IDENTIFICATION AND ASSESSMENT OF FOOD WASTE GENERATORS IN HAWAI'I

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ABSTRACT

This thesis provides information on food waste and cooking oil disposal and recycling methods, and recycled amounts. Data were obtained from a mail and phone survey conducted from Fall 2004 to Summer 2005 of all licensed food establishments in Hawaii. Of the 8,253 food establishments in Hawaii, 5,033 surveys were completed. It was found that relationships exist between food establishment size (measured by the number of meals served per day and the number of employees) and amount recycled; establishment type and recycling behavior; and establishment type and amount recycled.

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1.0 INTRODUCTION

1.1 Purpose and Scope of Study

As many landfills reach capacity, various waste management plans and recycling programs have been studied and implemented to reduce the amount of waste going into the landfills. Recycling can play an important role in waste management by diverting material from landfills. Two types of recycling—food waste and cooking oil recycling are the focus of this thesis. In Hawaii, food waste and/or cooking oil recycling are practiced by some restaurants, supermarkets, hotels, and schools.

In this thesis, food waste and cooking oil recycling practices were studied to determine how much food and oil are currently being recycled in Hawaii; how food and oil are recycled in Hawaii, and reasons why establishments do not recycle their food waste. This was achieved by surveying food establishments in Hawaii to collect information about their food waste and cooking oil disposal and recycling practices. This thesis focuses on commercial food waste generators and only those with food establishment permits issued by the State of Hawaii Department of Health. Businesses operating without the proper permits and households were not included.

Funding for this research came from the Hawaii Department of Agriculture (HDOA) and the Hawaii Natural Energy Institute (HNEI). Their reasons for supporting this project are explained in the following sections.

1.1.1 Hawaii Department of Agriculture (HDOA) and the Swine Health Protection Act

The HDOA is interested in knowing which food establishments recycle their food waste and where/how it is recycled, in particular farms that use food waste as feed for

pigs. The HDOA in cooperation with the U.S. Department of Agriculture (USDA) is responsible for licensing all pig farmers that feed food waste and also for monitoring compliance with the Federal Swine Health Protection Act (SHPA). HDOA was interested in identify the unlicensed pig farmers in the state, and the method chosen was to contact all the food establishments in Hawaii. Traditionally pig farmers collected food waste (slop/swill) from businesses and neighbors to feed to their pigs and the HDOA is interested in finding any unlicensed pig farmers through the suppliers/generators (the food establishments) of the food waste.

The SHPA regulates the practice of feeding food waste to pigs. Any food that is fed to pigs that contains meat or animal material or food that has come into contact with meat or animal products is regulated by the SHPA. The SHPA requires that anyone feeding food waste to pig(s) be licensed with the USDA and/or the chief agricultural or animal health official in the state. Furthermore, the SHPA sets guidelines for cooking the food waste—after reaching its boiling point (212 degrees Fahrenheit) the food waste must be boiled for at least 30 minutes[1].

It is necessary to regulate the feeding of food waste to prevent diseases from entering the pig population and spreading to other livestock or humans. Properly heat treating (cooking) food waste can prevent the transmission of exotic (not present in the U.S.) diseases (e.g., foot-and-mouth disease, hog cholera, African swine fever, swine vesicular disease) and common domestic pathogens (e.g., *Trichinella, Toxoplasma, Salmonella, Campylobacter*) by killing any disease organisms present in the food waste[2].

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[1] United States Department of Agriculture. (1994). *Waste Feeding and Swine: Cooking to Prevent Disease* (No. 1539). Washington DC.

[2] Westendorf, M.L., & Myer, R. O. (2004). *Feeding Food Wastes to Swine.* Retrieved February 5, 2006, from http://edis.ifas.ufl.edu/AN143

In other countries, many disease outbreaks in pigs and other livestock were traced back to the practice of the illegal feeding of untreated food waste.

1.1.2 Hawaii Natural Energy Institute (HNEI), University of Hawaii at Manoa

HNEI is a research unit of the University of Hawaii, located on the Manoa campus. HNEI was established by the State of Hawaii Legislature in 1974 in response to the OPEC oil embargo. When established, the goals of HNEI were to "...undertake the development of non-polluting natural energy sources for Hawaii...diminish Hawaii's total dependence on imported fossil fuels; meet the state's increasing energy demands with little or no environmental degradation..."[3]. Researchers with HNEI conduct research in various technologies including: biocarbons, biomass, biotechnology, battery and vehicle testing, fuel cells, hydrogen, ocean resources, photovoltaics and imaging[4].

Food waste and cooking oil are forms of biomass that can be used as renewable energy resources. The use of biomass as an energy source can reduce Hawaii's dependence on imported fossil fuels. Prior to this food waste and cooking oil project, research by HNEI was conducted on a biomass and bioenergy resource assessment for Hawaii. Types of biomass studied included food waste and used cooking oil and these findings are summarized in the background chapters on food waste and used cooking oil (see sections 2.2.6 and 3.2.2, respectively). Before detailing food waste and used cooking oil disposal and recycling, a brief overview of solid waste management is presented in the next section.

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[3] Hawaii Natural Energy Institute. (2004). *History of HNEI*. Retrieved April 17, 2006, from http://www.hnei.hawaii.edu/history.asp

[4] Hawaii Natural Energy Institute. (2004). *About HNEI*. Retrieved April 17, 2006, from http://www.hnei.hawaii.edu/about.asp

1.2 Municipal Solid Waste and Integrated Solid Waste Management

Waste can generally be divided into the following categories: municipal solid waste, industrial waste, medical waste, hazardous waste, and radioactive waste. Municipal solid waste (MSW) includes materials thrown away from homes and businesses such as paper, plastic, metal, glass, yard clippings, furniture, clothing, food scraps, appliances, electronic equipment, and chemicals. The amount of MSW produced in the United States has been rising. The U.S. Environmental Protection Agency (EPA) reports that in 1960, 88.1 million tons of MSW was generated (or 2.68 pounds of waste per person per day) and in 2003 that number increased to 236.2 million tons, which is approximately 4.45 pounds per person per day[5].

In order to manage all the waste generated, a strategy called integrated solid waste management (ISWM) was developed. ISWM can be defined as the selection and application of suitable techniques, technologies, and management programs to achieve specific waste management objectives and goals[6]. ISWM has evolved in response to the regulations developed to implement various waste reduction and recycling goals. The U.S. Environmental Protection Agency (EPA) has developed three basic management options for ISWM, which are incorporated into a solid waste management hierarchy. The hierarchy is as follows (listed from most preferable ways to address solid waste to the

[5] United States Environmental Protection Agency. (2005). Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2003 (No. EPA530-F-05-003). Washington DC.

[6] Tchobanoglous, G., & Kreith, F. (Eds.). (2002). *Handbook of Solid Waste Management*. New York: McGraw-Hill.

least preferred method): source reduction and reuse; recycling and composting; and incineration and landfilling (see Figure 1)[7].

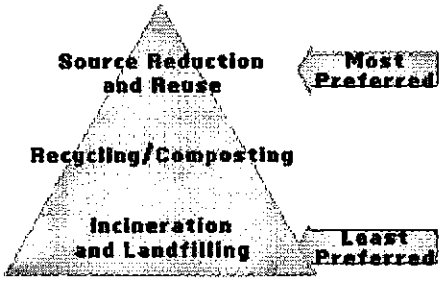

Figure 1. Solid Waste Management Hierarchy
Source: U.S. EPA

1.2.1 Food Waste Disposal and Recycling

The EPA has also created a food recovery and waste reduction hierarchy, which is as follows: [8]

- Recover food to feed hungry people
- Provide food to livestock, zoo animals, or animal shelters
- Recycle food for industrial purposes
- Compost food to improve soil fertility
- Dispose of the materials

Recovering food to feed hungry people is a way in which edible food that would otherwise go to waste can be diverted to those in the community who need it the most. This is important because there are between 24 to 27 million people in the U.S. who are food insecure or food insecure with hunger. The USDA has defined food insecure as "lack of access, at all times, to enough food for an active, healthy life for all household members, limited or uncertain availability of nutritionally adequate foods" and food

[7] United States Environmental Protection Agency. (no date). *Frequently Asked Questions about Recycling and Waste Management*. Retrieved April 9, 2005, from http://www.epa.gov/epaoswer/non-hw/muncpl/faq.htm

[8] United States Environmental Protection Agency. (1999). *Waste Not, Want Not: Feeding the Hungry and Reducing Solid Waste Through Food Recovery*. Retrieved September 14, 2005, from http://www.epa.gov/epaoswer/non-hw/reduce/wast_not.pdf

insecure with hunger as "an involuntary state that results from not being able to afford enough food"[9]. Millions of Americans depend on charitable food donations to survive and if just five percent of all food waste was recovered, an additional four million people could be fed daily[10]. In order to encourage businesses to donate food to food banks, homeless shelters, soup kitchens, and other non-profit organizations the federal government passed the Bill Emerson Good Samaritan Food Donation Act in 1996. This law protects any business, organization, or individual that donates food in good faith from any legal liability that may arise as a result of their donation[11].

Feeding food waste to livestock (specifically swine) is one method of garbage disposal that has occurred since animals were domesticated[12]. This practice has been an important part of solid waste management and the livestock industry throughout history. As far back as 1842, it was recorded that swine played an important role in municipal waste management in America[13]. When garbage was disposed of on the streets of cities, pigs were allowed (and protected by law) to eat the waste thrown out.

As far back as 1905 on Oahu the collection and transport of food waste by pig farmers was regulated by the City and County of Honolulu (then called Oahu County). At that time, the City had only 11 ordinances, one of which stated "no transport of swill

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[9] Mathematica Policy Research, Inc. (2006). *Hunger in America 2006: National Report Prepared for America's Second Harvest.* Retrieved March 10, 2006, from http://www.hungerinamerica.org/export/sites/hungerinamerica/about_the_study/A2HNationalReport.pdf

[10] United States Environmental Protection Agency. (1999). *Waste Not, Want Not: Feeding the Hungry and Reducing Solid Waste Through Food Recovery.* Retrieved September 14, 2005, from http://www.epa.gov/epaoswer/non-hw/reduce/wast_not.pdf

[11] Tchobanoglous, G., & Kreith, F. (Eds.). (2002). *Handbook of Solid Waste Management.* New York: McGraw-Hill.

[12] Hickman, H. L., & Eldredge, R. W. (2001). *A Brief History of Solid Waste Management in the US During the Last 50 Years.* Retrieved August 25, 2005, from http://www.forester.net/msw_9909_brief_history.html

[13] Neal, H. A., & Schubel, J. R. (1987). *Solid Waste Management and the Environment: The Mounting Garbage and Trash Crisis.* New Jersey: Prentice-Hall.

9am to 5pm and 9pm to 5am". Later, ordinances were enacted regulating the types of containers that could be used for food waste and the storage of the containers for collection by farmers. In 1931, the City passed a law that defined food waste into two separate categories: swill and garbage. Garbage was defined as "citrus peelings, coffee grounds, and fish offal" and swill was "all other animal and vegetable material remaining from the preparation of food". Swill was only to be colleted by the Honolulu Hog Raisers Association, which at the time had several hundred members. The City was responsible to collect the "garbage" food waste[14].

Currently, the practice of food waste feeding to animals is regulated and closely monitored by the USDA and HDOA. Many states have enacted laws that ban food waste feeding to swine because of the risk of disease transmission. In addition to the Swine Health Protection Act mentioned previously, the federal government has regulations regarding the feeding of food waste, particularly animal protein derived from mammalian tissues to ruminants (cattle, buffalo, sheep, goats, deer, etc.)[15]. This feeding ban was enacted to prevent the possible transmission of transmissible spongiform encephalopathies (TSEs), which are progressively degenerative central nervous system diseases that have no cure[16]. TSEs cause bovine spongiform encephalopathy (BSE or mad cow) in cattle or variant Creutzfeldt-Jakob (vCJD) disease in humans. Humans may contract this disease by eating BSE contaminated beef products.

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[14] Young, R. (no date). *Garbage in Paradise: A History of Honolulu's Refuse Division.* Retrieved February 15, 2006, from http://www.opala.org/history.html

[15] United States Food and Drug Administration. (2005). *Commonly Asked Questions About BSE in Products Regulated by FDA's Center for Food Safety and Applied Nutrition.* Retrieved February 19, 2006, from http://vm.cfsan.fda.gov/~comm/bsefaq.html

[16] Westendorf, M. L. (Ed.). (2000). *Food waste to Animal Feed.* Ames: Iowa State University Press.

If food cannot be donated to feed the hungry or recycled into food for livestock, recycling food for industrial purposes is the next preferred option. Rendering has been practiced for over 2,000 years, although only organized as a cohesive industry for the past 150 years. Traditionally, rendering was practiced by individuals who melted down animal fat to create tallow, which was then used to make soaps and candles[17]. Over time, rendering has evolved into a major industry. The current rendering industry processes liquid fats, grease, solid meat products (bone and fat), and slaughterhouse waste (hides, bones, heads, hooves, blood, feathers, offal—internal organs) [18]. These items are mainly converted to protein meals, feeding fats, fertilizer, boiler fuel, and tallow, which are sold as commodities. According to Baker Commodities Inc., one of the U.S.' largest rendering companies that operates a subsidiary (Island Commodities) in Hawaii, tallow is used to produce soap, lubricants, and fatty acids necessary to the manufacturer of cosmetics, plastics, organic detergents, and many other products[19].

After rendering, the next preferred recovery method for food waste is composting. There are many different methods for composting food waste: unaerated static pile, aerated windrow/pile, in-vessel, and vermicomposting[20]. A limitation of some of these methods is that meat products or oil/grease cannot be composted[21]. Composting in an unaerated static pile requires food waste to be mixed with a bulking material such as

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[17] Franco, D. A., & Swanson, W. (Eds.). (1996). *The Original Recyclers*. United States of America: The Animal Protein Producers Industry.

[18] Westendorf, M. L. (Ed.). (2000). *Food waste to Animal Feed*. Ames: Iowa State University Press.

[19] Baker Commodities Inc. (no date). *Tallow*. Retrieved March 8, 2006, from http://www.bakercommodities.com/products.html

[20] United States Environmental Protection Agency. (1998). *Don't Throw Away That Food* (No. EPA-530-F-98-023). Washington DC. Retrieved September 14, 2005, from http://www.epa.gov/epaoswer/non-hw/reduce/food/foodmain.pdf

[21] United States Environmental Protection Agency. (1999). *Waste Not, Want Not: Feeding the Hungry and Reducing Solid Waste Through Food Recovery*. Retrieved September 14, 2005, from http://www.epa.gov/epaoswer/non-hw/reduce/wast_not.pdf

leaves, waxed cardboard, wood chips, or sawdust. Unaerated static piles are good for small-scale operations. An aerated windrow pile is a long row or pile of organic material (food waste) that is aerated (turned). Aerated windrows are good for large-scale composting operations. In-vessel composting is done in an enclosed system where the moisture level and temperature are controlled and it has either a mechanical mixing or aerating system. Vermicomposting involves the use of red or earth worms to convert (eat) the food waste into castings. Worm castings may look like soil, but they contain bacteria, fungi, nematodes, decomposing organic matter, and tiny rock particles. Worm castings act as a fertilizer for plants and helps soil hold onto moisture and nutrients[22].

The least preferred method of the food recovery and waste reduction hierarchy for food waste is disposal (most commonly, landfilling or incineration). Food waste disposed of in landfills can produce leachate and greenhouse gases. Also, when incinerated in waste-to-energy plants, food waste is not an efficient fuel source because of its high moisture content[23].

Food waste recycling programs play an important role in diverting food waste from landfills and incinerators. Research into understanding food waste generation, recycling, and disposal methods practiced by food establishments in Hawaii are explored in this thesis. Specific research objectives of this thesis are included in section 1.3.

1.2.2 Used Cooking Oil Disposal and Recycling

Cooking oil is also referred to as fat, oil, and grease or FOG—these terms refer to edible oils from vegetables or animals. It is estimated that 30 percent of the foods we eat

[22] Frankel, Z. (no date). What are worm castings and why are they so good?
[23] Wirth, R. (2005). Diverting Food Residuals in Minnesota. *BioCycle, 46*(9), 47-48.

contain FOG, which can be found in meats, sauces, gravies, salad dressings, fried dishes, pastries, cheese, butter, and many other items[24]. The FOG that is not consumed can create a disposal problem, however, there are disposal alternatives such as recycling it into biodiesel or rendering.

FOG can be divided into two types: yellow grease and trap grease. Yellow grease is vegetable or animal oil (cooking oil) used for frying food, such as in restaurant fryers. This used cooking oil is normally drained out of fryers and kept in a container for collection by a recycling company. Yellow grease is a commodity that has economic value to recyclers and in some areas collection of it is a competitive business.

Trap grease is the FOG collected in grease traps. A grease trap is a collection system that separates out water from FOG and is installed in the drainage pipes of sinks and dishwashers. In many municipalities there are regulations that require grease traps to be installed in the drain lines of commercial food establishments to prevent FOG from entering the wastewater system. A grease trap must be serviced regularly by a pumping company (truck) that removes the FOG. The grease trap waste is often disposed of at an oil recycling facility. It is illegal for pumping companies to dispose of the collected FOG into the wastewater system without proper permits[25].

FOG that gets into the wastewater system can cause blockages in sewer lines, leading to spills of untreated wastewater backing up onto streets, parking lots, businesses, residences, and waterways. FOG enters the wastewater system by washing pots, pans, dishes, or utensils that have FOG on them, by deliberately pouring it in sink drains, or

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[24] City and County of Honolulu Department of Wastewater Management. (2002). *Environmental Information Bulletin for Restaurants and Food Processing Industry FOG*. Retrieved September 14, 2005, from http://www.co.honolulu.hi.us/env/rc/fog.pdf

[25] Turn, S. Q., Keffer, V., & Staackmann, M. (2002). *Biomass and Bioenergy Resource Assessment State of Hawaii*. Honolulu: University of Hawaii.

illegal dumping. Untreated wastewater back-ups/spills pose not only a public health problem, but also an environmental problem.

The EPA has not developed a recovery and waste reduction hierarchy for used cooking oil, however cooking oil recycling is commonly practiced. Two companies operating in Hawaii, Island Commodities and Pacific Biodiesel, offer FOG recycling. As previously mentioned, Island Commodities is a rendering company that processes liquid fats and grease into fertilizer and boiler fuel. Pacific Biodiesel is a company that recycles FOG into biodiesel.

Pacific Biodiesel was founded in 1996 on Maui (it is located at the Central Maui Landfill) and in 2000 opened a plant on Sand Island on Oahu[26]. Pacific Biodiesel receives FOG from collection and hauling companies, which collect it from food establishments, and, through a refinery process called transesterification, turns it into biodiesel[27]. Alcohol is chemically reacted with the oil to remove the glycerol molecule and the result is biodiesel and crude glycerin (soap)[28]. Biodiesel can be used in any diesel engine and can be used pure (100%) or as a blend (often 20% biodiesel and 80% petroleum diesel). Pacific Biodiesel sells fuel to individuals, governments (e.g., City and County of Honolulu and Maui County), and private companies (e.g., tour bus firms and

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[26] Pacific Biodiesel Inc. (2005). *About The Company.* Retrieved April 24, 2006, from http://www.biodiesel.com/aboutPacBio.htm

[27] Ambrozic-Mooz, C. (2005, September 29). Delicious Fuel. *Maui Time.* Retrieved April 24, 2006, from http://mauitime.com/PrintVersion.aspx?story_id=892

[28] Pacific Biodiesel Inc. (2005). *The Fuel.* Retrieved April 24, 2006, from http://www.biodiesel.com/theFuel.htm

tour boat operators)[29]. Pacific Biodiesel estimates that they convert most of the used cooking oil collected in the state[30].

Research into understanding the amounts of used cooking oil generated and amounts recycled is conducted as part of this thesis. On the surveys sent to all the food establishments in Hawaii, establishments were also asked about cooking oil disposal and recycling. Specific research objectives are included in the following section.

1.3 Research Objectives

This thesis focuses on the following research objectives:

- Determine how food establishments in Hawaii dispose of their food waste and cooking oil.
- Determine how many food establishments in Hawaii recycle food and cooking oil.
- Determine what types of food establishments in Hawaii recycle food and cooking oil.
- Identify methods used to recycle food and cooking oil in Hawaii.
- Determine if there is a relationship between the size of a food establishment and the amount of food and cooking oil recycled.
- Determine if there is a relationship between the type of establishment and their food and cooking oil recycling practices.
- Identify reasons why food establishments do not recycle their food waste.

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[29] TenBruggencate, J. (2004, November 24). Biodiesel fuel attracts loyal following in Islands: *The Honolulu Advertiser*. Retrieved April 24, 2006, from http://the.honoluluadvertiser.com/article/2004/Nov/08/ln/ln11p.html/?print=on

[30] McCall, W. (2006, April 23). Biodiesel now routine for some restaurants: *The Honolulu Advertiser*. Retrieved April 24, 2006, from http://the.honoluluadvertiser.com/article/2006/Apr/23/bz/FP604230314.html/?print=on

Results and analysis for food waste data can be found in chapter five and results and analysis for cooking oil data can be found in chapter six.

2.0 BACKGROUND INFORMATION ON FOOD WASTE

2.1 Food Waste Generation

Food waste disposal is a topic within the larger context of solid waste disposal. In general, food waste is any by-product or waste product from the production, processing, distribution, and consumption of food[31]. Food waste is basically any food that is not consumed by humans and can be generated at any level within the food chain (farms, processing plants, manufacturers, commercial establishments, and households).

2.1.1 National Food Waste Generation Amounts

The U.S. Environmental Protection Agency estimates that in 2003 the U.S. generated 27.6 million tons of food waste. This means that of the 236.2 million tons of MSW generated in the U.S., 11.7% of it was food waste (see Figure 2)[32]. Food waste that is disposed of via kitchen sink garbage disposal is not included in these MSW figures. It is unknown how much food waste is transferred into the wastewater system by garbage disposals.

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[31] Westendorf, M. L. (Ed.). (2000). *Food waste to Animal Feed.* Ames: Iowa State University Press.

[32] United States Environmental Protection Agency. (2005). *Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2003* (No. EPA530-F-05-003). Washington DC. Retrieved October 1, 2005, from http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/msw05rpt.pdf

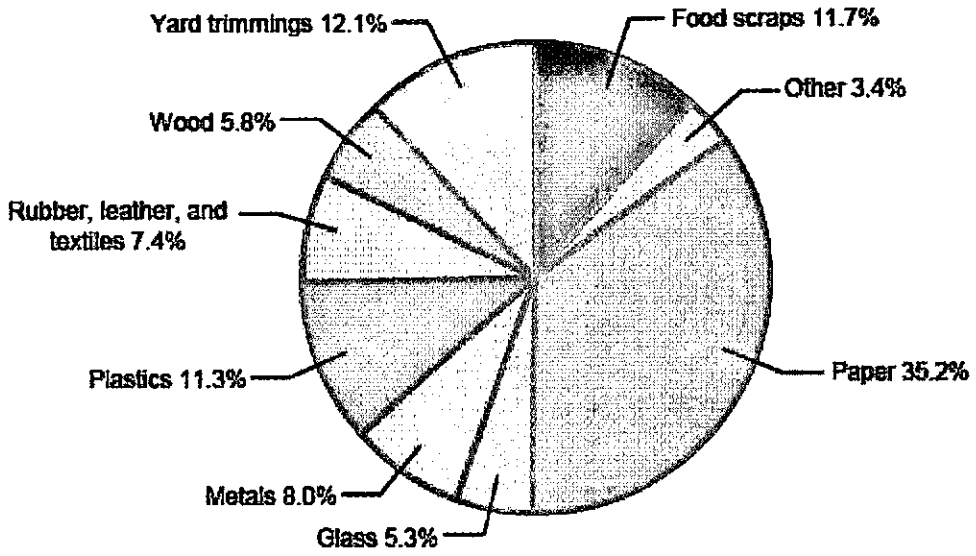

Figure 2. Municipal Solid Waste Generation
Source: U.S. EPA, 2005

2.1.2 Hawaii Food Waste Generation Amounts

The **Hawaii 2000 Plan for Integrated Solid Waste Management** estimates that in 1998, 1,888,477 tons of waste were generated statewide and of that amount, 147,802 tons (7.8%) were food waste[33]. Data to calculate the contribution by the City and County of Honolulu came from a 1999 waste characterization study. Data to calculate the amount of food waste generated on the neighbor islands came from a 1994 waste characterization study completed for Maui and then extrapolated and adjusted for the populations on Kauai, Lanai, Molokai, and Hawaii.

In 2002, researchers at the University of Hawaii conducted a study, which looked at the amount of food waste being generated in Hawaii. The researchers estimated that

[33] Belt Collins Hawaii, & Rifer Environmental. (2000). *Hawaii 2000 Plan for Integrated Solid Waste Management.* Honolulu. Retrieved August 1, 2005, from : http://www.hawaii.gov/health/environmental/waste/sw/pdf/swmgmpln.pdf

179,303 tons of food waste are generated annually in the state[34]. This study is further discussed in section 2.2.6.

2.2 Food Waste Studies

Food waste has been studied at the national and state level. This section summarizes one national study of food loss and five studies of food waste at the state level. States that have reports on food waste include Iowa, Connecticut, Massachusetts, and Hawaii.

2.2.1 Using Contemporary Archaeology and Applied Anthropology to Understand Food Loss in the American Food System[35]

Researchers at the University of Arizona have conducted a food loss study that quantifies the amount of food waste produced by the entire food marketing system (harvesting, processing, storage, retail distribution, food service, and households) in the United States. This study was conducted for the U.S. Department of Agriculture (USDA) Food Loss Project. Researchers found that commercial retail food establishments (fast food restaurants, full service restaurants, supermarkets, and convenience stores) across the country throw out 35 million tons of food annually. Researchers were also able to calculate the amount of food loss as a percentage of total food used by commercial establishment type (see Table 1).

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[34] Turn, S. Q., Keffer, V., & Staackmann, M. (2002). *Biomass and Bioenergy Resource Assessment State of Hawaii*. Honolulu: University of Hawaii.

[35] Jones, T. W. (2004). Using Contemporary Archaeology and Applied Anthropology to Understand Food Loss in the American Food System. Tucson: University of Arizona. and Jones, T. W. (2005). Analyzing Retail Food Loss. BioCycle, 46(12).

Table 1. Percentages of Food Loss in the U.S.

Commercial Establishment Type	Food Loss as a Percentage of Total Food Used
Convenience Store	26.33%
Fast Food Restaurants	9.55%
Full Service Restaurants	3.11%
Supermarkets	0.76%

Source: Jones, 2004

Convenience stores had the highest percentage of food loss because they keep cooked fresh food ready at all times, which results in periodically disposing of cooked food. Food loss in many large restaurant chains can be attributed to miscalculated demand and preparing too much food ahead of time. Fast food restaurants utilize the "just-in-time delivery" system where products are ordered from a regional warehouse (as opposed to local suppliers) and are delivered to the restaurant "just-in-time". With the "just-in-time delivery" system, fast food restaurants have designed stores with less frozen and cold storage capacity. Fast food restaurants do not want to run out of food and often food deliveries are greater than the storage space available. If demand is misjudged and the unused food reaches its expiration date it must be thrown away. Supermarkets have the lowest percentage of food loss because they have concentrated on improving their efficiency and will mark down food going out of date and/or donate food to local food banks.

This study noted three important policy implications. The first policy implication is that losses in the retail sector, farming, and in the home are unnecessarily large, easily reduced, and represent a significant negative impact on the national economy. The lack of education and training regarding food loss in conjunction with storage and transportation problems increases food loss. It takes many resources (land, fertilizer,

water, soil nutrients, pesticides, herbicides, fuel, and labor) to produce food and the waste of these resources is unsustainable and inefficient. In some retail sectors (convenience stores and fast food restaurants), a reduction in food losses by 25% would increase profits by 5%. It was estimated that food losses in the retail sector costs nearly $30 billion.

The second policy implication is that much of society, with the exception of some farming sectors, has lost an understanding of food. An understanding of food involves recognizing food's importance in continuing life and its function in the life cycle, high overall cost, and food safety and spoilage.

The third policy implication is that a Food Loss Reduction Implementation Plan is needed to provide security for America's food supplies. A Food Loss Reduction Implementation Plan would educate the various food sectors on how food losses could be reduced. If our fresh food supplies were threatened, the implementation of this plan could extend existing fresh food supplies by a month or more.

2.2.2 Feasibility Study of Organic Waste Conversion Facilities in Hawaii[36]

In March of 1991, Unisyn Biowaste Technology was contracted by the State of Hawaii Department of Business, Economic Development and Tourism to conduct a study on organic waste conversion. The study included an organic waste inventory for the state; identification of markets for the sale of bulk materials and value-added products; development of a financial model for a 200 and 2,000 tons per day of organic waste system; and a business plan.

Unisyn Biowaste Technology was a company operating in Waimanalo from 1984 to 1999 that processed organic wastes (e.g., farm manures, agricultural waste, food

[36] Unisyn Biowaste Technology. (1991). *Feasibility Study of Organic Waste Conversion Facilities in Hawaii.* Retrieved September 14, 2005, from http://www.hawaii.gov/dbedt/ert/unisyn/

processing waste, and green waste) using anaerobic digestion technology. Anaerobic digestion can convert organic waste into valuable by-products such as biogas, electricity, organic fertilizer, animal feed components, aquaculture feed, and soil amendment.

Unisyn estimated the quantity of food waste generated by commercial (market and institutional), residential (households), visitor, and agriculture sectors. Data on food waste generation amounts were estimates based on prior studies conducted by both the private and public sector. Unisyn used research conducted by several universities, the U.S. Environmental Protection Agency, and the USDA. In this study, Unisyn estimated that 731,085 tons of food waste is generated in the State of Hawaii annually.

A model was created to estimate the amount of food waste generated per school per year. The model is as follows:

food waste generated per school per year = number of meals served x 0.36 pounds x 175 days

Number of meals served was based on the total number of students, faculty, and staff. 175 days was the average number of school days per year. The factor of 0.36 pounds was not explained in the report.

Food waste generated by restaurants was estimated by calling 25 randomly selected restaurants from a list provided by the Hawaii Restaurant Association. The list provided the contact information and number of employees for each restaurant. Unisyn called the 25 randomly selected restaurants to determine the number of meals served per day. Then the number of meals served per day was divided by the number of employees at the restaurant to determine an average number of meals served per employee per day. With the average number of meals served per employee per day calculated, the number of

meals served per day at each restaurant listed with the Hawaii Restaurant Association was calculated. Then to estimate the total amount of food waste generated by the restaurant, the number of meals served per day was multiplied by 0.36 pounds.

2.2.3 State of Iowa Food Wastes Database[37]

Researchers at Kansas State University prepared a food waste database for the Iowa Department of Natural Resources Waste Management Assistance Division. This study's purpose was to gather information on the amounts, types, locations, and current disposal methods of waste generated by Iowa's food processing industry. All wastes generated by food processors were studied. This study looked at all types of wastes generated, not only food waste.

This study surveyed 444 industrial food processors with ten or more employees. Researchers calculated that food processors in Iowa generate 3.2 million tons of waste annually (this figure includes all types of wastes). However, there was no figure provided for only the amount of food waste generated in Iowa by food processors.

As part of this study, researchers used Geographic Information Systems (GIS) to map the locations of food waste generators across Iowa, studied the costs incurred in current waste disposal practices, and created a database that included information on the amounts and types of wastes generated by industrial food processors in Iowa.

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[37] Flores, R. A., & Shanklin, C. W. (1998). *Food Wastes Database Development.* Manhattan: Kansas State University.

2.2.4 Identification, Quantifying, and Mapping Food Residuals from Connecticut Businesses and Institutions: An Organics Recycling Planning Tool Using GIS[38]

Draper/Lennon, Inc., a consulting company in New Hampshire, was contracted by the Connecticut Department of Environmental Protection (CDEP) to study the generation of source-separated organic materials[39] (SSOM). The CDEP was interested in determining how much SSOM is generated in the state. The CDEP also wanted to know where potentially large amounts of SSOM were generated relative to the existing composting infrastructure and major transportation routes.

This study estimated the food waste generated by 1,314 large establishments in Connecticut. The categories of establishments included in the study were as follows: food manufacturers/processors, food wholesalers/distributors, health care facilities, colleges/universities, independent schools, correctional facilities, resorts/conference facilities, supermarkets, and major private employers. Only the establishments that met the minimum size cut-offs were included in this study. The minimum size cut-offs varied based on the type of generator and are summarized in Table 2.

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[38] Draper/Lennon Inc., & Atlantic Geoscience Corp. (2001). *Identifying, Quantifying, and Mapping Food Residuals from Connecticut Businesses and Institutions.* Concord. Retrieved July 10, 2004, from http://dep.state.ct.us/wst/compost/ssomfile/ssomreport.pdf

[39] SSOM is defined as food wastes from manufacturing, distribution, and/or kitchen operations that can potentially be separated from other wastes at the point of generation (food waste).

Table 2. Summary of Connecticut Food Waste Generators Analyzed In This Study

Generator Category	Minimum Size Included in Database
Food manufacturers / processors	≥5 employees
Food wholesalers / distributors	≥5 employees
Health Care Facilities	Inpatient or residential only, ≥$500,000 sales, and ≥10 employees
Colleges, Universities	All identified establishments included
Independent schools, primary and/or secondary	Boarding schools only, >250 students
Correctional facilities	All identified establishments included
Resorts / Conference Facilities	Banquet seating for ≥250 guests
Supermarkets	>$1.5 million sales, or >15 employees
Major Private Employers	Not applicable; cutoff established at 130 top private employers ranked by number of employees.

Source: Draper/Lennon, Inc., 2001

Mailed surveys and follow-up phone calls were used in this study to contact the establishments that met the minimum size requirement. Draper/Lennon, Inc. estimated that between 98,946 and 153,331 tons of SSOM is generated per year by all establishments analyzed in this Connecticut study. The estimated range of food waste generated is explained by Draper/Lennon, Inc. as follows, "The range of estimates is explained by the treatment of the Manufacturer/Processor and Wholesaler/Distributor categories, in that using mean waste generation values in these categories yields a significantly larger total waste generation estimate than using median waste generation values, because of the presence of a small number of very large generators who inflate the mean waste generation estimates."[40]

Another outcome of this study was to develop organic waste generation estimates as a function of facility size, sales, number of employees, or other readily available

[40] Page ES-5

parameters. Draper/Lennon, Inc. derived the models presented in Table 3 to estimate the amount of SSOM generated by an establishment in a particular category (to use these models, the establishment must first meet the minimum cut-off size).

Table 3. Food Waste Generation Estimates by Generator Category

Health Care Facilities Food waste (lbs/yr) = N of beds * 5.7 meals/bed/day * 0.6 lbs food waste/meal * 365 days/yr
Colleges, Universities, and Independent Preparatory Schools *Residential Institutions* Food waste (lbs/yr) = 0.35 lbs/meal * N of students * 405 meals/student/yr *Non-Residential Institutions (e.g., community colleges)* Food waste (lbs/yr) = 0.35 lbs/meal * N of students * 108 meals/student/yr
Correctional Facilities Food waste (lbs/yr) = 1.0 lb/inmate/day * N of inmates * 365 days/yr
Resorts / Conference Facilities Food waste (lbs/yr) = 1.0 lbs/meal * N of meals/seat/day[1] * N of seats * 365 days/yr
Supermarkets Food waste (lbs/year) = N of employees * 3,000 lbs/employee/yr
Notes: [1] Resort and conference facilities were divided into two classes, depending on how intensively they use their banquet/dining facilities. One has been given a value of 0.6 meals/day/seat of conference capacity, the other a value of 0.25 meals/day/seat of conference capacity.

Source: Draper/Lennon, Inc., 2001

This study used Microsoft Access to organize the data collected on the food waste generators. GIS was also used to map the food waste generators. GIS was used to create density maps that show where there are high concentrations of food waste generators. With GIS the locations of food waste generators can be matched against transportation routes or existing organic recycling infrastructure to identify potential new sources of SSOM to recycle.

2.2.5 Identification, Characterization, and Mapping of Food Waste and Food Waste Generators in Massachusetts[41]

Draper/Lennon, Inc., the same consulting company hired for the Connecticut study, was contracted by the Massachusetts Department of Environmental Protection Bureau of Waste Prevention to conduct a similar study on food waste generation in Massachusetts. The purpose of the study was to improve the climate for recovering and composting SSOM (food waste).

This study estimated the food waste generated by 5,799 large food establishments in Massachusetts. The categories of food waste generators included in the study were as follows: food manufacturers/processors, food wholesalers/distributors, hospitals, nursing homes, colleges/universities, independent schools, correctional facilities, resorts/conference properties, restaurants, and supermarkets/grocery stores. Only the establishments that met the minimum size cut-offs were included in this study. The minimum size cut-offs varied based on the type of generator and are summarized in Table 4.

[41] Draper/Lennon Inc. (2002). *Identification, Characterization, and Mapping of Food Waste and Food Waste Generators in Massachusetts*. Concord. Retrieved July 10, 2004, from http://www.mass.gov/dep/about/priorities/foodwast.doc

Table 4. Summary of Massachusetts Food Waste Generators Analyzed In This Study

Generator Category	Minimum Size Included in Database
Food manufacturers / processors	≥5 employees
Food wholesalers / distributors	≥5 employees
Hospitals	All identified inpatient establishments included
Nursing homes	All identified establishments included
Colleges, universities	All identified establishments included
Independent schools, primary and/or secondary	Boarding schools only, >250 students
Correctional facilities	All identified establishments included (state corrections system only, not including county and local jails)
Resorts / conference properties	Banquet seating for ≥250 guests
Restaurants	≥10 employees and ≥$200,000 annual sales
Supermarkets, grocery stores	>$1.5 million sales, or >15 employees (convenience stores excluded)

Source: Draper/Lennon, Inc., 2002

Draper/Lennon, Inc. estimated the total annual amount of food waste generated by the establishments analyzed in this study to be 881,000 tons. Manufacturers, restaurants, and supermarkets are the top three major food waste generators in Massachusetts. Draper/Lennon, Inc. was also able to derive the models included in Table 5 to estimate the amount of food waste generated by an establishment in a particular category (to use these models, the establishment must first meet the minimum cut-off size).

Table 5. Food Waste Generation Estimates by Generator Category

Hospitals Food waste (lbs/yr) = N of beds * 5.7 meals/bed/day * 0.6 lbs food waste/meal * 365 days/yr
Nursing Homes and Similar Facilities Food waste (lbs/yr = N of beds *3.0 meals/bed/day * 0.6 lbs food waste/meal * 365 days/yr
Colleges, Universities, and Independent Preparatory Schools *Residential Institutions* Food waste (lbs/yr) = 0.35 lbs/meal * N of students * 405 meals/student/yr *Non-Residential Institutions (e.g., community colleges)* Food waste (lbs/yr) = 0.35 lbs/meal * N of students * 108 meals/student/yr
Correctional Facilities Food waste (lbs/yr) = 1.0 lb/inmate/day * N of inmates * 365 days/yr
Resorts / Conference Properties Food waste (lbs/yr) = 1.0 lbs/meal * N of meals/seat/day[1] * N of seats * 365 days/yr
Supermarkets Food waste (lbs/year) = N of employees * 3,000 lbs/employee/yr
Restaurants Food waste (lbs/year) = N of employees * 3,000 lbs/employee/yr
Notes: [1] Resort and conference facilities were divided into two classes, depending on how intensively they use their banquet/dining facilities. One has been given a value of 0.6 meals/day/seat of conference capacity, the other a value of 0.25 meals/day/seat of conference capacity.

Source: Draper/Lennon, Inc., 2002

Another component of the Massachusetts study was a database of food waste generators that was combined with GIS capabilities. GIS can be used as a tool to produce queries, tables, and maps that can identify, characterize, and map SSOM by location, generator type, generator size, waste type, and other variables. This is a tool that can be used by current or prospective SSOM recyclers, SSOM generators, haulers, and waste management planners.

2.2.6 Biomass and Bioenergy Resource Assessment State of Hawaii[42]

Researchers from University of Hawaii conducted a study for the State of Hawaii Department of Business, Economic Development and Tourism on biomass resources. Biomass and bioenergy resources could play an important role in meeting Hawaii's increasing energy demands. One type of biomass resource identified in the study was food waste.

Researchers used information provided in county solid waste management plans and waste characterization studies to determine the amount of food waste generated in the state. This study estimated that 179,303 tons of food waste are generated annually in Hawaii.

2.3 Food Recycling

As previously stated, there are various ways in which food can be recycled. Current methods of food waste recycling include donating edible items to food banks, non-profit groups, or others (employees, homeless/needy people, friends, or family members); feeding food waste to animals (pigs, dogs, chickens, ducks, rabbits, etc.); rendering (recycling of meat trimmings, bones, oil, and other animal processing by-products into fertilizer and boiler fuel); and composting or vermicomposting (using worms). In addition to knowing how much food waste is disposed/generated it is also useful to know how much is recycled. The following section provides information on food recycling amounts and regulations.

[42] Turn, S. Q., Keffer, V., & Staackmann, M. (2002). *Biomass and Bioenergy Resource Assessment State of Hawaii.* Honolulu: University of Hawaii.

2.3.1 National Food Recycling Amounts

The U.S. Environmental Protection Agency estimates that in 2003 the U.S. recycled 0.75 million tons of 27.6 million tons generated of food waste, which equals a 2.7% recycling rate[43].

2.3.2 Hawaii Food Recycling Amounts

In Hawaii, the amount of food waste recycled has been estimated to be 13,926 tons (see Table 6)[44]. This equals a 9% recycling rate for food waste.

Table 6. Annual Waste and Recycling Generation Amounts (tons)
Amounts are from FY 1998-1999

Total amount of waste generated	1,888,477
Amount of food waste generated	147,802
Amount of food waste disposed	133,876
Amount of food waste recycled	13,926

Source: Belt Collins and Rifer Environmental, 2000

2.3.3 City and County of Honolulu Food Recycling Ordinance[45]

In 1996, the City and County of Honolulu enacted Ordinance 96-20, relating to recycling food waste. Ordinance 96-20 went into effect on January 1, 1997. This ordinance requires large food establishments to recycle their food waste provided that the cost of recycling is not greater than the disposal costs. Food establishments that are required by Ordinance 96-20 to recycle food waste include:

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[43] United States Environmental Protection Agency. (2005). *Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2003* (No. EPA530-F-05-003). Washington DC. Retrieved October 1, 2005, from http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/msw05rpt.pdf

[44] Belt Collins Hawaii, & Rifer Environmental. (2000). *Hawaii 2000 Plan for Integrated Solid Waste Management*. Honolulu. Retrieved August 1, 2005, from : http://www.hawaii.gov/health/environmental/waste/sw/pdf/swmgmpln.pdf

[45] City and County of Honolulu (no date). *Revised Ordinances of Honolulu Chapter 9 Collection and Disposal of Refuse, Sec. 9-3.5 Food Waste Recycling.* Retrieved June 29, 2005, from http://www.honolulu.gov/refs/roh/9.htm

- Restaurants that occupy 5,000 square feet or more of floor area and serve 400 or more prepared meals per day based on annualized average; bakeries and quick-serve food service establishments are excluded.
- Food courts, which are defined as an area within a building or shopping center where five or more food establishments are situated and serviced by a common dining area.
- Hotels with a kitchen or kitchens and one or more function rooms.
- Markets that occupy 18,000 square feet or more of floor area.
- Food manufacturers and processors that occupy 5,000 square feet or more of floor area.
- Catering establishments that serve or sell 400 or more prepared meals per day based on annualized average.
- Hospitals that serve 400 or more prepared patient meals per day based on annualized average.

There are approximately 247 food establishments in the City and County of Honolulu that fall under this ordinance. The food establishments that fall under Ordinance 96-20 were selected by the City and County of Honolulu's Recycling Office by looking through the yellow pages of the phone book. The number of establishments that are on the City and County of Honolulu's list represents a small percentage of the food establishments on Oahu. Ordinance 96-20 does not mandate food recycling by non-profit or church organizations (except for hospitals). Also excluded are government owned food establishments, such as school cafeterias.

Every year the City and County of Honolulu's Recycling Office sends out compliance forms to the food establishments that fall under Ordinance 96-20 to verify that they are recycling their food waste. The City and County of Honolulu monitors food recycling by random inspections of food establishments and will also visit establishments that do not return their compliance form. Food establishments that do not comply may be fined.

3.0 BACKGROUND INFORMATION ON COOKING OIL

3.1 Cooking Oil Generation

As previously mentioned, there are two types of FOG—yellow grease (used cooking oil) and trap grease (from grease traps). The amount of FOG generated in relationship to all wastes is not known because this amount is included in the food waste component, which was covered in the previous chapter. However, studies have been conducted on only cooking oil generation. Four of these studies are included in the following section.

3.2 Cooking Oil Studies

There have been four studies conducted that researched FOG generation—two done for Hawaii County, one for the State of Hawaii, and one that surveyed 30 metropolitan areas in the U.S. mainland.

3.2.1 Urban Waste Grease Resource Assessment[46]

Appel Consultants, Inc. conducted a study that collected and analyzed data on urban waste grease resources in 30 randomly selected metropolitan areas in the U.S. The study was conducted for the U.S. Department of Energy's National Renewable Energy Laboratory (NREL). NREL's objective in funding this study was to develop a cost effective methodology for estimating urban waste grease quantities and values on a state

[46] Appel Consultants Inc. (1998). *Urban Waste Grease Resource Assessment.* Retrieved September 14, 2005, from http://www.nrel.gov/docs/fy99osti/26141.pdf

and regional scale for the U.S. and implement it to produce state-level urban waste grease data.

The 30 randomly selected metropolitan areas were picked from the U.S. Census Bureau's State and Metropolitan Area Data Book, which included a list of 281 metropolitan areas. A metropolitan area is a core area containing a large population center (a minimum of 50,000 or more inhabitants) with adjacent communities having a high degree of economic and social integration with the core. To qualify as a metropolitan area the total population of the area must be over 100,000 inhabitants (75,000 inhabitants in New England).

Personnel from Appel Consultants, Inc. traveled to each of the 30 metropolitan areas and collected information via telephone and/or in-person interviews. Sewage treatment plants, grease collection/rendering companies, and restaurants were establishments included in the survey. The study focused on generation amounts and collection of yellow and trap grease. Appel Consultants, Inc. found that generations amounts could be predicted based on population with nine pounds of yellow grease produced per person per year and 13 pounds of trap grease produced per person per year.

3.2.2 Biomass and Bioenergy Resource Assessment State of Hawaii[47]

Researchers from University of Hawaii conducted a study for the State of Hawaii Department of Business, Economic Development and Tourism on biomass resources. Biomass and bioenergy resources could play an important role in meeting Hawaii's

[47] Turn, S. Q., Keffer, V., & Staackmann, M. (2002). *Biomass and Bioenergy Resource Assessment State of Hawaii*. Honolulu: University of Hawaii.

increasing energy demands. One type of biomass resource identified in the study was FOG.

Researchers used information provided by Pacific Biodiesel, a company located on Oahu and Maui that recycles yellow and trap grease into biodiesel, to estimate the amount of yellow grease and trap grease available. Pacific Biodiesel reported that on Maui the yellow grease resource is 480 tons per year and 432 tons per year for trap grease. It was estimated that the resource of yellow and trap grease on Kauai and Hawaii island would be about half that of Maui (240 tons per year of yellow grease and 216 tons per year of trap grease per island). No estimate was provided for Oahu.

In addition to using the figures provided by Pacific Biodiesel, researchers used the estimates provided by Appel Consultant Inc.'s *Urban Waste Grease Resource Assessment* to calculate the amount of yellow and trap grease generated in the State of Hawaii. Using the estimate of nine pounds of yellow grease produced per person per year and 13 pounds of trap grease produced per person per year, it was estimated that 6,012 tons of yellow grease and 8,684 tons of trap grease is generated in Hawaii annually. To calculate this amount the defacto population (from the 2001 State of Hawaii Data book) of each county was used, which included all persons physically present in the area regardless of military status or usual place of residence and thus includes transient populations such as military personnel and tourist. The breakdown of yellow and trap grease generated by county is provided in Table 7.

Table 7. Estimates of Yellow and Trap Grease Generated in Hawaii

County	Defacto Population	Grease (tons/year)		
		Yellow	Trap	Total
Honolulu	925,250	4,164	6,014	10,178
Hawaii	168,524	758	1,095	1,854
Kauai	74,088	333	482	815
Maui	168,213	757	1,093	1,850
Total	**1,336,075**	**6,012**	**8,684**	**14,697**

Source: Turn, et.al, 2002

3.2.3 Grease Disposal Study County of Hawaii[48]

The County of Hawaii contracted the environmental engineering and consulting company Brown and Caldwell to conduct a grease disposal study. Some of the tasks performed by Brown and Caldwell included: identifying the extent of the grease disposal problem; estimating the quantities of grease requiring disposal; and identifying and comparing alternatives for grease disposal.

Brown and Caldwell used two methods to determine the quantity of FOG requiring disposal on the island of Hawaii. The first method was a phone survey of FOG pumping contractors and haulers. Three companies were able to provide information on the quantities of FOG collected, which was 2,250 gallons per month or 110 tons per year. This amount only represents the FOG collected from 12 restaurants and is thus considered a low estimate for the amount of FOG generated.

The second approach used to quantify the amount of FOG requiring disposal in Hawaii County was to use data collected by Maui County. Maui County provided the amount of FOG collected at the landfill on Maui, which was 1,864 tons in 1997. Brown and Caldwell determined that it was reasonable to estimate that 1,864 tons of FOG was

[48] Brown and Caldwell. (1998). *County of Hawaii Grease Disposal Study*. Honolulu.

also generated in Hawaii County since the number of DOH permitted food establishments on Maui and Hawaii were equal (550 establishments).

This grease disposal study noted that there must be many improper and illegal FOG disposal practices occurring in Hawaii County because of the high concentrations of FOG accumulating in the wastewater system. In order to better manage the disposal of FOG, Brown and Caldwell identified three disposal options: wastewater treatment plant processing; landfill processing and disposal; and private processing (recycling). Wastewater treatment plant processing would require millions of dollars because the current systems would need to be upgraded. In order to dispose of FOG in the County landfill it would need to be mixed with a bulking material such as soil or green waste to meet the solid waste disposal regulations. Private processing could be done by the pumping contractors and haulers of FOG. Options for private processing include rendering or recycling into fuel. Based on cost factors, ease of implementation, institutional concerns, operation and maintenance requirements, environmental concerns, and liability it was recommended that the County of Hawaii pursue private processing of FOG.

3.3.4 Study Relating to Used Cooking Oil Generation and Biodiesel Production Incentives in the County of Hawaii[49]

The Hawaii County's Solid Waste Division conducted this study under a grant from the State of Hawaii's Department of Business, Economic Development and Tourism. Additional support for this project came from two University of Hawaii at Hilo

[49] County of Hawaii Department of Environmental Management Solid Waste Division. (2004). *Study Relating to Used Cooking Oil Generation and Biodiesel Production Incentives in the County of Hawaii*. Retrieved September 14, 2005, from http://www.hawaii.gov/dbedt/info/energy/publications/biodiesel04-report.pdf

students and C3 Consulting. The purpose of this study was to determine the overall disposal of used cooking oil on the island and if the market could support biodiesel production.

This study contacted by mail or phone 692 commercial food handling establishments (permitted with the Department of Health Sanitation Branch and Food and Drug Branch). The commercial food establishments included in this study were restaurants (dine in and takeout/delivery), food product manufacturers, and resort/hotels. Researchers decided not to contact gas/convenience stations, school cafeterias, coffee-only establishments, bar/liquor only establishments, and public institutions (hospitals and prisons) because their generation of used cooking oil was minimal.

The survey asked background questions about the establishment (establishment type, average number of meals served, type of food offered), if cooking oil was used, if there was a grease trap installed, how much cooking oil was purchased per month, how the cooking oil was disposed, how much cooking oil was disposed, who picks up the cooking oil, how often it was collected, how much it costs, what were the reasons for not recycling used cooking oil, and what reason(s) would convince the establishment to recycle. Of the 692 food establishments contacted, researchers were able to get 314 completed surveys (~45%). Therefore, the study notes that "due to the variation of response rates for particular questions on the survey instrument and the uncertainty regarding characteristics on the non-respondents, the results cannot be considered statistically accurate and are to be used for baseline information only"[50].

[50] Page 5

This study found that disposal methods utilized for cooking oil in Hawaii County included: recycling company, private recycling, pig farmer, trash, drain, pump truck, and other (see Table 8).

Table 8. Cooking Oil Disposal Methods

Disposal Methods	Frequency	Percent
Recycling Company	59	37%
Private Recycle	18	11%
Pig Farmer	22	14%
Trash	20	13%
Drain	3	2%
Pump Truck	34	22%
Other	2	1%
Total	**158**	**100%**

Source: County of Hawaii Department of Environmental Management Solid Waste Division, 2004

This study also estimated the amount of used cooking oil generated per establishment type. Resorts generate the most oil per establishment (158 gallons/month) and food product manufacturers generate the least oil per establishment (33 gallons/month). Table 9 lists the generation amounts for each establishment type. Overall it was reported that 380 tons of used cooking oil were disposed of annually by the 314 establishments included in the study. Researchers estimated that approximately 800 tons of used cooking oil are generated every year by all the commercial food establishments (includung those establishments that did not respond to the survey).

Table 9. Used Cooking Oil Generation

	Establishment Type			
	Dine-In	**Takeout**	**Food Product**	**Resort**
Survey Respondents	110	87	27	9
Total Used Oil Generated (gallons/month)	5601	4558	902	1420
Mean per Establishment (gallons/month)	51	52	33	158

Source: County of Hawaii Department of Environmental Management Solid Waste Division, 2004

The question, "if you don't have a recycler pick up your used cooking oil what are the reason(s) why?" received the following answers: too costly, not enough storage space, no storage containers, and unaware of cooking oil recycling opportunities. Food establishments were also asked, "which reason(s) would convince you to consider recycling your establishment's used cooking oil?" Reasons cited were: it is environmentally friendly; it is used to produce locally made alternative fuel, which reduces dependency on foreign oil; it conserves our declining landfill space; and it becomes illegal to dispose of used cooking oil down the drain.

Information from this study will be used to support recycling programs in the County of Hawaii. Actions that will be pursued to promote biodiesel production include: increasing diversion grants; passing legislation to waive the County fuel tax on diesel fuels containing 20% or more biodiesel; requiring the use of grease traps and strictly monitoring compliance; siting receiving stations for used cooking oil drop off on each side of the island; educating the public about the benefits of recycling used cooking oil and the negative impacts of illegal disposal; and educating food establishments on the costs and benefits of recycling FOG.

4.0 DATA COLLECTION

4.1 Data Collection Overview

Information collected on food establishments came from two sources: the State of Hawaii Department of Health (DOH) permit lists and a Food Waste Recycling Survey mailed to all permitted food establishments in the State of Hawaii. Additional surveying of food establishments was conducted by telephone for the food establishments that did not return their mail surveys.

After the surveys were completed, coding of the survey responses was conducted as well as data cleaning and re-coding where necessary. The data collected from the surveys were entered into a Microsoft Access database.

For each research objective, a results and discussion (including limitations and recommendations) section is included. Tables, figures, and statistical tests are included in the results section where applicable. The research objectives pertaining to food waste is included in chapter five, followed by the objectives relevant to used cooking oil in chapter six.

4.2 Committee on Human Studies

Since the present study includes surveying, approval from the Committee on Human Studies was required and obtained. The Committee on Human Studies determined that this study was exempt from the U. S. Department of Health and Human Services regulations, 45 CFR Part 46. The authority for the exemption is section 46.101 (b)(2). In general, section 46.101 (b)(2) grants exemptions if the responses, even if

disclosed outside the research, could not reasonably place the subject at risk of criminal or civil liability or be damaging to the subject's financial standing, employability, or reputation.

4.3 Food Establishments in Hawaii

Lists of permitted food establishments were requested from the DOH and were received from personnel at the state and county levels between July 8 and July 16, 2004. This population of food establishments permitted by the DOH was used as the mailing list for the surveys. Any new food establishments that may have opened since the lists were received were not included. The lists also contained establishments that were no longer in business.

The lists were obtained from two branches within the DOH—the Sanitation Branch and the Food and Drug Branch. The Sanitation Branch regulates food establishments where food is prepared, served, and consumed on-site—this is mostly restaurants, institutional kitchens (schools, hospitals), and hotels. The lists from the Sanitation Branch had to be obtained separately from the local DOH office for each county. The Food and Drug Branch regulates establishments that primarily sell already packaged food, such as retail (supermarkets, convenience stores) establishments. A state-wide list for the Food and Drug Branch was obtained.

The lists from the DOH contained the following information on each permitted food establishment:

- Permit Number
- Island
- Name of Establishment
- Owner
- Phone Number

- Mailing Address (street number, street name, city, zip code)
- Location Address (street number, street name, city, zip code)
- Establishment Type

After the lists were obtained, they were edited to exclude establishments that were listed multiple times or were on both the Sanitation Branch and the Food and Drug Branch lists. There were many establishments with multiple permits, for example, a hotel may have multiple kitchens and thus multiple permits. Establishments apply for more than one permit because in the event that one kitchen must be closed (due to sanitation reasons) the other permitted kitchens may remain open. The number of establishments from all lists totaled 9,599. Only 8,253 surveys were mailed out, however, because 1,346 establishments had more than one permit or were included on both lists.

4.4 Food Waste Recycling Surveys

All permitted food establishments in Hawaii were mailed a cover letter, survey, and postage paid reply envelope. A sample cover letter and survey can be found in Appendix 1. The cover letter and survey was developed with the assistance of Dr. Flachsbart, Dr. Turn, and personnel from the U.S. and Hawaii Departments of Agriculture. Before the cover letter and surveys were mailed out, it was pilot tested by six establishments on Oahu. The individuals contacted at these establishments provided valuable feedback that was used to improve the cover letter and survey.

The survey consisted of ten questions. The questions were as follows:

- What meals do you serve?
- What is the average number of meals served per day at the present time?
- How do you dispose of your food waste?
- If you recycle your food waste, what is the approximate quantity of food waste recycled per week?
- If you recycle your food waste, who collects the food waste from your establishment?

- If you don't recycle all of your food waste, what are the reason(s) for not recycling?
- If your establishment uses cooking oil, how do you dispose of it?
- If you recycle your cooking oil, how much is recycled?
- How many food service employees do you have?
- Do you have any comments?

Two different versions of the survey were created. Version 1 included all ten questions. Food establishments that received Version 1 of the survey included restaurants, school cafeterias, hotel kitchens, medical facilities, correctional facilities, catering businesses, and lunchwagons. There were 5,260 food establishments that were surveyed using Version 1.

Version 2 surveys were mailed to food manufacturers, processors, warehouses, and retail establishments. These food establishments do not serve meals (breakfast, lunch, dinner). Therefore, Version 2 of the Food Waste Recycling Survey did not include the two questions that pertained only to the food establishments that serve meals (what meals do you serve? and how many meals do you serve?). There were 2,993 food establishments that were surveyed using Version 2.

4.5 Survey Response Rates

4.5.1 Mail Surveys

A total of 8,253 surveys were bulk mailed to all the food establishments in the State of Hawaii. The surveys for Kauai and Hawaii were mailed on September 17, 2004; Maui, Molokai, and Lanai on September 24, 2004; and Oahu on October 1, 2004. The survey respondents were asked to complete and return the survey by October 15, 2004. A follow-up post card was mailed on October 8, 2004, to all establishments to remind them to complete and return their surveys.

There were 1,842 surveys returned by mail, which is a response rate of 22.3%. Neuman noted that the biggest disadvantage of a mail survey is a low response rate, and this was true for the present study[51]. The breakdown by island is provided in Table 10.

Table 10. Mail Survey Response Rates

	Number Mailed	Number Returned	Percentage Returned
Kauai	488	101	20.7%
Oahu	5,096	1,119	22.0%
Molokai	1,157	253	21.9%
Maui	79	22	27.8%
Lanai	27	9	33.3%
Hawaii	1,406	338	24.0%
Total	**8,253**	**1,842**	**22.3%**

4.5.2 Phone Surveys

Food establishments that did not return their survey by mail were later contacted by phone. Since this study was funded by the HDOA because it was interested in finding the unlicensed pig farmers through the food waste generators (food establishments), an attempt was made to contact by phone those establishments that did not return their mail surveys. It was decided that there would be eight attempts (phone calls) to reach each food establishment that had not responded to the mail survey. The decision to make eight attempts was based on the resources (time and money) available for this project. Six students were hired to assist in calling all of the food establishments. Appendix 2 includes the interview script and the phone surveys that were used when calling the food establishments.

Phone calling was conducted Monday through Friday from approximately 8 am to 5 pm. Occasionally establishments would ask to be called back on the weekend, before 8

[51] Neuman, W. L. (2004). *Basics of Social Research.* Boston: Pearson Education, Inc.

am, or after 5 pm. Every effort was made to contact these food establishments at the time(s) they requested.

As a result of the phone surveys, an additional 3,074 surveys were completed. However, not all food establishments on the Department of Health lists could be reached by phone. There were many establishments that did not have a phone number provided, had a disconnected phone number listed, had the wrong phone number listed, or the phone number provided was connected to a fax machine. The phone numbers for these establishments were looked up in the phone book and double checked. At the conclusion of the survey, there were 1,184 food establishments that could not be reached by phone.

There were 929 establishments that did not want to participate in answering the survey. In addition, there were 199 food establishments where the person on the phone said that they could not speak English well or at all so they would not be able to answer the survey. No further contact was made with these food establishments.

Despite calling eight times, there were 473 food establishments that did not respond to the survey. These establishments either did not answer their phone, the phone line was busy, their answer machine picked-up, the person who answered the phone asked to be called back at a later time, or a combination of these responses. There were also 435 food establishments that asked to have the survey faxed, emailed, or mailed to them, but did not return their survey. The breakdown of survey responses are provided in Table 11.

Table 11. Survey Response Rates

	Number	Percentage
Completed Mail Survey	1,842	22.3%
Completed Phone Survey	3,074	37.2%
Completed Email/Fax/Re-mail	117	1.4%
Total Completed	**5,033**	**61.0%**
Refused	929	11.3%
Does Not Speak English	199	2.4%
Total Refused/Does Not Speak English	**1,128**	**13.7%**
No Phone #	133	1.6%
Disconnected Phone #	584	7.1%
Wrong Phone #	424	5.1%
Fax Line	43	0.5%
Total Could Not Reach By Phone: No valid phone number	**1,184**	**14.3%**
No Response Email/Fax/Re-mail	435	5.3%
No Response Called 8 times	473	5.7%
Total No Response	**908**	**11.0%**
Total	**8,253**	

4.6 Survey Response Analysis

There were 5,033 (out of 8,253) food establishments that responded to the survey. Of the 5,033 respondents, 179 of these food establishments reported that they had closed. The remaining completed surveys, which total 4,854, are the basis for the data analysis. In order to better understand the food disposal and recycling behavior of 4,854 food establishments, they were categorized based on type of food establishment. For the purpose of this study there are 16 different establishment types. They are as follows:

- Restaurants
- Liquor Dispensers
- Limited Menu
- Schools/Daycare/Nutrition Programs
- Correctional Facilities
- Medical Facilities
- Hotels/Banquet/Convention Kitchen
- Catering/Commissary Kitchen
- Retail

- Manufacturers/Processors/Canning
- Beverages/Ice
- Food Warehouse/Wholesaling/Brokerages
- Pharmacies/Drug Wholesalers
- Cosmetics
- Plastic Bottles (manufacturer)
- Salvage/Food Banks

4.6.1 Food Establishment Types

An establishment type was assigned by the Department of Health's (DOH) Sanitation Branch or Food and Drug Branch to each food establishment on their licensee list. The 16 food establishment types were created by consolidating (re-coding) the establishment types assigned by the DOH. On the Sanitation Branch lists there were ten main types of establishments and 46 sub-groups. The number of sub-groups for each of the main establishment types varied. For example, there were no sub-groups for liquor dispensers and five sub-groups for institutional kitchens (i.e, schools, day care/preschool, correctional facilities, hospital/medical facilities, and care homes). The Food and Drug Branch list included 44 different establishment types.

Many of the categories included on the two lists overlapped and could be combined into the same food establishment type. This section provides an explanation and information on how the DOH food establishment types were consolidated and re-coded into the 16 food establishment types. The number of food establishments in each of the 16 food establishment types and its percentage in the population is included in Table 12.

Table 12. Establishment Types Distribution

Establishment Type	Number in Population	Percentage of Population
Restaurants	3,131	37.9%
Liquor Dispensers	268	3.2%
Limited Menu	466	5.6%
Schools/Daycare/ Nutrition Programs	767	9.3%
Correctional Facilities	10	0.1%
Medical Facilities	84	1.0%
Hotel/Banquet/ Convention Kitchen	62	0.8%
Catering/Commissary Kitchen	472	5.7%
Retail	1,805	21.9%
Manufacturers/ Processors/Canning	815	9.9%
Beverages/Ice	75	0.9%
Food Warehouse/ Wholesaling/ Brokerages	255	3.1%
Pharmacies/Drug Wholesalers	19	0.2%
Cosmetics	13	0.2%
Plastic Bottles (manufacturer)	5	0.1%
Salvage/Food Banks	6	0.1%
All Establishments	**8,253**	**100%**

Restaurants

Of the 8,253 permitted food establishments in the State of Hawaii, 3,131 of them are restaurants. This makes the restaurant category the largest of the 16 categories, accounting for approximately 38% of the total population.

Re-coding from the original DOH categories to this survey category, restaurants, was straight forward. The Sanitation Branch categorized restaurants into three categories: sit-down restaurants, take-out restaurants, and sit-down and take-out restaurants. The Food and Drug Branch does not permit restaurants. The three categories

of establishment types were recoded into one to ensure that all the restaurants would be analyzed together. Since each county had their own method of determining establishment type, there were inconsistencies in the categorization of the same restaurant across counties (e.g., a fast food chain that is found in all counties was put in different categories).

Liquor Dispensers

There are 268 (~3%) food establishments that are liquor dispensers in the state. Liquor dispensers were only permitted with the Sanitation Branch and were not divided into any sub-groups, thus no re-coding was required for this establishment type. Liquor dispensers are bars and night clubs, but not liquor stores, which are classified as retail establishments.

Limited Menu

The limited menu category contains 466 establishments (~6%). Food establishments included in this category have been categorized by the DOH as restricted/specialized kitchens with service area, no food prep (meal site), limited menu, or frozen dessert dispenser. Generally, this category is made up of coffee shops, ice cream shops, and snack bars.

Schools/Daycare/Nutrition Programs

This category contains all schools in Hawaii, which total 767 (~9%) establishments. The schools category is the fourth largest. While schools are not generally considered commercial food establishments they are required to be permitted by the DOH Sanitation Branch. Schools range from pre-kindergarten (daycare and pre-school programs) to post-high schools (colleges and universities). The DOH categorized

schools according to the type of kitchen it had (full service, service area with no food preparation, service area with limited food preparation, or daycare/preschool).

In the Department of Education (DOE) (Hawaii public school system) there are some schools which are considered serving kitchens—they do not have food preparation (cooking) equipment (stoves, ovens, freezers, etc.), which means that the meals are prepared at a nearby (often larger) school and then transported to the serving kitchen. Also many of the smaller private schools (including pre-schools) have their meals catered, which is similar to the DOE's serving kitchens in that no cooking is done on the school's premises. There are also schools (mainly daycare and pre-school facilities) that offer no meal service and require all students to bring lunch with them. Rather than having multiple categories for schools, all schools regardless of the location of the meal preparation are grouped into this category.

Correctional Facilities

According to the DOH, there are ten (<1%) correctional facilities in Hawaii. Correctional facilities were only permitted with the Sanitation Branch and were not divided into any sub-groups, thus no re-coding was required for this establishment type. Correctional facilities include jails (community correctional) and prisons (correctional facilities) for adults and juveniles.

Medical Facilities

There are 84 medical facilities (~1%) permitted by the DOH. Food establishments that fall under this category includes hospitals and care homes. The Sanitation Branch had separate categories for hospitals/medical facilities and care homes. For this study these two categories were merged into one.

Hotel/Banquet/Convention Kitchen

There are 62 (<1%) food establishments that are hotel, banquet, or convention kitchens. The Sanitation Branch permits these food establishments. This may seem like a small amount for Hawaii, however, hotels with multiple permits were only sent one survey (as explained in section 4.3) and not all hotels have kitchens. Hotel kitchens are often centralized and may prepare all of the meals for the employee cafeteria, hotel restaurants and bars, banquet and meeting rooms, and room service.

Catering/Commissary Kitchen

Catering and/or commissary kitchens comprise 6% of the population or 472 food establishments in the state. Food establishments that fall under this category are permitted by either the Sanitation Branch or Food and Drug Branch. There were many sub-groups from the Sanitation Branch's list that were consolidated into this category, which included mass feeding/support kitchens (catering, commissary) and mobile food establishments (carts, lunchwagons, frozen dessert, mobile kitchens, cruise boats). Mobile food establishments are included in this category because they have a support kitchen where the food is prepared and then transported to a different location to be sold. For the purposes of this study, the mobile food establishment and its support kitchen was considered one establishment and was only sent one survey.

Retail

The retail food establishment category is the second largest, with 1,805 (~22%) establishments in the state. Both the Sanitation Branch and Food and Drug Branch permit retail food establishments. Retail establishments include supermarkets, grocery stores, convenience stores, and health food stores. In some cases, the DOH categorized a

retail establishment by the specific type of food they sold (meats/poultry, seafood, or vegetable/fruit).

As experienced with the restaurant category, each county had their own method of determining establishment type, which created inconsistencies in the categorization of the same retail establishment across counties (a supermarket/grocery store chain that is found in all counties was put into different categories). In order to provide a comparison on a state-wide level it was necessary to group all retail establishments into one very large category.

Manufacturers/Processors/Canning

There are 815 establishments that are included in this category, which accounts for approximately 10% of the population. The manufacturers/processors/canning food establishment type is the third largest in the study. Establishments in this category come from both the Sanitation and Food and Drug Branch's lists. There were ten sub-groups categorized by the Sanitation Branch:

- meat/poultry/seafood/vegetables
- bakery
- poi
- confectionary
- noodles
- jams, jellies, and preserved fruit
- nut and nut products
- tofu
- dairy
- low acid can food

There were 22 food establishment types listed on the Food and Drug list:

- bakeries
- canneries
- confectioners
- dairies
- oriental manufacturers (mochi, sushi, bento)

- sandwich manufacturers
- meat/poultry manufacturers
- nuts, chips, popcorn, Chinese seeds
- sauces, dressings, seasonings, jams, jellies, syrups, oils
- pickled products (kim chee, takuan, chili pepper water)
- tofu
- poi
- aquaculture (prawns, seaweed, algae, tilapia)
- meat wholesalers/storage
- herbal supplement manufacturer/re-packer
- honey
- seafood manufacturer (smoked fish)
- sprouts
- noodle, pizza, pastels, tortillas, lumpia
- coffee/tea manufacturer/re-packer
- pet food
- other food manufacturers.

There were some types of food establishments that were categorized with the same name on both the Sanitation and Food and Drug Branch lists (e.g., poi, confectionary, bakery, tofu categories appeared on both lists). Rather than have many small categories, all manufactures, processors, and canning establishments were grouped into one establishment type.

Beverage/Ice

On the DOH lists there were 75 beverage or ice establishment types (<1%) in Hawaii. Similar to the manufacturers/processors/canning food establishment type, these establishments come from both the Sanitation and Food and Drug Branch lists. The sub-groups included by the Sanitation Branch include bottling or canning operations for water; non-alcoholic beverages; alcoholic beverages; and manufacturers or processors of ice. Establishment types included on the Food and Drug Branch list included: ice plants; beverage (juice); bottling plants (vending, soda, beer, wine); and bottled water. The

establishments types from both DOH branches were very similar and could be grouped into one type—beverages/ice.

Food Warehouse/Wholesaling/Brokerages

There are 255 (~3%) food establishments that can be categorized as food warehouse, wholesaling, or brokerages in the population. These food establishments come from both the Sanitation and Food and Drug Branch lists. Sub-groups included on the Sanitation Branch list include: dry food; refrigerated/frozen; produce; and re-packing. The Food and Drug Branch had three categories: food re-packing/packaging; warehouses; and brokerages. The establishments from both DOH branches were grouped into one category since they include similar establishment types.

Pharmacies/Drug Wholesalers

There are 19 (<1%) pharmacies and drug wholesalers permitted with the DOH. These establishments are permitted with the Food and Drug Branch. Two categories—pharmacies and drug wholesalers were combined to create this food establishment type. While this establishment type may not be considered a typical food establishment, for the purpose of this study it was agreed upon with the HDOA that all food establishments included on the DOH's lists would be surveyed.

Cosmetics

There are 13 (<1%) establishments that are labeled cosmetics by the Food and Drug Branch. The Food and Drug Branch had only one establishment type for cosmetics and no re-coding was required for this category.

Plastic Bottles (manufacturer)

There are five (<1%) establishments that are permitted by the Food and Drug Branch. These five establishments were listed as plastic bottle manufacturers. The Food and Drug Branch had only one establishment type for plastic bottle manufacturers and no re-coding was required for this category.

Salvage/Food Banks

There are 6 (<1%) salvage or food banks permitted by the Food and Drug Branch. The Food and Drug Branch had only one establishment type for salvage/food banks and no re-coding was required for this category.

4.6.2 Food Establishment Types Discussion

Based on the available information for each food establishment (as provided on the DOH lists), the food establishments were re-categorized from the DOH's original establishment types into 16 general categories. One recommendation for future studies would be to ask the establishment to report their establishment type. Rather than having general categories such as restaurants and retail, restaurants could be further categorized into fast food or full service and retail establishments could be divided into convenience stores or supermarkets. One reason to have more specific establishment types is because the amounts/rates of food waste generated may be different, as was found to be the case in the Jones study (see section 2.2.1).

4.6.3 Chi Square Goodness of Fit Test

The chi square goodness of fit test was conducted to determine if the sample (the establishments that completed the survey) was representative of the population. For a

sample to be representative, it would need to reflect the distribution in the population. The establishment type was the independent variable and completion of the survey (yes or no) was the dependent variable. The null hypothesis and alternative hypothesis were as follows:

> Null Hypothesis: The sample (survey respondents) distribution is not representative of the population.
>
> Alternative Hypothesis: The sample (survey respondents) distribution is representative of the population.

4.6.2.1 Chi Square Goodness of Fit Test Results

The chi square goodness of fit test was conducted in SPSS, the data and results are included in Table 13. The chi square value was 143.62 with 15 degrees of freedom, which made the p-value less than 0.005. The p-value indicates that the results are statistically significant and thus the null hypothesis is rejected and the alternative hypothesis is accepted. This means that the distribution of the survey respondents by establishment type does reflect the distribution in the population.

The proportions of each type of food establishments in the population should also be reflected in the sample. For example, correctional facilities account for 0.12% of the population so they should also account for 0.12% of the sample (i.e., six surveys are expected to be observed in the sample), which was the case. There were two other establishment types in the sample, cosmetics and salvage/food banks, where the number of completed surveys matched with the number of expected surveys. Five establishment types had a lower than expected response rate (number of completed surveys); restaurants, liquor dispensers, catering/commissary kitchen, retail, and manufacturers/processors/canning. The following seven establishment types had a higher

than expected response rate; limited menu, schools/daycare/nutrition programs, medical facilities, hotel/banquet/convention kitchen, beverage/ice, food warehouse/wholesaling/brokerages, pharmacies/drug wholesalers, and plastic bottles.

Table 13. Chi Square Goodness of Fit Test

Establishment Type	Number in Population	Percentage in Population	Observed (surveys completed)	Expected	$(O-E)^2/E$
Restaurants	3,131	37.94%	1,788	1,909	7.72
Liquor Dispensers	268	3.25%	126	163	8.58
Limited Menu	466	5.65%	309	284	2.17
Schools/Daycare/ Nutrition Programs	767	9.29%	676	468	92.72
Correctional Facilities	10	0.12%	6	6	0.00
Medical Facilities	84	1.02%	67	51	4.86
Hotel/Banquet/ Convention Kitchen	62	0.75%	43	38	0.71
Catering/ Commissary Kitchen	472	5.72%	227	288	12.86
Retail	1,805	21.87%	1,044	1,101	2.93
Manufacturers/ Processors/ Canning	815	9.88%	477	497	0.81
Beverages/Ice	75	0.91%	63	46	6.51
Food Warehouse/ Wholesaling/ Brokerages	255	3.09%	178	156	3.25
Pharmacies/Drug Wholesalers	19	0.23%	13	12	0.17
Cosmetics	13	0.16%	8	8	0.00
Plastic Bottles (manufacturer)	5	0.06%	4	3	0.30
Salvage/Food Banks	6	0.07%	4	4	0.03

Chi Square Value = 143.62

4.6.2.2 Chi Square Goodness of Fit Test Discussion

It is not known why some establishment types were more likely to complete the survey than others. Possible explanations could be that those that had a high response rate were more sympathetic to research projects and completing surveys or had more time to complete the survey. For those establishments that had a lower response rate than the overall average, it could be attributed to one of the following reasons: they refused to participate, they do not speak English, they did not answer their phone despite calling eight times (or asked to be called back each time), or could not be reached by phone (no phone number was listed, it was a disconnected phone number, it was the wrong phone number, or it was a fax line). For the establishments that could not be reached by phone, they could also have been no longer in business, but still on record with the DOH.

Ideally, a sample that is representative of the population is desired in any study, as was the case in this study. In order to help assure a representative sample, the sampling ratio should fall within the following recommended guidelines: for a small population (less than 1,000) the sampling ratio should be 30% and for a moderately large population (10,000) the sampling ratio should be 10%[52]. In this study, there are 8,253 food establishments in the population and the sampling ratio (percentage of completed surveys) is 61%. It is important to note that the sampling ratio was actually 100% since all establishments in the population were mailed a survey and those that did not return the survey were attempted to be reached by phone. In this thesis, the sample is considered the establishments that completed their survey.

[52] Neuman, W. L. (2004). *Basics of Social Research.* Boston: Pearson Education, Inc.

There are various strategies that could be used to increase the sample size (response rate). The survey could have been mailed out again to those establishments that did not reply to the first mail survey, more phone attempts could have been conducted, or the establishments could have been visited in person. There were many survey respondents that reported not being able to speak English so translating the survey into different languages may have also increased the response rate. However, this would require multi-lingual telephone interviewers and translators to enter in the answers from the mail surveys.

For the purpose of this thesis, a census of the population was required because each food establishment needed to be contacted to find out if food waste was being collected for recycling. For future studies, it would be more practical to survey only those establishments that generate large amounts of food waste and/or cooking oil. In the food waste generation studies conducted by Draper/Lennon, Inc. for Connecticut and Massachusetts (see chapter 2), minimum establishment sizes were determined and only establishments that met the minimum size were surveyed. Draper/Lennon, Inc. also did not survey all food establishment types, only health care facilities, colleges/universities/independent preparatory schools, correctional facilities, resort/conference facilities, restaurants, and supermarkets were included in their study.

5.0 FOOD WASTE RESULTS AND ANALYSIS

5.1 Food Waste Disposal and Recycling

One of the main objectives of this study was to determine how food establishments dispose of and recycle their food waste. In the cover letter that was sent with the survey, food waste was described as, "any food that you discard, such as expired food, food preparation/processing wastes, and table scraps". On the survey food establishments were asked to indicate how they dispose of food waste. Four options were provided and the directions were to check all disposal methods that applied: throw it away in the trash, donate edible items to the food bank, recycle it (recycling company, pig farm), or other (respondents were asked to specify).

After all the responses to this question were reviewed, another disposal option was added: do not have any food waste. In addition, donate edible items to the food bank was coded as recycle it. The following responses were received as "other" methods of food waste disposal:

- compost or worm bin
- give uneaten food to family members, friends, and/or employees
- feed other animals (not including pigs) such as fish, dogs, rabbits, ducks, or chickens any left over food

5.1.1 Food Waste Disposal Results

Table 14 presents the overall responses including the number of food establishments and percentage for each disposal method. Figure 3 displays the results in the form of a pie chart.

Table 14. Summary of Survey Results for Methods of Food Waste Disposal

Disposal Method(s)	Number of Food Establishments	Percentage
Throw It Away	2,177	45%
Recycle It	1,073	22%
No Food Waste	1,206	25%
Throw It Away & Recycle It	398	8%
Total	**4,854**	**100%**

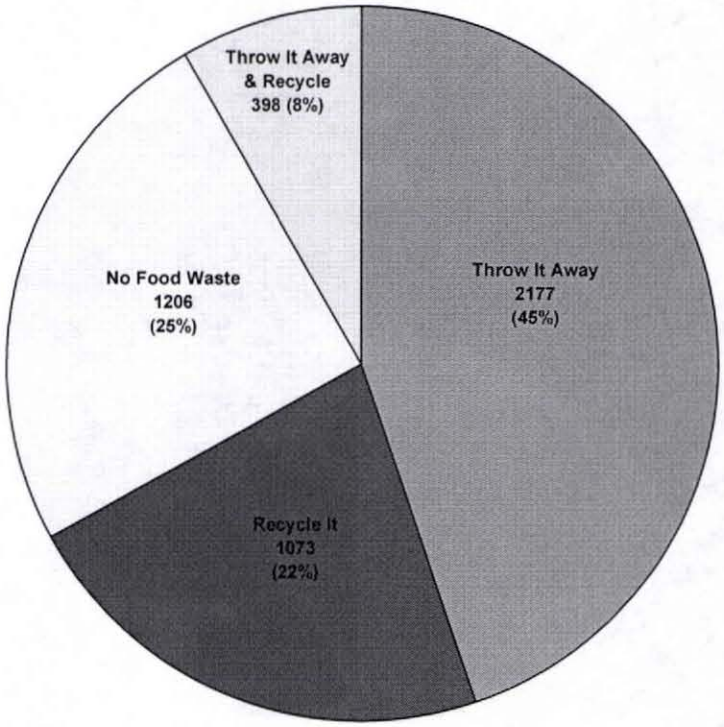

Figure 3. Summary of Survey Results for Methods of Food Waste Disposal

The majority (45%) of the food establishments in Hawaii throw away all of their food waste. A quarter (25%) of the sample reported that they have no food waste, 22% of respondents said they recycle their food waste, and 8% of the sample said they throw some of their food waste away and recycle some of their food waste.

Table 15 gives the breakdown of responses (in percentages) for each disposal method by establishment type.

Table 15. Breakdown of Disposal of Food Waste by Establishment Type

Establishment Type	Throw It Away	Recycle It	No Food Waste	Throw It Away & Recycle It
Restaurants	61.1%	25.3%	6.0%	7.6%
Liquor Dispensers	38.1%	2.5%	59.3%	0.0%
Limited Menu	39.7%	16.6%	29.8%	13.9%
Schools/Daycare/Nutrition Programs	46.1%	18.8%	28.0%	7.1%
Correctional Facilities	0.0%	100.0%	0.0%	0.0%
Medical Facilities	43.3%	43.3%	6.0%	7.5%
Hotel/Banquet/Convention Kitchen	16.3%	76.7%	2.3%	4.7%
Catering/Commissary Kitchen	33.7%	23.5%	31.1%	11.7%
Retail	35.9%	16.9%	39.0%	8.2%
Manufacturers/Processors/Canning	34.7%	29.5%	27.1%	8.7%
Beverages/Ice	4.8%	17.7%	74.2%	3.2%
Food Warehouse/Wholesaling/Brokerages	13.1%	15.4%	58.3%	13.1%
Pharmacies/Drug Wholesalers	0.0%	0.0%	100.0%	0.0%
Cosmetics	0.0%	0.0%	100.0%	0.0%
Plastic Bottles (manufacturer)	0.0%	0.0%	100.0%	0.0%
Salvage/Food Banks	25.0%	75.0%	0.0%	0.0%

5.1.2 Food Waste Disposal Discussion

As previously mentioned, a definition of "food waste" was provided in the cover letter for survey respondents to read. However, many surveys were returned with the comment "we are not a food establishment...we have no food waste". Many establishments felt that if they only sold pre-packed food items such as candies or other types of snacks that they were not a food establishment and/or did not have food waste. All establishments that were sent surveys were on the DOH's food establishment permit

lists. Many of the survey respondents that did not view their establishment as a food establishment felt that since they were not a restaurant and/or did not serve typical meals that the survey did not apply to them.

Another reason some establishments reported not having any food waste was because they use/sell all their food items and do not have anything to throw away or were not responsible for the food's disposal. The types of food establishments that reported not being responsible for the disposal of food waste included take-out restaurants where customers would eat and dispose of any food waste at a different location; retail establishments where the vendor would take back any unsold or expired products; or places where the meals were catered and then the caterer would take back any waste and dispose of it.

There were 398 establishments (8% of survey respondents) that reported they throw away and recycle their food waste. It may be possible that more of the survey respondents also throw away and recycle their food waste. On the mail survey, there were four options for food waste disposal: throw it away in the trash, donate edible items to the food bank, recycle it, or other (respondents were asked to specify); many respondents may have not considered all the additional ways that food is disposed of since the choices were not listed. Additional methods, which were later included in the phone surveys as methods of recycling, include: compost or worm bin; give uneaten food to family members, friends, and/or employees; or feed other animals any left over food.

Limitations of the Food Waste Disposal Data

The answers used in this thesis were provided by the survey respondents and no verification was made to confirm the reported disposal method(s). As mentioned in the discussion, there were many establishments that reported not having any food waste, which was may be untrue. Also, the surveys were completed between Fall 2004 through Summer 2005 and the disposal method(s) used for food waste may have since changed.

Recommendations for Future Studies on Food Waste Disposal

On the mail surveys it would have been beneficial to list all the food recycling options that respondents listed as "other". Another method of food waste disposal that was not considered in this survey was the use of in-sink food waste disposals (garbage disposals). It would be interesting to find out how prominently garbage disposals are used in food establishments.

5.1.3 Food Waste Recycling Results

There were 1,471 establishments that reported they recycle some or all of their food waste. Table 16 provides the breakdown for the number of establishments that reported they recycle. An establishment may use various methods of recycling and therefore, the categories are not mutually exclusive.

Table 16. Methods of Food Waste Recycling

Method of Recycling	Number of Food Establishments (Counts include establishments using multiple methods)
Recycling Company	188
Pig Farm	625
Donations	370
Composting	136
Give to Others	193
Give to Other Animals	138

The most commonly reported method of recycling was pig farm (625 establishments), followed by donations (370 establishments), give to others (193 establishments), recycling company (188 establishments), give to other animals (138 establishments), and composting (136 establishments). The breakdown by establishment type for each method of recycling is provided in Table 17. An establishment may use several methods of recycling and therefore, the categories are not mutually exclusive.

Table 17. Methods of Food Waste Recycling By Establishment Type

Establishment Type	Recycling Company	Pig Farm	Donations	Compost	Give to Others	Give to Other Animals
Restaurants	106	284	73	36	78	33
Liquor Dispensers	1	1	0	0	0	1
Limited Menu	3	12	48	15	15	5
Schools/Daycare/ Nutrition Programs	1	125	12	15	14	19
Correctional Facilities	2	4	1	0	0	0
Medical Facilities	8	18	1	3	2	5
Hotel/Banquet/ Convention Kitchen	11	23	5	0	1	0
Catering/Commissary Kitchen	6	13	18	9	20	13
Retail	34	87	106	15	34	38
Manufacturers/ Processors/ Canning	13	43	65	38	22	20
Beverages/Ice	1	6	3	3	0	3
Food Warehouse/ Wholesaling/ Brokerages	2	7	37	2	7	1
Pharmacies/Drug Wholesalers	0	0	0	0	0	0
Cosmetics	0	0	0	0	0	0
Plastic Bottles (manufacturer)	0	0	0	0	0	0
Salvage/Food Banks	0	2	1	0	0	0

An establishment may use multiple methods of recycling and the various combinations of recycling methods used are included in Table 18. Of the 1,471 establishments that recycle some or all of their food waste, the majority (~89% or 1,304) of them use only one method of recycling. There were 155 establishments that use two methods of recycling and 12 establishments that use three methods of recycling.

Table 18. Combinations of Food Waste Recycling Methods Used

Method(s) of Recycling	Number of Food Establishments
Recycling Company (pigs and/or rendering)	162
Pig Farm	541
Donate	260
Compost	105
Others (give to other humans)	146
Animals (other than pigs)	90
Company, Pigs, Donate	3
Company, Donate	22
Company, Animals	1
Pigs, Donate	47
Pigs, Compost	9
Pigs, Others	6
Pigs, Animals	13
Pigs, Donate, Compost	1
Pigs, Donate, Others	3
Pigs, Donate, Animals	2
Donate, Compost	7
Donate, Others	18
Donate, Animals	5
Donate, Compost, Animals	1
Donate, Others, Animals	1
Compost, Others	3
Compost, Animals	9
Compost, Others, Animals	1
Others, Animals	15

5.1.4 Food Waste Recycling Discussion

There are many types of food recycling options and some of these categories may seem as though they overlap such as "donations" and "give to others". These responses were given separate categories because this is how respondents answered the survey question. In general "donations" are to non-profit organizations that feed the hungry such as homeless shelters, food banks, and soup kitchens. Food provided for donations can be

both perishable and non-perishable. Many establishments participate in food donation programs that coordinate the transportation of perishable food (such as food prepared for a buffet line, but not touched) to meal distribution centers (homeless shelters, soup kitchens). Non-perishable food that is donated often comes from retail establishments (supermarkets). Respondents that reported they give left over food to others usually meant that family, friends, or employees took home any left over food at the end of the shift or day. This quantity of food is normally small, such as a few hot dogs or a bento. Also included in this category (give to others) were respondents who said they "eat any left overs".

Additional categories that may appear to overlap include "pig farm" and "give to other animals". The main reason to keep these responses separate was the purpose of this survey—finding unlicensed pig farmers for the Hawaii Department of Agriculture (HDOA). Since the HDOA licenses pig farmers who feed food waste, it was important to keep track of which establishments were providing food to which farmers. The type of food waste provided for each response is also different—food collected for pigs includes all food waste whereas, food waste fed to other animals would be separated based on the animal it was going to feed. For example, bread is saved for ducks, chickens, and fish; produce for rabbits and guinea pigs; and meat for dogs. Many of the respondents that reported they give food waste to other animals said that it is given to their employees for their pets.

The category "recycling company" includes two types of recycling companies: rendering and intermediary recyclers. As mentioned previously, Island Commodities is a local business that collects meat trimmings, bones, and oil for rendering. Intermediary

recyclers are business that pick up food waste and delivers it to pig farms. Intermediary recyclers may charge the food establishments to collect their food waste and deliver the food waste to the pig farms for free. The HDOA does not license intermediary companies because they are the deliverers of food waste and not the food waste feeder, although the owner of a company may also raise pigs (and in this case they would be licensed). It is the food waste feeder (the pig farmer) who is responsible to cook the food waste according to the regulations put in place by the USDA.

Limitations of the Food Waste Recycling Data

The answers used in this thesis were voluntarily provided by the survey respondents and no verification was made to confirm the reported recycling method(s). There may have been respondents that did not consider all the ways food was disposed of/recycled at their establishment, which could mean that there is actually more establishments recycling food waste than reported. Also, the surveys were completed between Fall 2004 through Summer 2005 and the recycling method(s) used for food waste may have since changed.

Recommendations for Future Studies on Food Waste Recycling

In order to provide respondents with more choices for how they dispose of their food waste, on the mail surveys, it would have been beneficial to list all the food recycling options that respondents provided as "other" methods of food waste disposal (i.e., compost or worm bin; give uneaten food to family members, friends, and/or employees; and feed other animal such as fish, dogs, rabbits, ducks, or chickens any left over food). For all surveys (mail and phone) the option of "recycling company" should

have been divided into two categories—rendering company and intermediary food waste recycler (for pig farms).

5.2 Relationship between the Size of an Establishment and the Amount of Food Waste Recycled

In this study, the size of a food establishment can be characterized in two ways—by the number of meals they serve per day and by the number of employees they have. One of the research objectives is to determine if there is a relationship between the size of a food establishment and the amount of food recycled. In general, the assumption is that as the number of meals a food establishment serves or number of employees increases, so does the amount of food waste it recycles. Therefore, the null hypothesis and alternative hypothesis are as follows:

> Null Hypothesis: There is no relationship between the size of an establishment and the amount of food waste they recycle.
>
> Alternative Hypothesis: There is a relationship between the size of an establishment and the amount they recycle—the larger the food establishment, the more food waste they recycle.

In order to test the hypothesis that size of an establishment is related to the amount of food recycled, scatter plots and correlation coefficients were calculated. The hypothesis was tested in two ways: first using the number of meals as the independent variable and the amount recycled as the dependent variable and second by using the number of employees as the independent variable and the amount recycled as the dependent variable. The results and discussion sections for the number of meals and the amount recycled is presented first, followed by the number of employees section. For the number of meals data, only those establishments that completed survey Version 1 were included in the analysis.

5.2.1 Relationship between Number of Meals Served and Amount of Food Waste Recycled

5.2.1.1 Amount of Food Waste Recycled Results

Only food establishments that said they recycle their food waste and completed survey Version 1 (establishments that serve meals) were included in these results. There were 3,130 establishments that completed Version 1 and of those, 980 establishments that said they recycle. The 980 establishments that reported they recycle include all types of recycling (recycling company, pig farm, donations, composting, give to others, and give to other animals). Of the 980 establishments that recycle, 420 of them provided the amount recycled on the survey. The majority (560 establishments) did not provide the amount they recycle. Descriptive statistics of the 980 establishments are presented in Table 19. The amount of food recycled per day for this group ranged from zero to 471 gallons. The median amount recycled was 17 gallons, the mean was 37 gallons, and the mode was 1 gallon. The standard deviation was 54 gallons.

Table 19. Descriptive Statistics for Number of Meals and Amount of Food Waste Recycled

		Number of Meals Served Per Day	Gallons of Food Recycled Per Day
N	Valid	703	420
	Missing	277	560
Mean		362	37
Median		190	17
Mode		100	1
Std. Deviation		534	54
Minimum		4	0
Maximum		5,225	471

It is important to point out that the descriptive statistics presented in Table 19 apply only to the 980 establishments that completed survey Version 1 and reported that

they recycle. Table 19 represents only a portion of the establishments that recycle—in the whole sample there were 1,471 establishments that reported recycling (this amount also includes establishments that completed Version 2). The descriptive statistics of the 1,471 establishments are presented later in Table 21.

5.2.1.2 Amount of Food Waste Recycled Discussion

Many establishments did not know how much food they recycled. There was an option on the mail survey for respondents to "check the box" if they recycle food waste, but did not know how much is recycled. When food is recycled by a recycling company or pig farm, normally the establishment is charged monthly for the service. In many cases the monthly fee is based on a combination of factors including: pick up frequencies (amount of times per week), location (travel distance and proximity to other customers), and number of containers collected (food waste is often collected in 64 gallon containers or 55 gallon drums). Most establishments are not concerned with calculating and tracking the amount of food they recycle. Also, often the person who completed the survey was at the management level and did not have frequent contact with the kitchen staff responsible for the disposal of food waste and those that handled the food waste on a daily basis.

In order to aid in calculating the amount of food waste collected for recycling, the survey asked for the size of the container(s) for food waste, the number of times the container(s) are emptied per week, how full the container(s) are when collected, and the number of container(s) used. With this information the amount of food waste recycled could be estimated. Information was provided in gallons or pounds of food waste recycled. A conversion to gallons from pounds was made by dividing the number of

pounds by 7.4909 pounds/gallon.[53] There were also establishments that provide unclear or incomplete information on their survey. In these cases, the establishment was re-contacted to clarify or verify the amount recycled. If the amount could not be accurately calculated, the amount recycled was left blank.

Estimating the amount of food recycled is complicated if the establishment recycles food waste in more than one way. The amount provided on the survey is only what is collected by a recycling company and/or pig farmer. The estimate does not include the food that is donated to non-profit organizations, which is not normally measured in gallons or pounds (it could be loaves of bread, boxes of bakery items, canned goods, etc.).

For establishments that recycle food by donations, composting, give to others, and give to other animals it is difficult for them to report the amount recycled in gallons or pounds because food waste is not collected in containers as it is for recycling companies and pig farmers. Often this food for recycling is the daily leftovers such as bento, musubi, hot dogs, or bake goods. Most times food waste recycled is minimal and is not weighed by the establishment. Food waste recycled by feeding to other animals (other than pigs) is also leftovers, which could be from school children's meals such as bread and crackers that are thrown outside for birds, ducks, or chickens. There are also some pig hunters who collect food waste to feed their hunting dogs, in this case they only want meat scraps, not produce or bakery waste. Retail establishments (supermarkets) sometimes leave produce scraps outside their store for pick up by community members for their pets.

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[53] United States Environmental Protection Agency. (1997). *Measuring Recycling A Guide for State and Local Governments* (No. EPA-530-R-97-011). Washington DC. Retrieved September 10, 2005, from http://www.epa.gov/recycle.measure/docs/guide.pdf

There were many establishments that did not provide data for amount of food waste recycled. For some of the surveys, the manager at an individual establishment forwarded the survey to the corporate office. The specific amount recycled at each establishment was not reported by the corporate office because one survey was completed for all of the company's locations in Hawaii.

Limitations of the Amount of Food Waste Recycled Data

The data used in this thesis were provided by the survey respondents and no additional measurement or verification was made to confirm the reported amounts. It was commonly reported by survey responders that the amount of food recycled varies greatly from day-to-day depending on the actual number of customers (there may be more food wasted if the estimated or anticipated number of customers for the day is not reached, especially in the case of restaurants) and/or personal preference (as with school lunches—the amount of food waste recycled depends on what is served that day).

Also, these data were collected from Fall 2004 through Summer 2005 and the amount of food recycled could fluctuate based on seasonal trends (i.e., food establishments catering to the visitor industry or the holiday season—Thanksgiving, Christmas, New Years, etc.). It is also possible that some of the establishments that reported they recycle no longer do and that there may be additional establishments that have started recycling since completing the survey.

Recommendations for Future Studies on Food Waste Recycling Amounts

In order to get the most accurate data on the amount recycled, it would be beneficial to visit the establishments and weigh all food recycled. Measurements could be taken over a period of time (one year) to determine the daily average and would thus take into account any seasonal fluctuations. This would be more feasible to do if a small random sample of the population was surveyed and/or the study was only conducted for Oahu.

Another way to verify food recycling amounts would be to ask the businesses and individuals who are doing the collection and actual recycling. However, food recycling companies view their data as proprietary and receiving their cooperation is anticipated to be difficult. This method would also require visits to weigh the food waste collected. It may also be interesting to see if all the food waste collected is actually recycled as the food establishment intends it to be. For example, there may be too much food waste collected and the pig farmer may have to throw some of it away if his/her pigs cannot consume all of it before it spoils.

It would also be interesting to determine the recycling capture rate. Many establishments reported that they recycle all their food waste. However, it is not known for sure if this is actually occurring. This could be verified by conducting a waste audit at the establishment. The waste audit would include sorting through all of the establishment's trash and weighing any food waste. It would also be good to determine how much food waste is disposed of via in-sink food waste disposals. The food waste collected for recycling would also be weighed and the capture rate would be that amount recycled divided by the total amount of food waste generated. This could also be

expanded to measure all types of waste thrown away and recycled (paper, plastic, cardboard, bottles/cans, etc.) and determine the percentages of each type of waste generated at the establishment and their recycling rates.

5.2.1.3 Number of Meals Served Results

On Version 1 of the survey, there were two questions pertaining to meals served: what meals do you serve (breakfast, lunch, dinner, other) and what is the average number of meals served per day. There were 3,130 establishments that completed Version 1 of the survey and of the 3,130, 980 establishments reported that they recycle. The results reported in this section are only for those establishments that recycle. Descriptive statistics for the number of meals served for establishments that recycle are presented in Table 19. The number of meals served per day ranged from 4 to 5,225. The median number of meals served per day was 190, the mean was 362, and the mode was 100. The standard deviation was 534. Answers collected from the question, "What meals do you serve?", was not used for these results.

5.2.1.4 Number of Meals Served Discussion

There were many establishments that did not provide the number or their answer could not be converted into the number of meals served (many establishments provided the number of items sold on a daily basis, such as pizzas or sandwiches). Some food establishments did not serve every meal every day (they may close on one day per week or open for lunch and dinner on the weekdays and for breakfast, lunch, and dinner on the weekends). In these cases the number of meals was an average.

Additional reasons for the missing numbers include the person filling out the survey may have unintentionally missed the question, the question could have been purposely left blank (respondent felt the information was confidential/proprietary or did not know the answer), or interpreted and answered the question differently than it was intended. A common response was "it varies" meaning that the respondent could not provide an average of the numbers of meals served per day.

There were many establishments that did not provide data for the number of meals served per day. For some of the surveys, the manager at an individual establishment forwarded the survey to the corporate office. The number of meals served per day at each establishment was not reported by the corporate office because one survey was completed for all of the company's locations in Hawaii.

There are some food establishments where meals are consumed, but not prepared, cooked, or served. Common examples include schools (meals are brought from home, catered—purchased from an outside vendor, or prepared by another nearby school and delivered) and meal sites for programs like Meals on Wheels or similar programs (where meals are prepared at a central facility and delivered to various locations for consumption). For establishments falling into one of the previously mentioned circumstances, the answer for the number of meals served varied according to the respondent's interpretation of the question. Some survey respondents would indicate that zero meals are served (referring to the process of preparing and cooking the meals) and some would report the number of people who were served (consumed) meals at the site (for schools, this would be the number of students who purchased breakfast and lunch).

If the number of meals served was unclear and could not be verified, the number of meals would be left blank.

Another way the interpretation of the question was not as intended occurred when people would count the number of meals served each day and not the number of people who ate each meal. For example, if a restaurant serves breakfast and lunch daily their response would be "two meals served per day". However, the intention of this question was to find out the total number of people (on average) who were served breakfast and lunch at the restaurant daily. If 100 people were served breakfast and 150 were people served lunch (on average), the number that should have been reported on the survey was 250.

Limitations of the Number of Meals Served Data

It is also important to point out that the above mentioned problems occurred only in surveys completed by mail, fax, or email because there was no person who was able to clarify the intent of the question as there was with the phone surveys.

The data used in this thesis were provided by the survey respondents and no additional measurement or verification was made to confirm the reported amounts. Also, these data were collected from Fall 2004 through Summer 2005 and the number of meals served fluctuates based on seasonal trends (i.e., food establishments catering to the visitor industry or the holiday season—Thanksgiving, Christmas, New Years, etc.). The question asked to report the average number of meals at the present time.

Recommendations for Future Studies Collecting Data on Number of Meals Served

In order to prevent any of the problems encountered with the interpretation of the question regarding the number of meals served per day on the written survey, the wording of the question and/or answer choices should be improved. Rather than asking "What is the average number of meals served per day at the present time?" the question could be asked as follows:

> Indicate the average number of meals served for each category per day:
> Breakfast: _____
> Lunch: _____
> Dinner: _____
> Other (specify: _____) _____

5.2.1.5 Scatter Plot and Correlation for Number of Meals and Amount of Food Waste Recycled Results

There were 703 establishments reporting the number of meals served and 420 establishments that provided the amount of food recycled. However, there were only 350 establishments that provided both the number of meals and the amount recycled. To determine if there is a relationship between size (measured by number of meals served per day) and amount of food recycled (gallons per day) a scatter plot was created and correlations were calculated in SPSS. The R^2 value is 0.108. The scatter plot is included as Figure 4. The equation of the regression line in Figure 4 is:

$$Y = 0.029x + 24.372$$

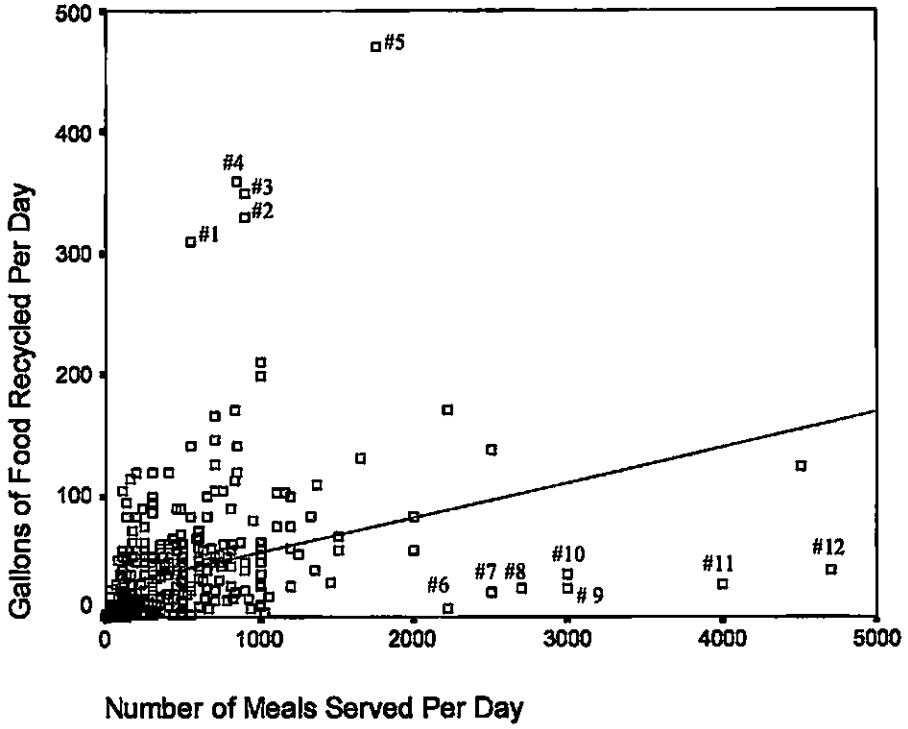

Figure 4. Scatter Plot of Number of Meals Served and Amount of Food Waste Recycled

The scatter plot in Figure 4 shows a positive relationship between number of meals served per day and gallons of food recycled per day. There are some establishments that serve high numbers of meals (2,000-5,000 daily), but recycle a relatively low amount of food (less than 50 gallons per day). There are also establishments that serve less than 2,000 meals per day, but recycle 300 to 500 gallons of food per day.

Table 20 provides the Pearson Correlation coefficient and the two-tailed significance level for this set of data. For all establishments, the Pearson Correlation coefficient is 0.328 and is significant at the 0.01 level. Table 20 also includes the statistics for each establishment type if calculated separately.

Table 20. Correlation for Number of Meals Served and Amount of Food Waste Recycled

Establishment Type	Valid N	Pearson Correlation	Sig.	R^2	Equation
Restaurants	196	.421	.000	.178	Y = .059x + 12.599
Limited Menu	8	.977	.000	.955	Y = .383x – 25.339
Schools/Daycare/ Nutrition Programs	99	.299	.003	.089	Y = .025x + 30.479
Correctional Facilities	4	.766	.234	.587	Y = .012x + 76.327
Medical Facilities	16	.581	.018	.338	Y = .031x + 6.330
Hotel/Banquet/ Convention Kitchen	19	-.205	.400	.042	Y = -.019x + 105.517
Catering/Commissary Kitchen	8	.277	.506	.077	Y = .005x + 15.710
All Establishments	**350**	**.328**	**.000**	**.108**	**Y = .029x + 24.372**

5.2.1.6 Scatter Plot and Correlation for Number of Meals and Amount of Food Waste Recycled Discussion

In general, the amount recycled ranges from 0 to 200 gallons, but there were five establishments (labeled #1-5) that recycle between 300 to 500 gallons per day. These establishments do not follow the generally expected pattern of the greater the number of meals served, the more food is recycled. These five establishments serve between 500 and 2,000 meals per day, but recycle much more than the majority of establishments that serves the same number of meals per day. A brief description of each of the establishments labeled #1-5 in Figure 4 is as follows:

#1: This is a school located on the island of Hawaii. They serve 540 meals and recycle 309 gallons of food waste per day.
#2: This is a limited menu establishment located on Oahu. They serve 900 meals and recycle 330 gallons of food waste per day.
#3: This is a restaurant located on Oahu. They serve 900 meals and recycle 350 gallons of food waste per day.
#4: This is a hotel located on Oahu. They serve 850 meals and recycle 360 gallons of food waste per day.
#5: This is a restaurant located on Oahu. They serve 1,750 meals and recycle 471 gallons of food waste per day.

As you can see, there is no shared characteristic between these five establishments that could account for the low number of meals, but high amount of food recycled.

The scatter plot in Figure 4 also shows establishments that serve high numbers (2,000 to 5,000) of meals per day and recycle a small amount of food waste (less than 40 gallons per day). These establishments are labeled #6-12 and a brief description of each is listed below:

#6: This is a restaurant located on Oahu. They serve 2,225 meals and recycle 6 gallons of food waste per day.
#7: This is a hotel located on Oahu. They serve 2,500 meals and recycle 20 gallons of food waste per day.
#8: This is a medical facility located on Oahu. They serve 2,700 meals and recycle 24 gallons of food waste per day.
#9: This is a school located on Oahu. They serve 3,000 meals and recycle 24 gallons of food waste per day.
#10: This is a restaurant located on Oahu. They serve 3,000 meals and recycle 34 gallons of food waste per day.
#11: This is a hotel located on Maui. They serve 4,000 meals and recycle 27 gallons of food waste per day.
#12: This is a catering establishment on Oahu. They serve 4,697 meals and recycle 38 gallons of food waste per day.

There is no shared characteristic between these seven establishments that could account for the high number of meals, but low amount of food recycled.

The Pearson Correlation coefficient for all establishments shown in Table 20 indicates weak association between the number of meals served and the amount of food recycled. This is because there are some establishments that have a high number of meals served associated with low amounts of food recycled and establishments that have a low number of meals served associated with high amounts of food recycled. However, the correlation coefficient is significant at the 0.01 level. This means that the null hypothesis can be rejected and the alternative hypothesis is accepted. Therefore, there is a relationship between the number of meals served and the amount of food recycled. In

general, it can be predicted that the more number of meals an establishment serves, the more amount of food waste will be recycled.

Limitations of the Scatter Plot and Correlation for Number of Meals and Amount of Food Waste Recycled

As previously mentioned, the data used in this thesis were provided by the survey respondents and no additional measurement or verification was made to confirm the reported amounts. Therefore, these establishments may have reported the amounts of meals served or food recycled incorrectly.

The main limitation of these results is the relatively small useable data set when compared to the number of establishments that completed the survey and recycle some or all of their food waste. On the scatter plot, there are 350 points. However, there were 980 establishments that completed survey Version 1 and recycle some or all of their food waste. There were 703 responses for number of meals served and 420 responses for amount of food waste recycled. Of these responses, 350 establishments provided both responses.

5.2.2 Relationship between Number of Employees and Amount of Food Waste Recycled

5.2.2.1 Amount of Food Waste Recycled Results

All food establishments that said they recycle their food waste were included in these results. There were 1,471 establishments that said they recycle. Of the 1,471 establishments that recycle, 524 of them provided the amount recycled on the survey. The majority (947 establishments) did not provide the amount they recycle. Descriptive statistics of the 1,471 establishments are presented below in Table 21. The amount of food recycled per day for this group ranged from zero to 1,280 gallons. The median

amount recycled was 16 gallons, the mean was 44 gallons, and the mode was 1 gallon. The standard deviation was 90 gallons.

Table 21. Descriptive Statistics for Number of Employees and Amount of Food Waste Recycled

		Gallons of Food Recycled Per Day	Total Number of Employees
N	Valid	524	1,125
	Missing	947	346
Mean		44	25
Median		16	10
Mode		1	2
Std. Deviation		90	84
Minimum		0	1
Maximum		1,280	2,325

5.2.2.2 Amount of Food Waste Recycled Discussion

The discussion section (including limitations and recommendations) for the amount of food recycled has already been included with the results from Version 1 surveys and can be found in section 5.2.1.2.

5.2.2.3 Number of Employees Results

Both versions of the survey asked for the number of full-time and part-time food service employees. Results reported here reflect the total number (full-time plus part-time employees) of food service employees. As previously mentioned, only the establishments that reported that they recycled (1,471 establishments) were included in the results. Descriptive statistics of the 1,471 establishments are presented in Table 21. The number of food service employees for this group ranged from 1 to 2,325. The median number of food service employees was 10, the mean was 25, and the mode was 2. The standard deviation was 84.

5.2.2.4 Number of Employees Discussion

Not all of the establishments that recycle provided data about their employee numbers on the survey. Possible explanations for this are that the respondents did not want to provide the numbers of employees because they felt (or corporate policies prohibited them from providing the numbers), the information was confidential/proprietary, they did not know the exact number, they unintentionally skipped the question, they answered the question incorrectly, or they did not think the question applied to them and skipped it.

This question may have been unintentionally missed if the survey responder did not turn the mail survey over (the survey was two pages, printed on the front and back of a sheet of paper) to complete the questions on the back of the page. The question may have also been left unanswered if people did not see it and accidentally skipped it.

In a few cases this question was answered incorrectly by the respondent. The question asked for the number of food service employees and there was a line to write the answer on for full-time and part-time employees (Full-Time: _____ Part-Time: _____). However, there were a small number of respondents who wrote on the line "yes" or "no" or made a check (✓) mark on the line(s).

As previously noted, survey respondents were asked to provide the number of full-time and part-time food service employees separately. However, for this data analysis the total number of food service employees was used. The total number of food service employees was used because there were many establishments that did not provide a separate number for full-time and part-time food service employees.

Many respondents did not think this question applied to them because on the mail survey it asked for the number of food service employees. The intent of the wording (food service employees) of the question was to capture only the employees directly involved with preparing, cooking, and serving the food. The surveys were sent to many different types of establishments. Many places had large numbers of employees who did not work in food service. For example, this is the case in correctional facilities, medical facilities, and hotels. These places are required to have food establishment permits, but they have additional employees working as prison guards, doctors, nurses, housekeepers, custodians, etc., that are not related to food service.

There were also some establishment types where survey responders felt they had no food service employees. This was a common response from the retail sector. Often the only food service employees a super market counted were the deli and bakery employees. For some small retail stores, the person completing the survey was the owner who also operated the establishment by themselves and reported that there were zero employees. Another instance in which the survey respondent said that there were no food service employees was when the individuals that worked at the establishment were not on the payroll (e.g., volunteers or family members) or were not hired specifically for a food service position (many teachers at pre-schools are the ones who prepare the food, but they are not food service employees). As a result of the wording for this question, it may be possible that some establishments may have under or over reported their employees.

There were many establishments that did not provide data for number of employees. For some of the surveys, the manager at an individual establishment forwarded the survey to the corporate office. The specific number of employees at each

establishment was not reported by the corporate office because one survey was completed for all of the company's locations in Hawaii.

Limitations of the Number of Employees Data

It is also important to point out that the above mentioned problems occurred only in surveys completed by mail because there was no person who was able to clarify the intent of the question as there was with the phone surveys. For the phone surveys, respondents were asked to provide the number of employees and not the number of food service employees. However, for establishments where there were other employees not related to food service, only the number of food service employees were counted.

The data used in this thesis were provided by the survey respondents and no additional measurement or verification was made to confirm the reported amounts. Also, these data were collected from Fall 2004 through Summer 2005 and the number of employees fluctuates based on seasonal needs (i.e., food establishments catering to the visitor industry or the holiday season—Thanksgiving, Christmas, New Years may frequently adjust their number of employees) and availability of labor.

Recommendations for Future Studies Collecting Data on Number of Employees

Depending on what the intent of the study is going to be, it would be important to clearly define which employees to count (i.e., food service or all employees). It would also be important to define "food service" employees. It may be helpful to create surveys specific to the establishment type to resolve any confusion regarding who should be counted and how to count the number of employees. This recommendation applies to mail surveys only where there is no person who would be able to clarify the intent of the question (which employees to count) as there was with the phone surveys.

5.2.2.5 Scatter Plot and Correlation for Number of Employees and Amount of Food Waste Recycled Results

There were 1,125 establishments reporting the number of food service employees and 524 establishments that provided the amount of food recycled. However, there were only 450 establishments that provided both the number of food service employees and the amount recycled. To determine if there is a relationship between size (measured by number of food service employees) and amount of food recycled (gallons per day) a scatter plot was created and correlations were calculated in SPSS. The R^2 value is 0.040. The scatter plot is included as Figure 5. The equation of the regression line in Figure 5 is:

$$Y = 0.277x + 37.453$$

Figure 5. Scatter Plot of Number of Employees and Amount of Food Waste Recycled

Figure 5 shows a positive relationship between number of employees and gallons of food recycled per day. There are some establishments that have high numbers of

employees, but recycle a relatively low amount of food. There are also establishments that have low numbers of employees, but recycle high amounts of food per day.

Table 22 provides the Pearson Correlation coefficient and the two-tailed significance level for this set of data. The Pearson Correlation coefficient for all establishment types is 0.201, which indicates a weak association between the numbers of employees and the amount of food recycled. The correlation coefficient for all establishment types is significant at the 0.01 level. Table 22 also includes the statistics for each establishment type if calculated separately.

Table 22. Correlations for Number of Employees and Amount of Food Waste Recycled

Establishment Type	Valid N	Pearson Correlation	Sig.	R^2	Equation
Restaurants	211	.720	.000	.518	Y = 1.110x – 1.351
Limited Menu	10	.947	.000	.898	Y = 1.995x -5.384
Schools/Daycare/ Nutrition Programs	95	.086	.408	.007	Y = .757x + 43.095
Correctional Facilities	4	.430	.570	.185	Y = .665x + 85.617
Medical Facilities	17	.747	.001	.557	Y = 1.359x – 3.767
Hotel/Banquet/ Convention Kitchen	20	.145	.541	.021	Y = .051x + 86.171
Catering/ Commissary Kitchen	12	.986	.000	.972	Y = .451x + 1.432
Retail	49	.099	.498	.010	Y = .796x + 68.881
Manufacturers/ Processors/Canning	26	.547	.004	.299	Y = 2.006x + 26.700
Beverages/Ice	1	-	-	-	-
Food Warehouse/ Wholesaling/ Brokerages	4	-.450	.550	.202	Y = -4.184x + 282.921
Pharmacies/Drug Wholesalers	0	-	-	-	-
Cosmetics	0	-	-	-	-
Plastic Bottles (manufacturer)	0	-	-	-	-
Salvage/Food Banks	1	-	-	-	-
All Establishments	**450**	**.201**	**.000**	**.040**	**Y = .277x + 37.453**

5.2.2.6 Scatter Plot and Correlation for Number of Employees and Amount of Food Waste Recycled Discussion

In general, the amount recycled ranges from 0 to 500 gallons, but there were two establishments (labeled #1 and 2 in Figure 5) that recycle over 500 gallons per day. These establishments do not follow the generally expected pattern of the higher the number of employees, the more food is recycled. These establishments have less than 50 employees, but recycle much more than the establishments that have the same number or more employees. Brief descriptions of the establishments labeled #1and 2 are as follows:

#1: This is a retail establishment located on Oahu. They have 42 employees and recycle 1,280 gallons of food waste per day.

#2: This is a retail establishment located on Oahu. They have 10 employees and recycle 960 gallons of food waste per day.

Both of these are retail establishments. It is possible that the survey respondent did not report all of their employees on the survey because they felt they were not included in food service. The amount of food recycled per day is very high and for this amount to be proportional to the number of employees there would need to be approximately an additional 600 to 1,000 employees. It is possible that that both reported figures are accurate and these establishments have a lot of food waste to recycle.

Figure 5 also shows establishments that have high numbers of employees, but recycle a small amount of food waste. These establishments are labeled #3-5 and a brief description of each is listed below:

#3: This is a hotel located on Oahu. They have 500 employees and recycle 20 gallons of food waste per day.
#4: This is a hotel located on Maui. They have 600 employees and recycle 27 gallons of food waste per day.
#5: This is a hotel located on Maui. They have 1,000 employees and recycle 210 gallons of food waste per day.

All three of these establishments are hotels. These establishments may have provided the number for all the hotel employees and not just the food serve employees and/or may have under reported the amount of food waste recycled. These establishments reported that they recycle all of their food waste (as opposed to throw some away and recycle), but it is possible that there is food waste thrown away.

Table 22 provides the Pearson Correlation coefficient and the two-tailed significance level for this set of data. The Pearson Correlation coefficient for all establishments is 0.201, which indicates a weak association between the numbers of employees and the amount of food recycled. However, the correlation coefficient is

significant at the 0.01 level. This means that the null hypothesis can be rejected and the alternative hypothesis is accepted. Therefore, there is a relationship between the number of employees and the amount of food recycled. In general, it can be predicted that the higher number of employees an establishment has, the greater the amount of food waste will be recycled.

Limitations of the Scatter Plot and Correlation for Number of Employees and Amount of Food Waste Recycled

As previously mentioned, the data used in this thesis were provided by the survey respondents and no additional measurement or verification was made to confirm the reported amounts. Therefore, these establishments may have reported the number of employees or food recycled incorrectly.

The main limitation of the results is the relatively small useable data set when compared to the number of establishments that completed the survey and recycle some or all of their food waste. On the scatter plot, there are 450 points. However, there were 1,125 establishments that completed the survey and recycle some or all of their food waste. There were 1,125 responses for number of employees and 524 responses for amount of food waste recycled. Of these responses, only 450 establishments provided both responses.

5.3 Relationship between the Type of Food Establishment and Food Waste Recycling Practices

There are 4,854 food establishments included in this study and in order to better understand their food recycling practices, they were grouped according to establishment type. As previously explained, the Department of Health (DOH) classifies food establishments into one of 90 categories, but for the purpose of this thesis the DOH's categories were consolidating into 16 food establishment types. One of the research objectives for this thesis is to determine if there is a relationship between the type of food establishment and their food recycling practices, which can be addressed in two ways: first by looking at food recycling behavior/practices (i.e., does a food establishment recycle food waste or not) and second by looking at the amount of food recycled (gallons per day).

5.3.1 Relationship between Food Waste Recycling Practices and Type of Food Establishment

The null and alternative hypothesis to determine if there is a relationship between the type of food establishment and their food recycling practices is as follows:

> Null Hypothesis: There is no relationship between the type of an establishment and their food waste recycling practices.
>
> Alternative Hypothesis: There is a relationship between the type of establishment and their food waste recycling practices.

Food recycling behavior/practices refers to whether or not a food establishment recycles some or all of their food waste. There were 1,073 establishments that reported they recycle all of their food waste and 398 establishments that reported they throw away some of their food waste and recycle some of their food waste. In sum, there were 1,471

establishments that recycle food waste. To test the hypothesis, the independent variable is the type of establishment and the dependent variable is recycling practice (does not recycle or does recycle). The statistical test used to test the hypothesis was the chi square test, which was conducted in SPSS.

5.3.1.1 Food Waste Recycling Practices and Type of Food Establishment Results

The breakdown of recycling practices by establishment type is included in Table 23 and Figure 6.

Table 23. Food Waste Recycling Practices

Establishment Type	# Recycles	% Recycles	# Does Not Recycle	% Does Not Recycle
Restaurants	567	33%	1,159	67%
Liquor Dispensers	3	3%	115	97%
Limited Menu	92	30%	210	70%
Schools/Daycare/Nutrition Programs	174	26%	498	74%
Correctional Facilities	6	100%	0	0%
Medical Facilities	34	51%	33	49%
Hotel/Banquet/Convention Kitchen	35	81%	8	19%
Catering/Commissary Kitchen	69	35%	127	65%
Retail	254	25%	757	75%
Manufacturers/Processors/ Canning	171	38%	276	62%
Beverages/Ice	13	21%	49	79%
Food Warehouse/Wholesaling/ Brokerages	50	29%	125	71%
Pharmacies/Drug Wholesalers	0	0%	13	100%
Cosmetics	0	0%	8	100%
Plastic Bottles (manufacturer)	0	0%	4	100%
Salvage/Food Banks	3	75%	1	25%

Figure 6. Food Waste Recycling Practices

Overall, there were more establishments that did not recycle their food waste (3,383 establishments or approximately 70%) compared to those establishments that did recycle their food waste (1,471 establishments or approximately 30%). There were three food establishment types that did not recycle food waste at all, they were: Pharmacies/Drug Wholesalers; Cosmetics; and Plastic Bottles (manufacturer). There was one establishment type, Correctional Facilities, where all survey respondents indicated they recycled their food waste.

The chi square test performed in SPSS resulted in a chi square value of 180.665 with 15 degrees of freedom and a p-value of 0.000. This p-value indicates that the results are statistically significant and thus the null hypothesis is rejected and the alternative hypothesis is accepted, i.e. there is a relationship between the type of establishment and their food recycling practices.

5.3.1.2 Food Waste Recycling Practices and Type of Food Establishment Discussion

Determining if there is a relationship between the type of establishment and their food recycling practices is helpful in knowing which type of establishments to target for food recycling programs and to increase food recycling rates. However, these results do not report what type(s) of recycling an establishment practices (see Table 17 Methods of Recycling by Establishment Type) nor does it explain why food establishment do not recycle their food waste.

As previously mentioned, the EPA's food recovery and waste reduction hierarchy is as follows:

- Recover food to feed hungry people
- Provide food to livestock, zoo animals, or animal shelters
- Recycle food for industrial purposes

- Compost food to improve soil fertility
- Dispose of the materials

These results do not look at what method is used to recycle food because it may not always be feasible to do the first (most preferred) method as it is not appropriate for all types of food waste. For example, recycling food for industrial purposes (rendering) is listed third in the hierarchy, but for some types of food waste like meat trimmings, fat, and bone this is the only feasible way to dispose of it other than throwing it away. Another example is post-consumer food waste (food scraps/plate waste), which is more appropriate for feeding animals or composting rather than feeding people.

Of the 3,383 establishments that did not recycle their food waste, 1,206 of them reported not having any food waste. These establishments were included in the results as "does not recycle", which may be misleading because they reported not having food to recycle. In order to fully understand a food establishment's recycling behavior it is also useful to look at the reason(s) why they do not recycle, which will be included in section 5.4. Ideally, the best situation for a food establishment would be to have no food waste to dispose. If that is not possible, encouraging food establishments to recycle using any method may be a better strategy than trying to follow the EPA's hierarchy since not all options are feasible and may not be available to the food establishments.

Limitations of Food Waste Recycling Practices and Type of Food Establishment Data

These results do not indicate how much food waste is recycled or if there is a relationship between food establishment type and amount recycled (gallons per day), which will be covered next.

Recommendations for Future Studies on Food Waste Recycling Practices

In addition to knowing if the food establishment recycles their food waste or not, the percentage of food waste recycled could also be measured. For those food establishments that reported recycling their food waste, some establishments reported recycling all their food waste or a combination of throwing away and recycling food waste. For those food establishments that do not recycle all of their food waste, it would be useful to know how much of the food waste is thrown away and how much is recycled.

5.3.2 Relationship between Food Waste Recycling Amount and Type of Food Establishment

The previous section focused on a relationship between food recycling practices and establishment type, with food recycling practices defined as "yes" meaning the establishment recycles and "no" meaning the establishment does not recycle food waste. This section looks at a possible relationship between the amount of food recycled (in gallons per day) and establishment type.

The null and alternative hypothesis to determine if there is a relationship between type of food establishment and the amount of food waste recycled is as follows:

> Null Hypothesis: There is no relationship between the establishment type and the amount of food waste recycled.
>
> Alternative Hypothesis: There is a relationship between the establishment type and the amount of food waste recycled.

To test the hypothesis, the independent variable is the type of establishment and the dependent variable is the amount of food recycled (measured in gallons per day). The

statistical test used to test the hypothesis was the one way analysis of variance, which was conducted in SPSS.

5.3.2.1 Amount of Food Waste Recycled by Establishment Type Results

Before presenting the one way analysis of variance results, descriptive statistics for amount of food waste recycled by establishment type are included in Table 24. This table provides the breakdown of the minimum value, maximum value, median, mean, and standard deviation for amount recycled (all units are gallons per day, except number of establishments).

Table 24. Descriptive Statistics for Amount of Food Waste Recycled by Establishment Type

Establishment Type	Number of Establishments		Gallons Per Day				
	Valid N	Missing N	Min. Value	Max. Value	Median	Mean	SD
Restaurants	249	318	0	471	11.0	28.4	50.5
Liquor Dispensers	0	3	-	-	-	-	-
Limited Menu	10	82	0	330	2.5	44.7	102.9
Schools/Daycare/ Nutrition Programs	105	69	0	309	38.0	46.6	44.9
Correctional Facilities	4	2	59	124	103.0	97.3	27.4
Medical Facilities	18	16	3	171	19.5	29.1	38.5
Hotel/Banquet/ Convention Kitchen	21	14	7	360	75.0	93.3	85.7
Catering/Commissary Kitchen	13	56	1	90	5.0	13.7	25.0
Retail	65	189	0	1,280	13.0	83.9	202.3
Manufacturers/ Processors/Canning	30	141	0	292	8.0	52.6	80.8
Beverages/Ice	2	11	19	275	147.0	147.0	181.0
Food Warehouse/ Wholesaling/ Brokerages	6	44	0	206	44.0	68.8	82.1
Pharmacies/Drug Wholesalers	0	0	-	-	-	-	-
Cosmetics	0	0	-	-	-	-	-
Plastic Bottles (manufacturer)	0	0	-	-	-	-	-
Salvage/Food Banks	1	2	38	38	38.0	38.0	0.0

In the above table, there are four establishment types that do not have any data. In the category of Liquor Dispensers, there were three establishments that reported they recycle their food waste, but no amounts were provided. In the categories: Pharmacies/Drug Wholesalers, Cosmetics, and Plastic Bottles none of the survey respondents reported recycling food waste and therefore, there is no data for these

establishment types. Overall there were 1,471 establishments that reported recycling, but only 524 establishments (~36%) provided the amount of food waste they recycle.

Using the data available, the one way analysis of variance test was performed in SPSS and the results are presented in Table 25.

Table 25. One Way Analysis of Variance for Food Waste Data

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	280951.416	11	25541.038	3.163	.000
Within Groups	3957206.552	490	8075.932		
Total	4238157.968	501			

The one way analysis of variance F-test statistic was 3.163 and the significance level was 0.000, which means that the null hypothesis can be rejected and the alternative hypothesis is accepted, i.e, there is a relationship between the type of establishment and the amount they recycle.

5.3.2.2 Amount of Food Waste Recycled by Establishment Type Discussion

Determining if there is a relationship between the type of establishment and the amount of food waste they recycle can help to predict the amounts of food waste that are recycled in Hawaii. There were many establishments that did not provide data on the amount of food they recycle and in order to calculate the average amount of food waste recycled in Hawaii on a daily basis, this number had to be extrapolated from the existing data. For each establishment type, the mean amount of food waste recycled on a daily basis was multiplied by the number of establishments that reported recycling food waste to come up with a figure for the total estimate amount recycled in Hawaii (i.e., 69,878 gallons of food is recycled per day). Table 26 presents the total estimated amount of food waste recycled per day, calculated by establishment type. As shown in Table 26, no data

were available for Liquor Dispensers, and therefore the food waste recycled by this establishment type is not included in the total.

Table 26. Estimated Amounts of Food Waste Recycled Per Day

Establishment Type	Valid N	Missing N	Total N	Mean	Total Gallons Recycled Per Day
Restaurants	249	318	567	28.4	16,103
Liquor Dispensers	0	3	3		0
Limited Menu	10	82	92	44.7	4,112
Schools/Daycare/ Nutrition Programs	105	69	174	46.6	8,108
Correctional Facilities	4	2	6	97.3	584
Medical Facilities	18	16	34	29.1	989
Hotel/Banquet/ Convention Kitchen	21	14	35	93.3	3,266
Catering/Commissary Kitchen	13	56	69	13.7	945
Retail	65	189	254	83.9	21,311
Manufacturers/ Processors/Canning	30	141	171	52.6	8,995
Beverages/Ice	2	11	13	147.0	1,911
Food Warehouse/ Wholesaling/ Brokerages	6	44	50	68.8	3,440
Pharmacies/Drug Wholesalers	0	0	0		0
Cosmetics	0	0	0		0
Plastic Bottles (manufacturer)	0	0	0		0
Salvage/Food Banks	1	2	3	38.0	114
Estimate of Total Gallons Recycled by All Establishments					**69,878**

Additional discussion (including limitations and recommendations) for the amount of food recycled has already been included with the previous objective and can be found in section 5.2.1.2.

5.4 Food Waste Generation Amount

In the previous section, the estimated amount of food waste recycled by all establishments in the survey was presented (see Table 26). This section presents an estimate of the amount of food waste generated by all food establishments in Hawaii. In order to calculate this amount, the following assumptions were made:

- The non-responders follow the same trend as the responders for disposal of food waste methods. The numbers of establishments disposing of their food waste by each method was calculated using the percentages in Table 15.
- The average amount of food waste recycled equals the amount of food waste generated at each establishment (see Table 24 for averages).
- The average amount of food waste recycled for those establishments that provided this data is the same for those establishments that did not provide this data.
- The conversion from gallons of food waste to pounds is 1 gallon = 7.4909 pounds. This estimate comes from an EPA report[54].

To calculate the amount of food waste generated by all food establishments, the number of food waste generators was multiplied by the average amount of food waste recycled. Table 27 presents the estimated amount of food waste generated by establishment type. It is estimated that 371,003 tons of food waste is generated annually by food establishments in Hawaii.

[54] United States Environmental Protection Agency. (1997). *Measuring Recycling A Guide for State and Local Governments* (No. EPA-530-R-97-011). Washington DC. Retrieved September 10, 2005, from http://www.epa.gov/recycle.measure/docs/guide.pdf

Table 27. Estimated Amount of Food Waste Generated in Hawaii Annually

Establishment Type	Number of Food Waste Generators	Average Amount Recycled (Gallons Per Day)	Pounds of Food Waste Generate Per Year
Restaurants	2,942	28	228,475,090
Liquor Dispensers	109		
Limited Menu	327	45	39,980,641
Schools/Daycare/Nutrition Programs	552	47	70,385,753
Correctional Facilities	10	97	2,660,359
Medical Facilities	79	29	6,284,423
Hotel/Banquet/Convention Kitchen	61	93	15,448,331
Catering/Commissary Kitchen	325	14	12,177,767
Retail	1,102	84	252,697,280
Manufacturers/Processors/Canning	594	53	85,483,210
Beverages/Ice	19	147	7,779,188
Food Warehouse/Wholesaling/Brokerages	106	69	20,009,711
Pharmacies/Drug Wholesalers	0		
Cosmetics	0		
Plastic Bottles (manufacturer)	0		
Salvage/Food Banks	6	38	623,393
Estimated Pounds of Food Waste Generated Annually			742,005,145
Estimated Tons of Food Waste Generated Annually			**371,003**

The estimate of 371,003 tons of food waste generated annually by all food establishments in Hawaii is higher than previously reported amounts. There were two previous studies that estimated the amount of food waste generated in Hawaii. In the 1998 study that amount was 147,802 tons and in the 2002 study it was 179,303 tons (see section 2.1.2). These estimates were for the entire state (households and businesses) and not just commercial food establishments.

A possible reason for the high estimate in Table 27 is that the average amount recycled should only be applied to those establishments that recycled by recycling

company or pig farm. As previously mentioned, there were many establishments that did not know how much food waste was recycled, especially for those establishments that recycle by donations, composting, give to other, and give to other animals. For those establishments who recycle using these methods, the average amount of food waste generated is probably much smaller than the amounts generated by establishments that use recycling companies and pig farmers.

A recommendation for future studies on food waste disposal would be to ask respondents for the amount of food waste recycled for each method. Another suggestion is to do a food waste audit of the establishment, which would measure (weigh) all food waste generated and how much food waste is recycled (by each method).

5.5 Reasons Food Establishments Do Not Recycle Food Waste

The majority of the food establishments that completed the survey did not recycle all of their food waste. There were 2,177 establishments that reported throwing away all of their food waste and 398 establishments that reported throwing away and recycling their food waste. This is a total of 2,575 establishments (53% of the sample) that do not recycle all of their food waste.

On the survey, respondents that did not recycle all of their food waste were asked to identify the reason(s) they do not recycle. The mail survey provided the following choices:

- Separating food waste from other trash is too time consuming/costly
- Contracting a separate food recycling company is too time consuming/costly
- Recycling food waste causes certain problems (respondents were asked to specify)
- Other reasons (respondents were asked to specify)

The respondents of the mail survey specified many additional reasons why they do not recycle all of their food waste. After going through all the responses and categorizing them, the following categories were created:

- Separating food waste from other trash is too time consuming/costly
- Contracting a separate food recycling company is too time consuming/costly
- Storage, transportation, and logistical problems (pick-up problems)
- Health and sanitation problems
- Liability issues
- No food waste/small amount generated
- Did not know you could recycle food waste
- No opportunity to recycle
- Not allowed to recycle food waste

These categorizes were used for the phone surveys and the mail survey responses were re-coded into one of the above answers.

5.5.1 Reasons Food Establishments Do Not Recycle Food Waste Results

The frequencies for each response are included in Table 28 and Figure 7. The establishments were asked to specify all reasons why they do not recycle so the counts include establishments reporting multiple reasons.

Table 28. Reasons for Not Recycling

	No food waste/small amount generated	Separating food waste from other trash is too time consuming/costly	No opportunity to recycle	Contracting a separate food recycling company is too time consuming/costly	Not allowed to recycle food waste	No answer	Health and sanitation problems	Storage, transportation, and logistical problems (pick-up problems)	Did not know you could recycle food waste	Liability issues	Other	Causes problems
Restaurants	517	177	169	120	155	97	127	60	38	33	9	6
Liquor Dispensers	34	5	2	6	0	2	3	1	2	0	0	0
Limited Menu	101	10	5	5	5	10	29	4	5	1	1	0
Schools/Daycare/ Nutrition Programs	137	67	78	48	11	39	28	35	30	3	2	6
Medical Facilities	11	1	5	1	3	5	6	3	3	0	0	0
Hotel/Banquet/ Convention Kitchen	3	2	2	2	0	1	2	1	2	1	0	0
Catering/Commissary Kitchen	46	16	9	6	5	10	6	9	0	0	1	0
Retail	255	83	38	69	69	51	25	8	9	1	2	0
Manufacturers/ Processors/Canning	122	14	15	11	1	21	10	3	3	11	1	1
Beverages/Ice	2	1	1	1	0	1	0	0	0	1	0	0
Food Warehouse/ Wholesaling/ Brokerages	20	4	2	2	2	12	4	0	2	1	1	0
Salvage/Food Banks	0	1	1	1	0	0	0	1	0	0	0	0
Total	**1,248**	**381**	**327**	**272**	**251**	**249**	**240**	**125**	**94**	**52**	**17**	**13**

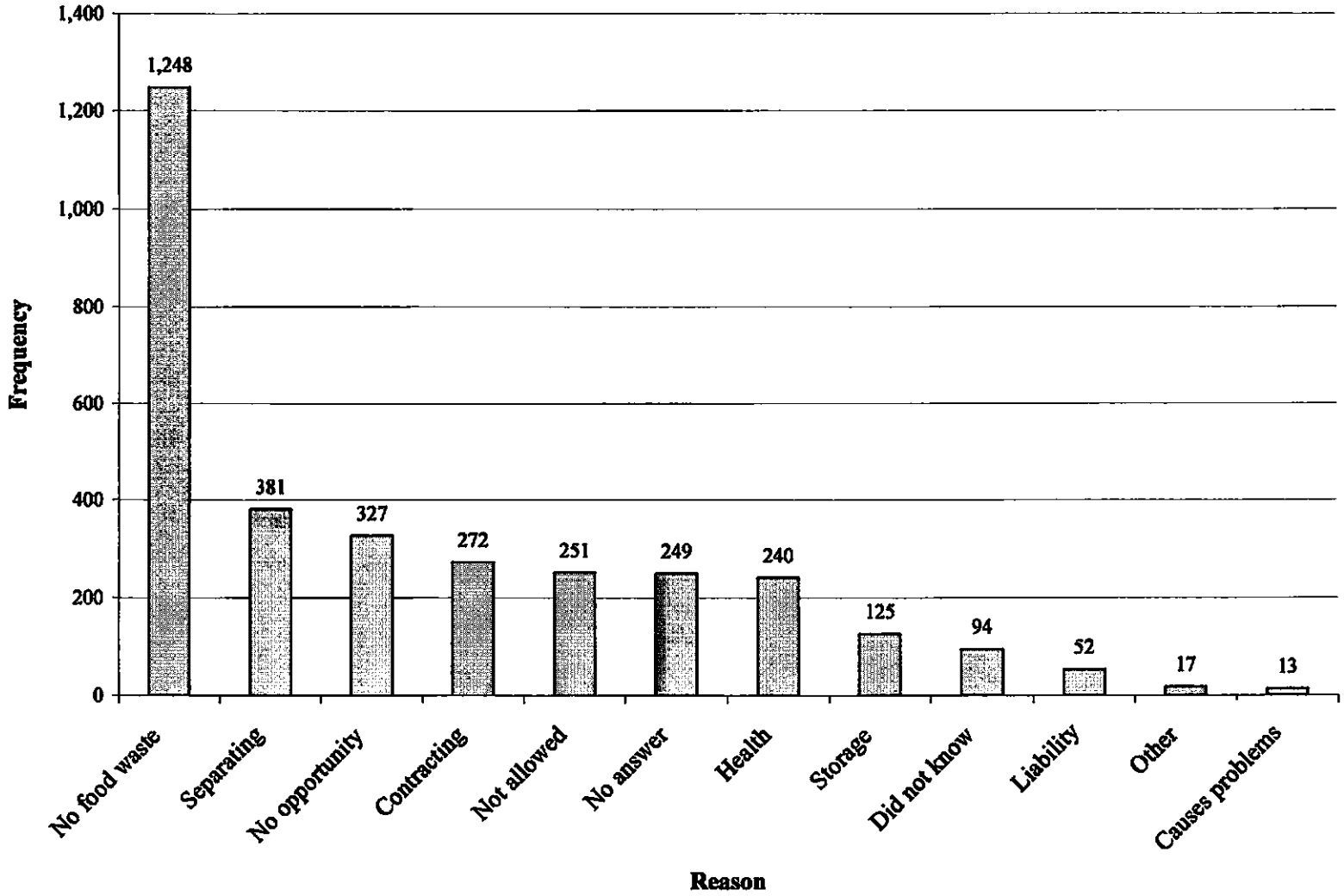

Figure 7. Reasons Why Food Establishments Do Not Recycle Food Waste

The most common reason for not recycling was that the establishment did not generate food waste or there was only a small amount generated (1,248 establishments). The second most common response was that separating food waste from other trash is too time consuming and/or costly (381 establishments). The third most common response was that there was no opportunity to recycle (327 establishments).

5.5.2 Reasons Food Establishments Do Not Recycle Food Waste Discussion

Listed in Table 28 there are 12 reasons for not recycling, including "causes problems" and "other". Frequencies for these latter two responses, 13 establishments and 17 establishments, respectively, represent the respondents that did not specify their reason(s) and put a check (✓) on the line. There were also 249 establishments that did not answer the question. It is possible that the establishments that did not answer the question completely may have had additional reasons why they do not recycle that are not included in these results.

These results include only those establishments that reported throwing away some or all of their food waste and do not include those that reported recycling all of their food waste or not having any food waste to dispose. Responses to this question from establishments that recycle were in the form of complaints about their current food waste recycler (e.g., "farmer does not pick-up every day and it attracts flies"). Establishments that said they had no food waste to dispose were not asked to respond to this question, however, their responses would be expected to add to the 1,248 establishments that reported not recycling because they had no food waste or only generated a small amount.

Recommendations to Increase Food Waste Recycling

The data gathered from this question are helpful in understanding why establishments do not recycle all of their food waste and can be used to increase food recycling and improve current recycling programs.

The most commonly reported (1,248 establishments) reason establishments do not recycle was that they generated a small amount of food waste or none at all. For the most part, these establishments only considered the post-consumer food waste and not the food waste that is generated in the food preparation stage. Common responses that were grouped into this category included: "there's not enough food waste to make it worth the effort/efficient" and "food is consumed away from the establishment". For establishments that generate only a small amount of food waste, a pig farmer or recycling service would not be practical, but other methods of recycling such as composting could be a possibility. For food establishments whose customers consume the food away from the establishment (i.e., take-out food) survey respondents assumed that the food is all consumed (eaten).

The second most common response (381 establishments) was that separating food waste from other trash is too time consuming and/or costly. For establishments that have food recycling programs in place, separating food waste does not take them much longer than throwing everything away if the right set up is in place. Having a food waste only container next to the trash container makes separating the two waste streams more efficient. It is also important to properly train staff in what foods can and cannot be recycled (it may vary based on farmer preference and type of food recycling use). It is possible that costs could be decreased by recycling food waste, if food waste takes up the

majority of space in the trash containers, removing it could save disposal costs since these costs are often calculated by volume or frequency of collection.

There were 327 establishments that reported "no opportunity to recycle" as a reason for not recycling their food waste. These responses came from establishments that know about food waste recycling programs and would like to recycle their food waste, but do not know of a pig farmer that would collect it. Pig farmers generally collect food waste from the large generators (hotels, resorts, supermarkets, banquet facilities) because it is more efficient for them to go to a few large generators rather than many small generators. The location of the food establishment can also be a reason farmers do not want to collect the food waste. It is easier for farmers to go to one location (i.e., Waikiki) with a large concentration of food waste generators rather than driving to multiple, dispersed food waste generator locations. Establishments that want to recycle but cannot find a pig farmer to collect the food waste could consider alternative food waste recycling options such as composting. Survey respondents who reported composting food waste did the composting themselves at home (took home the food waste to compost). There may also be opportunities for food establishments to take food waste to a green waste composting facility, however, they would need to haul it there themselves or pay a hauling company to transport it and a tipping fee would need to be paid.

Contracting a separate food recycling company is too time consuming and/or costly was the reason 272 establishments reported not recycling. Intermediate food recyclers (companies that collect food waste and deliver it to pig farmers) charge the food waste generator (the food establishment) for the collection service and because this information is viewed as proprietary, the costs of this service are unknown. Depending

on the island, the pig farmers who collect the food waste charge the food establishment, pay the food establishment, or pick up for free.

There were 251 establishments that reported as a reason for not recycling food waste was that they were "not allowed to recycle food waste". Establishments mentioned that their corporate policies required that food waste be thrown away rather than recycled, one respondent cited the reason for this was to "maintain the integrity of our proprietary foods and brand". For companies worried about protecting their brand name(s) should consider food recycling such as pig farmers or composting, which are methods of recycling where the food is not re-served to people. Many establishments view throwing away food waste the only option for disposal, rather than thinking about how it can be diverted from the landfill and recycled, for example, food waste can be composted and turned into soil amendment.

Health and sanitation problems were the reason that 240 establishments reported not recycling food waste. Food establishments were most concerned about attracting flies, bugs, and rodents and the odor food waste would create. One way to reduce this health hazard would be to have containers for food waste that can be sealed or covered while waiting for collection. Some larger establishments with adequate storage space hold the food waste in a refrigerator until the farmer or collection company comes to pick it up. This eliminates the problems associated with food waste sitting outside for collection.

Storage, transportation, and logistical problems were the reasons 125 establishments reported not recycling their food waste. The most common response under this category was "would recycle if slop bucket was provided and picked up daily".

Food establishments are concerned that if food waste is not picked up daily it will cause health and sanitation problems as previously mentioned. Many establishments reported that the person picking up food waste in the past was unreliable and would not stick to a pick up schedule, which caused the food waste to smell and attract flies. Another concern was that containers used to collect the food waste, were not cleaned between pick-ups causing health and sanitation problems. One way to avoid the problems with storage and pick-ups is to use an intermediate company that provides covered food waste containers to keep out pests, that makes collections on a regular schedule, and whose primary business activity is food waste recycling. This service may be more costly than other recycling options and may not be available in all locations.

There were 94 establishments that cited, "did not know you could recycle food waste," as their reason for not recycling. An educational campaign to inform food establishments about the benefits, methods, and costs of food recycling could target these establishments. In the State of Hawaii, the Counties have recycling offices that could produce informational packets and serve as a resource for establishments looking to start up a food recycling program. For example, the City and County of Honolulu has a flier on food waste recycling that is sent to approximately 247 food establishments that fall under the food recycling ordinance (see section 2.3.3 for more information). This food recycling information could be more widely distributed, not only to those establishments that are required to recycle.

The City and County of Honolulu has a program called Partnership for the Environment that consists of peer consultants and certified businesses[55]. The Partnership for the Environment is a program that helps businesses set up recycling programs and reduce waste. Peer consultants work at certified businesses on Oahu and have knowledge in food waste recycling and recycling other materials (cardboard, aluminum, glass, etc.). A similar program could be implemented on the neighbor islands to help food establishments start their own food recycling programs.

There were 52 establishments that reported not recycling their food waste because of liability concerns. However, there is the Federal Bill Emerson Good Samaritan Food Donation Act that protects from legal liability businesses that donate food waste in good faith. Many food establishments may be unaware of this Federal law that releases them from any liability concerns and could be more inclined to donate food waste if they knew about this law.

[55] City & County of Honolulu's Department of Environmental Services. (2005). *Partnership for the Environment.* Retrieved August 29, 2006, from http://envhonolulu.org/solid_waste/Partnership_for_the_Environment.html

6.0 COOKING OIL RESULTS AND ANALYSIS

6.1 Cooking Oil Disposal and Recycling

One of the main objectives of this study was to determine how food establishments dispose of and recycle their cooking oil. As previously mentioned, there are two types of cooking oil that is collected for recycling: yellow grease (used cooking oil) and trap grease (from grease traps). On the survey food establishments were asked, "if your establishment uses cooking oil, how do you dispose of it?". The answer choices provided on the survey were: throw it away in the trash, pour it down the drain, recycle it, and other. Responses that were reported for other were either a form of recycling or that the establishment does not use cooking oil.

6.1.1 Cooking Oil Disposal Results

Table 29 presents the responses including the number of food establishments and percentage for each disposal method. Figure 8 displays the result in the form of a pie chart.

Table 29. Summary of Survey Results for Methods of Cooking Oil Disposal

Disposal Method	Number of Food Establishments	Percentage
Do Not Use	3,020	62.2%
Throw It Away	418	8.6%
Pour Down Drain	24	0.5%
Recycle It	1,392	28.7%
Total	**4,854**	**100%**

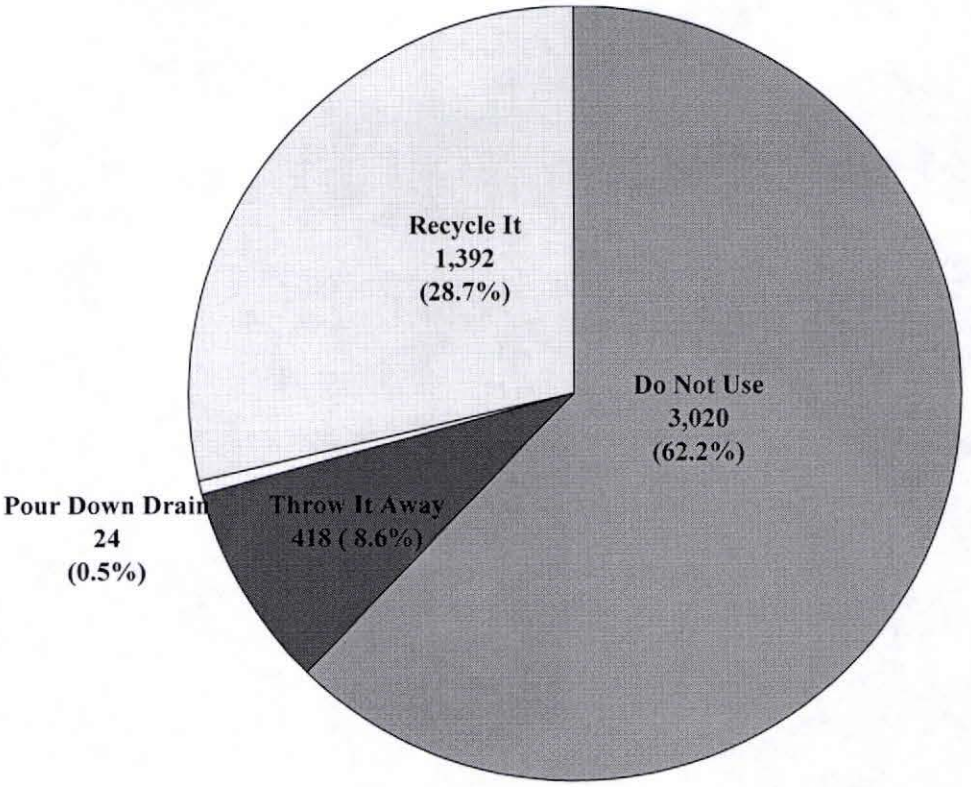

Figure 8. Summary of Survey Results for Methods of Cooking Oil Disposal

The majority (3,020 or 62%) of the food establishments in Hawaii does not use cooking oil and therefore, does not have to dispose of it. Table 30 has the breakdown for only those establishments that use cooking oil (1,834 establishments). Of those food establishments that use cooking oil, the majority (1,392 or 76%) of them recycles it, 418 establishments (23%) throw it away, and 24 establishments (1%) pour it down the drain.

Table 30. Disposal Method for Establishments that use Cooking Oil

Disposal Method	Number of Food Establishments	Percentage
Recycle It	1,392	75.9%
Throw It Away	418	22.8%
Pour Down Drain	24	1.3%
Total	**1,834**	**100%**

Table 31 gives the breakdown of responses (in percentages) for each disposal method by establishment type. There were five establishment types where no cooking oil

is used—beverage/ice, pharmacies/drug wholesalers, cosmetics, plastic bottles (manufacturer), and salvage/food banks.

Table 31. Breakdown of Disposal of Cooking Oil by Establishment Type

Establishment Type	Do Not Use	Throw It Away	Pour Down Drain	Recycle It
Restaurants	28%	11%	1%	61%
Liquor Dispensers	69%	12%	0%	19%
Limited Menu	92%	4%	0%	4%
Schools/Daycare/Nutrition Programs	78%	14%	0%	8%
Correctional Facilities	50%	33%	0%	17%
Medical Facilities	25%	28%	4%	42%
Hotel/Banquet/Convention Kitchen	7%	5%	0%	88%
Catering/Commissary Kitchen	71%	13%	0%	16%
Retail	85%	4%	0%	10%
Manufacturers/Processors/Canning	83%	6%	1%	10%
Beverages/Ice	100%	0%	0%	0%
Food Warehouse/Wholesaling/Brokerages	98%	0%	0%	2%
Pharmacies/Drug Wholesalers	98%	0%	0%	0%
Cosmetics	100%	0%	0%	0%
Plastic Bottles (manufacturer)	100%	0%	0%	0%
Salvage/Food Banks	100%	0%	0%	0%

6.1.2 Cooking Oil Disposal Discussion

The data collected for cooking oil disposal method do not provide details on the type of recycling used. As mentioned previously, both yellow grease (oil from fryers) and trap grease can be recycled. On the survey, respondents were only asked if they recycle cooking oil and not specifically asked which type(s) of oil they recycle. It is not uncommon for food establishments to recycle both the yellow and trap grease. The yellow and trap grease may or may not be collected by the same company that transports

it for recycling and/or rendering. It is also not known which method (biodiesel production or rendering) is used to recycle the cooking oil.

There were 24 establishments that reported pouring the cooking oil down the drain, which could negatively impact the wastewater system if they do not have a grease trap. A grease trap is required for most commercial food establishments in Hawaii. If these establishments have a grease trap, it is likely that the trap waste pumped out of it is recycled.

The majority of the food establishments reported not using cooking oil. Based on the wording of the question, "if your establishment uses cooking oil, how do you dispose of it?", it was assumed that all respondents that did not answer the question did not use cooking oil. The validity of this assumption remains untested.

Limitations of the Cooking Oil Disposal Data

The answers used in this thesis were provided by the survey respondents and no verification was made to confirm the reported disposal method. Also, the surveys were completed between Fall 2004 through Summer 2005 and the disposal method used for cooking oil may have since changed.

Recommendations for Future Studies on Cooking Oil Disposal

On the survey it would have been beneficial to ask respondents what type of grease (yellow and/or trap) is collected at their establishment and what does the grease hauler do with it after it is collected (e.g., haul it to Pacific Biodiesel to turn into biodiesel or haul it to Island Commodities for rendering). Another improvement to the survey would be to include a box for respondents to check (☑) if they do not use cooking oil,

this way it would be clear if the respondent does not use cooking oil or does use cooking oil, but did not answer the question.

Unlike the food waste section of the survey, respondents that did not recycle all of their cooking oil were not asked why they do not recycle it. There were 418 establishments that reported throwing away the cooking oil in the trash and 24 establishments that reported pouring the used cooking oil down the drain. Both of these disposal options can have negative effects on landfills or wastewater system. It would be useful to understand why these establishments do not use a more environmentally responsible method to dispose of their used cooking oil.

6.2 Relationship between the Size of an Establishment and the Amount of Cooking Oil Recycled

In this study, the size of a food establishment can be characterized in two ways—by the number of meals they serve per day and by the number of employees they have. One of the research objectives is to determine if there is a relationship between the size of a food establishment and the amount of cooking oil recycled. In general, the assumption is that if the number of meals a food establishment serves increases or the number of employees at the establishment increases, so does the amount of cooking oil it recycles. Therefore, the null hypothesis and alternative hypothesis are as follows:

> Null Hypothesis: There is no relationship between the size of an establishment and the amount of cooking oil it recycles.
>
> Alternative Hypothesis: There is a relationship between the size of an establishment and the amount it recycles—the larger the food establishment, the more cooking oil it recycles.

In order to test the hypothesis that size of an establishment is related to the amount of cooking oil recycled, scatter plots were made and correlation coefficients were

calculated. The hypothesis was tested in two ways: first using the number of meals as the independent variable and the amount recycled as the dependent variable and second by using the number of employees as the independent variable and the amount recycled as the dependent variable. The results and discussion sections for the number of meals and the amount recycled is presented first, followed by the number of employees section. For the number of meals data, only those establishments that completed survey Version 1 were included in the analysis.

6.2.1 Relationship between Number of Meals Served and Amount of Cooking Oil Recycled

6.2.1.1 Amount of Cooking Oil Recycled Results

Only food establishments that said they recycle cooking oil and completed survey Version 1 (establishments that serve meals) were included in these results. There were 3,130 establishments that completed Version 1 and of those, 1,238 establishments that said they recycle. Of the 1,238 establishments that recycle, 800 of them provided the amount recycled on the survey. There were 438 establishments that did not provide the amount they recycle. Descriptive statistics of the 800 establishments are presented in Table 32. The amount of cooking oil recycled per day for this group ranged from 0 to 183 gallons. The median amount recycled was 2 gallons, the mean was 4 gallons, and the mode was 2 gallons. The standard deviation was 9 gallons.

Table 32. Descriptive Statistics for Number of Meals and Amount of Cooking Oil Recycled

		Number of Meals Served Per Day	Gallons of Oil Recycled Per Day
N	Valid	875	800
	Missing	363	438
Mean		343	4
Median		188	2
Mode		100	2
Std. Deviation		480	9
Minimum		5	0
Maximum		5,225	183

It is important to point out that the descriptive statistics presented in Table 32 apply only to the 1,238 establishments that completed survey Version 1 and reported that they recycle. Table 32 represents only a portion of the establishments that recycle—in the whole sample there were 1,392 establishments that reported recycling (this amount also includes establishments that completed Version 2). The descriptive statistics of the 1,392 establishments are presented later in Table 34.

6.2.1.2 Amount of Cooking Oil Recycled Discussion

There are two types of cooking oil that is collected for recycling (yellow and trap grease), however, the question on the survey did not ask respondents to specify the amounts of each type that is recycled. It is not known if the data for the amount of cooking oil recycled is yellow grease only, trap grease only, or the total amount (yellow plus trap grease) recycled.

There were many establishments that did not provide data for amount of cooking oil recycled. For some of the surveys, the manager at an individual establishment

forwarded the survey to the corporate office. The specific amount recycled at each establishment was not reported by the corporate office because one survey was completed for all of the company's locations in Hawaii. Other reasons for not reporting the amount of cooking oil recycled could be that the amount fluctuated and/or the respondent did not know.

Limitations of the Amount of Cooking Oil Recycled Data

The data used in this thesis were provided by the survey respondents and no additional measurement or verification was made to confirm the reported amounts. Also, these data were collected from Fall 2004 through Summer 2005 and the amount of cooking oil recycled could fluctuate based on seasonal trends (i.e., activity in the visitor industry or holiday seasons—Thanksgiving, Christmas, New Years, etc. may produce more cooking oil). It is also possible that some of the establishments that reported not recycling (throwing it away in the trash or pouring it down the drain) may have started recycling since completing the survey.

Recommendations for Future Studies on Cooking Oil Recycling Amounts

As mentioned, it is not known if the recycled cooking oil data are for yellow grease only, trap grease only, or both. To collect more accurate information on both types of cooking oil recycled, the survey could have included two separate questions—one for amount of yellow grease recycled and one for amount of trap grease recycled.

One way to get the most accurate data on amount of cooking oil recycled would be to ask the companies who are doing the collection. Asking the companies directly would also be helpful in obtaining separate amounts for yellow grease and trap grease collected. However, recycling companies view their data as proprietary and receiving

their cooperation is anticipated to be difficult.

6.2.1.3 Number of Meals Served Results

Version 1 of the survey included the question, "what is the average number of meals served per day?". Of the 3,130 establishments that completed Version 1 of the survey, 1,238 establishments reported that they recycle. The results from the latter group are reported in this section. Descriptive statistics for the number of meals served for establishments that recycle are presented in Table 32. The number of meals served per day ranged from 5 to 5,225. The median number of meals served per day was 188, the mean was 343, and the mode was 100. The standard deviation was 480.

6.2.1.4 Number of Meals Served Discussion

The discussion section (including limitations and recommendations) for the number of meals served has already been included in the food waste results and analysis chapter and can be found in section 5.2.1.4.

6.2.1.5 Scatter Plot and Correlation for Number of Meals and Amount of Cooking Oil Recycled Results

There were 875 establishments that reported the number of meals served and 800 establishments that provided the amount of cooking oil recycled. However, there were only 604 establishments that provided both the number of meals and the amount of cooking oil recycled. To determine if there is a relationship between size (measured by number of meals served per day) and amount of cooking oil recycled (gallons per day) a scatter plot was created and correlations were calculated in SPSS. The R^2 value is 0.044.

The scatter plot is included as Figure 9 below. The equation of the regression line in Figure 9 is:

$$Y = 0.004x + 2.700$$

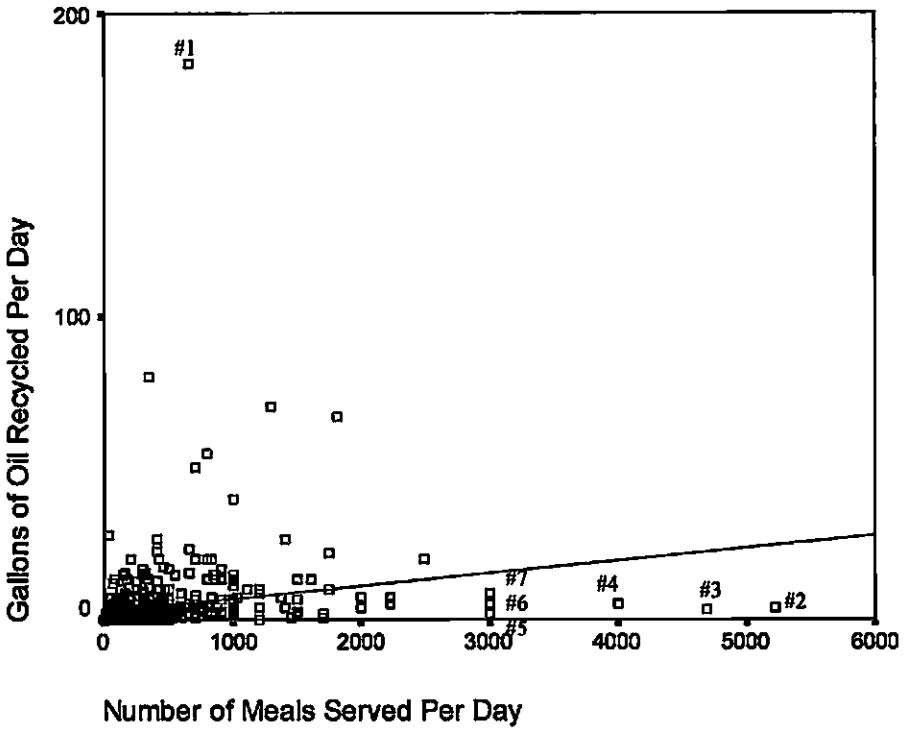

Figure 9. Scatter Plot of Number of Meals Served and Amount of Cooking Oil Recycled

The scatter plot in Figure 9 shows a positive relationship between number of meals served per day and gallons of cooking oil recycled per day. There is one establishment (labeled #1 in Figure 9) that serves a low number of meals (650 daily), but recycles a large amount of cooking oil (183.33 gallons per day). There are also establishments that serve high number of meals (3,000-6,000 daily), but recycle a relatively low amount of cooking oil (less than 10 gallons per day).

Table 33 provides the Pearson Correlation coefficient and the two-tailed significance level for this set of data. The Pearson Correlation coefficient is 0.210 and is significant at the 0.01 level.

Table 33. Correlation for Number of Meals Served and Amount of Cooking Oil Recycled

		Number of Meals Served Per Day	Gallons of Oil Recycled Per Day
Number of Meals Served Per Day	Pearson Correlation	1	.210**
	Sig. (2-tailed)	.	.000
	N	875	604
Gallons of Oil Recycled Per Day	Pearson Correlation	.210**	1
	Sig. (2-tailed)	.000	.
	N	604	800

**Correlation is significant at the 0.01 level (2-tailed).

6.2.1.6 Scatter Plot and Correlation for Number of Meals and Amount of Cooking Oil Recycled Discussion

In Figure 9 there was one establishment (labeled #1) that serves a relatively low number of meals, but recycles a high amount of cooking oil per day. In Figure 9, this establishment is label #1 and a brief description for it is included below:

#1: This is a hotel/banquet/convention kitchen located on Oahu. They serve 650 meals and recycle 183.33 gallons of cooking oil per day.

Also included in the scatter plot in Figure 9 are establishments that serve a high number of meals (3,000-6,000 daily), but recycle relatively low amounts of cooking oil (less than 10 gallons per day). These establishments are labeled #2-7 and a brief description of each is as follows:

#2: This is a catering/commissary kitchen located on Oahu. They serve 5,225 meals and recycle 4 gallons of cooking oil per day.
#3: This is a catering/commissary kitchen located on Oahu. They serve 4,697 meals and recycle 3 gallons of cooking oil per day.
#4: This is a hotel located on Maui. They serve 4,000 meals and recycle 5.33 gallons of cooking oil per day.
#5: This is a school located on Oahu. They serve 3,000 meals and recycle 1.83 gallons of cooking oil per day.
#6: This is a hotel located on Oahu. They serve 3,000 meals and recycle 5 gallons of cooking oil per day.
#7: This is a restaurant located on Oahu. They serve 3,000 meals and recycle 8.33 gallons of cooking oil per day.

There is no shared characteristic between these six establishments that could account for the high number of meals, but low amount of cooking oil recycled.

Table 33 provides the Pearson Correlation coefficient and the two-tailed significance level for the number of meals served and amount of cooking oil recycled data. The Pearson Correlation coefficient is 0.210, which indicates weak association between the number of meals served and the amount of cooking oil recycled. This is because there are some establishments that have a high number of meals served associated with low amounts of cooking oil recycled and an establishment that has a low number of meals served associated with a very high amount of cooking oil recycled. However, the correlation coefficient is significant at the 0.01 level. This means that the null hypothesis can be rejected and the alternative hypothesis is accepted. Therefore, there is a relationship between the number of meals served and the amount of cooking oil recycled. In general, it can be predicted that the more number of meals an establishment serves, the more amount of cooking oil will be recycled.

Limitations of the Scatter Plot and Correlation for Number of Meals and Amount of Cooking Oil Recycled

As previously mentioned, the data used in this thesis were provided by the survey respondents and no additional measurement or verification was made to confirm the reported amounts. Therefore, these establishments may have reported the amounts of meals served or cooking oil recycled incorrectly.

6.2.2 Relationship between Number of Employees and Amount of Cooking Oil Recycled

6.2.2.1 Amount of Cooking Oil Recycled Results

All food establishments that said they recycle their cooking oil were included in these results. There were 1,392 establishments that said they recycle. Of the 1,392 establishments that recycle, 885 of them provided the amount recycled on the survey. There were 507 establishments did not provide the amount they recycle. Descriptive statistics of the 1,392 establishments are presented in Table 34. The amount of cooking oil recycled per day for this group ranged from 0 to 183 gallons. The median amount recycled was 2 gallons, the mean was 4 gallons, and the mode was 2 gallons. The standard deviation was 9 gallons.

Table 34. Descriptive Statistics for Number of Employees and Amount of Cooking Oil Recycled

		Gallons of Oil Recycled Per Day	Total Number of Employees
N	Valid	885	1,076
	Missing	507	316
Mean		4	32
Median		2	15
Mode		2	3
Std. Deviation		9	87
Minimum		0	1
Maximum		183	2,325

6.2.2.2 Amount of Cooking Oil Recycled Discussion

The discussion section (including limitations and recommendations) for the amount of cooking oil recycled has already been covered and can be found in section 6.2.1.2.

6.2.2.3 Number of Employees Results

On all versions of the survey it asked for the number of full-time and part-time employees. For these results, the total number (full-time plus part-time employees) of employees was used. As mentioned previously, only the establishments that reported that they recycled (1,392 establishments) were included in the results. Descriptive statistics of the 1,392 establishments are presented in Table 34. The number of employees for this group ranged from 1 to 2,325. The median number of employees was 15, the mean was 32, and the mode was 3. The standard deviation was 87.

6.2.2.4 Number of Employees Discussion

The discussion section (including limitations and recommendations) for the number of employees has already been covered in the food waste chapter and can be found in section 5.2.2.4.

6.2.2.5 Scatter Plot and Correlation for Number of Employees and Amount of Cooking Oil Recycled Results

There were 1,076 establishments reporting the number of employees and 885 establishments that provided the amount of cooking oil recycled. However, there were only 726 establishments that provided both the number of employees and the amount recycled. To determine if there is a relationship between size (measured by number of employees) and amount of cooking oil recycled (gallons per day) a scatter plot was created and correlations were calculated in SPSS. The R^2 value is 0.012. The scatter plot is included as Figure 10. The equation of the regression line in Figure 10 is:

$$Y = 0.010x + 3.764$$

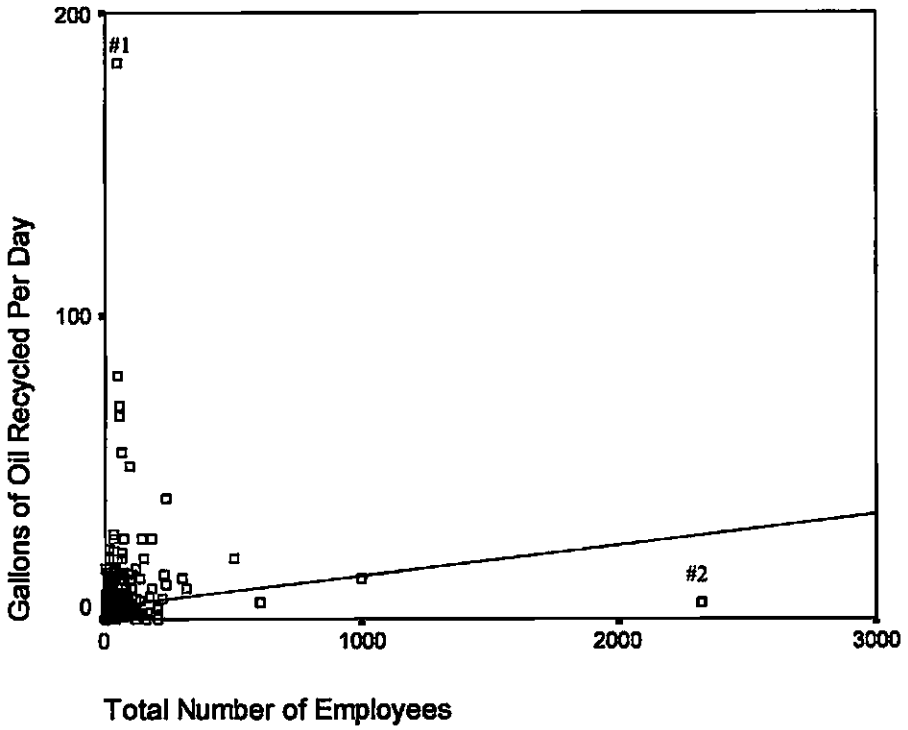

Figure 10. Scatter plot of Number of Employees and Amount of Cooking Oil Recycled

Figure 10 shows a positive relationship between number of employees and gallons of cooking oil recycled per day. There is one establishment that has a high number of employees, but recycles a relatively low amount of cooking oil. There is also one establishment that has a low number of employees, but recycles a high amount of cooking oil per day.

Table 35 provides the Pearson Correlation coefficient and the two-tailed significance level for this set of data. The Pearson Correlation coefficient is 0.112 and is significant at the 0.01 level.

Table 35. Correlations for Number of Employees and Amount of Cooking Oil Recycled

		Gallons of Oil Recycled Per Day	Total Number of Employees
Gallons of Oil Recycled Per Day	Pearson Correlation	1	.112**
	Sig. (2-tailed)	.	.003
	N	885	726
Total Number of Employees	Pearson Correlation	.112**	1
	Sig. (2-tailed)	.003	.
	N	726	1,076

** Correlation is significant at the 0.01 level (2-tailed).

6.2.2.6 Scatter Plot and Correlation for Number of Employees and Amount of Cooking Oil Recycled Discussion

In Figure 10 there is one establishment (labeled #1) that has a relatively low number of employees, but recycles a high amount of cooking oil per day. In Figure 10, this establishment is label #1 and a brief description for it is included below:

> #1: This is a hotel/banquet/convention kitchen located on Oahu. They serve 650 meals and recycle 183.33 gallons of cooking oil per day.

Also included in the scatter plot in Figure 10 is an establishment that has a high number of employees, but recycles a relatively low amount of cooking oil. This establishment is labeled #2 and a brief description for it is listed below:

> #2: This is a hotel located on Oahu. They have 2,325 and recycle 5 gallons of cooking oil per day.

If these two (establishments labeled #1 and #2) are removed from the data set, the R^2 value would change from 0.012 to 0.067; the regression equation would change from $Y = 0.010x + 3.764$ to $Y = 0.300x + 2.897$; and the Pearson Correlation coefficient would change from 0.112 to 0.258 (also significant at the 0.01 level). Removing the two

establishments creates a slight improvement in the R^2 and Pearson Correlation coefficient.

Table 35 provides the Pearson Correlation coefficient and the two-tailed significance level for this set of data. The Pearson Correlation coefficient is 0.112 and is significant at the 0.01 level. This means that the null hypothesis can be rejected and the alternative hypothesis is accepted. Therefore, there is a relationship between the number of employees and the amount of cooking oil recycled. In general, it can be predicted that the higher number of employees an establishment has, the greater the amount of cooking oil recycled.

Limitations of the Scatter Plot and Correlation for Number of Employees and Amount of Cooking Oil Recycled

As previously mentioned, the data used in this thesis were provided by the survey respondents and no additional measurement or verification was made to confirm the reported amounts. Therefore, these establishments may have reported the amounts of meals served or cooking oil recycled incorrectly.

6.3 Relationship between the Type of Food Establishment and Cooking Oil Recycling Practices

There are 4,854 food establishments included in this study and in order to better understand their cooking oil recycling practices, they were grouped according to establishment type. As previously explained, the Department of Health (DOH) classifies food establishments into one of 90 categories, but for the purpose of this thesis the DOH's categories were consolidating into 16 food establishment types. One of the research objectives for this thesis is to determine if there is a relationship between the type of food establishment and their cooking oil recycling practices, which can be

addressed in two ways: first by looking at cooking oil recycling behavior/practices (i.e., does a food establishment recycle cooking oil or not) and second by looking at the amount of cooking oil recycled (gallons per day). For these results, only those establishments (1,834) that reporting using cooking oil were analyzed.

6.3.1 Relationship between Cooking Oil Recycling Practices and Type of Food Establishment

The null and alternative hypothesis to determine if there is a relationship between the type of food establishment and their cooking oil recycling practices is as follows:

> Null Hypothesis: There is no relationship between the type of an establishment and their cooking oil recycling practices.
>
> Alternative Hypothesis: There is a relationship between the type of establishment and their cooking oil recycling practices.

Cooking oil recycling behavior/practices refers to whether or not a food establishment recycles their cooking oil. Of the 1,843 establishments that use cooking oil, 1,392 of them recycle it. To test the hypothesis, the independent variable is the type of establishment and the dependent variable is recycling practice (does not recycle or does recycle). The statistical test used to test the hypothesis was the chi square test, which was conducted in SPSS.

6.3.1.1 Cooking Oil Recycling Practices and Type of Food Establishment Results

The breakdown of recycling practices by establishment type is included in Table 36 and Figure 11. There were five establishment types where no cooking oil is used—beverage/ice, pharmacies/drug wholesalers, cosmetics, plastic bottles (manufacturer), and salvage/food banks.

Table 36. Cooking Oil Recycling Practices

Establishment Type	# Recycles	% Recycles	# Does Not Recycle	% Does Not Recycle
Restaurants	1,051	84%	194	16%
Liquor Dispensers	23	62%	14	38%
Limited Menu	13	54%	11	46%
Schools/Daycare/Nutrition Programs	52	35%	98	65%
Correctional Facilities	1	33%	2	67%
Medical Facilities	28	56%	22	44%
Hotel/Banquet/Convention Kitchen	38	95%	2	5%
Catering/Commissary Kitchen	32	56%	25	44%
Retail	105	70%	45	30%
Manufacturers/Processors/Canning	46	61%	29	39%
Beverages/Ice	N/A	-	N/A	-
Food Warehouse/Wholesaling/Brokerages	3	100%	0	0%
Pharmacies/Drug Wholesalers	N/A	-	N/A	-
Cosmetics	N/A	-	N/A	-
Plastic Bottles (manufacturer)	N/A	-	N/A	-
Salvage/Food Banks	N/A	-	N/A	-

Figure 11. Cooking Oil Recycling Practices

The chi square test performed in SPSS resulted in a chi square value of 245.262 with 10 degrees of freedom and a p-value of 0.000. This p-value indicates that the results are statistically significant and thus the null hypothesis is rejected and the alternative hypothesis is accepted, i.e. there is a relationship between the type of establishment and their cooking oil recycling practices.

6.3.1.2 Cooking Oil Recycling Practices and Type of Food Establishment Discussion

Determining if there is a relationship between the type of establishment and their cooking oil recycling practices is helpful in knowing which type of establishments to target for recycling programs. The majority of the food establishments in the sample recycle cooking oil and those establishments that do not should be targeted to start recycling. However, it is not known how much cooking oil is generated at these establishments (cooking oil generation may be minimal) nor is it know why they do not recycle cooking oil.

Limitations of Cooking Oil Recycling Practices and Type of Food Establishment Data

These results do not indicate how much cooking oil is recycled nor if there is a relationship between food establishment type and amount recycled (gallons per day), which will be covered next.

Recommendations for Future Studies on Cooking Oil Recycling Practices

It would be interesting to know the reason(s) why establishments do not recycle their cooking oil. This question (why don't you recycle?) was asked for food waste disposal on the survey, but not for cooking oil.

6.3.2 Relationship between Cooking Oil Recycling Amount and Type of Food Establishment

The previous section focused on a relationship between cooking oil recycling practices and establishment type, with cooking oil recycling practices defined as "yes" meaning the establishment recycles and "no" meaning the establishment does not recycle cooking oil. This section looks at a possible relationship between the amount of cooking oil recycled (in gallons per day) and establishment type.

The null and alternative hypothesis to determine if there is a relationship between type of food establishment and the amount of cooking oil recycled is as follows:

> Null Hypothesis: There is no relationship between the establishment type and the amount of cooking oil recycled.
>
> Alternative Hypothesis: There is a relationship between the establishment type and the amount of cooking oil recycled.

To test the hypothesis, the independent variable is the type of establishment and the dependent variable is the amount of cooking oil recycled (measured in gallons per day). The statistical test used to test the hypothesis was the one way analysis of variance, which was conducted in SPSS.

6.3.2.1 Amount of Cooking Oil Recycled by Establishment Type Results

Descriptive statistics for amount of cooking oil recycled by establishment type are included in Table 37. This table provides the breakdown of the minimum value, maximum value, median, mean, and standard deviation for amount recycled (all units are gallons per day, except number of establishments).

Table 37. Descriptive Statistics for Amount of Cooking Oil Recycled by Establishment Type

Establishment Type	Number of Establishments		Gallons Per Day				
	Valid N	Missing N	Min. Value	Max. Value	Median	Mean	SD
Restaurants	689	362	0.0	80.0	1.8	4.3	7.1
Liquor Dispensers	12	11	0.2	1.8	0.4	0.7	0.6
Limited Menu	9	4	0.1	13.2	1.8	3.1	4.0
Schools/Daycare/ Nutrition Programs	19	33	0.1	4.2	1.0	1.3	1.2
Correctional Facilities	1	0	0.3	0.3	0.3	0.3	.
Medical Facilities	18	10	0.2	7.3	0.9	1.4	1.6
Hotels/Banquet/ Convention Kitchen	32	6	0.6	183.3	4.3	12.4	31.8
Catering/Commissary Kitchen	20	12	0.0	27.5	1.7	2.9	6.0
Retail	56	49	0.0	13.3	1.9	3.1	2.7
Manufacturers/ Processors/Canning	27	19	0.1	16.7	0.8	2.2	3.8
Beverages/Ice	0	0	-	-	-	-	-
Food Warehouse/ Wholesaling/ Brokerages	2	1	0.1	2.7	1.4	1.4	1.8
Pharmacies/Drug Wholesalers	0	0	-	-	-	-	-
Cosmetics	0	0	-	-	-	-	-
Plastic Bottles (manufacturer)	0	0	-	-	-	-	
Salvage/Food Banks	0	0	-	-	-	-	-

In Table 37 there are five establishment types that do not have any data. In the categories of beverage/ice, pharmacies/drug wholesalers, cosmetics, plastic bottles (manufacturer), and salvage/food banks none of the survey respondents reported using cooking oil and therefore, there is no data for these establishment types. Overall there were 1,392 establishments that reported recycling, but only 885 establishments (~64%) provided the amount of cooking oil they recycle.

Using the data available, the one way analysis of variance test was performed in SPSS and the results are presented in Table 38.

Table 38. One Way Analysis of Variance for Cooking Oil Data

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2851.164	10	285.116	3.697	.000
Within Groups	67408.552	874	77.126		
Total	70259.716	884			

The one way analysis of variance F-test statistic was 3.697 and the significance level was 0.000, which means that the null hypothesis can be rejected and the alternative hypothesis is accepted, i.e, there is a relationship between the type of establishment and the amount they recycle.

6.3.2.2 Amount of Cooking Oil Recycled by Establishment Type Discussion

Determining if there is a relationship between the type of establishment and the amount of cooking oil they recycle can help to predict the amounts of cooking oil that is recycled in Hawaii. There were many establishments that did not provide data on the amount of cooking oil they recycle and in order to calculate the average amount of cooking oil recycled in Hawaii on a daily basis, this number had to be extrapolated from the existing data. For each establishment type, the mean amount of cooking oil recycled on a daily basis was multiplied by the number of establishments that reported recycling cooking oil to come up with a figure for the total amount recycled. Overall, approximately 5,631 gallons of cooking oil is recycled per day in Hawaii. Table 39 presents the total amount of cooking oil recycled per day, calculated by establishment type. Table 39 only includes the 11 establishment types that reported using cooking.

Table 39. Amounts of Cooking Oil Recycled Per Day

Establishment Type	Valid N	Missing N	Total N	Mean	Total Gallons Recycled Per Day
Restaurants	689	362	1,051	4.3	4,478
Liquor Dispensers	12	11	23	0.7	15
Limited Menu	9	4	13	3.1	40
Schools/Daycare/ Nutrition Programs	19	33	52	1.3	69
Correctional Facilities	1	0	1	0.3	0
Medical Facilities	18	10	28	1.4	39
Hotels/Banquet/ Convention Kitchen	32	6	38	12.4	470
Catering/Commissary Kitchen	20	12	32	2.9	94
Retail	56	49	105	3.1	322
Manufacturers/ Processors/Canning	27	19	46	2.2	100
Food Warehouse/ Wholesaling/ Brokerages	2	1	3	1.4	4
Total Gallons Recycled by All Establishments					**5,631**

Additional discussion (including limitations and recommendations) for the amount of cooking oil recycled has already been included with the previous objective and can be found in section 6.3.1.2.

7.0 SUMMARY AND CONCLUSIONS

7.1 Summary and Conclusions

7.1.1 Food Waste Results

One of the main objectives of this study was to determine how food establishments dispose of and recycle their food waste. The majority (45%) of the food establishments in Hawaii throw away all of their food waste. A quarter (25%) of the sample reported that they have no food waste, 22% of respondents said they recycle their food waste, and 8% of the sample said they throw some of their food waste away and recycle some of their food waste.

Another objective was to determine how many establishments recycle food waste and to identify methods used to recycle food. There were 1,471 establishments that reported they recycle some or all of their food waste. The most commonly reported method of recycling was pig farm (625 establishments), followed by donations (370 establishments), give to others (193 establishments), recycling company (188 establishments), give to other animals (138 establishments), and composting (136 establishments). An establishment may use several methods of recycling and therefore, the categories are not mutually exclusive.

Determining if there is a relationship between the size of a food establishment and the amount of food recycled was the next objective in this study. The size of a food establishment can be characterized in two ways—by the number of meals they serve per day and by the number of employees they have. In general, the assumption is that as the number of meals or number of employees increases, so does the amount of food waste it recycles. In order to test the hypothesis that size of an establishment is related to the

amount of food recycled, scatter plots and correlation coefficients were calculated. The hypothesis was tested in two ways: first using the number of meals as the independent variable and the amount recycled as the dependent variable and second by using the number of employees as the independent variable and the amount recycled as the dependent variable. It was found that there is a positive relationship between the size (for both number of meals and number of employees) of an establishment and the amount of food recycled. In general, it can be predicted that the more meals an establishment serves or the greater number of employees an establishment has, the more food waste will be recycled.

Another of the research objectives for this thesis was to determine if there is a relationship between the type of food establishment and their food recycling practices. This can be addressed in two ways: first by looking at food recycling behavior/practices (i.e., does a food establishment recycle food waste or not) and second by looking at the amount of food recycled (gallons per day). The results of the chi square test were statistically significant indicating a relationship between the type of establishment and their food recycling practices. The results of the one way analysis of variance was also statistically significant indicated a relationship between the type of establishment and the amount they recycle.

The last research objective for food waste was to determine why food establishments do not recycle all of their food waste. The majority of the food establishments that completed the survey did not recycle all of their food waste. There were 2,177 establishments that reported throwing away all of their food waste and 398 establishments that reported throwing away and recycling their food waste. This is a total

of 2,575 establishments (53% of the sample) that do not recycle all of their food waste. On the survey, respondents that did not recycle all of their food waste were asked to identify the reason(s) they do not recycle, their responses were grouped into the following categories:

- Separating food waste from other trash is too time consuming/costly
- Contracting a separate food recycling company is too time consuming/costly
- Storage, transportation, and logistical problems (pick-up problems)
- Health and sanitation problems
- Liability issues
- No food waste/small amount generated
- Did not know you could recycle food waste
- No opportunity to recycle
- Not allowed to recycle food waste

7.1.2 Cooking Oil Results

The majority (3,020 or 62%) of the food establishments in Hawaii does not use cooking oil and therefore, does not have to dispose of it. Of those food establishments that use cooking oil, the majority (1,392 or 76%) recycles it, 418 establishments (23%) throw it away, and 24 establishments (1%) pour it down the drain. There were five establishment types where no cooking oil is used—beverage/ice, pharmacies/drug wholesalers, cosmetics, plastic bottles (manufacturer), and salvage/food banks.

In this study, the size of a food establishment can be characterized in two ways—by the number of meals they serve per day and by the number of employees they have. One of the research objectives was to determine if there is a relationship between the size of a food establishment and the amount of cooking oil recycled. In general, the assumption is that as the number of meals a food establishment serves or number of employees increases, so does the amount of cooking oil it recycles. In order to test the hypothesis that size of an establishment is related to the amount of cooking oil recycled,

scatter plots and correlation coefficients were calculated. The hypothesis was tested in two ways: first using the number of meals as the independent variable and the amount recycled as the dependent variable and second by using the number of employees as the independent variable and the amount recycled as the dependent variable. It was found that there is a positive relationship between the size (for both number of meals and number of employees) of an establishment and the amount of cooking oil recycled. In general, it can be predicted that the more meals an establishment serves or the greater number of employees an establishment has, the more cooking oil will be recycled.

The last research objective for cooking oil was to determine if there is a relationship between the type of food establishment and their cooking oil recycling practices, which can be addressed in two ways: first by looking at cooking oil recycling behavior/practices (i.e., does a food establishment recycle cooking oil or not) and second by looking at the amount of cooking oil recycled (gallons per day). The results of the chi square test were statistically significant indicating a relationship between the type of establishment and their cooking oil recycling practices. The results of the one way analysis of variance was also statistically significant indicated a relationship between the type of establishment and the amount they recycle.

7.2 Recommendations

7.2.1 Selecting Food Establishments to Survey

For the purpose of this thesis, a census of the population was required because each food establishment needed to be contacted to find out if food waste was being collected for recycling. For future studies, it would be more practical to survey only those establishments that generate large amounts of food waste and/or cooking oil. In the

food waste generation studies conducted by Draper/Lennon, Inc. for Connecticut and Massachusetts (see chapter 2), minimum establishment sizes were determined and only establishments that met the minimum size were surveyed. Draper/Lennon, Inc. also did not survey all food establishment types, only health care facilities, colleges/universities/independent preparatory schools, correctional facilities, resort/conference facilities, restaurants, and supermarkets were included in their study.

7.2.2 Categorizing Food Establishment Types

Based on the available information for each food establishment (as provided on the DOH lists), the food establishments were re-categorized from the DOH's original establishment types into 16 general categories (see section 4.6.1). One recommendation for future studies would be to ask the establishment to report their establishment type. Rather than having general categories such as restaurants and retail, restaurants could be further categorized into fast food or full service and retail establishments could be divided into convenience stores or supermarkets. One reason to have more specific establishment types is because the amounts/rates of food waste generated may be different, as was found to be the case in the Jones study (see section 2.2.1).

7.2.3 Number of Employees Reported

The mail survey asked for the number of food service employees. Because of the words "food service" many respondents may have thought this question did not apply to them. The intent of the wording of the question was to capture only the employees directly involved with preparing, cooking, and serving the food. The surveys were sent to many different types of establishments. Many places had large numbers of employees

who did not work in food service. For example, this is the case in correctional facilities, medical facilities, and hotels. These places are required to have food establishment permits, but they have additional employees working as prison guards, doctors, nurses, housekeepers, custodians, etc., that are not related to food service.

There were also some establishment types where survey responders felt they had no food service employees. This was a common response from the retail sector. Often the only food service employees a super market counted were the deli and bakery employees. For some small retail stores, the person completing the survey was the owner who also operated the establishment by themselves and reported that there were zero employees. Another instance in which the survey respondent said that there were no food service employees was when the individuals that worked at the establishment were not on the payroll (e.g., volunteers or family members) or were not hired specifically for a food service position (many teachers at pre-schools are the ones who prepare the food, but they are not food service employees). As a result of the wording for this question, it may be possible that some establishments may have under or over reported their employees.

It is also important to point out that the above mentioned problems occurred only in surveys completed by mail because there was no person who was able to clarify the intent of the question as there was with the phone surveys. For the phone surveys, respondents were asked to provide the number of employees and not the number of food service employees. However, for establishments where there were other employees not related to food service, only the number of food service employees were counted.

In the future, depending on the intent of the study, it would be important to clearly define the employees to be counted (i.e., food service or all employees). It would also be

important to define "food service" employees. It may be helpful to create surveys specific to the establishment type to resolve any confusion with who should be counted and how to count the number of employees. This recommendation applies to mail surveys only where there is no person who would be able to clarify the intent of the question (which employees to count) as there was with the phone surveys.

7.2.4 Reported Amounts of Food Waste Recycled

The data used in this thesis were provided by the survey respondents and no additional measurement or verification was made to confirm the reported amounts. There were some establishments where the amount they recycled seemed unlikely for their size. However, these data were included in the results of this thesis.

There were many establishments that did not report the amount of food waste they recycled. It was commonly reported by survey responders that the amount of food recycled varies greatly from day-to-day depending on the actual number of customers (there may be more food wasted if the estimated or anticipated number of customers for the day is not reached, especially in the case of restaurants) and/or personal preference (as with school lunches—the amount of food waste recycled depends on what is served that day). Also, these data were collected from Fall 2004 through Summer 2005 and the amount of food recycled could fluctuate based on seasonal trends (i.e., food establishments catering to the visitor industry or the holiday season—Thanksgiving, Christmas, New Years, etc.) or may have changed since the surveys were completed.

In order to get the most accurate data on the amount of food waste generated and recycled, it would be beneficial to visit the establishments and weigh all food waste. Measurements could be taken over a period of time (one year) to determine the daily

average and would thus take into account any seasonal fluctuations. This would be more feasible to do if a small random sample of the population was surveyed and/or the study was only conducted for Oahu.

Another way to verify food recycling amounts would be to ask the businesses and individuals who are doing the collection and actual recycling. However, food recycling companies view their data as proprietary and receiving their cooperation is anticipated to be difficult. This method would also require visits to weigh the food waste collected. It may also be interesting to see if all the food waste collected is actually recycled as the food establishment intends it to be. For example, there may be too much food waste collected and the pig farmer may have to throw some of it away if his/her pigs cannot consume all of it before it spoils.

7.2.5 Total Amount of Food Waste Recycled and Generated

The total amount of food waste recycled for all establishments in the study was estimated to be 69,878 gallons per day (see Table 26). However, the amount of food waste recycled is a function of the method(s) used to recycle. The amount provided on the survey in most cases was only what is collected by a recycling company and/or pig farmers. In general, the amounts of food waste recycled by donating, composting, giving to others, and giving to other animals are minimal.

The estimate of 371,003 tons of food waste generated annually by all food establishments in Hawaii is higher than previously reported amounts. There were two previous studies that estimated the amount of food waste generated in Hawaii. In the 1998 study that amount was 147,802 tons and in the 2002 study it was 179,303 tons (see

section 2.1.2). These estimates were for the entire state (households and businesses) and not just commercial food establishments.

A possible reason for the high estimate from the present work is that the average amount recycled should only be applied to those establishments that recycled by recycling company or pig farm. As previously mentioned, there were many establishments that did not know how much food waste was recycled, especially for those establishments that recycle by donations, composting, give to other, and give to other animals. For those establishments who recycle using these methods, the average amount of food waste generated is probably much smaller than the amounts generated by establishments that use recycling companies and pig farmers.

In order to get the most accurate data on the amount of food waste generated and recycled, it would be beneficial to visit the establishments and weigh all food waste. Measurements could be taken over a period of time (one year) to determine the daily average and would thus take into account any seasonal fluctuations. This would be more feasible to do if a small random sample of the population was surveyed and/or the study was only conducted for Oahu.

7.2.6 Increasing Food Waste Recycling

There are many methods of food waste recycling practiced in Hawaii—recycling companies (rendering and intermediary recyclers), pig farms, donations, composting, giving it to others, and giving it to other animals. The majority of the survey respondents do not recycle food waste for various reasons. Expanding informational campaigns about food waste recycling options is the first step to increasing participation in food waste recycling programs. In order for those establishments that are familiar with food waste

recycling to start recycling programs, the efficiency, reliability, and cleanliness of the food waste collection system must be improved.

7.2.7 Cooking Oil Recycling

The survey questions for cooking oil disposal and recycling do not distinguish between yellow grease (oil from fryers) and trap grease. On the survey, respondents were only asked if they recycle cooking oil and not specifically asked which type(s) of oil they recycle. It is not known if the amount of cooking oil recycled data is for yellow grease only, trap grease only, or both. To collect more accurate information on both types of cooking oil recycled, the survey could have included two separate questions—one for amount of yellow grease recycled and one for amount of trap grease recycled.

Method used for recycling (rendering or biodiesel production) is another distinction that is not made on the survey. A question that could be included in future surveys is: "What does the grease hauler do with it after it is collected (e.g., haul it to Pacific Biodiesel to turn into biodiesel or does it go to Island Commodities for rendering)?".

Unlike for food waste, survey respondents that did not recycle all of their cooking oil were not asked why they do not recycle it. There were 418 establishments that reported throwing away the cooking oil in the trash and 24 establishments that reported pouring the used cooking oil down the drain. Both of these disposal options can have negative effects on the landfills or wastewater system. It would be useful to understand why these establishments do not use a more environmentally responsible method to dispose of their used cooking oil. Also, the establishments that do not recycle should be

informed of the cooking oil recycling options available and compliance with proper cooking oil disposal should be monitored.

APPENDIX 1: COVER LETTER AND SURVEYS

UNIVERSITY OF HAWAI'I AT MĀNOA

School of Ocean and Earth Science and Technology
Hawai'i Natural Energy Institute

Dear Food Establishment Owner/Manager,

Researchers with the Hawaii Natural Energy Institute and the Department of Urban and Regional Planning at the University of Hawaii are developing a database of food waste recycling for Hawaii funded by the Hawaii State Department of Agriculture (HDOA). Food waste is any food that you discard, such as expired food, food preparation/processing wastes, and table scraps. The HDOA is interested in food waste recycling in Hawaii because much of the recycled food is used as feed at local swine/pig farms. Knowing who is recycling their food waste and which farmers receive the waste will aid in keeping Hawaii's pig population healthy.

In addition to keeping Hawaii's pig population healthy, your participation will help to facilitate food waste recycling programs. Food waste recycling programs have been effective in reducing the amount of material entering our landfills and can also reduce your waste disposal fees. Food waste recycling can benefit your establishment, pig farmers, and our environment.

We are distributing this survey to all licensed food establishments in Hawaii. Please complete the survey as soon as possible. We recommend that the survey be completed by the food service manager or the person most knowledgeable about food waste generation and recycling. Please complete the survey even if you do not recycle your food waste. If you have any questions about this project or the survey please do not hesitate to contact us. Thank you very much for your time and cooperation.

Sincerely,

Dr. Scott Turn
Associate Researcher
(808) 956-2346
sturn@hawaii.edu

Dr. Peter Flachsbart
Associate Professor
(808) 956-8684
flachsba@hawaii.edu

Wendy Okazaki
Graduate Research Asst.
(808) 956-2341
okazakiw@hawaii.edu

1680 East-West Road, POST 109, Honolulu, Hawai'i 96822
Telephone: (808) 956-8890 Facsimile: (808) 956-2336
An Equal Opportunity/Affirmative Action Institution

Food Waste Recycling Survey (Version 1)

Please complete the following survey and return by October 15, 2004

<Establishment Name>
<DOH Permit Number>
<Mailing Address>

Please make any corrections to the above information on the label

Please fill in your location/street address below (if different than mailing address):

Location Address: _____

City: _____ **Zip Code:** _____

CONTACT INFORMATION (person completing the survey):

Contact Name: _____

Contact Phone Number: _____

Alternative Phone Number: _____

PLEASE ANSWER THE FOLLOWING QUESTIONS TO THE BEST OF YOUR ABILITY:

1) Please check the meals that you serve:

___ Breakfast ___ Lunch ___ Dinner ____Other (please specify): ___

2) What is the average number of meals served per day at the present time? _____

3) Please indicate how you dispose of your food waste (check all that apply):

_____ Throw it away in the trash
_____ Recycle it (recycling company, pig farm)
_____ Donate edible items to the Food Bank
_____ Other (please specify): _____

4) If you recycle your food waste, Please indicate the approximate quantity of food waste recycled per week:

What is the size of your container(s) for food waste? _____

How often is the food waste emptied? _____

How full is your container(s) each time it is emptied? _____

____ I recycle food waste, but do not know how much is recycled per week.
□ I do not recycle food waste.

5) If you recycle your food waste, please fill in the information below. Companies or farmers collecting food waste from your establishment:

Name: _____ Phone Number: _____

Name: _____ Phone Number: _____

-OVER-

6) **If you do not recycle all of your food waste, please let us know why (Check all that apply):**

_____ Separating food waste from other trash is too time consuming/costly
_____ Contracting a separate food recycling company is too time consuming/costly
_____ Recycling food waste causes certain problems (please specify): _____

_____

_____ Other Reasons (please specify): _____

_____

7) **If your establishment uses cooking oil, how do you dispose of it?**

_____ Throw it away in the trash _____ Recycle it
_____ Pour it down the drain _____ Other (please specify): _____

8) **If you recycle your used cooking oil, please fill in the information below:**

Name of Company collecting the used cooking oil: _____

Approximately how many times a month is it picked-up at the present time? _____

Approximately how much is collected at each pick-up? _____ pounds _____ gallons

9) **To help us understand the size of your establishment, please indicate the number of food service employees you have:**

Full Time: _____ Part Time: _____

10) **Please use the space below for any additional comments you may have:**

_____

_____

_____

_____

_____

_____

_____

Mahalo for completing this survey!
Your responses will help to facilitate food recycling & aid in keeping Hawaii's pig population healthy.

Please return this completed survey by October 15, 2004
in the enclosed postage-paid envelope.

Food Waste Recycling Survey (Version 2)

Please complete the following survey and return by October 15, 2004

<Establishment Name>
<DOH Permit Number>
<Mailing Address>

Please make any corrections to the above information on the label

Please fill in your location/street address below (if different than mailing address):

Location Address: _____

City: _____ **Zip Code:** _____

CONTACT INFORMATION (person completing the survey):

Contact Name: _____

Contact Phone Number: _____

Alternative Phone Number: _____

PLEASE ANSWER THE FOLLOWING QUESTIONS TO THE BEST OF YOUR ABILITY:

1) Please indicate how you dispose of your food waste (check all that apply):

_____ Throw it away in the trash
_____ Recycle it (recycling company, pig farm)
_____ Donate edible items to the Food Bank
_____ Other (please specify): _____

2) If you recycle your food waste, Please indicate the approximate quantity of food waste recycled per week:

What is the size of your container(s) for food waste? _____

How often is the food waste emptied? _____

How full is your container(s) each time it is emptied? _____

_____ I recycle food waste, but do not know how much is recycled per week.
□ I do not recycle food waste.

3) If you recycle your food waste, please fill in the information below. Companies or farmers collecting food waste from your establishment:

Name: _____ Phone Number: _____

Name: _____ Phone Number: _____

Name: _____ Phone Number: _____

-OVER-

4) **If you do not recycle all of your food waste, please let us know why (Check all that apply):**

_____ Separating food waste from other trash is too time consuming/costly
_____ Contracting a separate food recycling company is too time consuming/costly
_____ Recycling food waste causes certain problems (please specify): _____

_____

_____ Other Reasons (please specify): _____

_____

5) **If your establishment uses cooking oil, how do you dispose of it?**

_____ Throw it away in the trash _____ Recycle it
_____ Pour it down the drain _____ Other (please specify): _____

6) **If you recycle your used cooking oil, please fill in the information below:**

Name of Company collecting the used cooking oil: _____

Approximately how many times a month is it picked-up at the present time? _____

Approximately how much is collected at each pick-up? _____ pounds _____ gallons

7) **To help us understand the size of your establishment, please indicate the number of food service employees you have:**

Full Time: _____ Part Time: _____

8) **Please use the space below for any additional comments you may have:**

_____

_____

_____

_____

_____

_____

_____

Mahalo for completing this survey!
Your responses will help to facilitate food recycling & aid in keeping Hawaii's pig population healthy.

Please return this completed survey by October 15, 2004
in the enclosed postage-paid envelope.

APPENDIX 2: PHONE INTERVIEW SCRIPT AND SURVEYS

Hello can I speak with the _____

Restaurants/Retail: Manager

Schools/Hospitals/Care Homes: Cafeteria Manager

My name is _____ and I'm a student at UH working on a project regarding food recycling and cooking oil recycling. I'm calling all of the food establishments in Hawaii in order to create a database. This project is funded by the Hawaii Department of Agriculture. Your participation in this survey is voluntary and you are free to withdraw from participating at any time. Do you agree to participate in this survey?

If they are busy, ask them when's a good time to call them back (be sure to get their name) or if you could fax/email/mail them the survey (get fax number/email address).

Ask them their Name and if they have an alternative phone number.

Ask for their location address if needed.

QUESTION #1:

Interviewer: What do you do with your food waste?

If they say: What do you mean by food waste?

Interviewer: Your left over food, old food you can't use anymore, table scraps, kitchen waste…Do you throw it away, does a pig farmer pick it up, do you compost it, do you give it to others/employees?

Restaurant-possible answer 1: We don't have any food waste **(SKIP TO QUESTION #6)**

Restaurant-possible answer 2: We just throw it away. **SKIP TO QUESTION #5: *Are there any reasons why you don't recycle it?***

Restaurant-possible answer 3: We give it away to our employees/food bank, donate it, etc. **(SKIP TO QUESTION #6)**

Restaurant-possible answer 4: Someone picks it up (to feed to pigs, hunting dogs, other animals; Recycling Company picks it up, we compost it, etc.) **CONTINUE ONTO:**

QUESTION #3 AND #4

Interviewer: Do you know who picks it up (first name, last name, phone number)?

Do you know how much they pick up?

Important: on amount recycled, be sure to get the unit of measurements. **If they don't know the exact amount, we can calculate it:

How many containers do you usually have?
What is the size of the container(s)?
How full are they when they are picked up?
How many times a week are they picked up?

QUESTION #6

Interviewer: What about your used cooking oil, what do you do with it?

Restaurant-possible answer 1: We don't use any cooking oil. **(SKIP TO #8)**

Restaurant-possible answer 2: We throw it away or pour it down the drain **(SKIP TO #8)**

Restaurant-possible answer 3: We have someone pick it up/we recycle it.

Interviewer: Do you know who picks it up? How much?

QUESTION #8 (ONLY ON VERSION #1)

Interviewer: What meals do you serve….breakfast, lunch, dinner?

QUESTION #9 (ONLY ON VERSION #1)

Interviewer: How many do you serve per day on average?

QUESTION #10 (#8 ON VERSION #2)

Interviewer: Do you know how many employees (food service only) you have (full time and part time)?

Interviewer: That's all the questions I have…do you have any comments about this survey/food and oil recycling?

If you have any questions regarding this project please contact Wendy Okazaki at (808) 956-2341 or if you have comments or complaints, contact UH's Committee on Human Studies (808) 956-5007.

Thank you very much for your time and have a nice day.

PHONE SURVEY (version #1)

Establishment Name:
DOH Permit Number:
Phone Number:
Establishment Type:
Island:

CALL LOG:

Attempt #	Name	Date	Day	Time	Result/Notes
1					
2					
3					
4					
5					
6					
7					
8					

Contact Person Name: _____

Alternative Phone Number: _____
Need Location Address: Yes/No

1) What do you do with your food waste (kitchen waste, extra food, expired food, table scraps, etc.)?

1= Throw it away in the trash **SKIP TO #5**
2= Recycle it (Recycling Company, Pig Farmer, Donate, Compost, Give away, Feed other animals)
3= Don't have any food waste **SKIP TO #6**

4= Other : _____
5= Throw it away & recycle it
6= Throw it away & other
7= Recycle it & other
8= Throw it away, recycle it, & other

2) <u>How is it recycled (if applicable)?</u>

___ Recycling Company (2)
___ Pig Farm (2)
___ Donate it (3) **SKIP TO #6**
___ Compost or Worm Bin (4) **SKIP TO #6**
___ Give to Others (7) **SKIP TO #6**
___ Give to Other Animals (8) **SKIP TO #6**

3) <u>If you recycle your food waste</u>, how much is recycled?

Amount: _____

# of containers: _____ size of containers: _____

how full when p/u: _____ # of p/u per week: _____

4) <u>If you recycle your food waste</u>, who picks up your food waste?

Name: _____

Phone Number:_____

5) <u>If you do not recycle your food waste</u>, please let us know why:

- o Separating food waste from other trash is too time consuming/costly
- o Contracting a separate food recycling company is too time consuming/costly
- o Storage, Transportation, & Logistical Problems (Pick-up problems)
- o Health & Sanitation Problems
- o Liability Issues
- o No food waste/small amount generated
- o Did not know you could recycle food waste
- o Did recycle in the past, but stopped
- o No opportunity to recycle
- o Not allowed to recycle food waste
- o Other:_____

6) If your establishment uses cooking oil, how do you dispose of it?

0= Do not use cooking oil **SKIP TO #8**
1= Throw it away in the trash **SKIP TO #8**
2= Pour it down the drain **SKIP TO #8**
3= It is picked up by: _____

7) <u>If you recycle your cooking oil</u>, how much is recycled?

Amount: _____

How many times a month p/u: _____

How much p/u: _____ lbs/gal.

8) What meals do you serve?

___ Breakfast ___ Lunch ___ Dinner ____Other: _____

9) What is the average number of meals served per day? _____

10) How many employees do you have? _____ Full Time _____ Part Time

COMMENTS:

PHONE SURVEY (version #2)

Establishment Name:
DOH Permit Number:
Phone Number:
Establishment Type:
Island:

CALL LOG:

Attempt #	Name	Date	Day	Time	Result/Notes
1					
2					
3					
4					
5					
6					
7					
8					

Contact Person Name: _____

Alternative Phone Number: _____
Need Location Address: Yes/No

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1= Throw it away in the trash **SKIP TO #5**
2= Recycle it (Recycling Company, Pig Farmer, Donate, Compost, Give away, Feed other animals)
3= Don't have any food waste **SKIP TO #6**

4= Other : _____
5= Throw it away & recycle it
6= Throw it away & other
7= Recycle it & other
8= Throw it away, recycle it, & other

2) <u>How is it recycled (if applicable)?</u>

___ Recycling Company (2)
___ Pig Farm (2)
___ Donate It (3) **SKIP TO #6**
___ Compost or Worm Bin (4) **SKIP TO #6**
___ Give to Others (7) **SKIP TO #6**
___ Give to Other Animals (8) **SKIP TO #6**

3) <u>If you recycle your food waste</u>, how much is recycled?

Amount: _____

# of containers: _____ size of containers: _____

how full when p/u: _____ # of p/u per week: _____

4) <u>If you recycle your food waste</u>, who picks up your food waste?

Name: _____

Phone Number:_____

5) <u>If you do not recycle your food waste</u>, please let us know why:

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- o Contracting a separate food recycling company is too time consuming/costly
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Amount: _____

How many times a month p/u: _____

How much p/u: _____ lbs/gal.

8) How many employees do you have? _____ Full Time _____ Part Time

COMMENTS:

LITERATURE CITED

Ambrozic-Mooz, C. (2005, September 29). Delicious Fuel. *Maui Time*. Retrieved April 24, 2006, from http://mauitime.com/PrintVersion.aspx?story_id=892

Appel Consultants Inc. (1998). *Urban Waste Grease Resource Assessment*. Retrieved September 14, 2005, from http://www.nrel.gov/docs/fy99osti/26141.pdf

Baker Commodities Inc. (no date). *Tallow*. Retrieved March 8, 2006, from http://www.bakercommodities.com/products.html

Belt Collins Hawaii, & Rifer Environmental. (2000). *Hawaii 2000 Plan for Integrated Solid Waste Management*. Honolulu. Retrieved August 1, 2005, from http://www.hawaii.gov/health/environmental/waste/sw/pdf/swmgmpln.pdf

Brown and Caldwell. (1998). *County of Hawaii Grease Disposal Study*. Honolulu.

City and County of Honolulu (no date). *Revised Ordinances of Honolulu Chapter 9 Collection and Disposal of Refuse, Sec. 9-3.5 Food Waste Recycling*. Retrieved June 29, 2005, from http://www.honolulu.gov/refs/roh/9.htm

City & County of Honolulu's Department of Environmental Services. (2005). *Partnership for the Environment*. Retrieved August 29, 2006, from http://envhonolulu.org/solid_waste/Partnership_for_the_Environment.html

City and County of Honolulu Department of Wastewater Management. (2002). *Environmental Information Bulletin for Restaurants and Food Processing Industry FOG*. Retrieved September 14, 2005, from http://www.co.honolulu.hi.us/env/rc/fog.pdf

County of Hawaii Department of Environmental Management Solid Waste Division. (2004). *Study Relating to Used Cooking Oil Generation and Biodiesel Production Incentives in the County of Hawaii*. Retrieved September 14, 2005, from http://www.hawaii.gov/dbedt/info/energy/publications/biodiesel04-report.pdf

Draper/Lennon Inc. (2002). *Identification, Characterization, and Mapping of Food Waste and Food Waste Generators in Massachusetts*. Concord. Retrieved July 10, 2004, from http://www.mass.gov/dep/about/priorities/foodwast.doc

Draper/Lennon Inc., & Atlantic Geoscience Corp. (2001). *Identifying, Quantifying, and Mapping Food Residuals from Connecticut Businesses and Institutions*. Concord. Retrieved July 10, 2004, from http://dep.state.ct.us/wst/compost/ssomfile/ssomreport.pdf

Flores, R. A., & Shanklin, C. W. (1998). *Food Wastes Database Development.* Manhattan: Kansas State University.

Franco, D. A., & Swanson, W. (Eds.). (1996). *The Original Recyclers*. United States of America: The Animal Protein Producers Industry.

Frankel, Z. (no date). What are worm castings and why are they so good?

Hawaii Natural Energy Institute. (2004). *About HNEI.* Retrieved April 17, 2006, from http://www.hnei.hawaii.edu/about.asp

Hawaii Natural Energy Institute. (2004). *History of HNEI.* Retrieved April 17, 2006, from http://www.hnei.hawaii.edu/history.asp

Hickman, H. L., & Eldredge, R. W. (2001). *A Brief History of Solid Waste Management in the US During the Last 50 Years*. Retrieved August 25, 2005, from http://www.forester.net/msw_9909_brief_history.html

Jones, T. W. (2004). *Using Contemporary Archaeology and Applied Anthropology to Understand Food Loss in the American Food System.* Tucson: University of Arizona.

Jones, T. W. (2005). Analyzing Retail Food Loss. *BioCycle, 46*(12).

McCall, W. (2006, April 23). Biodiesel now routine for some restaurants: *The Honolulu Advertiser*. Retrieved April 24, 2006, from http://the.honoluluadvertiser.com/article/2006/Apr/23/bz/FP604230314.html/?print=on

Mathematica Policy Research, Inc. (2006). *Hunger in America 2006: National Report Prepared for America's Second Harvest.* Retrieved March 10, 2006, from http://www.hungerinamerica.org/export/sites/hungerinamerica/about_the_study/A2HNationalReport.pdf

Neal, H. A., & Schubel, J. R. (1987). *Solid Waste Management and the Environment: The Mounting Garbage and Trash Crisis*. New Jersey: Prentice-Hall.

Neuman, W. L. (2004). *Basics of Social Research.* Boston: Pearson Education, Inc.

Pacific Biodiesel Inc. (2005). *About The Company.* Retrieved April 24, 2006, from http://www.biodiesel.com/aboutPacBio.htm

Pacific Biodiesel Inc. (2005). *The Fuel.* Retrieved April 24, 2006, from http://www.biodiesel.com/theFuel.htm

Tchobanoglous, G., & Kreith, F. (Eds.). (2002). *Handbook of Solid Waste Management.* New York: McGraw-Hill.

TenBruggencate, J. (2004, November 24). Biodiesel fuel attracts loyal following in Islands: *The Honolulu Advertiser.* Retrieved April 24, 2006, from http://the.honoluluadvertiser.com/article/2004/Nov/08/ln/ln11p.html/?print=on

Turn, S. Q., Keffer, V., & Staackmann, M. (2002). *Biomass and Bioenergy Resource Assessment State of Hawaii.* Honolulu: University of Hawaii.

Unisyn Biowaste Technology. (1991). *Feasibility Study of Organic Waste Conversion Facilities in Hawaii.* Retrieved September 14, 2005, from http://www.hawaii.gov/dbedt/ert/unisyn/

United States Department of Agriculture. (1994). *Waste Feeding and Swine: Cooking to Prevent Disease* (No. 1539). Washington DC.

United States Environmental Protection Agency. (no date). *Frequently Asked Questions about Recycling and Waste Management.* Retrieved April 9, 2005, from http://www.epa.gov/epaoswer/non-hw/muncpl/faq.htm

United States Environmental Protection Agency. (1997). *Measuring Recycling A Guide for State and Local Governments* (No. EPA-530-R-97-011). Washington DC. Retrieved September 10, 2005, from http://www.epa.gov/recycle.measure/docs/guide.pdf

United States Environmental Protection Agency. (1998). *Don't Throw Away That Food* (No. EPA-530-F-98-023). Washington DC. Retrieved September 14, 2005, from http://www.epa.gov/epaoswer/non-hw/reduce/food/foodmain.pdf

United States Environmental Protection Agency. (1999). *Waste Not, Want Not: Feeding the Hungry and Reducing Solid Waste Through Food Recovery.* Retrieved September 14, 2005, from http://www.epa.gov/epaoswer/non-hw/reduce/wast_not.pdf

United States Environmental Protection Agency. (2005). *Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2003* (No. EPA530-F-05-003). Washington DC. Retrieved October 1, 2005, from http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/msw05rpt.pdf

United States Food and Drug Administration. (2005). *Commonly Asked Questions About BSE in Products Regulated by FDA's Center for Food Safety and Applied Nutrition.* Retrieved February 19, 2006, from http://vm.cfsan.fda.gov/~comm/bsefaq.html

Westendorf, M. L. (Ed.). (2000). *Food waste to Animal Feed.* Ames: Iowa State University Press.

Westendorf, M. L., & Myer, R. O. (2004). *Feeding Food Wastes to Swine.* Retrieved February 5, 2006, from http://edis.ifas.ufl.edu/AN143

Wirth, R. (2005). Diverting Food Residuals in Minnesota. *BioCycle, 46*(9), 47-48.

Young, R. (no date). *Garbage in Paradise: A History of Honolulu's Refuse Division.* Retrieved February 15, 2006, from http://www.opala.org/history.html