



Industry Perspectives on Non- O157

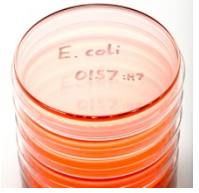
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IAFP 2011

Commitment to Food Safety



- The global meat industry is dedicated to providing high quality, nutritious and safe products
- American Meat Institute – Food safety is not a competitive issue
- Data and best practices for food safety are routinely shared within the meat industry
- Cargill – “Our food safety goal is to provide high quality, safe food, every time, everywhere.”
- Many examples of collaboration between industry, government, consumer groups and academia
- Everyone has the same goal – public health protection

E. coli non-O157 STEC

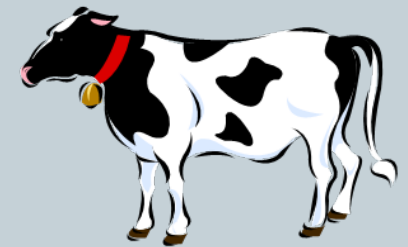


- STEC = Shigatoxin producing *E. coli*
 - VTEC = Verotoxin producing *E. coli*
 - EHEC = Enterohemorrhagic *E. coli*
 - pSTEC = Pathogenic STEC
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- ETEC = Enterotoxigenic *E. coli*
 - EPEC = Enteropathogenic *E. coli*
 - EIEC = Enteroinvasive *E. coli*
 - EAEC = Enteroaggregative *E. coli*
 - DAEC = Diffusely adherent *E. coli*

The “Big Six”



- O26, O45, O103, O111, O121, O145
- Approximately 50 other STEC serotypes have been known to cause illness
- Over 435 serotypes of STEC have been isolated from cattle, and over 470 from humans



Pathogenicity



- **STEC can cause illness ranging from mild diarrhea to severe illness with high mortality rates (Hemolytic-uremic syndrome or HUS)**
 - O145 believed to be most likely to cause HUS
 - O104:H4 – an EAEC combined with a STEC
 - ✦ 909 cases of HUS/3941 illnesses, 52 deaths
 - ✦ Late-breaking session tomorrow



CDC Foodborne Outbreaks: 1998-2008

	O157	Non-O157
All Foods	298	12
Beef Related	93	0
% Beef Related	31%	0%

Source: CDC Foodborne Outbreak Online Database. <http://wwwn.cdc.gov/foodborneoutbreaks/>. Accessed February 18, 2011. Slide courtesy of Dr. Betsy Booren, AMI



Critical Questions

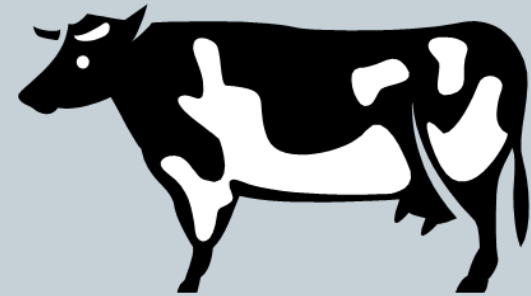


- How closely does the ecology and physiology of non-O157 STEC mimic *E. coli* O157:H7?
- Do control measures for *E. coli* O157:H7 also work to control non-O157 STEC?
- How do we define STEC?
 - By serology?
 - By virulence?
- What is the public health risk of non-O157 STEC in meat?
- Will testing beef products benefit public health?

Ecology of non-O157 STEC



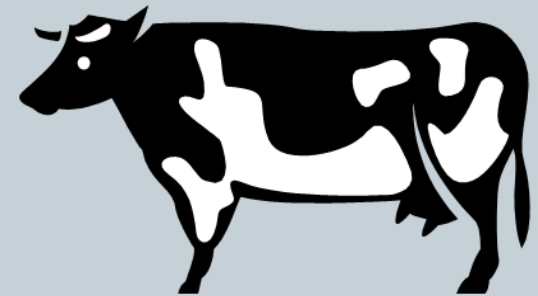
- Widely believed that ruminants, especially cattle, are a natural reservoir (often cited, rarely sourced)
- Probably also common in wild ruminants and other animals
- Seasonality?
 - Believed to track with O157
- Regionality?
 - May be slightly lower in west and upper mid-west compared to southeast and northeast US (Bosilevac and Koohmaraie, 2011)



Ecology of non-O157 STEC



- Super-shedders ($> \log 4$ / g feces) or Persistent-Shedders (positive fecal samples for > 3 consecutive months) are well known for *E. coli* O157:H7 and are believed to play an important role
 - Transmission within herds
 - Reinfection of animals
 - Total burden in the environment
 - Cause of positive ground beef and trim



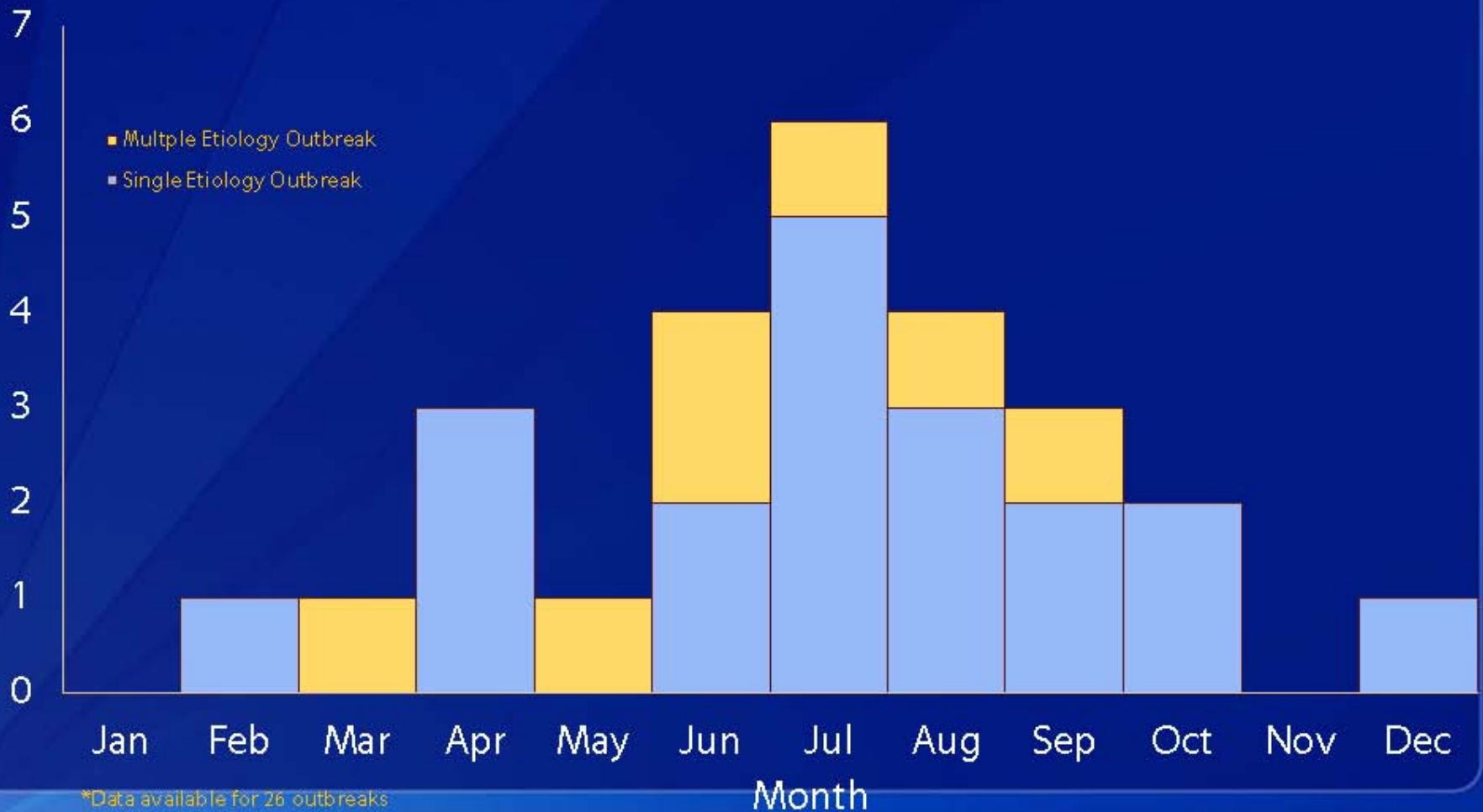
Ecology of non-O157 STEC



- Limited data available for non-O157 STEC
- Study in dairy cattle (Menrath et al., 2010):
 - 14 out of 140 cows were defined as super-shedders (*stx* positive by PCR screening on at least 4 consecutive months and in $> \frac{1}{2}$ of the total samples)
 - Found 24 different STEC serovars (O113:NM and O22:H8 most prevalent)
 - A cow kept in a herd with a super-shedder was 2 times as likely to test positive for *stx*
 - Prevalence was highest in summer, lowest in spring

Number of reported outbreaks of Non-O157 STEC Infection, 1990-2008, by Month*

Number of outbreaks



Focus on Prevention



- The global beef industry is already applying a variety of interventions aimed at reducing *E. coli* O157:H7
- Interventions range from practices during dressing to prevent intestinal and hide contamination from reaching the carcass to specific pathogen-reducing interventions such as steam, hot water, oxidizing chemicals and organic acids
- The STECS are all very closely related – no real reason to believe their resistances would be substantially different

Hide-On Carcass Wash and Sanitizing Assembly



Photo from Chad Company, www.chadcompany.com

Verifeye™ Fecal Identification System

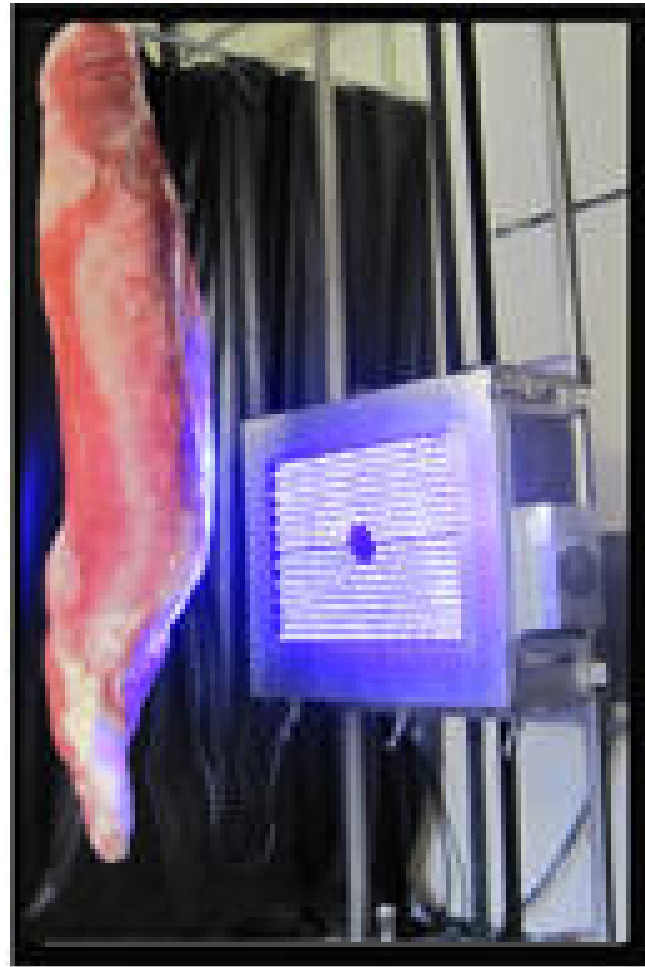


Photo from Chad Company, www.chadcompany.com

Antimicrobial Spray Cabinets



Photo from Chad Company,
www.chadcompany.com

Control of non-O157 STECs by Interventions



- **Nonspecific interventions targeting *E. coli* O157:H7 also impact non-O157 STECs, supported by numerous studies:**
 - ARS Clay Center study on commonly used antimicrobials (Kalchayanand et al., 2011)
 - ARS Wyndmoor brine-injected gas-grilled steak study (Luchansky et al., 2011)
 - GMA pepperoni study (Enache and Mathusa, 2010)
 - GMA apple juice study (Enache and Mathusa, 2010)



Commonly-Used Interventions



- Most relevant to the beef slaughter industry, work done at USDA Clay Center
- Will be covered in much more detail this afternoon in Symposium S9
- Conclusion: all antimicrobial compounds tested (sodium hypochlorite, peroxyacetic acid, FreshFx, lactic acid, activated hydrobromic acid and hot water) used by the meat industry appear to be effective against non-O157 STEC

Kalchayanand et al., 2011, final report to AMI



Control of non-O157 STECs by Interventions



- Vaccines such as Epitopix SRP vaccine are expected to be effective against non-O157 STECs, but the data is just beginning to be gathered
 - Siderophore Receptor and Porin proteins allow bacteria to scavenge iron from the host – highly conserved in pathogenic gastrointestinal bacteria
 - The vaccine causes antibodies to be produced against the SRP proteins, killing the bacteria by depriving them of iron
- Bacteriophage treatments of live animals may be possible, but finding and maintaining a cocktail of phage active against all pSTEC will be extremely challenging

E. coli O157:H7 as an Indicator/Index for STEC



- **Indicator Organism** – indicates a process control failure
 - Coliforms indicate undercooking
- **Index Organism** – signals an increased likelihood of presence of a pathogen from a similar source
 - Generic *E. coli* indicates presence of *Salmonella*

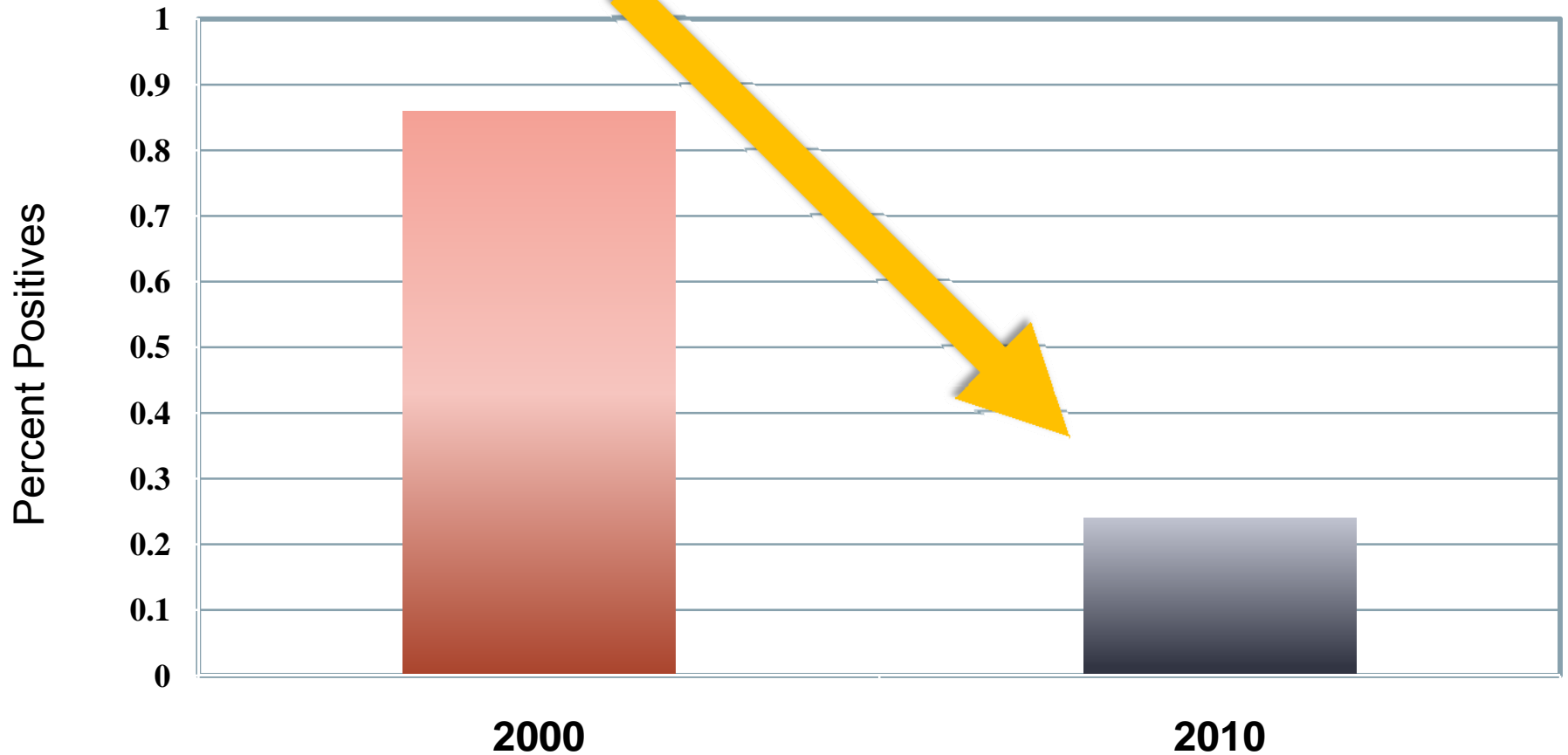
E. coli O157:H7 as an Indicator/Index for STEC



- The beef industry does extensive testing for *E. coli* O157:H7 at various stages of production
 - Some live animal and environmental testing
 - Hide testing
 - Carcass swabs
 - Extensive final product testing
 - ✦ Primal, trim and ground beef
- Preliminary results indicate that *E. coli* O157:H7 could serve as a very good process control indicator and a good index organism for all STEC

Prevalence of *E. coli* O157:H7 in Ground Beef*

72% Reduction



* Microbiological results of raw ground beef products analyzed for *Escherichia coli* O157:H7. Slide courtesy of Dr. Betsy Booren, AMI

Impact to Meat Industry of naming non-O157 STECs Adulterants



- **How much product would need to be destroyed or cooked?**
 - If screening for STEC (*stx1/stx2*), about 15 -24 % of samples could be expected to test positive
 - If screening for EHEC (*stx1/stx2* plus *eae*) up to 5 % of samples might be positive
 - If screening for pSTEC (*stx1/stx2*, *eae*, *subA* and *nle*) with cultural confirmation, around 0.24 % positives expected (same as USDA 2010 *E. coli* O157:H7 prevalence)

(Hill et al., 2011; Bosilevac and Koohmaraie, 2011)

Current Methods



- **Only a couple methods are commercially available as beta test versions and have had limited validation**
- **Most methods are a combination of enrichment and PCR, with or without immunoconcentration**
 - Our preliminary work indicates it is best to clean up the sample first with IMS, then run PCR
- **Without going to cultural confirmation (at least 5 days), many screens are going to be “false positives”**
 - Are genes all in the same bug?
- **Without a finalized, validated method and a large baseline study, it is impossible to accurately predict what the impact to industry would be**

Public Health Benefit



- Only a single outbreak of non-O157 STEC in the US has been linked to beef (3 mild illnesses, *E. coli* O26, Pennsylvania, 2010)
- CDC is beginning a major FoodNet Case-Control Study that will answer many questions about attribution and virulence
- USDA is funding a \$25 million AFRI grant that will fill many research gaps about ecology, physiology and detection
- Since the majority of non-O157 STEC illnesses appear to be due to environmental exposure and fresh produce consumption, control at the farm might have the biggest public health benefit

Non-O157 STEC Outbreaks¹ – U.S.



Year	State	Serogroup	Setting	Vehicle
1990	Ohio	O111	Home/family outbreak	Unknown
1994	Montana	O104	Home	Pasteurized milk
	Montana	O121	Camp	Unknown
1999	Texas	O111	Camp	Salad bar; Ice from barrel
	Connecticut	O121	Community	Recreational lake water
	Minnesota	O145	Daycare	Person-to-person
2000	Minnesota	O111	Camp	Animal contact - calves
	Washington	O103	Banquet hall	Water-based punch
	Utah	O111	Camp	Irrigation water
2001	Minnesota	O111, O51	Camp	Animal contact - calves
	Minnesota	O26	Swimming beach	Recreational lake water
	South Dakota	O111	Daycare	Person-to-person
2004	New York	O111	Community	Unpasteurized apple cider
2005	Nevada	O26	Daycare	Person-to-person
	Oregon	O145	Camp	Drinking water
	New York	O45	Correctional facility	Ill food workers

¹ Centers for Disease Control and Protection. http://blogs.cdc.gov/publichealthmatters/files/2010/05/nono157stec_obs_052110.pdf • Accessed June 10, 2011. Slide

Non-O157 STEC Outbreaks¹ – U.S.



Year	State	Serogroup	Setting	Vehicle
2006	North Carolina	O45	Family farm	Animal contact - goats
	Nebraska	O121	Daycare	Person-to-person
	Utah	O121	Catered event	Lettuce
	Massachusetts	O26	Community	Strawberries, blueberries
2007	Maine	O111	Daycare	Person-to-person
	North Dakota	O111	Elementary school	Person-to-person
	North Dakota	O111	Private home	Ground beef
	Colorado	O121, O26, O84	Correctional facility	Pasteurized American cheese, margarine
	New Hampshire	O45	Fair – petting zoo	Animal contact
2008	Oklahoma	O111	Restaurant	Unknown
	Minnesota	O111	Daycare	Person-to-person
2010	Multi-state ²	O145	Food service	Romaine lettuce
	Multi-state ³	O26	Home	Ground beef

¹ Centers for Disease Control and Protection. http://blogs.cdc.gov/publichealthmatters/files/2010/05/nono157stec_obs_052110.pdf. Accessed June 10, 2011.

² Centers for Disease Control and Protection. http://www.cdc.gov/ecoli/2010/ecoli_o145/index.html. Accessed June 10, 2011.

³ Food Safety and Inspection Service. http://www.fsis.usda.gov/News_&_Events/Recall_050_2010_Release/index.asp. Accessed June 10, 2011. Slide courtesy of Dr. Betsy Booren, AMI

Public Health Benefits



- While very few illnesses have been attributed to the non-O157 STEC/beef pairing in the US, it is known that these organisms can occur in cattle
- Consideration should be given to focusing on pathogenic STEC, not the “top 6” serotypes
- It should be possible to use the molecular risk assessment concept to develop rapid methods that would target the pathogenic STEC group
- Further risk assessment is necessary to determine if testing beef for additional STEC would have any impact on public health

Public Health Benefits



- **Results of a large ground beef survey by USDA ARS:**
 - Of 4,133 samples of commercial ground beef, 7.3 % were culture confirmed to contain STEC
 - Only 10 samples (0.24%) had virulence factors that indicate a significant public health risk (pSTEC)
 - Nearly 1/3 of the pSTEC isolated did not fall in “top 6”
 - 4 of the 10 pSTEC would have been missed by the current FSIS non-O157 STEC method
 - In these 4,133 samples, only 4 “top 6” isolates were found and most of these lacked virulence genes (were not pSTEC)
- “Narrowly focusing on only the described “top six” STEC will identify numerous isolates of little pathogenic concern while missing others that should not go unnoticed”
- (Bosilevac and Koohmaraie, 2011)

Summary Comments



- Focus should be on prevention
- The industry is ready and willing to do what it takes to make safe product – this makes good business sense and it's the right thing to do
- *E. coli* O157:H7 can serve as an indicator of process control and an index organism that will cover all STECs
- Many significant research gaps remain
- A validated test method that will give results in a timely manner and find pSTEC does not exist, even in Beta format
- Reducing levels in live cattle may have the best impact
- All regulatory and industry efforts should be focused on public health outcome