CPS CENTER for PRODUCE SAFETY

CPS 2010 RFP
FINAL PROJECT REPORT

Project Title

A baseline analysis of Washington state fresh market apple food safety programs and practices relating to microbial pathogens

Project Period

January 1, 2011 – December 31, 2011

Principal Investigator

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Objectives

1. Meet with The Pacific Northwest Food Safety Executive Committee to gain an understanding of the potential apple microbial issues, practices used and current data availability.
2. Solicit industry support for scope and participation in the project during the Washington State's Horticultural Association's annual meeting in December 2010.
3. Develop a questionnaire for distribution to packing houses to obtain information on the food safety programs and efforts contributing to the mitigation of microbial pathogens currently in place.
4. Collect industry data.
5. Prepare database and evaluate data quality.
6. Prepare a baseline report of microbial pathogens, food safety programs and current mitigation practices and their ability to reduce microbial pathogens.

FINAL REPORT

Abstract

In early 2011, Intertox began work on the Center for Produce Safety (CPS) and Washington State Department of Agriculture-funded research project entitled, "A Baseline Analysis of Washington State Fresh Market Apple Food Safety Programs and Practices Relating to Microbial Pathogens." The project goal was to document the current food safety programs and mitigation practices that the fresh market apple packing companies in the state of Washington are using to address potential microbial pathogens. To achieve this goal, Intertox partnered with the Northwest Horticultural Council (NHC) and the Washington Tree Fruit Research Commission (WTFRC) for research support and access to the packing houses. The study methodology used to address the project's objectives included the development and delivery of a survey instrument followed by the collection of microbiological testing data, creation of a database and data analysis. The survey respondents represent 55% of all apple packing companies (conventional and organic) in Washington. Microbiological testing data of water, environmental, and product samples from 2005-2010 was collected from 17 companies which represent 29% of the companies in the fresh market apple packing industry.

Background

As the leading tree fruit supplier in the U.S., Washington and its research entities and associations such as the NHC and the WTFRC are particularly focused on ensuring the produce grown, packed, stored, and distributed remains safe from microbial contamination. To this end, in 2010 the NHC and the WTFRC collaborated with the CPS and the Washington State Department of Agriculture to sponsor work that would "fill the gaps in our basic understanding in specific areas of food safety practices for fruit…production, harvest and post-harvest handling" (CPS, 2010). The NHC and the WTFRC further focused this initial research project on apples and, in particular, fresh market apples in packing houses. While there is some research on the effectiveness of various practices used to mitigate microbial pathogens on apples, these studies are primarily related to the production of apple juice and not specifically to the occurrence of pathogens on the fruit itself or on packing houses that pack fresh market apples (Yuste, 2003; Reinders, 2001; Dingman, 2000). To better understand how current practices affect occurrence of pathogens in the packing house environment, the NHC and the WTFRC sought to evaluate levels of microbial pathogens at Washington fresh market apple packing houses and measures currently used to mitigate these populations. The research therefore centered on compiling data on pathogen occurrence and analyzing it for variations and trends, in order to provide the fresh market apple industry in Washington with valuable information on how their practices affect product safety.

After meetings with the Pacific Northwest Food Safety Executive Committee in 2010 and visits to individual packing houses to understand the potential apple microbial issues, practices used, and current data availability, Intertox met with apple packing house companies at the Washington State Horticultural Association's annual meeting in December 2010 to provide an overview of the project and to request individual company support and participation.

Research Methods and Results

The objectives of this tree fruit research project were to:

1. Determine if "existing public and private datasets can be collated and utilized to help establish baseline levels of microbial contaminants and common mitigation procedures."
2. Determine "the frequency of generic microbial contamination on Washington fresh market

apples in packing houses."

3. Identify "mitigation steps that could be used to manage generic microbial contamination risks for Washington fresh market apples." (CPS 2010)

The study methodology used to address each of the above three objectives included the development and delivery of a survey instrument, data collection, creation of a database, and data analysis. The survey was developed and distributed with the support of the NHC and the WTFRC and was fielded in order to obtain information on the food safety programs, efforts contributing to the mitigation of microbial pathogens, and types and frequency of microbial testing currently in place. The survey was also used to solicit packing houses' willingness to provide historical microbial testing data for the project in order to collate and utilize private datasets. After obtaining individual packing house permission to access and use their testing data, Intertox hired Intertox Decision Sciences (IDS) to collect the data, purge confidential company details, and build a Microsoft Excel (2010)-based microbial test database. Intertox then evaluated the data in order to establish baseline microbial pathogen levels, food safety programs, and current mitigation practices and their ability to reduce microbial pathogens. The research findings were presented to the Pacific Northwest Food Safety Executive Committee in December 2011 and to attendees at the annual Washington State Horticultural Association's meeting also in December 2011.

Prior to fielding the survey, Intertox worked with the NHC and the WTFRC to size the fresh market apple packing industry in Washington. Using the Washington State Department of Ecology's 2010 fresh fruit packing permit list, Intertox determined that the number of companies actively packing fresh market apples is 58.[1] Since packing operations are expected to vary based on the size of the packing house, Intertox worked with the NHC using input from individual packing houses to segment the packing house industry by the number of boxes shipped. According to Grower-Shipper data, 102.7 million 40 lb. boxes of fresh market apples were shipped from Washington in 2010.[2] The segmentation resulted in three groupings: small (<1.25 million boxes), medium (1.26 – 3.75 million boxes), and large (>3.76 million boxes) packing houses. Using industry mailing lists and industry knowledge, Intertox, the NHC, and the WTFRC were collectively able to determine the appropriate size segmentation for each of the 58 active apple packing companies. The resulting segmentation consists of 26 small, 24 medium, and 8 large packing houses.

Survey results

In December 2010, the NHC distributed a packing house survey consisting of 19 questions via email to its membership, and the WTFRC distributed the survey to non-NHC members. As noted previously, the purpose of the survey was to obtain information on the current food safety programs, microbial testing, and mitigation practices. In addition, the survey was used to bring awareness of the project to Washington companies, to validate the company segmentation, and to identify companies willing to provide test data for the project. Survey results were sent directly to Intertox; company-specific results were confidential. When the survey closed on April 5, 2011, thirty-two completed surveys had been received. Using the industry size data, the survey respondents represent 55% of all apple packing companies (conventional and organic) in Washington. Fifty percent of packers responding to the survey categorized their operations as medium, 34% as small, and 16% as large.

According to the Washington State Department of Ecology, most water utilized in fresh fruit packing in Washington comes from municipal purveyors and/or private wells (WA DOE, 2009). Of the 32

[1] The Department of Ecology's Water Quality Program issues permits for wastewater discharges from packing facilities.
[2] Grower Shipper of Yakima collects fees from packinghouses based on the number of boxes shipped.

participating packing companies, 72% used water from a municipal source for at least some of their operations while 41% obtained some or all of their water from wells on their property. Water testing is prevalent with 94% of survey respondents reporting that they test their process water regularly for microbial load including all of the respondents categorized as small and large companies. Of those companies that test their water, 93% tested their source water. Testing frequency varied with 15 companies reporting that they test the water source quarterly, four companies test annually, one company tests three times a year, three companies test monthly and three test semi-annually. The organisms most often tested for are fecal coliform and generic *E. coli*. Organisms other than fecal coliform and generic *E. coli* included total coliform, *Listeria*, and *Salmonella*.

Microbial swabbing is often used to validate cleaning and sanitizing processes in food processing facilities. Seventy-eight percent of the survey respondents reported using environmental testing to check microbial levels at their packing facility including 100% of large companies and 82% and 69% of small- and medium-sized companies, respectively. They reported testing for fecal coliform, generic *E. coli*, *E. coli* O157:H7, total coliform, *Listeria* spp., and *Salmonella*. The location and frequency of environmental testing were reported as well. Of the companies that reported their testing frequency, the majority said they did so quarterly while other report testing annually, semi-annually, 3-4 times per year, and monthly. Areas commonly sampled by companies include equipment, drains and the wall area in the production part of the facility.

Of the 32 survey respondents, nine reported they conduct microbiological testing of their apples before shipping to customers (end product testing). Of these responses, reasons for testing include buyer requirements, audit requirement, food safety program verification, and foreign market requirements. Seventy-eight percent of companies that test their apples took samples at the end of the packing line. Other points in the packing process where apples were tested were after washing but before packing and before sizing.

More than 40% of Washington apple packing houses follow more than one auditable food safety program. Food safety programs apple packers report following are Safe Quality Food (SQF) 2000, PrimusGFS™, USDA's Audit Verification Program, HACCP, and buyer-specific programs. Of the 32 survey respondents, the SQF 2000 food safety program was the most commonly followed program with a 78% participation rate that included all large company respondents. Eight companies reported following buyer-required food safety programs.

Database

In preparing the research plan, Intertox, the NHC, and the WTFRC established a goal of obtaining five years of microbial test data from 10 packing houses in order to ensure the data was representative of the industry. Once the survey closed, Intertox had commitments from 17 companies to provide their microbial data. The distribution of the 17 packing houses is 31%, 25%, and 38% of the total small, medium, and large companies, respectively.

Individual packing house data were collected between May 2011 and November 2011. During that time, IDS contacted each of the 17 packing houses to discuss its survey responses and to obtain agreement on how and when to acquire its microbial data. IDS contracted with Cascade Analytical, Inc. to obtain individual company data upon receiving the appropriate authorization forms. Most packing houses providing data did so through Cascade Analytical. After receiving the data, IDS compiled the results into a Microsoft Excel (2010) database and then removed confidential record details. Company names were replaced with numerical references. Process identifiers such as line names and locations were also removed.

Initially, the dataset consisted of approximately 3,000 records. More than 500 records were removed from the dataset either because they contained grower tests or tests for other fruits such as cherries and pears. Other records were removed because final test results were missing. The remaining test records were considered to be of sufficient quality to be included in the dataset.

Several data limitations were noted in the process of compiling the dataset. First, the dataset contains test results from five different laboratories each using different test methods. For this reason, a comparison of some data, MPN (most probable number) results in particular, is difficult. Many of the tests, however, are conducted on a presence/absence basis that does allow for comparison across laboratories using approved methods. Second, even though data was collected from 2005-2010 and represented 29% of the companies in the industry, there are relatively few test results for environmental and product tests. This is the result of many companies beginning only recently to regularly conduct testing. Also, the frequency of testing, in some cases annual testing, had an effect on the amount of test results; infrequent testing did not produce a large number of results. The second limitation had the greatest impact on the results described in the following section. To address the limitations, Intertox has discussed a plan with the NHC and the WTFRC for acquiring additional data in 2012.

Test methods used by laboratories to analyze the microbial populations of water, environmental, and product samples are, for the most part, methods that are AOAC validated and approved by the FDA or, in the case of water, the U.S. EPA. Test methods used include traditional culturing methods, which provide the ability to visually count or quantify the microbes and thus estimate the number of microbes in the original sample (e.g. MPN, Petrifilm) as well as methods that indicate the presence or absence of a microbe (e.g. PCR, immunoassays). Presence/absence test methods typically produce results in less time than culturing methods.

The Code of Federal Regulations requires water that contacts food to "be safe and of adequate sanitary quality." Therefore water used in packing facilities is commonly tested, typically for indicator organisms such as total or fecal coliform or generic *E. coli*. If packing houses use municipal water, they may rely on the municipal testing and results rather than conduct their own source water testing at their facility. The U.S. EPA requires municipal water supplies to be tested for total coliform with positive samples also tested for fecal coliform or *E. coli*. In addition to source water, packing houses test water used in the packing line, specifically in the dump tank and at spray bars.

Participating packing houses report a total of 516 water tests for the period of 2005 through 2010 – 60% of all water test results were for total coliform, 23% for fecal coliform, and 16% for generic *E. coli*. Of the water samples that were tested for fecal coliform and generic *E. coli*, 84% and 72%, respectively, had levels less than 2 MPN/100 mL. Water samples analyzed for fecal coliform and generic *E. coli* were taken from the dump tank, source water, and other areas of the pack line such as the pressure wash, rinse bar, and flume.

Thresholds for fecal coliform that are currently used by the industry include the Washington State Department of Ecology's recreational water standards for primary contact which have a maximum threshold for a single sample of 200 CFU/100 mL and a geometric mean of 100 CFU/100 mL. At least 96% of all tests for fecal coliform in water were $\leq$ 200 MPN/100 mL and at least 94% were $\leq$ 100 MPN/100 mL.[3] With the exception of one sample, all water samples with results $\geq$500 MPN/100 mL were taken from the dump tank; the remaining sample location was listed as process water.

[3] For the purposes of water testing, MPN and CFU are considered equivalent.

The Colilert® test method is often used to test water for total coliform and generic *E. coli*. Colilert® water test results (n = 310)were most often negative for both total coliform and *E. coli* (86%), with 13% positive for total coliform but negative for *E. coli*, and only 1% positive for both total coliform and generic *E. coli*. Sample locations included source water, process water, and locations other than the packing line including water in offices, shops, laboratories, fountains, and break rooms. Two source water samples were positive for both total coliform and *E. coli* and 19 source water samples were positive for total coliform but negative for *E. coli*. For process water, 18 process water samples were positive for total coliform but negative for *E. coli,* and one sample was positive for both total coliform and *E. coli*.

Microbiological testing of surfaces in a packing facility is often used to validate a packing house's processes such as its HACCP plan and corresponding standard operating procedures (SOPs) and sanitation standard operating procedures (SSOPs). The test data show that companies test environmental surfaces for both pathogens and indicator organisms. Companies tested environmental surfaces in their packing houses for generic *E. coli* and *Listeria* spp. more than they did for *Salmonella* or total coliform.

Environmental testing increased in 2009 and 2010 from previous years. From 2009 to 2010, with the exception of *Salmonella* testing, testing for all target organisms increased substantially: total coliform increased by 83%, generic *E. coli* by 81%, *Listeria* by 74%, and *Salmonella* by 25%. Not only did the volume of testing increase from 2005 to 2010, but the number of sampling locations increased as well indicating that packing houses are broadening the scope of their environmental sampling programs

When examining the environmental test data, positive results were reported for total coliform, *E. coli*, and *Listeria*. There were no human pathogens (e.g., *E. coli* O157:H7 and *Salmonella*) detected in the environmental tests.

Packing companies may test their apples for microbiological contaminants to ensure the effectiveness of their HACCP plan, SOPs, and SSOPs. Between 2005 and 2010 when products were tested, they were more frequently tested for *Salmonella* (41%), *Listeria* (29%), and *E. coli* O157:H7 (20%) than for generic *E. coli* (9%) and *Listeria monocytogenes* (1%). When examining product testing by year, in 2008 the number of tests conducted for *Salmonella* and *E. coli* O157:H7 peaked and then rapidly declined. By 2010, the number of tests for both pathogens had fallen below 2006 levels. *Listeria* testing remained relatively flat between 2007 and 2009. By 2010, however, *Listeria* testing had also declined below 2006 levels. The limited number of generic *E. coli* tests ranged from five to 14 per year over the five year period.

In the six year period from 2005 through 2010, there were 565 product tests and slightly less than one percent was positive. There were 118 tests for the human pathogens *Listeria monocytogenes* (4 tests) and *E. coli* O157:H7 (114 tests), resulting in one positive *E. coli* O157:H7 and one positive *Listeria monocytogenes* result. The positive product tests for *E. coli* O157:H7 and *Listeria monocytogenes* occurred at two separate companies, and in further examination, there is no linkage between these results and any of the positive environmental or water test results.

While there is little information from the test data to determine what happens when tests results are positive, the industry survey does provide information on how packing houses respond. In the survey results, when microbiological test results are positive or higher than expected, respondents described mitigation steps or corrective actions taken by the company. The most common action included retesting (44%). Other common actions included re-cleaning or re-sanitizing (34%), a review of cleaning/sanitizing/disinfecting procedures (28%), a system/process line check for failure (22%), retraining (6%), and isolating or quarantining the product until the issue is resolved (6%).

Packing house control and mitigation measures to prevent contamination

Factors that could contribute to the lack of reported illnesses associated with the consumption of whole fresh market apples include growers practicing good agricultural practices that effectively control pathogens on apples, packing houses successfully controlling and mitigating pathogens in the packing line by using good handling practices, and consumers washing apples before consuming them. The research results provide some indication of the measures apple packing houses have taken to control and mitigate contamination. Unless otherwise cited, information about these measures was gathered in the industry survey, in site visits to several packing houses, and in conversations with members of the industry.

Water used in the packing line usually contains a disinfectant. If disinfectant is not added to the flumes at the beginning of the line, then it is added to the water further downstream during the washing and rinsing processes. The most commonly used disinfectants are chlorine or peracetic acid (PAA). Choice of disinfectant chemical and concentrations used depends on the condition of the apple (i.e. calcium build-up from water exposure in the orchard), waste water discharge requirements, program requirements (organic standards), and customer requirements among other factors. The length of time apples spend in the flume varies per operation, but generally allows product to have contact with disinfectant for over a minute.

Concentrations of chlorine are generally in the range of 10 – 100 ppm with higher concentrations used at the beginning of the line due to suspended organic and inorganic load from residues on the fruit and bins coming out of the orchard. Also some foreign countries require use of high concentrations of chlorine as a condition for imports.

In the industry survey, participants were asked to report their use of disinfectant chemicals and monitoring frequency. Types of disinfectant chemicals used vary greatly per respondent with most companies indicating they use more than one chemical disinfectant. The two most commonly used disinfecting chemicals are PAA (66%) and chlorine dioxide (63%). Fifteen companies use a combination of these two chemicals in their operations, and eighteen companies use other disinfectants such as ozone or other forms of chlorinated products. One company reported not using disinfecting chemicals in their packing operations. Of the respondents who monitor disinfectant levels, eleven companies reported monitoring continuously, twelve at one-to-two hour intervals, and seven three-to-four times daily. Other monitoring frequencies reported are every 30 minutes and twice a day. At least six companies reported using more than one monitoring frequency such as one time interval for manual monitoring and another for automated monitoring. One company indicated that they had a specific monitoring system for a particular buyer.

In addition to disinfectants in the water, the apple washing process includes the use of hot water and cleaning agents that provide another mechanism to control and mitigate microbial contamination. During washing, apples are subject to high-pressure sprays of hot water, detergents, and brushing – all of which have the potential to clean away microbes as well as dirt and chemical residues. Water temperatures in these processes generally range between 27°C to 49°C (80° to 120° F). Fleischman et al. (2001) reported that immersing whole apples in 80 and 95°C water for 15 seconds or less, resulted in a greater than 5-$\log_{10}$ reduction of *E. coli* O157:H7. Kenney and Beuchat (2001) assessed removal of *E. coli* O157:H7 from bruised and not bruised apples by washing and found that washing significantly reduced E. *coli* levels on apples under both conditions.

The characteristics of commercially available cleaning agents used to wash apples vary from acidic (low pH) to basic (high pH) with contact times that range from seconds to over a minute (Kenney, 2002). Kenney and Beuchat (2002) investigated the effectiveness of five commercially available cleaners to

remove *Salmonella* and *E. coli* O157:H7 from apples. *Salmonella* was removed more effectively than *E. coli* O157:H7 by all the cleaners with reductions ranging from a 3.11-$\log_{10}$ reduction on the high end to a 0.18-$\log_{10}$ reduction on the low end in comparison to apples washed with water alone. The pH, exposure time, and cleaner concentration were not correlated with the reduction in microbial population.

Another area in the packing line that may present a challenge to microbial survival is the waxing and drying process. Some waxes contain chemicals that have antimicrobial activity. Kenney et al. (2002) investigated whether these chemical components of wax affected the survival of *E. coli* O157:H7 and *Salmonella* Muenchen. Apples that were inoculated with *E. coli* O157:H7 before being waxed, dried, and stored at 2°C exhibited significant reductions in pathogen levels with 3.05 $\log_{10}$ and 4.95 $\log_{10}$ reductions at 3 and 6 weeks of storage, respectively. Apples that were inoculated with *Salmonella* Muenchen under the same experimental conditions had significant reductions in pathogen number with reductions as great as 4.72 $\log_{10}$ at both 6 and 12 weeks of storage. Apples that were inoculated but not waxed exhibited very little reduction in either pathogen at 6 weeks of storage.

After wax is applied, the wax goes through a "setting" process (WA DOE, 2009). Wax is most often set by exposure to heated air in a drying tunnel. During this setting process, apples travel through a drying tunnel where temperatures are generally in the range of 100° to 150° F. Exposure times at this temperature vary, but may be as long as a minute. However, in the study mentioned above by Kenney et al. (2002), drying temperatures of 70° F and 131° F had no significant effect on populations of *E. coli* O157:H7 and *Salmonella* Muenchen.

Cleaning and sanitizing of equipment is a critical step in food safety to help eliminate or reduce microbial populations including human pathogens. These activities are especially crucial for surfaces that have direct contact with the apples (food contact surfaces). Controlling for potential contamination from food contact surfaces usually involves routine cleaning and sanitizing of those surfaces. Cleaning frequency varies depending on the surface. If dump tank water contains disinfectants, then bins are exposed to disinfectant when they are immersed in the dunk tank. In addition to this, some companies have a separate bin washing and sanitizing step for bins that hold incoming fruit. Dump tanks are emptied and cleaned every one to three days, depending on the use of disinfectants in the water. Other contact surfaces such as conveyors, guides, and brushes are cleaned and sanitized on a routine basis (e.g., daily, weekly, or monthly). Curtains and conveyors are made of a variety of materials depending on their intended use. Conveyors, depending on whether they are flat or inclined, may contain product gripping mechanisms that may be more difficult to clean due to grooves, indentations, etc. Some of these materials may also contain antimicrobials such as silver or copper.

Humans can transmit pathogens to food if their hands are contaminated and they handle food items. Food safety programs in the fresh produce industry include measures to address employee hygiene practices. Workers handle apples at various points in the packing house line, primarily during sorting and packing activities. When handling apples, workers may or may not use gloves. If gloves are used, they may or may not be disposable. One of the primary reasons cited for not wearing gloves was the diminished ability to assess the apple quality without physical contact with the apple.

Outcomes and Accomplishments

The goals for this project were to establish baseline levels and frequency of microbial contamination on Washington fresh market apples in packing houses and to identify mitigation steps that are being used to manage generic microbial contamination risks. To achieve these goals, individual company test data were collected and used to populate a database in order to establish microbial contamination baseline levels and frequencies. A survey instrument was used to collect and evaluate efforts made by packing houses to control and mitigate potential contamination risks.

While the number of companies providing test data represents 29% of the total market (31% of small companies, 25% of medium companies and 35% of large companies), unfortunately too few total environmental and product tests data points were available to establish baseline levels and frequency of generic microbial contamination. At best, the resulting data is informative but does not allow for a clear understanding of the baseline levels and frequencies of microbial contamination. Given that routine environmental testing programs have only recently been implemented in a number of the packing houses, the addition of 2011 data and the inclusion of additional packing houses could produce enough data points for establishing a baseline for environmental contamination and frequency. However, this may not be the case for product testing. Over the six year period from 2005 to 2010, environmental testing has generally increased while product testing has decreased after peaking in 2008. This may reflect a shift in focus of food safety programs toward prevention with sampling programs redirected to identify potential contamination of food contact surfaces instead testing the end product for contamination. Further research in 2012 will include efforts to collect additional environmental and product test data in order to complete the baseline analysis.

While the microbiological testing results that were obtained during this project resulted in very few positives, it is unclear whether the data indicate a measure of success for the food safety programs of the participating packing houses. Although the research is not at a point of establishing a correlation between microbial control and mitigation practices and results, the research was effective in establishing baseline mitigation practices. With 55% of all packing houses responding to the microbial survey representing small, medium, and large companies, the survey results are reflective of the total market. Information collected during the survey provides insight into the types of microbial contaminants controlled for by packing houses control and how they are controlled, monitored, or tested.

Summary of Findings and Recommendations

Summary of Survey Findings:

- Thirty-two companies, representing 55% of all apple packing companies (conventional and organic) in Washington, completed surveys. Thirty-four percent of the survey respondents categorized their operations as small (<1.25 million boxes), 50% as medium (1.26 – 3.75 million boxes), and 16% as large (>3.76 million boxes).
- 94% of survey respondents reported that they test the water used in the packing line regularly for microbial load. The organisms most often tested for are fecal coliform and generic *E. coli.* Target organisms other than fecal coliform and generic *E. coli* included total coliform, *Listeria*, and *Salmonella*.
- Seventy-eight percent of the survey respondents reported using environmental testing to check microbial levels at their packing facility including testing for fecal coliform, generic *E. coli*, *E. coli* O157:H7, total coliform, *Listeria* spp., and *Salmonella*.
- Of the 32 survey respondents, nine reported they conduct microbiological testing of their apples before shipping to customers.

Summary of Data Findings:
Based on the test results, packing houses conduct microbiological testing of water, various surfaces in the packing house, and occasionally, apples at various points in the packing line.

- Water testing is more prevalent than other types of testing. 516 water tests were reported for the period of 2005 through 2010 with 60% tested for total coliform, 23% for fecal coliform, and 16% for generic *E. coli*. Of the water samples that were tested for fecal coliform and generic *E. coli*, 84% and

72%, respectively, had levels less than 2 MPN/100 mL. Colilert® water test results (n = 310)were most often negative for both total coliform and *E. coli* (86%), with 13% positive for total coliform but negative for *E. coli*, and only 1% positive for both total coliform and generic *E. coli*.

- Environmental testing has generally increased since 2006. Companies tested environmental surfaces in their packing houses for generic *E. coli* (39%) and *Listeria* spp. (30%) more than they did for *Salmonella* (17%) or total coliform (14%).
- From 2009 to 2010, with the exception of *Salmonella* testing, environmental testing for all target organisms increased substantially. From 2005 to 2010, the number of sampling locations increased as well. Positive results were reported for total coliform, generic *E. coli*, and *Listeria* spp. *E. coli* O157:H7 and *Salmonella* were not detected in the environmental tests.
- Product testing has decreased since 2008. Of the 565 product tests conducted between 2005 and 2010, slightly less than one percent was positive.

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APPENDICES

Publications and Presentations (required)

The attached presentation was made to the Washington State Horticultural Association on December 7, 2011. The data used was preliminary and has since been revised.

Budget Summary (required)

The total Budget for this grant was $58,885.00. The breakdown of Budget was $51,229 for Salaries & Wages, Travel $738, Supplies $318 and Subcontractors/Consultants $6,600. The Grant has been billed out at 100%. Except for the P.I.'s costs, the grant funding covered the project costs.

Suggestions to CPS (optional)

A Baseline Analysis of Washington State Fresh Market Apple Food Safety Programs and Practices Relating to Microbial Pathogens

Intertox, Inc.
The Northwest Horticultural Council
The Washington Tree Fruit Research Commission

December 7, 2011

Project Background

- Center for Produce Safety Project
  - "Can existing public and private datasets be collated and utilized to help establish baseline levels of microbial contaminants?"
  - "What is the frequency of generic microbial contamination on WA fresh market apples in packing houses?"
  - "What mitigations steps could be used to manage generic microbial contamination risks?"

Project Objectives

- Develop and field a questionnaire on packinghouse microbial testing
- Obtain agreement from packinghouses to provide their proprietary test data
- Collect test data, build a database, and analyze data for patterns and trends
- Prepare a baseline report on microbial populations and mitigation measures

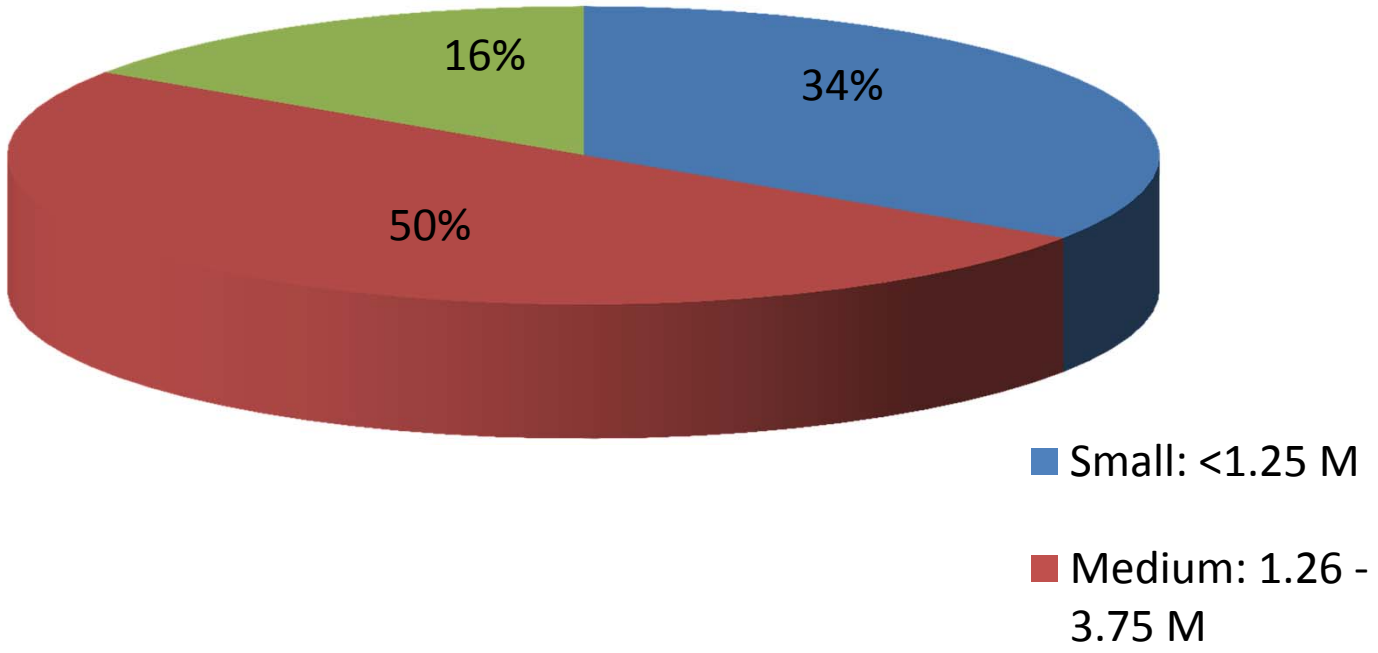
Packinghouse Survey

- Baseline existing food safety practices and testing, verify packinghouse size and solicit data for database
- Addressable market
  - Number of packinghouses-Department of Ecology data and research from the NHC and WTFRC
  - Market segmentation- 2010 Grower-Shipper data and interviews with packers
  - Packinghouse distribution by size -data and research from the NHC and WTFRC

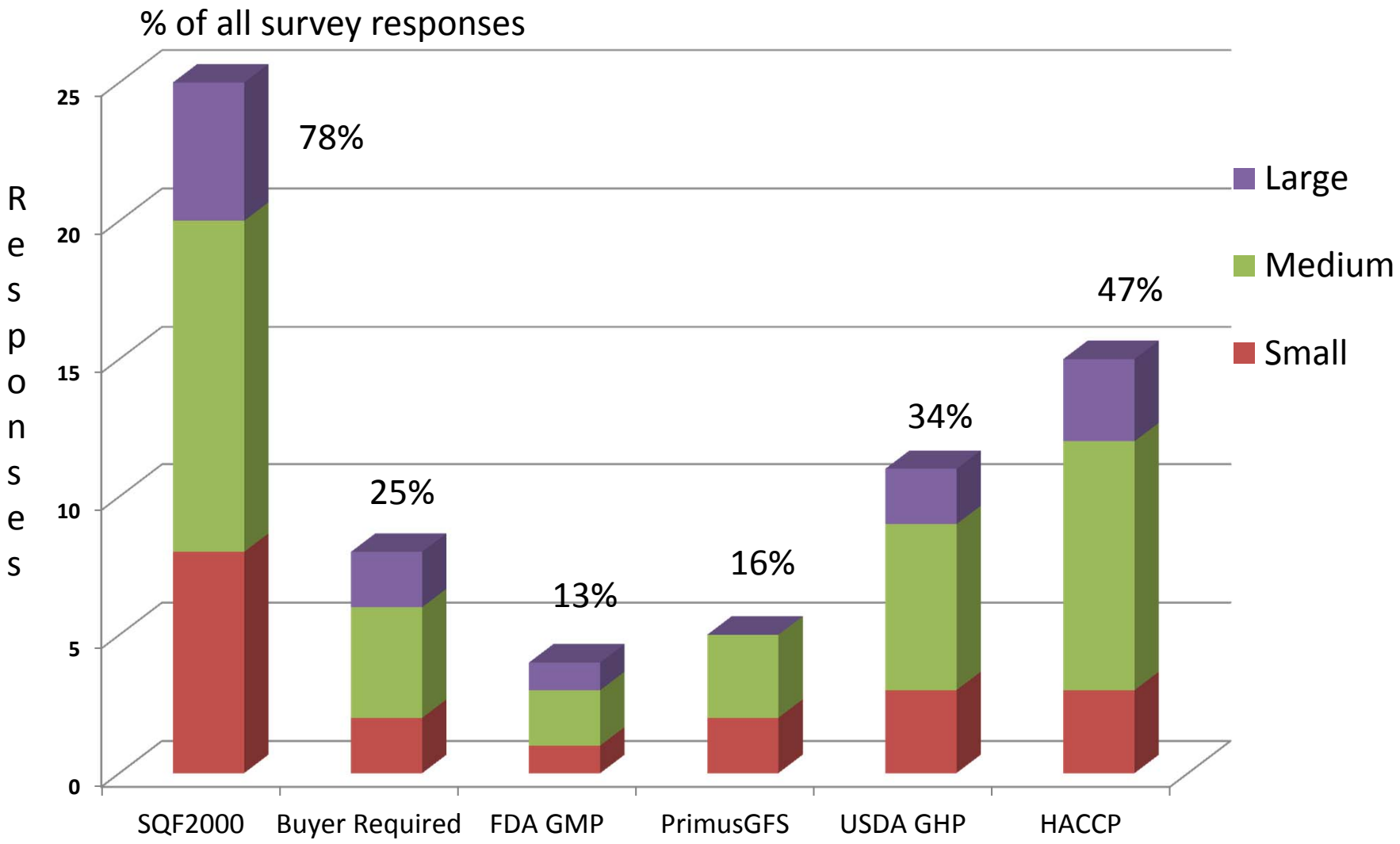
Washington State Apple Packing

- Total of 58 apple packinghouses
- Market segmentation - size based on millions of boxes packed
  - Small < 1.25 m
  - Medium 1.26m -3.75m
  - Large > 3.75m
- Packinghouse distribution
  - 26 Small
  - 24 Medium
  - 8 Large

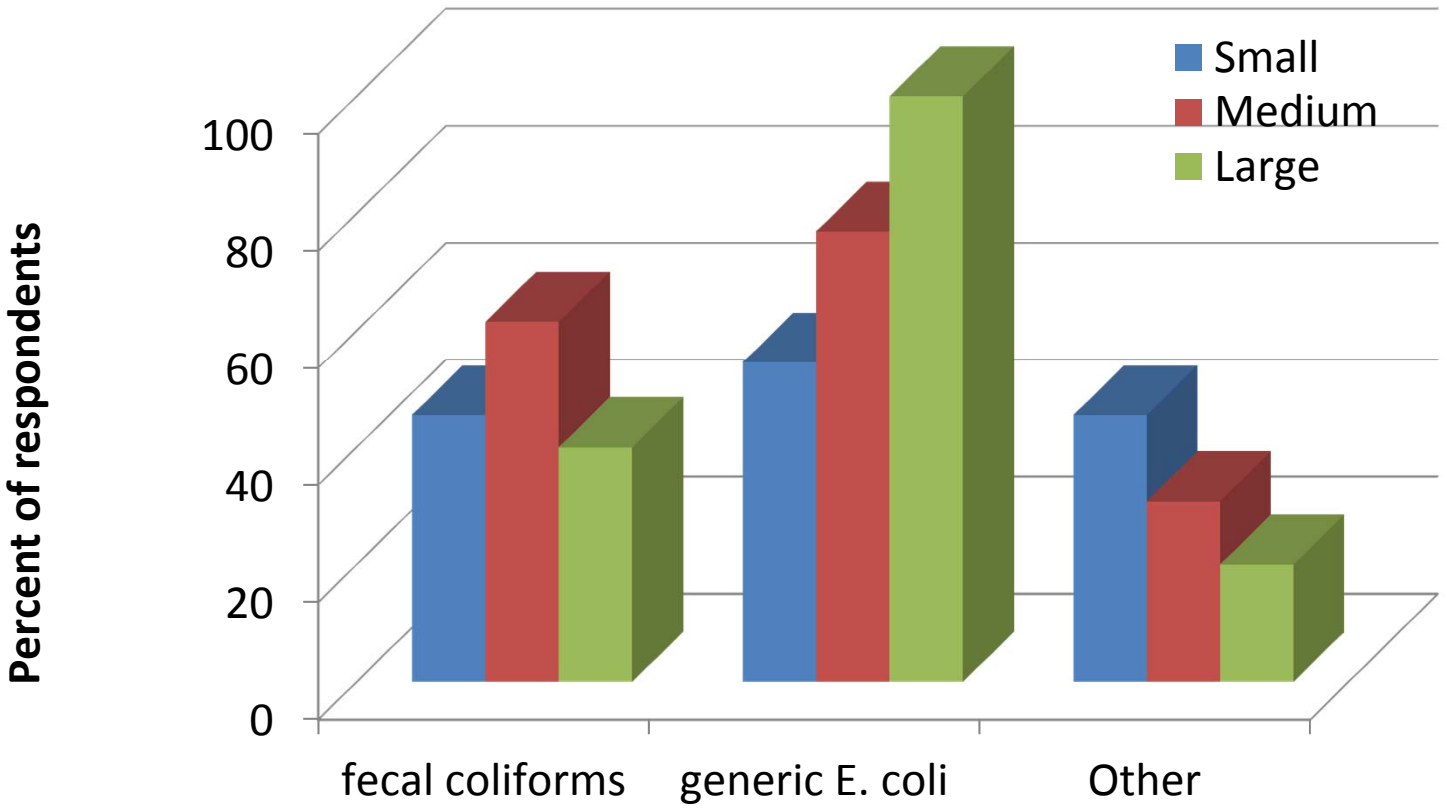
Survey Respondents by Size (n=32)



Food Safety Programs



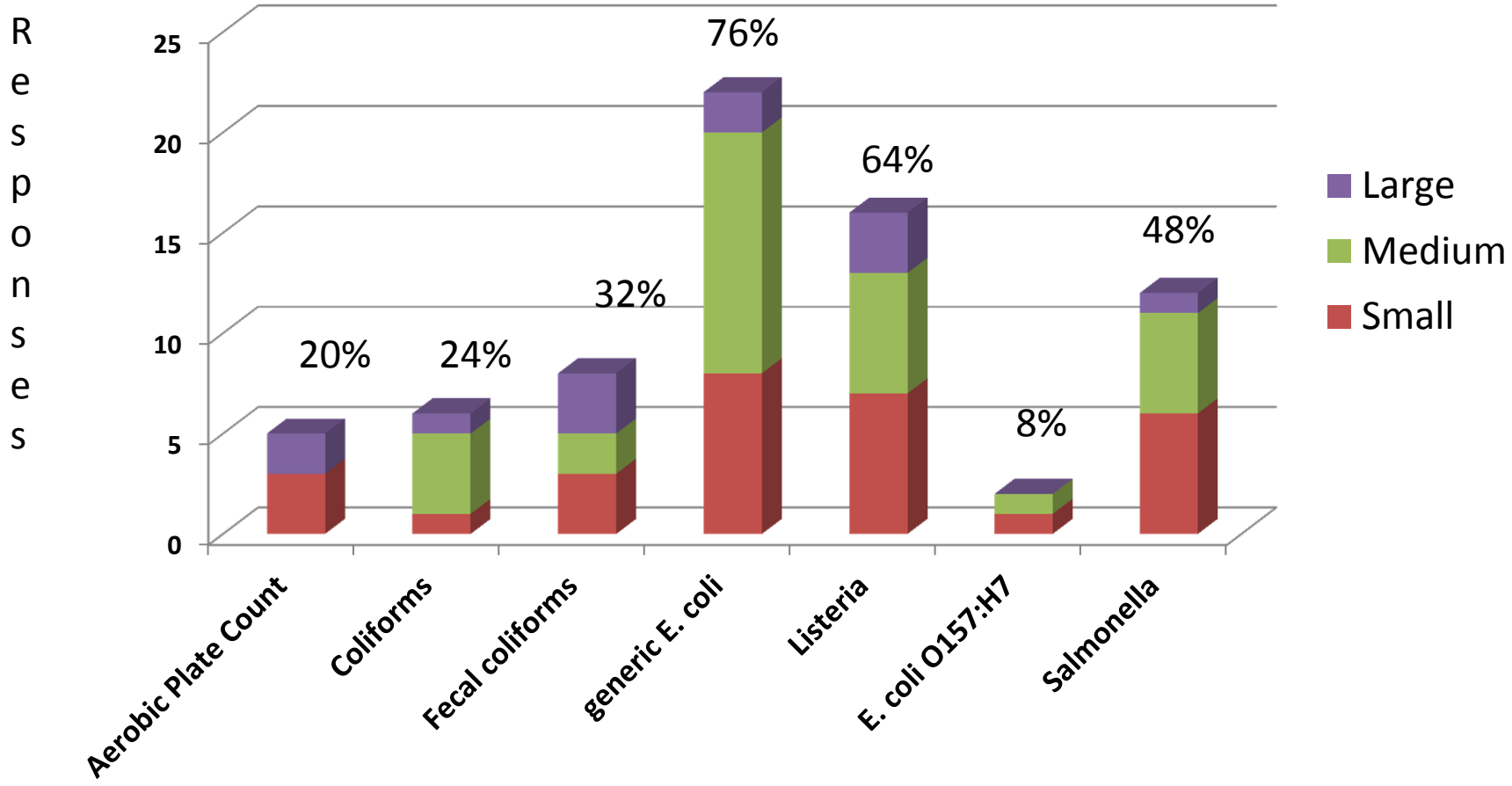
Process Water Testing – Target Organisms



Other includes Salmonella and Listeria

Target Organisms for Environmental Testing

% of all survey responses



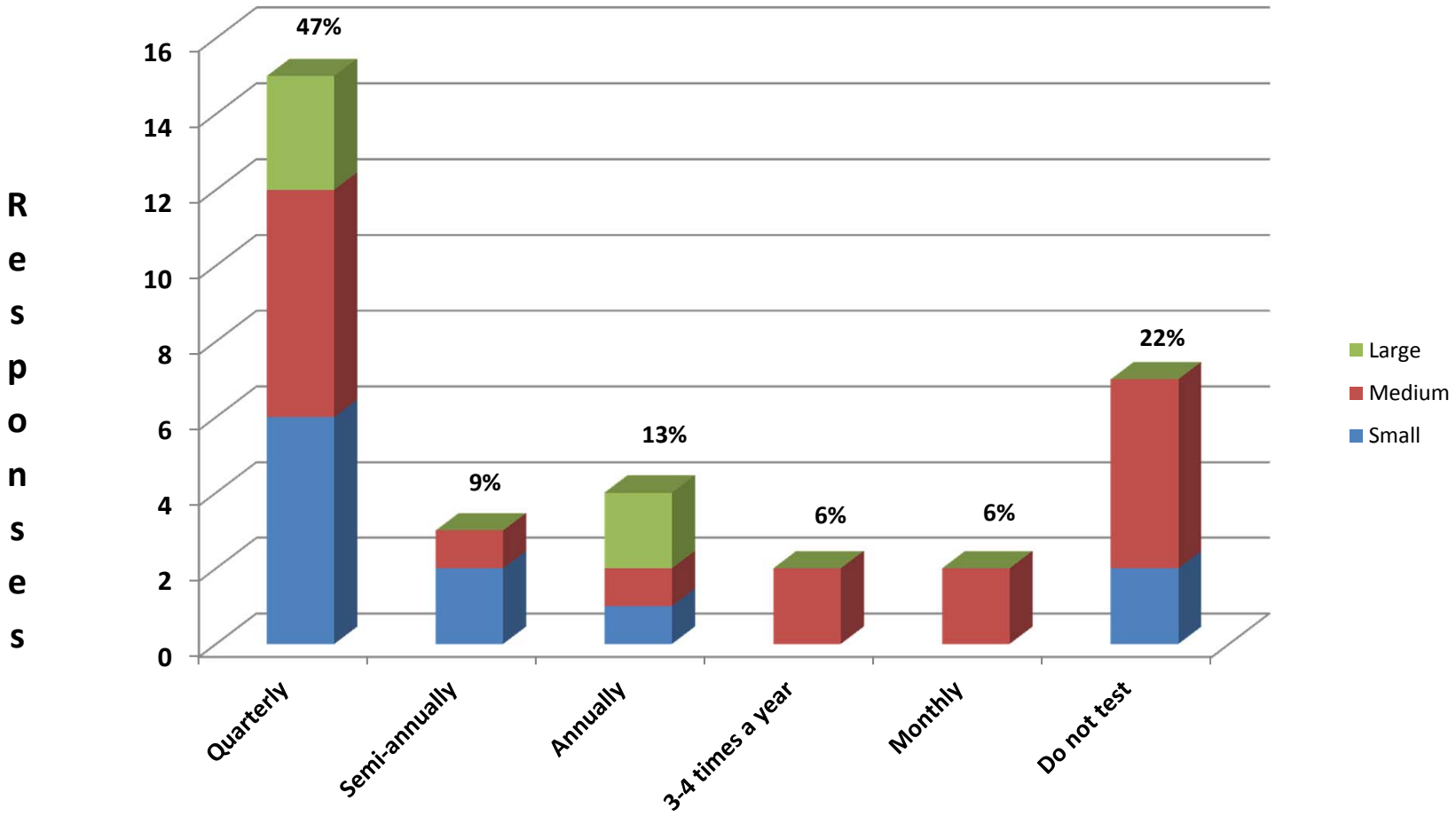
Swab Testing

Location of swab test	% of respondents who test	Small	Medium	Large
Equipment	100%	100%	100%	100%
Drains	67%	89%	69%	20%
Restroom walls	44%	44%	46%	40%
Restroom floors	7%	11%	8%	0%
Production room walls	59%	56%	69%	40%
Cold storage walls	22%	44%	8%	20%
Other*	30%	22%	38%	20%

*Other includes door handles, doors and fruit contact surfaces

Frequency of Environmental Testing

% of all survey responses



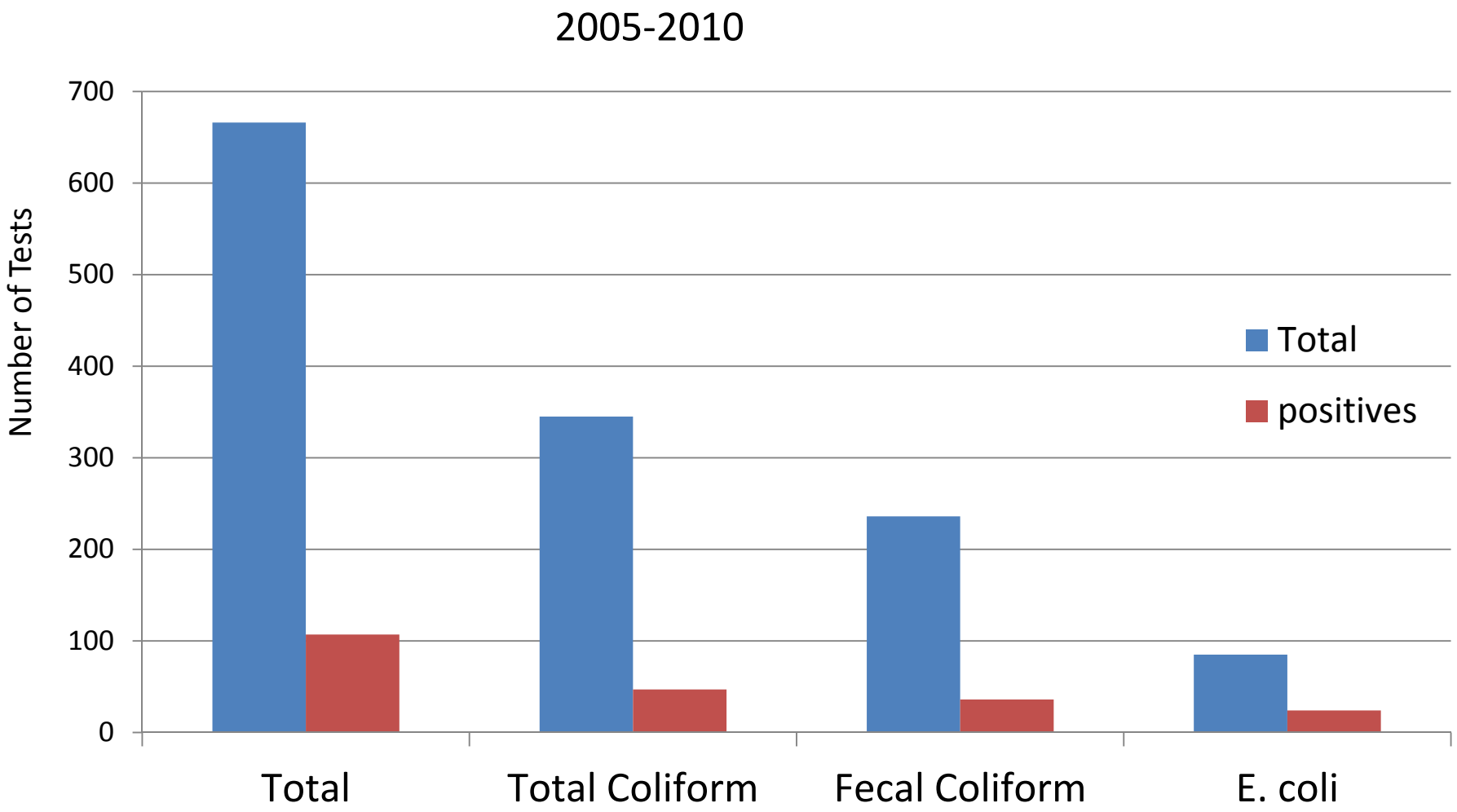
Microbial Test Data

- Goal was to obtain 5 years of data from 10 companies
  - Data from 2005-2010 (plus)
  - Received data from 17 companies – 29% of market
    - Small (31%), medium (25%) and large (38%)
- Cascade Analytical provided data for majority of packinghouses; other data came directly from packinghouses
- Test results from five laboratories

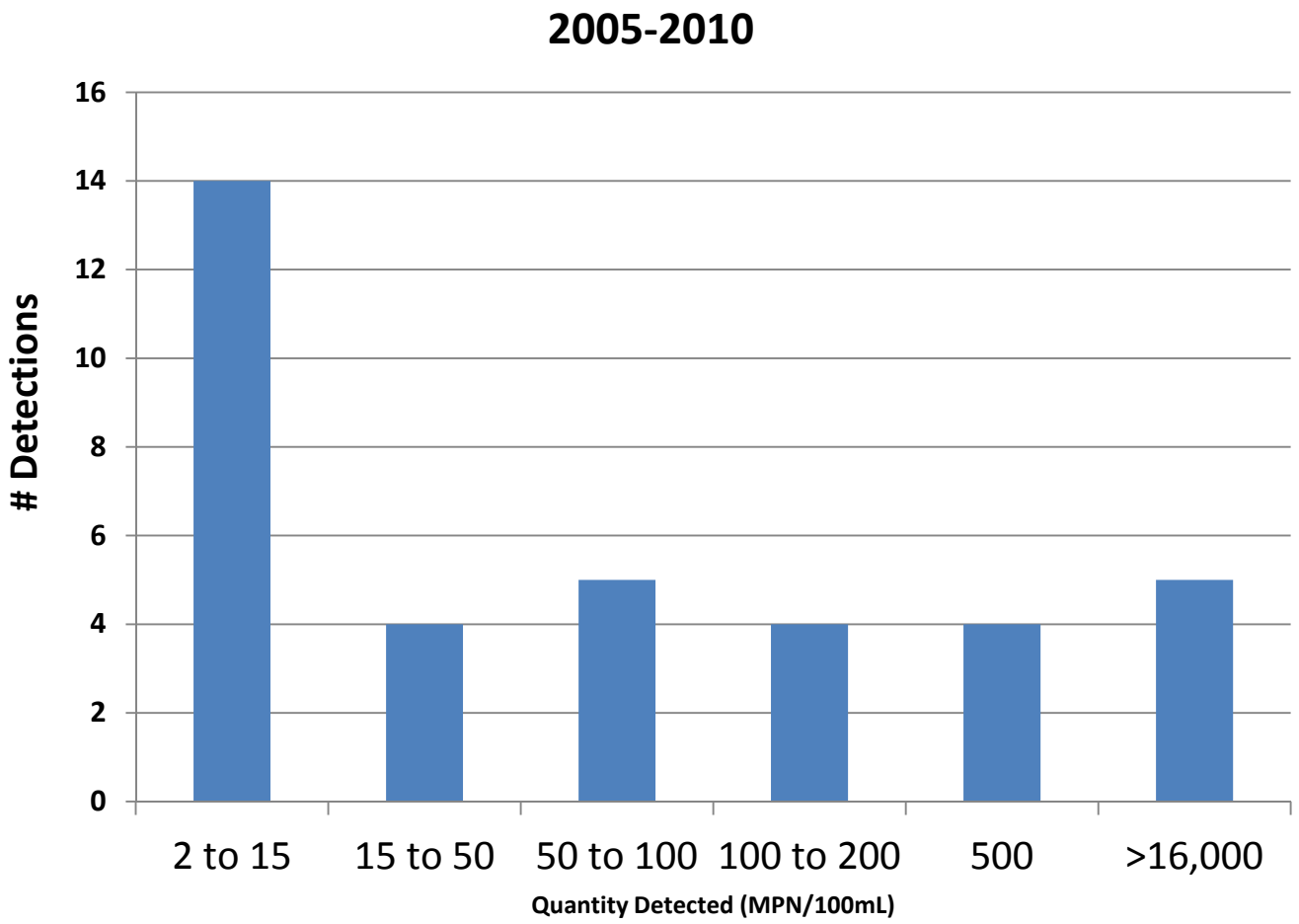
Database Statistics

- Obtained 2,748 records, included 2,285 test records in database
- Test areas:
  - Water sampling – source and process water
  - Environmental testing – swab testing

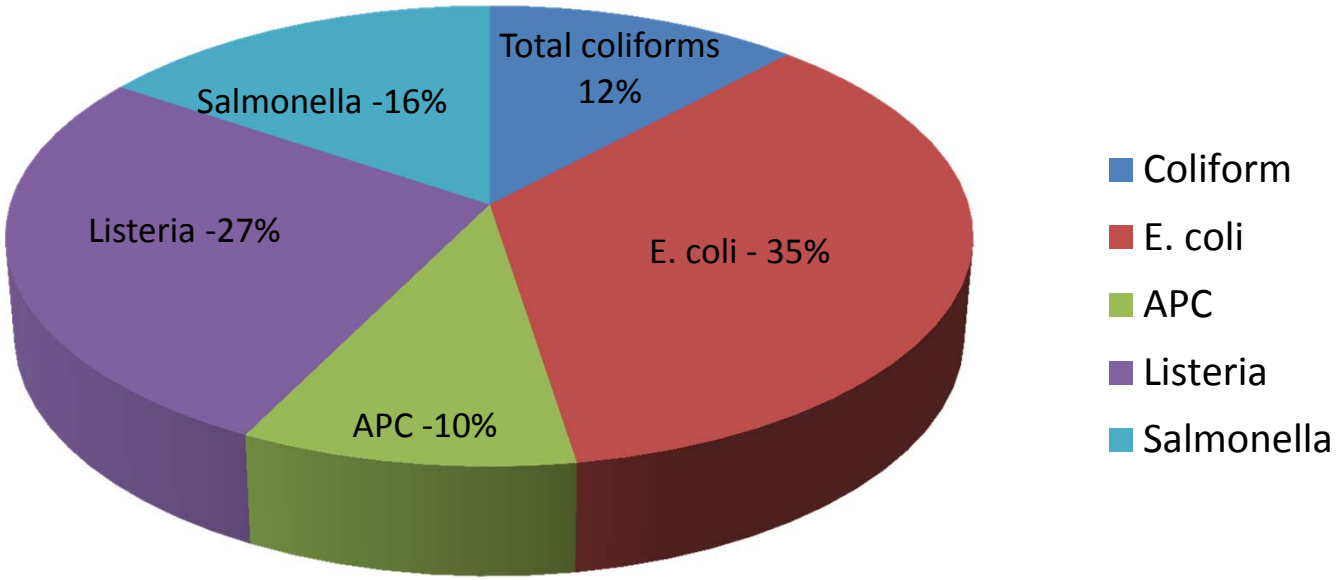
Water Sampling – Total and Positives



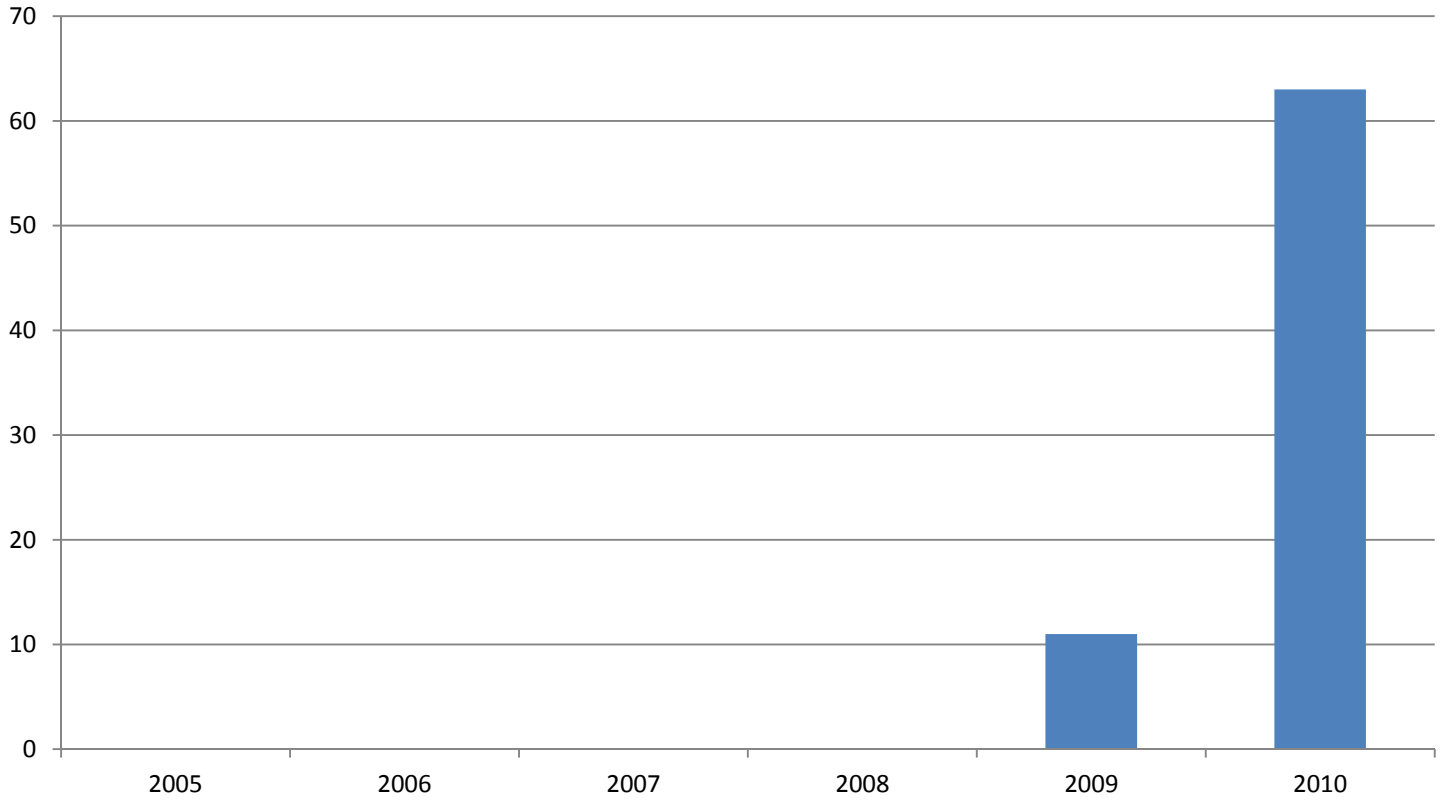
Fecal Coliform Quantities



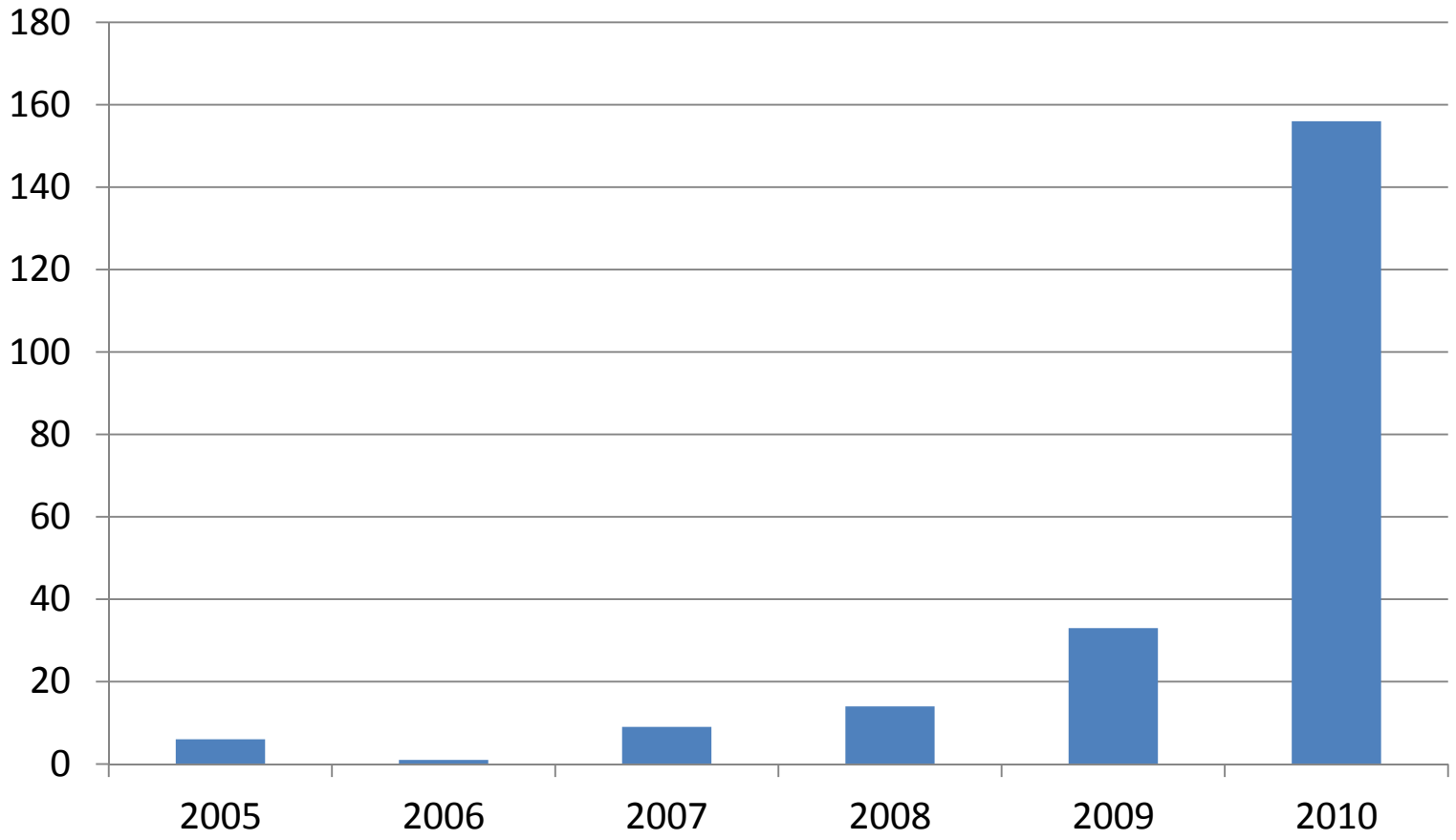
Environmental Tests - All



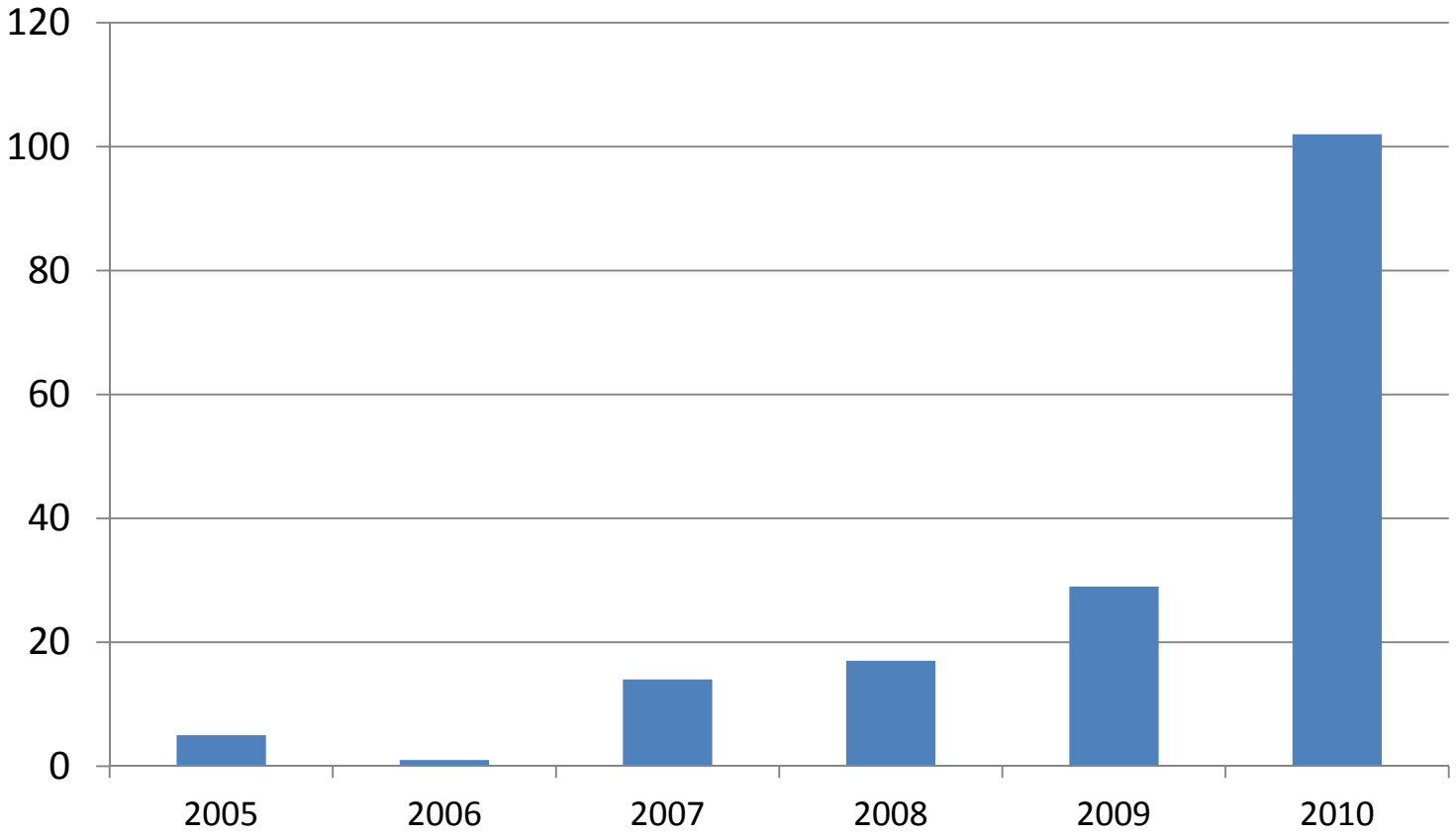
Environmental Tests – Total Coliforms



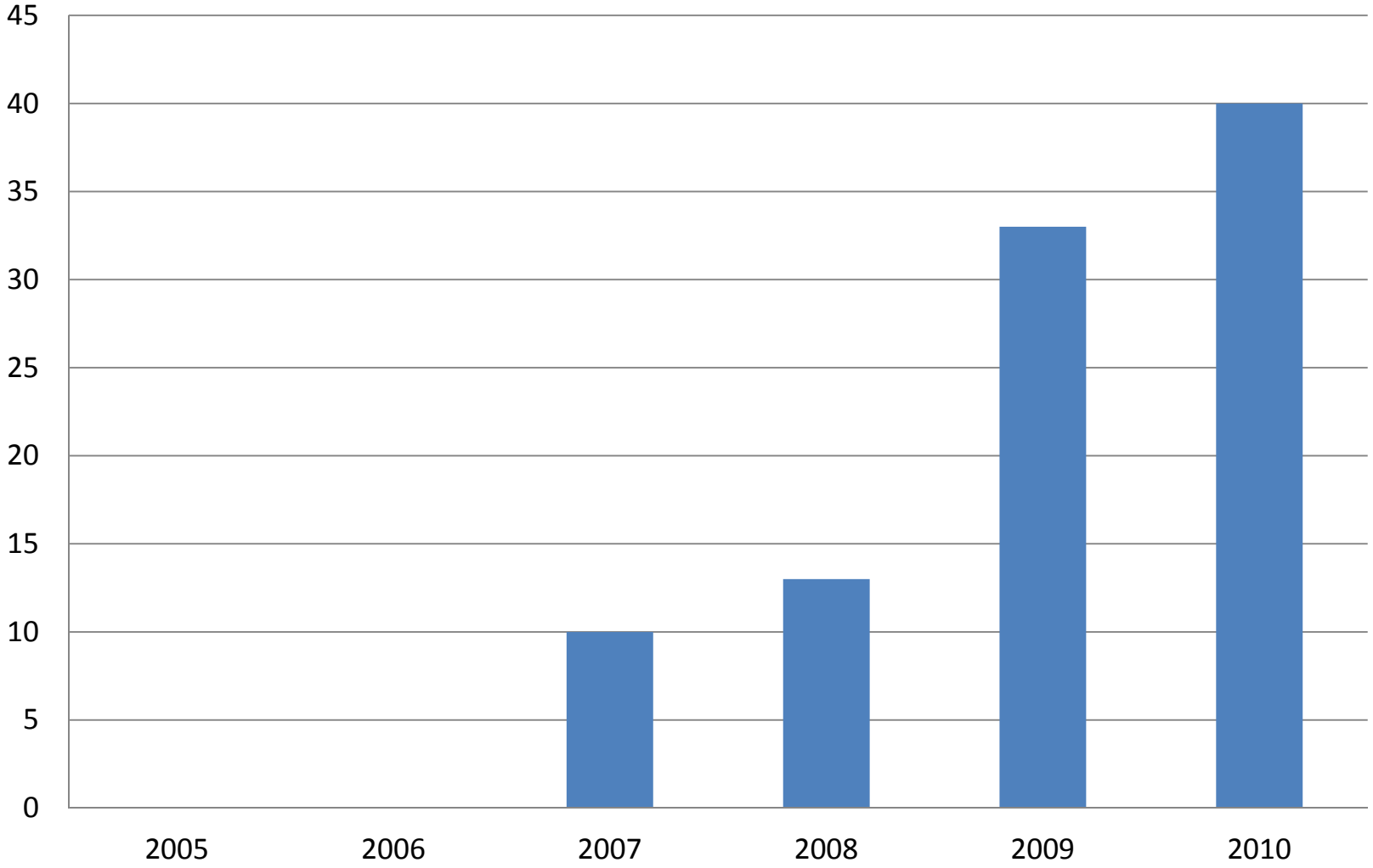
Environmental Tests – E. coli



Environmental Tests - Listeria



Environmental Tests - Salmonella



Environmental Test Results

Organism	Total Tests	Positive Results
Total coliform	74	0
E. coli	219	1*
E. coli O157	4	0
Listeria	168	1
Salmonella	96	0

*different test methods

Environmental Test Locations

Location	Sampling Locations by Organisms			
	E. Coli	Coliform	Salmonella	Listeria
Belt	26%	37%	9%	6%
Brushes	14%	11%	14%	11%
Contact Surface	1%	0	8%	1%
Drop	8%	14%	0	0
Dryer	5%	11%	3%	1%
Drain	1%	0	0	13%
Restrooms, walls	2%	0	7%	29%
Sizer	4%	6%	5%	1%
Sorting/Packing Tables	13%	14%	2%	1%
Rinse Bar	1%	0	0	1%
Rollers	5%	0	11%	5%
Tub	7%	8%	3%	2%

Key Findings

- Water sampling results – presence of Total Coliform, Fecal coliform and E. coli
- Environmental tests – lack of positives

Next Steps

- Report on microbial mitigation practices
- Add grower information
- Risk Assessment

Special Thanks to…

- Participating Packing Houses
- The Northwest Horticultural Council
- The Washington Tree Fruit Research Commission
- Cascade Analytical, Inc.