Cornell University
College of Agriculture and Life Sciences

Environmental Pathogen Monitoring programs for small dairy processing facilities

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November 11, 2016

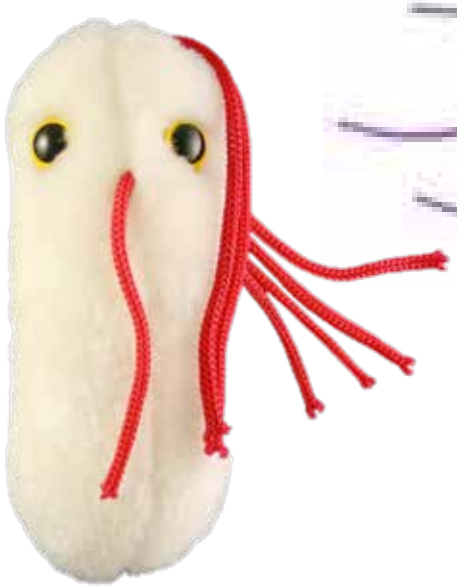
Dairy Practices Council

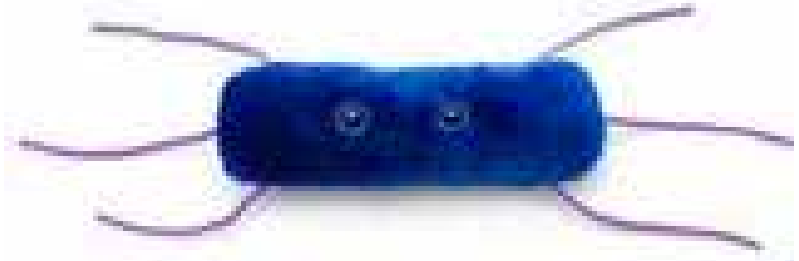
Outline

- Dairy Pathogens
- Outbreak Detection
- Pathogen Environmental Monitoring Programs

Key Pathogens in Dairy

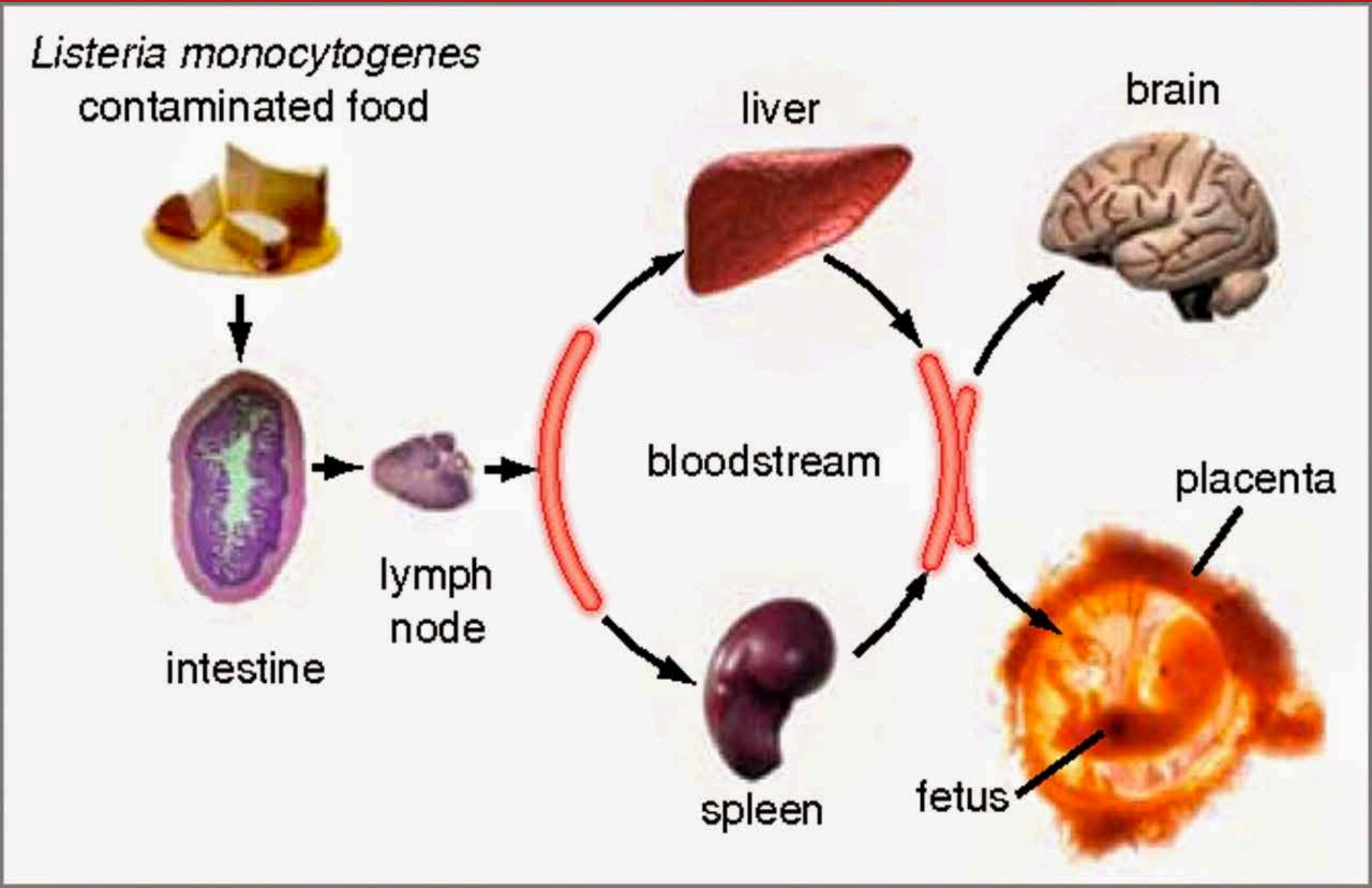
- *Listeria monocytogenes*
- *Salmonella*
- *Cronobacter*





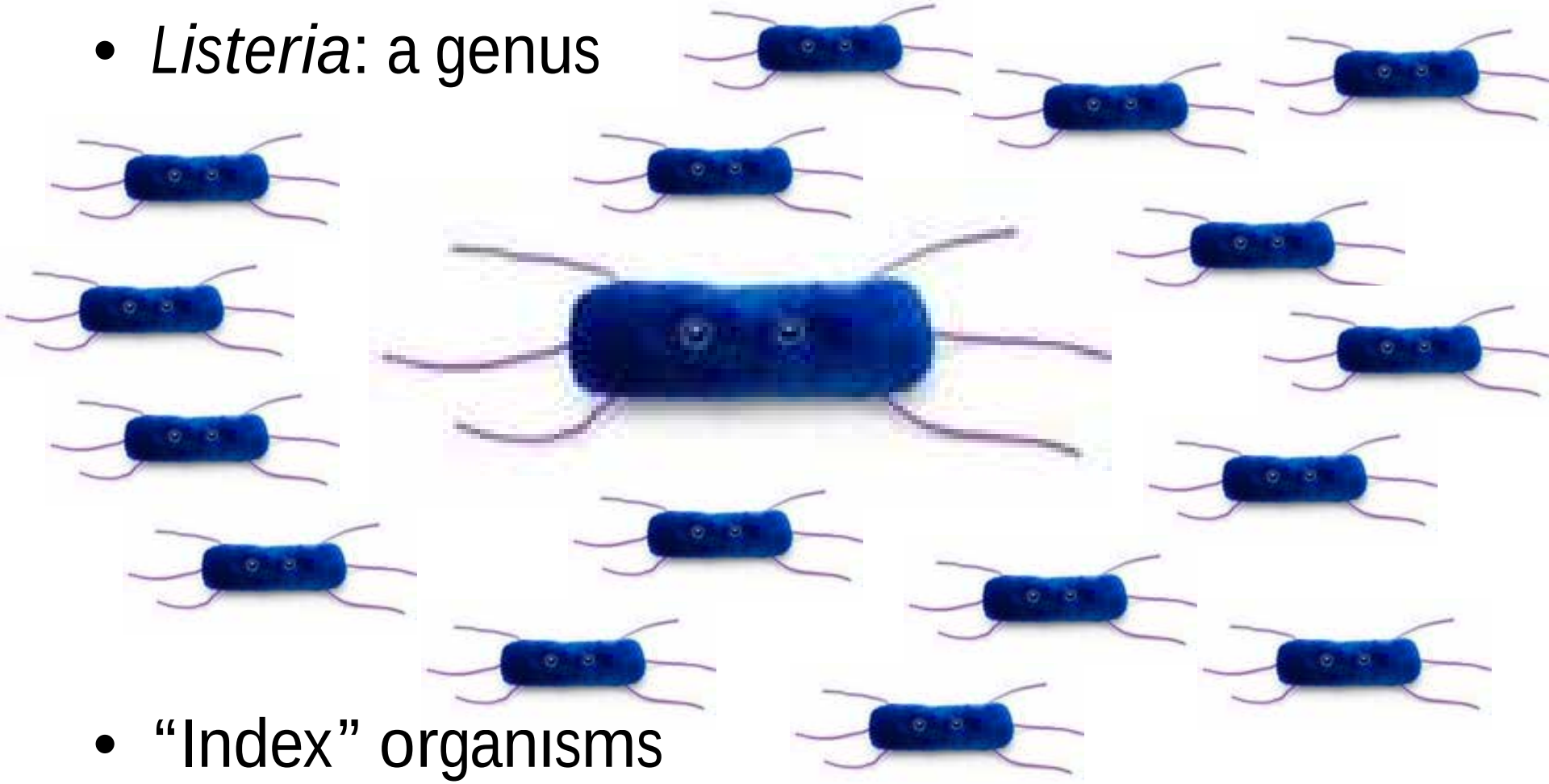
Listeria monocytogenes: Human Pathogen

- 1,300 cases/year in the United States
  - 255 deaths (~20% mortality rate)
- Most commonly affected:
  - Pregnant women
  - Elderly
  - Immunocompromised individuals
  - Infants
- Grows at refrigeration temperatures


Listeria monocytogenes
contaminated food
liver
brain
bloodstream
placenta
lymph
node
intestine
spleen
fetus

Not all *Listeria* are pathogenic

- *Listeria*: a genus



- "Index" organisms

Listeria is everywhere

- Natural environments: 1.3% to 8% (NYS data)
- Urban environments: 7.3% (NYS data)
- Ruminant farms
  - Bovine farms with listeriosis cases: 24.3% (n=616)
  - Bovine farms without listeriosis cases: 20.1% (n=643)
  - Small ruminant farms with listeriosis: 32.9% (n=322)
  - Small ruminant farms without listeriosis: 5.9% (n=475)
- *Listeria* species are often found at around 30% prevalence

Sauders et al., 2012. Diversity of *Listeria* species in urban and natural environments. *Appl. Environ. Microbiol*. 78(12): 4420-4433

Nightingale et al., 2004. Ecology and transimission of *Listeria monocytogenes* infecting ruminants and in the farm environment. *Appl. Environ. Microbiol*. 70(8): 4458-4467

Outline

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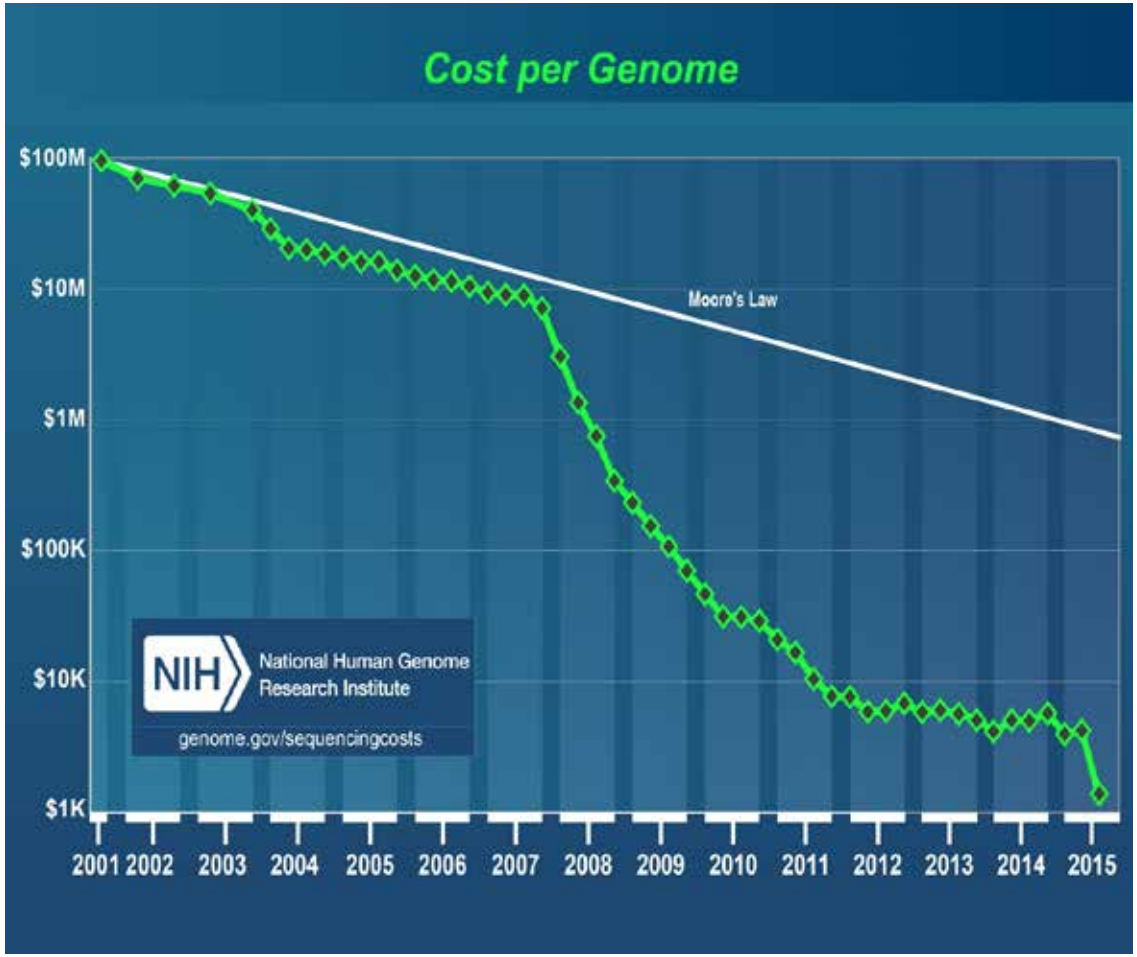
The genome sequence revolution



Multistate Outbreak of Listeriosis Linked to Soft Cheeses Distributed by Karoun Dairies, Inc.

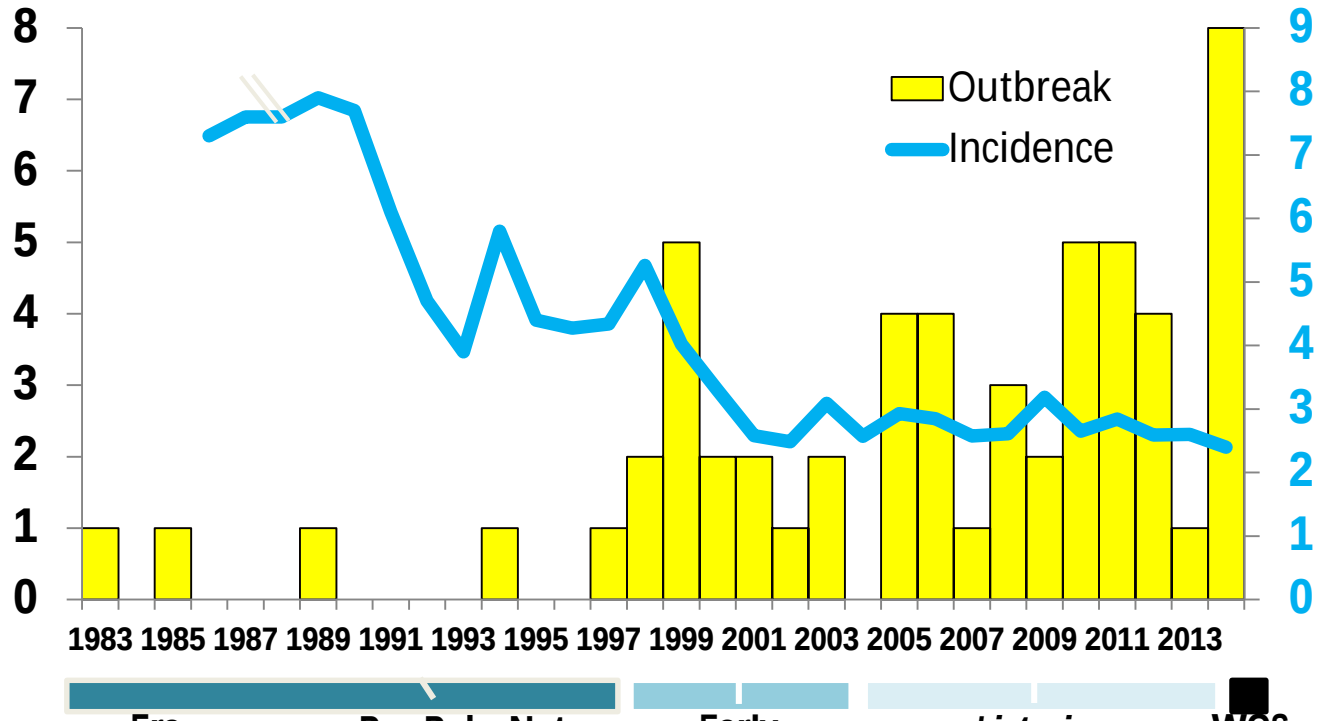
Posted September 23, 2015 3:45 PM ET

- 24 people infected with one of the closely related *Listeria* strains have been reported from 9 states since August 8, 2010.
  - 22 people were hospitalized. Five illnesses were pregnancy-related; one resulted in a fetal loss. One death was reported from Ohio.

  - FDA isolated *Listeria monocytogenes* from two environmental samples collected in September 2015 from the Central Valley Cheese, Inc. manufacturing facility in Turlock, California. Central Valley Cheese, Inc. manufactures cheese for Karoun Dairies. Whole genome sequencing showed that the two isolates are closely related genetically to isolates from ill people.

In addition, whole genome sequencing showed that 5 Listeria isolates collected in 2010 from the same facility were also closely related genetically to isolates from ill people.

Listeria Outbreaks and Incidence, 1983-2014



Era	Pre-PulseNet	Early PulseNet	*Listeria* Initiative	WGS
Outbreaks per year	0.3	2.3	2.9	8
Median cases per outbreak	69	11	5.5	4.5

Data are preliminary and subject to change

Outline

- Dairy Pathogens
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- Pathogen Environmental Monitoring Programs

Importance of PEM

- Preventing recalls
  - Reduce risk of an outbreak
- Long term program improvements
- Verification of cleaning and sanitizing program
- Verification of hygienic/transition areas
- Required written records under FSMA

Seek and destroy

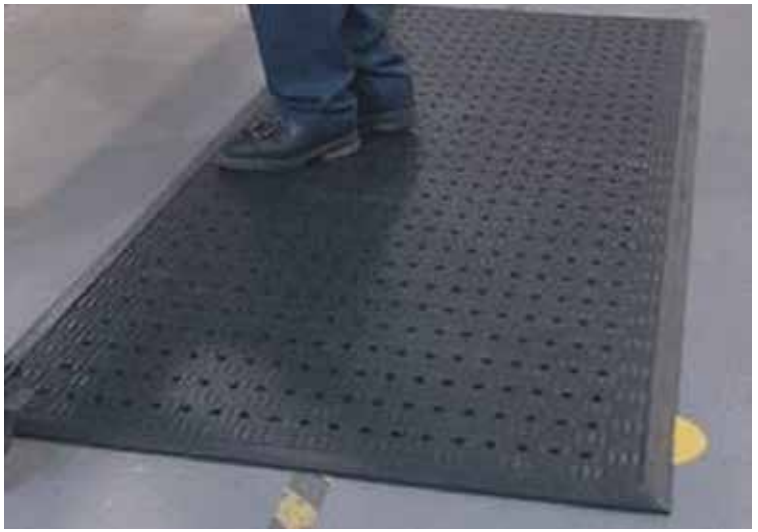
- *Listeria* contamination is often linked to the processing environment
- Implementing a pathogen environmental monitoring program allows tracking of the problem
  - Determining appropriate action toward positives will lead to better control

Seek and destroy targets Niches

- Niches
  - Drains, floor cracks, floor-wall junctures, hollow table legs, etc.
  - Used to identify sources
- Transfer points
  - Door handles, hands, wheels on a cart, etc.
  - Help determine how the pathogen is moving through the plant

Growth Niches

Locations harboring the organism after the routine sanitation process for that area has been completed.

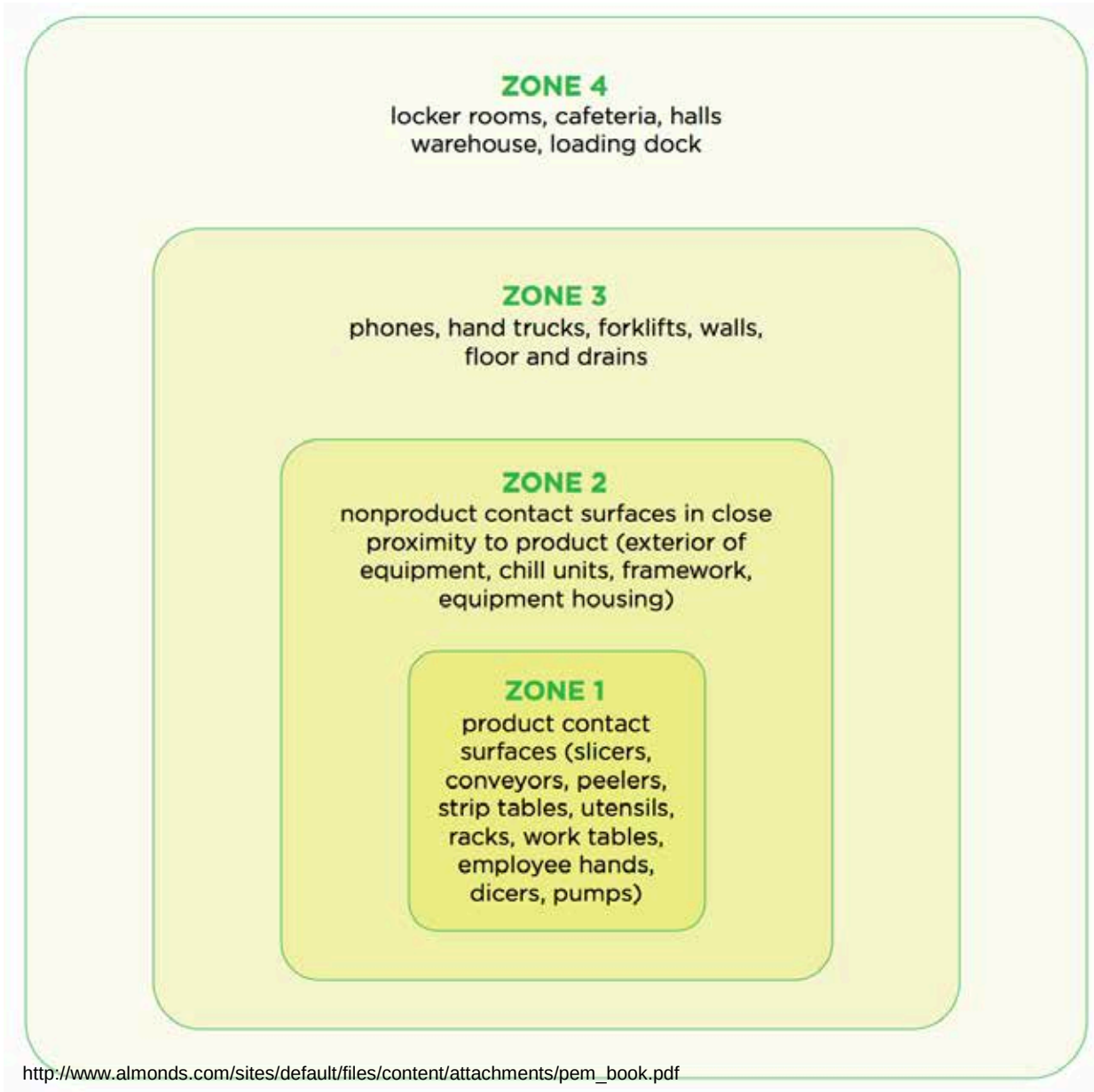


What are you sampling?

What about when you hear…

"Our company goal for 2016 is zero Listeria environmental positives" (Anonymous)

"FDA will collect 100s of environmental samples in your plant if your records show a single Listeria positive" (industry rumors after an FDA visit and record review, followed by FDA swab-a-thon)



http://www.almonds.com/sites/default/files/content/attachments/pem_book.pdf

Testing Considerations

- Prioritize sampling sites
  - After kill step (pasteurization)
  - Before final packaging
- Focus attention on zones 2 & 3.
- Sites with historic positive results
- Reference plant layout, traffic patterns and hygienic zone areas to help determine additional sites

Number of Samples:

Considerations

- Based on facility size
- Aging facilities=increased risk=increased sampling
- Geography of facility
  - Proximity to hazards
- Budget
- Manpower

Methodology

- Sponge
  - used with gloves
  - most commonly used
- Handled sponge
- Crevice Swabs

Results

- Send samples to a certified lab
- Review results upon arrival
- Apply corrective actions
- Monitor trends

Follow-Up and Corrections

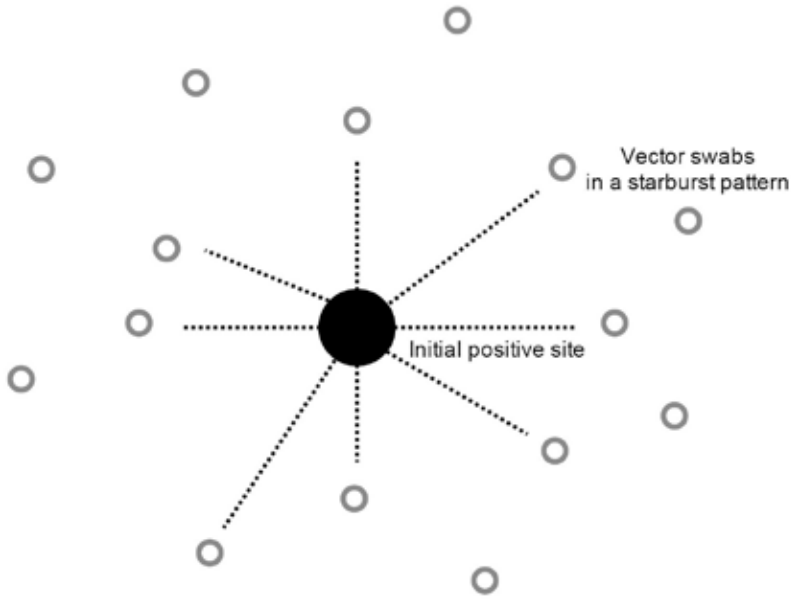
- Plant specific and may differ by zone
- Consider frequency of sampling vs. root cause analysis
- Intensified cleaning and sanitizing required
- Long-term trending and analysis
  - Pathogens
  - Index and indicator organisms

Corrective Actions

- Positive samples need follow-up: re-testing and vector swabbing
- Shutting down problem areas
- Written records

Vector Swabbing

Additional samples should be taken from environmental area that showed positive results



Managing a Problem Area

		May	June	July	July	August	September	October	November	December	January	February	March	April
Site #	Zone	5/22/14	6/17/14	7/1/14	7/9/14	8/11/14	9/16/14	10/8/14	11/13/14	12/10/14	1/13/15	2/4/15	3/11/15	4/21/15
1	3	Neg	Neg	NS	L. spp.	Neg	Neg	L. spp.	Neg	Neg	Neg	Neg	Neg	Neg
2	3	Neg	Neg	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
3	3	Neg	Neg	NS	L. mono	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
4	3	Neg	Neg	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
5a	3	Neg	Neg	NS	Neg	Neg	L. mono	Neg	Neg	Neg	Neg	Neg	Neg	Neg
5b	3	Neg	Neg	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
5c	3	Neg	L. mono	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
6	3	Neg	Neg	NS	Neg	Neg	Neg	L. spp.	Neg	Neg	Neg	Neg	Neg	Neg
7	3	L. spp.	Neg	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
8	3	L. spp.	Neg	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
9	3	Neg	L. mono, L. sp	L. spp.	L. spp.	L. mono., L. sp	NS	NS	NS	NS	NS	NS	NS	NS
9a	3	NS	NS	NS	NS	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
10	3	Neg	Neg	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
11	3	Neg	L. spp.	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	L. spp.
12a	3	Neg	Neg	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
12b	3	Neg	Neg	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
13a	3	Neg	Neg	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	NS	NS
13b	3	Neg	Neg	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	NS	NS
14a	3	Neg	Neg	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
14b	3	Neg	Neg	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
14c	3	Neg	Neg	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
15	3	Neg	Neg	NS	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg

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Date of Environmental Sampling/Swabbing: 5/15/2013

Site Found Positive: 23 Circle one: (*Listeria monocytogenes*) or *Listeria* species or *Salmonella*

Date action taken: 5/23/2013

Detailed description of action taken on positive site:

Thorough cleaning with an acid cleaner (vs. our old chlorine bleach) was performed

Mark which applies:

- X perform immediate out of cycle testing
- ○ swab again during next scheduled testing

Follow-up Environmental testing Results (circle one): (Negative) or Repeat Positive

ADA 6/13/2013

Investigation of a Positive Finding

- Review infrastructure and equipment in the area
- Targeted cleaning
- Review records
- Corrective action
  - Location (zone)
  - Trends

Tracking Results

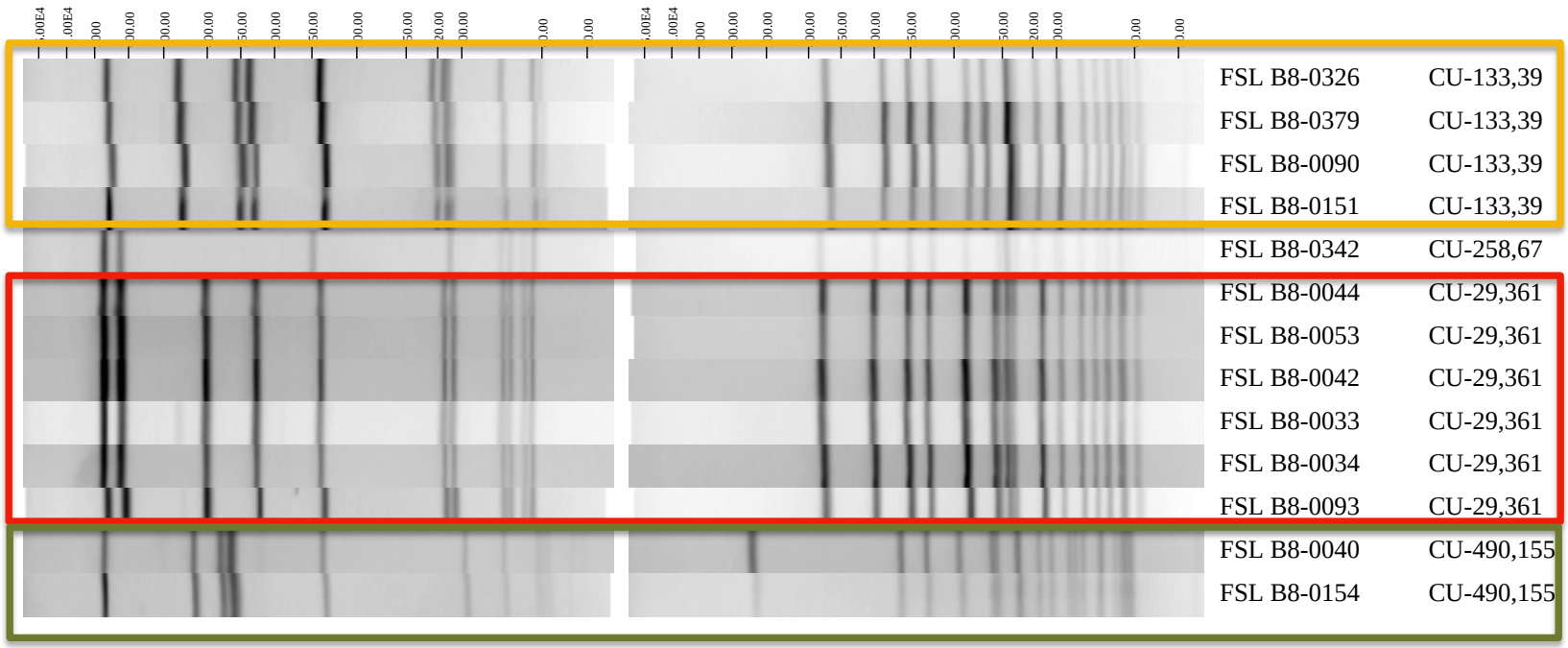
- Track and trend environmental data
- Collect and record data to provide actionable information
- Establish a baseline to monitor trends
- Detection of a pathogen in Zone 1 requires immediate action as product may be contaminated

DNA fingerprinting and persistence

- Pathogens can persist in the environment for years
- DNA fingerprinting can be used to identify sites where the pathogen may be persisting

DNA Fingerprinting

PFGE-AscI **PFGE-ApaI**



Persistence?

	May	June	July	August	September	October	November	December	January	February	March	April
Site #	5/22/14	6/19/14	7/22/14	8/11/14	9/15/14	10/9/14	11/19/14	12/9/14	1/14/15	2/11/15	3/11/15	4/13/15
1a	*L. mono*	*L. spp.*	*L. mono*	*Neg*	*Neg*	*Neg*	*L. spp.*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*
1b	*L. spp.*	*L. spp.*	*Neg*	*Neg*	*Neg*	*Neg*	*L. spp.*	*L. mono*	*Neg*	*Neg*	*Neg*	*Neg*
2	*Neg*	Neg	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*
3	*L. mono & L. spp.*	*L. spp.*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*L. spp.*	*Neg*	*Neg*	*Neg*
4	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*
5	*Neg*	*L. mono*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*
6	*L. mono*	*L. mono*	*L. mono*	*Neg*	*Neg*	*Neg*	*Neg*	*L. mono*	*Neg*	*Neg*	*L. mono*	*Neg*
7	*L. spp.*	*L. spp.*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*
8a	*L. mono*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*
8b	*L. mono & L. spp.*	*Neg*	*Neg*	*Neg*	*L. spp.*	*Neg*	*Neg*	*L. spp.*	*Neg*	*Neg*	*Neg*	*Neg*
8c	*L. mono & L. spp.*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*
9	*Neg*	*L. spp.*	*Neg*	*L. spp.*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*L. spp.*	*Neg*
10	*Neg*	*L. spp.*	*Neg*	*Neg*	*Neg*	*L. spp.*	*Neg*	*Neg*	*Neg*	*Neg*	*L. spp.*	*Neg*
15	**NS**	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*
16	**NS**	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*
17	**NS**	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*
18	**NS**	*L. spp.*	*Neg*	**NS**	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*
19	**NS**	*Neg*	*Neg*	*Neg*	*L. spp.*	*L. spp.*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*	*Neg*
24a	**NS**	**NS**	**NS**	**NS**	*Neg*	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
24b	**NS**	**NS**	**NS**	*Neg*	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
24c	**NS**	*Neg*	**NS**	*Neg*	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Plant A2	2/28/01	3/26/01	4/24/01	5/22/01	6/19/01	7/17/01	8/14/01	9/18/01	10/9/01	11/6/01	12/12/01	1/29/02	2/25/02
Raw Product Samples	1062D	1060A	-	-	-	-	-	-	-	L.spp	-	L.spp	
	1 of 6	1 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	3 of 6	6 of 6	1 of 6	
Raw/In-Process Areas													
E3: Floor drain, raw salmon ro	1053A	-	-	-	-	-	-	-	-	L.spp	L.spp	L.spp	
Salmon receiving floor drain				-	-	L.spp	1053A	-	-	L.spp	-	-	
Raw salmon room, Drain (SB-FD1)													
Raw salmon room, Drain (SB-FD2)													
Raw salmon room, 3 floor mats													
RawSalmon room, mats- post cleaning													
Raw salmon room, plstic pallet													
Raw Salmon room, pallet, post cleaning													
Raw salmon room, pallet jacket handle													
E8: Apron, employee in raw are	1062D	-	-	1053A	-	1053A	1025A	-	1053A	-	1053A	-	
Incoming raw material packaging												-	
Finished Product Areas													
E1: Trench Drain, processing r	L.spp	-	-	116.693	L.spp	L.spp	L.spp	-	L.spp	L.spp	-	L.spp	
E2: Trench Drain, smoke roon	-	-	-	-	-	-	-	-	-	-	-	-	
Smoke room trench drain, in use													
E4: Cart wheels, for box transp	L.spp	-	-	-	-	-	-	L.spp	-	L.spp	-	-	
E5: Floor, under conveyor belt	L.spp	-	-	-	-	L.spp	L.spp	L.spp	L.spp	L.spp	L.spp	-	
Finish Room, floor mats #1													L.spp
Finish room, floor mats #2													L.spp
Finish room, floor mats, reg. Clean													
Finish room, floor mats, reg. Clean													L.spp
Finish room, 1200 ppm Quat, weekend													L.spp
Finish room, 1200 ppm Quat, weekend													-
Bootdip valve cover, processin	-	-	L.spp										
E6: Platform under Geba #1 sli	-	-	-	-	-	-	L.spp	L.spp	L.spp	-	-	-	
E9: Sliding door handle, skinnir	L.spp	-	-	-	-	-	-	1053A	L.spp	-	-	-	
Food Contact Surfaces													
E7: Gloved hands, finish prod.	-	-	-	-	-	-	-	-	-	-	-	-	
E10: Skinning machine	L.spp	-	L.spp	-	-	-	L.spp	L.spp	L.spp	-	L.spp	-	
E11: Geba #5 slicer	L.spp	-	-	-	-	-	-	-	-	-	L.spp	-	
E12: 20/20 vac belt	-	-	-	L.spp	-	-	-	-	-	-	-	-	
	6 of 6	6 of 6	6of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	
Finished Product Sample	-	-	-	-	-	-	-	-	-	-	-	-	

Plant A2	2/28/01	3/26/01	4/24/01	5/22/01	6/19/01	7/17/01	8/14/01	9/18/01	10/9/01	11/6/01	12/12/01	1/29/02	2/25/02	3/5/02	4/2/02	4/16/02	5/14/02	6/10/02	7/1/02	7/23/02	8/20/02	9/17/02	10/15/02	11/12/02	12/10/02
														1-L.spp			2-L.spp			1-L.spp					1-L.spp
Raw Product Samples	1062D	1060A	-	-	-	-	-	-	-	L.spp	-	L.spp		1025A	-		1053C	-	-	1039C	-	-	-	-	1039C
	1 of 6	1 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	3 of 6	6 of 6	1 of 6		1 of 6	6 of 6		1 of 6	6 of 6	6 of 6	1 of 6	6 of 6	6 of 6	6 of 6	6 of 6	1 of 6
Raw/In-Process Areas																									
E3: Floor drain, raw salmon ro	1053A	-	-	-	-	-	-	-	-	L.spp	L.spp	L.spp		1053A	-		-	-	-	-	-	-	-	-	-
Salmon receiving floor drain				-	-	L.spp	1053A	-	-	L.spp	-	-		L. spp	-		-	-	-	L.spp	L.spp	L.spp	-	-	-
Raw salmon room, Drain (SB-FD1)														1053A	1053A		-	-	1053a	1053A	-	1053A	1062A	L.spp	1053A
Raw salmon room, Drain (SB-FD2)														1053A	1053A		1053A	-	L.spp	1053A	1053A	L.spp			-
Raw salmon room, 3 floor mats														1053A	1053A			1053A	1053A	1053A	1053A	1053A	1053A	1053A	1053A
RawSalmon room, mats- post cleaning																1053A	1053A								
Raw salmon room, plstic pallet														1053A	-			-	L.spp	-	-	-	-	-	-
Raw Salmon room, pallet, post cleaning																									
Raw salmon room, pallet jacket handle														-	-		-	-	-	-	-	-	-	-	-
E8: Apron, employee in raw are	1062D	-	-	1053A	-	1053A	1025A	-	1053A	-	1053A	-		-	-		-	-	-	-	-	-	-	-	-
Incoming raw material packaging												-		-	-		-	-	-	-	-	L.spp	-	L.spp	-
Finished Product Areas																									
E1: Trench Drain, processing r	L.spp	-	-	116.693	L.spp	L.spp	L.spp	-	L.spp	L.spp	-	L.spp		1042C	L.spp		1042C	L.spp	-	-	L.spp	L.spp	L.spp	L.spp	L.spp	L. spp
E2: Trench Drain, smoke room	-	-	-	-	-	-	-	-	-	-	-	-		-	-		-	-	L.spp	-	-	L.spp	-	-	L. spp
Smoke room trench drain, in use																1053A	-	-	-	-	-	-	-	-	-
E4: Cart wheels, for box transp	L.spp	-	-	-	-	-	-	L.spp	-	L.spp	-	-		-	-		-	-	-	-	-	L.spp	L.spp	-	L. spp
E5: Floor, under conveyor belt	L.spp	-	-	-	-	L.spp	L.spp	L.spp	L.spp	L.spp	L.spp	-		-	-		-	-	-	-	-	-	1053	1053	-
Finish Room, floor mats #1													L.spp												
Finish room, floor mats #2													L.spp												
Finish room, floor mats, reg. Clean														L.spp	L.spp	L.spp	L.spp	L.spp	L.spp	L.spp	L.spp	1042B	L.spp	L.spp	L. spp
Finish room, floor mats, reg. Clean													L.spp												
Finish room, 1200 ppm Quat, weekend													L.spp												
Finish room, 1200 ppm Quat, weekend													-												
Bootdip valve cover, processin	-	-	L.spp																						
E6: Platform under Geba #1 sli	-	-	-	-	-	-	L.spp	L.spp	L.spp	-	-	-		-	-		-	-	-	-	-	-	-	-	-
E9: Sliding door handle, skinnir	L.spp	-	-	-	-	-	-	1053A	L.spp	-	-	-		-	-		-	-	-	L.spp	-	-	-	-	-
Food Contact Surfaces																									
E7: Gloved hands, finish prod.	-	-	-	-	-	-	-	-	-	-	-	-		-	-		-	-	-	-	-	-	1053	-	L. spp
E10: Skinning machine	L.spp	-	L.spp	-	-	-	L.spp	L.spp	L.spp	-	L.spp	-		L.spp	-		-	-	-	-	-	L.spp	-	L. spp	-
E11: Geba #5 slicer	L.spp	-	-	-	-	-	-	-	-	-	L.spp	-		-	-		-	-	-	-	-	-	1053	-	-
E12: 20/20 vac belt	-	-	-	L.spp	-	-	-	-	-	-	-	-		-	-		-	-	-	-	-	-	-	-	-
	6 of 6	6 of 6	6of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6		6 of 6	6 of 6		6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	6 of 6	1 of 6	6 of 6
Finished Product Sample	-	-	-	-	-	-	-	-	-	-	-	-		-	-		-	-	-	-	-	-	-	1039A	-

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Research Paper

Development and Validation of Pathogen Environmental Monitoring Programs for Small Cheese Processing Facilities

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ABSTRACT

Pathogen environmental monitoring programs (EMPs) are essential for food processing facilities of all sizes that produce ready-to-eat food products exposed to the processing environment. We developed, implemented, and evaluated EMPs targeting *Listeria* spp. and *Salmonella* in nine small cheese processing facilities, including seven farmstead facilities. Individual EMPs with monthly sample collection protocols were designed specifically for each facility. *Salmonella* was detected in only one facility, with likely introduction from the adjacent farm indicated by pulsed-field gel electrophoresis data. *Listeria* spp. were isolated from all nine facilities during routine sampling. The overall *Listeria* spp. (other than *Listeria monocytogenes*) and *L. monocytogenes* prevalences in the 4,430 environmental samples collected were 6.03 and 1.35%, respectively. Molecular characterization and subtyping data suggested persistence of a given *Listeria* spp. strain in seven facilities and persistence of *L. monocytogenes* in four facilities. To assess routine sampling plans, validation sampling for *Listeria* spp. was performed in seven facilities after at least 6 months of routine sampling. This validation sampling was performed by independent individuals and included collection of 50 to 150 samples per facility, based on statistical sample size calculations. Two of the facilities had a significantly higher frequency of detection of *Listeria* spp. during the validation sampling than during routine sampling, whereas two other facilities had significantly lower frequencies of detection. This study provides a model for a science- and statistics-based approach to developing and validating pathogen EMPs.

Key words: *Listeria*; Persistence; Raw milk; *Salmonella*

Project Outline

- 2 years
- 9 processing facilities
- > 5,000 samples
- Zones 2-4
- Routine vs. Validation sampling

Listeria prevalence in small cheese processing facilities

TABLE 1. *Summary of facilities sampled*

Facility[a]	Environment[b]	Approx production vol (lb milk/yr)	Processing schedule	No. of sampling times	Sampling period	Environmental samples tested for *Listeria* spp. (LS) and *L. monocytogenes* (LM)			Environmental samples tested for *Salmonella*	
						Total no. of samples[c]	No. (%) of LS samples[d]	No. (%) of LM samples	Total no. of samples	No. (%) of positive samples
A	Farmstead	874,000	Year round	24	Apr. 2013–Mar. 2015	917	29 (3.2)	12 (1.3)	156	0 (<0.6)
C	Farmstead	30,000	Year round	10	Apr. 2013–Jan. 2014	257	32 (12)	15 (5.8)	91	1 (1.1)
D	Farmstead	21,000	Seasonal	9	Apr. 2013–May 2014	202	3 (1.5)	2 (0.99)	82	0 (<1.2)
E	Farmstead	420,000	Year round	24	Apr. 2013–Mar. 2015	1,000	127 (12.7)	7 (0.7)	185	0 (<0.5)
F	Farmstead	NA[e]	Seasonal	14	Apr. 2013–Oct. 2014	422	4 (0.9)	0 (<0.2)	74	0 (<1.4)
G	Farmstead	860,000	Year round	12	May 2014–Apr. 2015	596	25 (4.2)	8 (1.3)	NS[f]	NS
H	Stand alone	500,000	Year round	12	May 2014–Apr. 2015	259	35 (13.6)	13 (5.02)	NS	NS
I	Stand alone	35,000	Year round	12	May 2014–Apr. 2015	501	1 (0.2)	0 (<0.2)	NS	NS
J	Farmstead	70,000	Year round	12	June 2014–May 2015	276	11 (4.0)	3 (1.1)	NS	NS

[a] Facility B dropped out of the study prior to the first sampling and therefore is not included in the facility list. Facility I is the Cornell University cheese processing facility.
[b] Farmstead facilities are located within 100 m of a dairy farm that provides raw milk for processing.
[c] Includes samples collected during routine and verification sampling.
[d] LS numbers do include samples positive for *L. monocytogenes*.
[e] NA, not available. Because the production volume for facility F number was not provided, we estimated that this facility processes <50,000 lb of milk per year.
[f] NS, not sampled.

How do you know your program is working?

Facility	Prevalence (from routine)	Prevalence (from validation)
A	**5.12%** (34/664)	**1.33%** (2/150)
E	**11.97%** (88/735)	**10%** (6/60)
F	**<0.3%** (0/334)	**6%** (3/50)
G	**8.33%** (19/228)	**2.35%** (2/85)
H	**22.64%** (24/106)	**8%** (2/50)
J	**0.94%** (1/106)	**14%** (7/50)

Take Home Messages

- *Listeria* is a genus of 17 species. *L. monocytogenes* is a pathogen.
- We are detecting more outbreaks due to Whole Genome Sequencing
- Look for *Listeria*. Find it. Get rid of it.

Thank You!

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