. Report discharge commencement to appropriate operational commander.

Table 1.1 - MARPOL Solid Waste Regulations

research the procurement of more environmental friendly products, identify reuse opportunities, and identify packaging alternatives to decrease the amount of plastic packaging on certain items in the supply chain.

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3 Study Results

This section of the report presents the results of study and analysis of relevant data collected from the waste characterization study. Table 3.1 shows the total weight of waste produced during the two days of the study and provides the average weight for a 24-hour period. All subsequent percentages and values discussed in the report also represent the average as obtained from the two 24-hour collection periods.

During the study period, the crew consisted of a total of 4,316 people (including the 6 person study team). Therefore, USS Nimitz generated an average of 3.7 pounds of solid waste per person per day.

	Day 1	Day 2	Total	24-Hour Average
Weight (lbs)	16,713	15,334	32,048	16,024

Table 3.1 - Waste Characterization Study Daily Waste Totals

3.1 Distribution by Type

Figure 3.2 shows the distribution of waste collected by type from all of the identified departments for a 24-hour average. Most noteworthy, food waste accounted for just over 50 percent and a total weight of 8,093 pounds of the total solid waste generated on the ship. The composition of the food waste was a combination of excess prepared items, spoiled food, and uneaten food waste. The second largest contributor of solid waste was cardboard at 14 percent, followed by dunnage, paper, and plastic. A detailed analysis of plastic waste is described in Section 3.3.

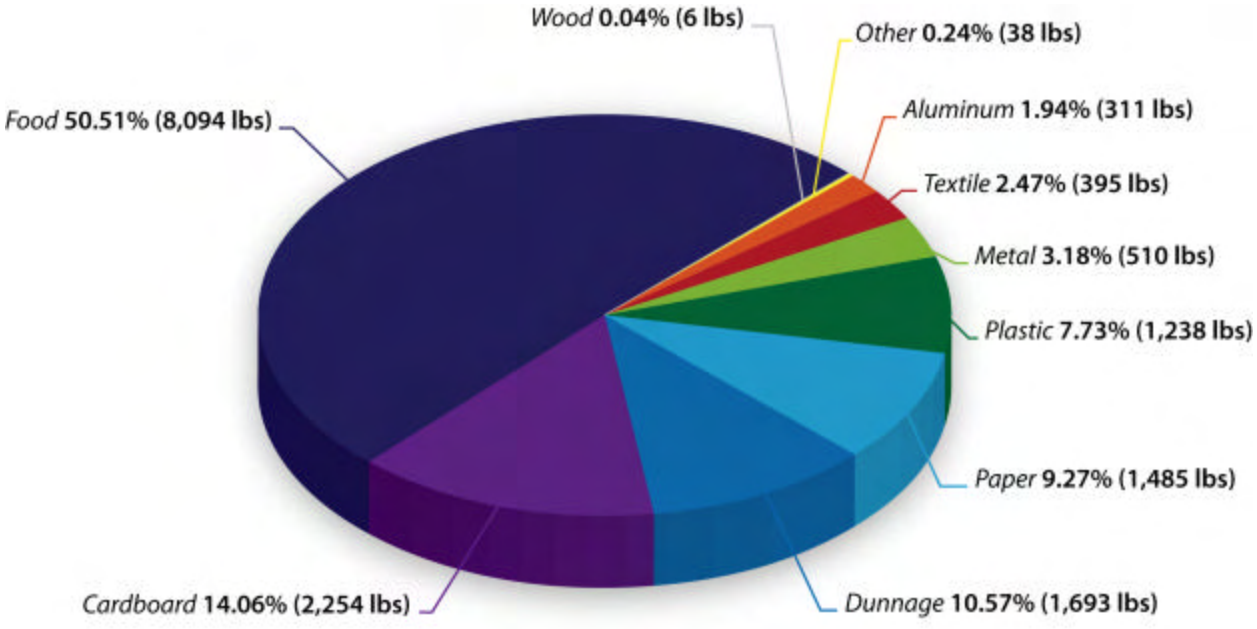

Figure 3.2 - Solid Waste Distribution by Type

The team noted that a portion of food waste was regularly disposed of directly into the garbage disposal units located in several sinks in the various galleys. This disposal method was used mainly to dispose of liquid food waste and food residue from galley plates. The weight of food waste disposed of in galley garbage disposal units was not captured and is not included in the data presented in this report. Observation indicates that this waste was not a significant contributor to the total amount of solid waste generated aboard.

3.2 Distribution by Department

Figure 3.3 identifies the waste generated by the 11 departments who contributed to the solid waste stream.

The galley generated the most waste with a daily average weight of 10,556 pounds generated, representing 65 percent of all the solid waste produced by the entire ship. The other departments combined made up the remaining 35 percent (a total daily average weight of 5,467 pounds). The large amount of galley waste was expected, given that food accounted for over 50 percent of all solid waste. The galley produces large quantities of food of many different varieties to accommodate the high demand for meals provided around the clock in multiple serving locations. Unused food must be disposed of each day due to food safety and crew health considerations. The Supply Department ranked second in solid waste generation with 15 percent of the total solid waste. All other departments generated less than 3 percent each of the total solid waste.

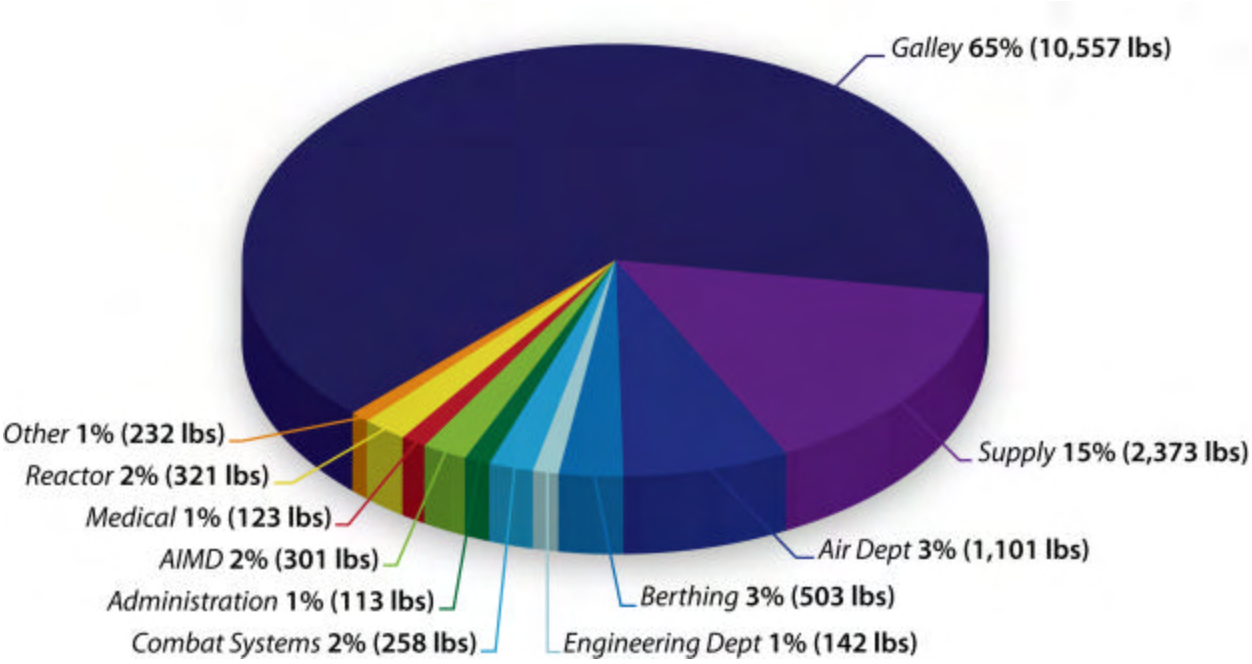

Figure 3.3 - Solid Waste Distribution by Department

3.3 Plastic Waste Analysis

Storage and disposal of plastic solid waste represents the greatest waste stream management challenge for any Navy ship and can negatively impact the ship's ability to effectively execute its missions. According to MARPOL regulations, all plastic waste must be stored until the next offload opportunity or the next port-of-call. This continues to be an issue throughout the entire deployment as more and more solid waste is accumulated and stored awaiting offload at the next port of call or UNREP opportunity. Plastic is difficult to process and it is often contaminated with food waste. Health and sanitary issues are always present when massive amounts of contaminated processed plastic waste are stored on the hangar deck. Transferring tons of plastic waste to a Combat Logistics Force (CLF) ship can increase the duration of each UNREP evolution, adding to the time the CVN is unable to launch and recover aircraft.

Improvements in the commercial sector have resulted in a significant increase in plastic food packaging over the last 30 years. Plastic packaging has enabled manufacturers to increase the shelf-life of certain foods; helped to prevent pilferage, tampering, breakage; and provided an area for label application. Unfortunately, these commercial trends have led to the increase in the amount of plastic delivered to Navy ships increasing the challenges of maintaining MARPOL Annex V compliance.

Plastic solid waste averaged 7.7 percent or 1,238 pounds of the daily waste generated aboard the Nimitz during the study period. Figure 3.4 details the origin/location of the plastic solid waste generated aboard the ship during the study period. The galley generated 39 percent of the plastic solid waste on the entire ship. Plastic waste coming from the galley accounted for only 3 percent of the ship's overall waste stream during the study period, but presents the greatest operational challenges. Based on an estimated volume of plastic waste, the average weight for a 30-gallon bag of plastic was 6.9 pounds. Therefore, during an average 24-hour period, the ship generates 179 30-gallon bags of plastic waste.

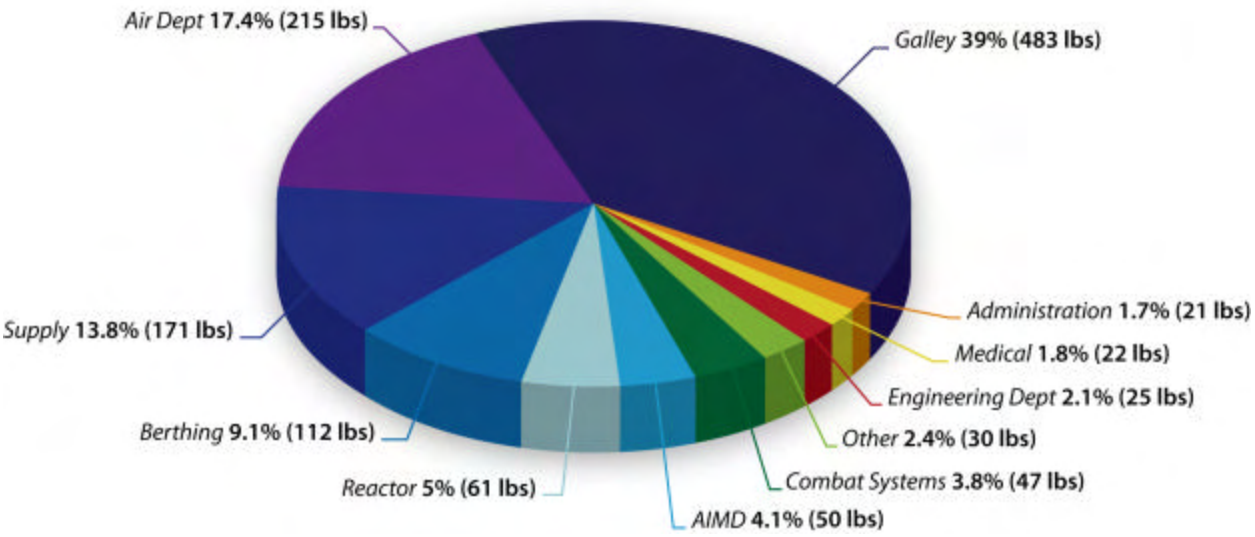

Figure 3.4 - Plastic Waste by Originating Department/Location

Figure 3.5 illustrates the plastic waste accumulation in the hanger bay during normal operations.

Figure 3.5 - Plastic Accumulation in Hangar Bay

3.4 Comparison to USS Truman 2004 Study/Cruise Line Industry

3.4.1 Comparison to USS Truman 2004 Study

The NAVICP 077 Team has conducted previous waste characterization and distribution studies to measure, target, and understand solid waste management afloat. Waste characterization studies were conducted in 1996, 1999, 2000, and 2004. However, the only comparable study was completed aboard USS Truman (CVN 75) in 2004. The 2004 study is similar to the Nimitz study in that it was conducted on an aircraft carrier with a full air wing complement during an overseas deployment.

The purpose of USS Truman study was to characterize the solid waste generated aboard a large deck ship while underway and to identify areas of improvement. Additionally, the 2004 study evaluated the supply and distribution process, and how this process impacts the waste generated at sea.

The results of the 2004 study indicated that the galley accounted for over 70 percent of the total waste generated. This study also determined the shipboard disposal process observed was effective and compliant for most types of waste. However, plastic waste processing, 13 percent of total waste, was very labor intensive and problematic, with excessive down time and unreliability of the waste processing equipment contributing to the challenges of compliance for shipboard personnel.

Table 3.6 below provides a comparison of the 2004 USS Truman study's data collection processes between the two reports.

	TRUMAN STUDY 2004	NIMITZ STUDY 2008
Data Collection Process	Test Plan	Test Plan
Data Collection Times	0500 – 0700 0700 – to darken ship 0700 – 2300	48 continuous hours 0800 – 0800
Data Collection Locations	(3) Food Service Trash Room Forward Waste Processing Room Main Incinerator Room	(2) Galley Processing Room Aft Processing Room
Number of Personnel Collecting Data	(8) 4 on 12 hour day shift 4 on 12 hour night shift	(6) 3 on 12 hour day shift 3 on 12 hour night shift
Total Number of Weighs Collected	705	3,304
Average Pound Per Weigh	15.42 lbs	10.31 lbs

Table 3.6 - Comparison of 2004 and 2008 Solid Waste Study Test Plans

The operating environment for the 2004 study was more challenging than the 2008 study. During the 2004 Truman study, the ship was operating in the Persian Gulf in support of Operation Iraqi Freedom, and continuous waste stream monitoring was not always possible. The 2008 Nimitz study was conducted during a transit period in the Pacific Ocean.

Improvements in data collection and recording during the 2008 Nimitz study, along with a more permissive operating environment led to a more accurate snapshot of the ship's waste stream during this event.

Table 3.7 and Table 3.8 provide comparisons of the type and origin of solid waste between the two studies. Table 3.7 on the next page shows that the Nimitz study found a larger total daily amount of waste (16,024 pounds) compared to the 10,874 pounds measured in the Truman study. Although the daily pounds of solid waste captured during the 2008 study was significantly higher, viewed as percentages the departmental distribution was similar. There was a small decrease in percent of waste generated in the Administration Department and the galley in 2008 when compared to the 2004 study results. The Supply Department waste increased from 9 percent to 14.8 percent of total solid waste in the Nimitz study.

Generating Location/Department	TRUMAN STUDY 2004		NIMITZ STUDY 2008	
	Waste (lbs)	Distribution	Waste (lbs)	Distribution
Admin	693	6%	113	1%
AIMD	157	1%	301	2%
Air Dept	607	6%	1,101	7%
Berthing	176	2%	503	3%
Combat Sys	257	2%	258	2%
Engr Dept	228	2%	142	1%
Galley	7,638	70%	10,557	66%
Medical	87	1%	123	1%
Other	11	0%	232	1%
Reactor	39	0%	321	2%
Supply	981	9%	2,373	15%
TOTAL	10,874	100%	16,024	100%

Table 3.7 - Average Daily Comparison by Department

Table 3.8 on the following page, shows the increase of food waste from 31 percent to 50 percent with an increase of 4,678 pounds between the two studies. Over 90 percent of the total increase in daily waste recorded by weight between the 2004 study and the 2008 study was food waste.

Nimitz produced a daily average of 1,238 pounds of plastic waste during the April 2008 study. This was a decrease of 125 pounds as compared to previous results that showed a continued increase in the weight of plastic waste generated. When viewed as a percentage of the ship's total waste stream, the overall plastic waste documented decreased from 12.5 percent on the Truman to 7.7 percent on the Nimitz. Specifically in the galley, the solid plastic waste produced was a reduction of 295 pounds or 5.6 percent from the Truman study.

Other noteworthy differences in the data between the 2 studies include a 246 pound reduction in paper waste observed in 2008, and a 320 pound increase in the amount of textiles, recorded in 2008. When viewed as percentages of the ship's solid waste stream the other types of waste observed during the Nimitz study produced similar results as the Truman study.

Type of Waste Generated	TRUMAN STUDY 2004		NIMITZ STUDY 2008	
	Waste (lbs)	Distribution	Waste (lbs)	Distribution
Food	3,416	31%	8,094	51%
Cardboard	2,135	20%	2,254	14%
Paper	1,731	16%	1,485	9%
Plastic	1,363	13%	1,238	8%
Metal	446	4%	821	5%
Textiles	75	1%	395	2%
Dunnage	1,509	14%	1,693	11%
Other	200	2%	44	0%
TOTAL	10,874	100%	16,024	100%

Table 3.8 - Comparison by Type

3.4.2 Cruise Line Industry Comparison

Both commercial cruise lines and the US Navy operate surface ships, however, their missions, methodology, and operational constraints are considerably different. Many of the solid waste management processes used by commercial cruise liners and Navy ships are similar, but there are too many differences in operations to allow for a full system-wide comparison. However, it is relevant to provide an analysis of the solid waste practices and the comparison of types and amounts of waste generated aboard commercial cruise lines.

Cruise lines operate numerous types of vessels for the purpose of passenger recreation. Large cruise ships can accommodate up to 5,000 passengers and crew. Cruise ships are underway an average of 3 to 14 days between ports of call. Ships typically operate on a scheduled circuit visiting the same ports on a repetitive basis. This predictable schedule allows cruise ship companies to arrange for robust port services including waste disposal support and servicing of waste processing equipment on a frequent basis.

Cruise ship solid waste includes bottle, can, plastic, cardboard, and food wastes. Approximately 75 to 80 percent of cruise ship solid waste is incinerated at sea and then the ash is dumped into the ocean or offloaded in port. Some trash is stored and taken ashore for disposal and recycling. Cruise ships are beginning to utilize plasma arc incineration technology to incinerate waste to cut down on solid waste disposal charges and processing time.

In contrast, the US Navy operates a diverse fleet of ships, carrying crew members from several hundred to over 6,000. Navy ship schedules are far less predictable than cruise liners, with longer underway periods, typically a 180-day deployment, and less consistent access to a standard level of port services. US Navy ships sustain operations at sea for long periods, sometimes consecutive months at a time, operate in extreme

physical environments, and continue to perform to high standards even while in combat environments. Navy personnel perform most of the required repair and maintenance activities while underway.

According to a 2007 EPA[4] draft report, cruise ships generate from 0.7 to 7.7 pounds of solid waste per person daily. In the report, analysis of five studies produced by a range of organizations including environmental groups and the cruise industry identified an average of 4.48 pounds per person per day. The April 2008 Nimitz study calculated an average of 3.7 pounds per person per day. These encouraging results have been achieved despite the fact that Navy vessels accommodate a higher number of personnel for longer periods of time at sea, replenish supplies, and perform maintenance while underway.

[4] *Draft Cruise Ship Discharge Assessment Report*, (EPA842-R-07-005), U.S. Environmental Protection Agency, Oceans and Coastal Protection Division Office of Wetlands, Oceans, and Watersheds, December 2007