New Jersey's Strategy for Microbial Source Tracking

Water Monitoring & Standards

Bureau of Marine Water Monitoring

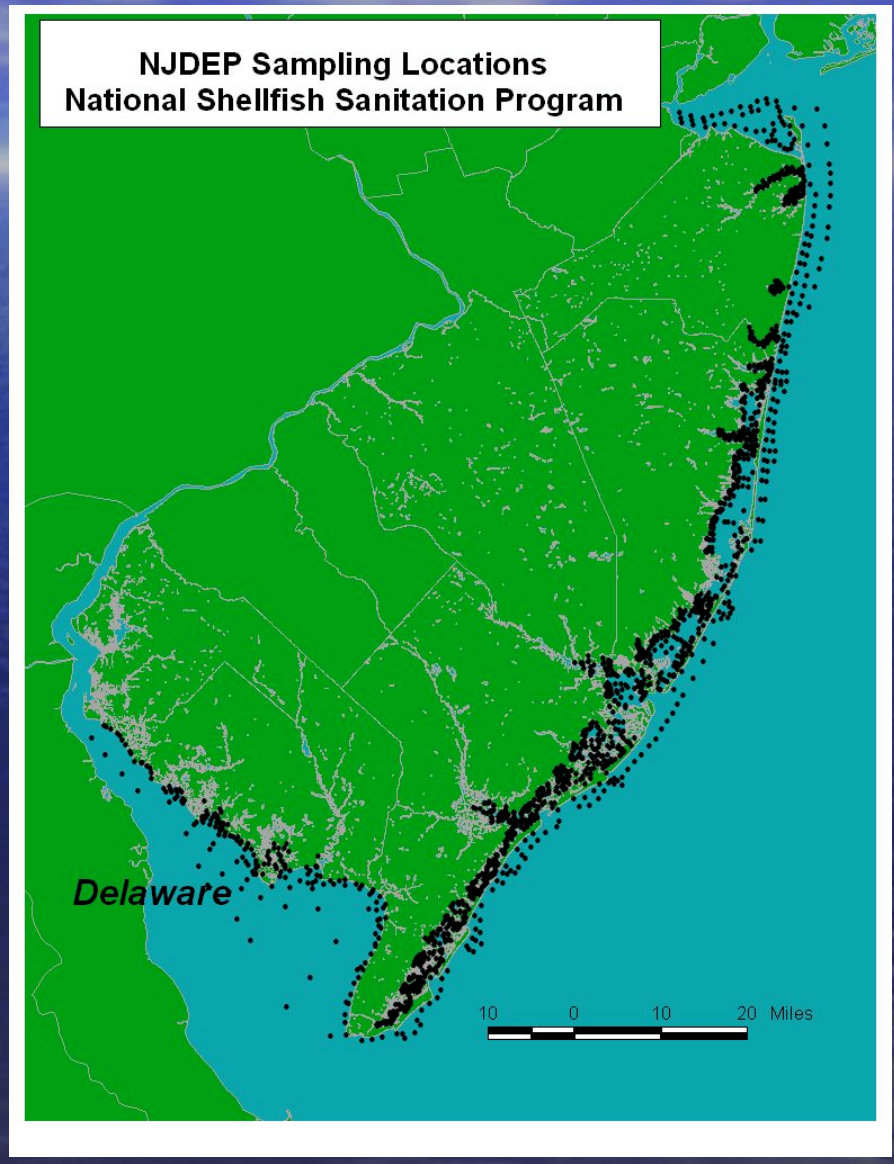
Monitoring Areas

- National Shellfish Sanitation Program
- Coastal Monitoring Network
- Non-Point Runoff Studies
- Emergency Spills

http://www.state.nj.us/dep/dsr/bmw/index.htm

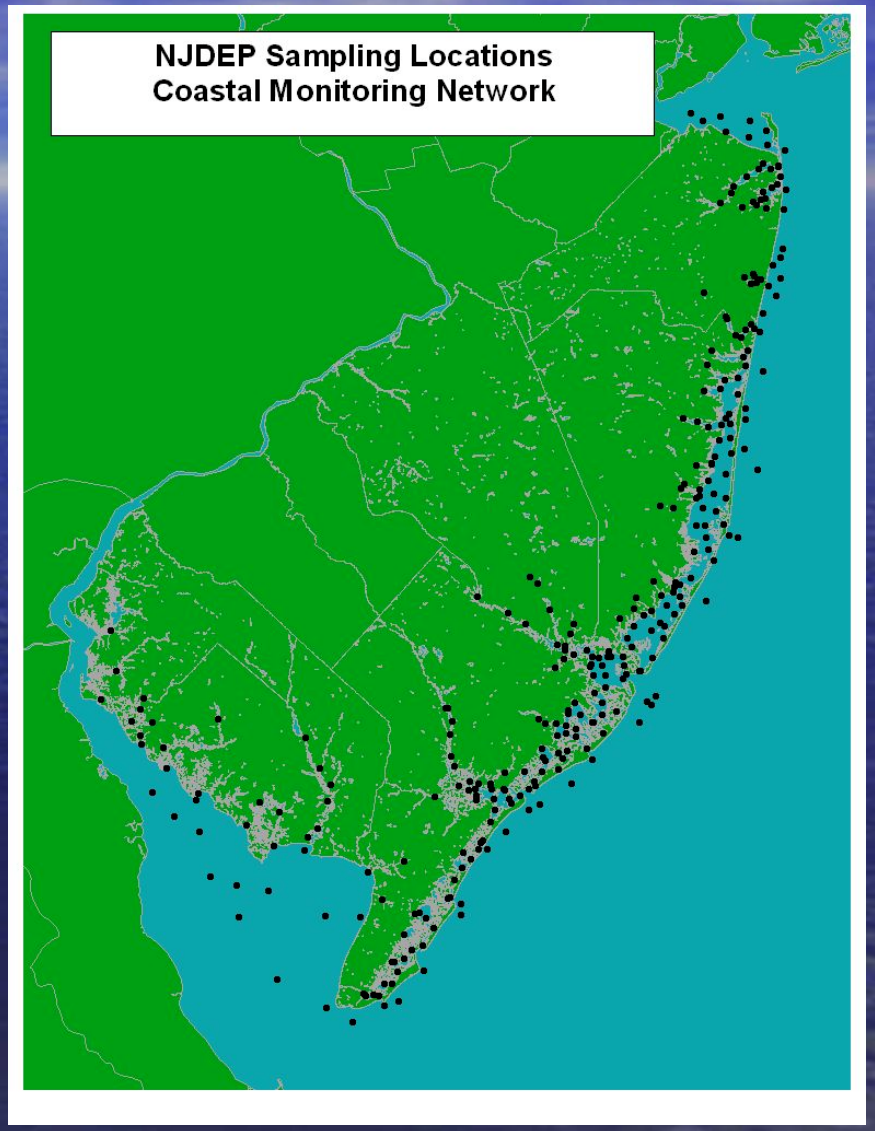
NSSP Monitoring Network

- Approximately 2,500 sampling locations
- Samples collected 5-12x per year
- Samples analyzed for total coliform and fecal coliform bacteria - indicators of human waste.

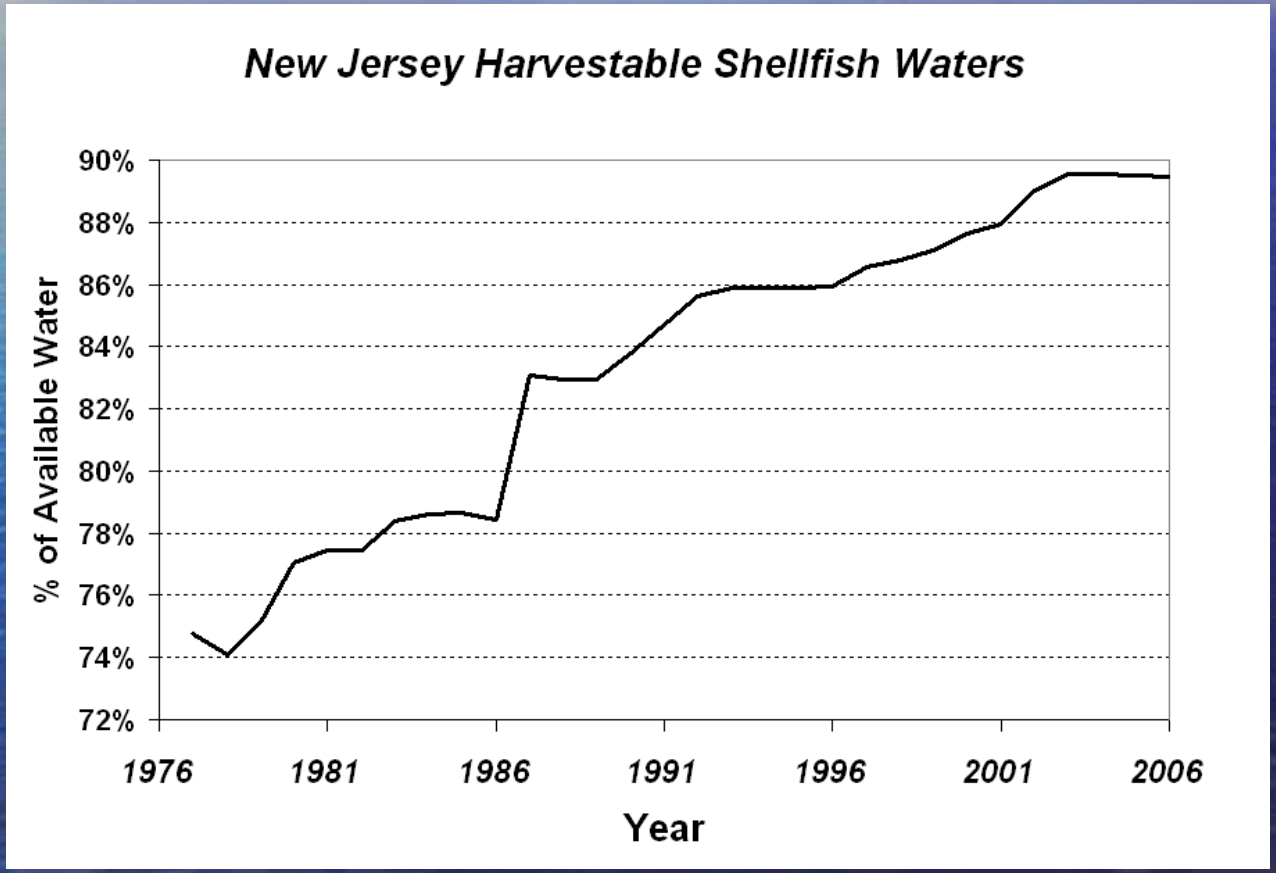


Coastal Monitoring Network

- Established to provide consistent long-term monitoring of basic water quality
- Salinity
- DO
- Nutrients
- Temperature
- Chlorophyll
- Secchi Depth
- Enterococci



Harvestable Acreage in NJ



Stormwater Impacts

Areas shaded red represent coastal waters where fecal coliform levels are elevated following a storm event.

Stormwater Monitoring

- Developed field methods for estimating pollutant loads from storm events
- Perform monitoring during storm conditions to delineate major sources
- Use specialized tests to identify sources of contamination
- Data used to address impaired areas of the State

Decision Criteria for MST

- Is The Problem Adequately Defined?
  - beach closures
  - TMDLs
- Has An Adequate Sanitary Survey Been Conducted?
- How Many Sources Were Identified In the Sanitary Survey?

Decision Criteria

- Is The Watershed Of Manageable Size?
  - Generally, watersheds with drainage areas greater than 14 digit USGS code are not amenable to using MST
- What Is The Desired level of Discrimination?

Decision Criteria

- Levels of Discrimination
  - Humans vs. all other sources
  - Species specific (humans, cows, geese, dogs, etc.)
  - Host Group (humans vs. livestock vs. wildlife)
  - Individual hosts (cows from a certain farm vs. other farms)

MST Strategy

- Evaluate long-term microbial monitoring results
- Perform stormwater monitoring to delineate major sources
- Use specialized tests to aid in source ID
- Evaluate data in conjunction with sanitary survey info (GIS land use coverage, hydrographic studies, actual/potential sources

Seaside Heights Area Study

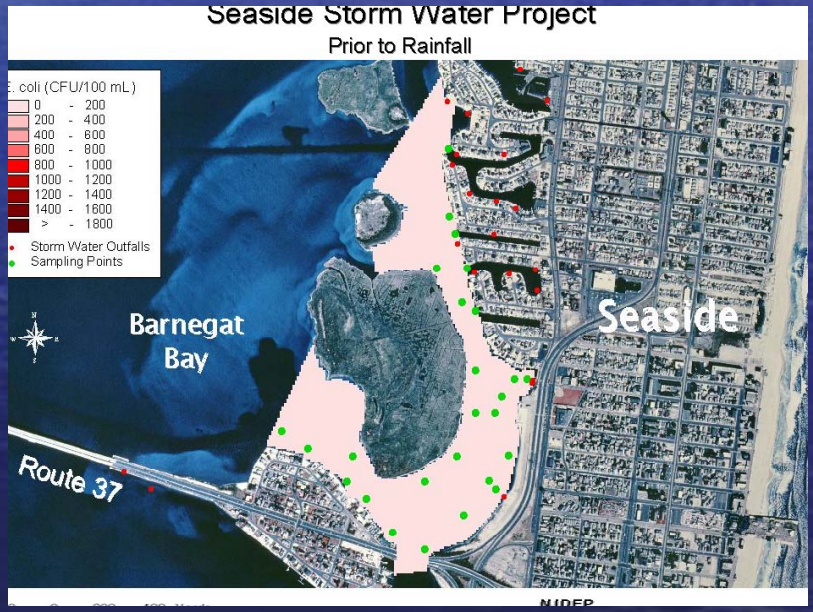
- Area with use impairment - Bathing Beach and shellfish water closure
- Area contains numerous sources:

Sampling Sites and Sources

- Routine sampling stations shown in green
- Stormwater pipe discharges shown in red

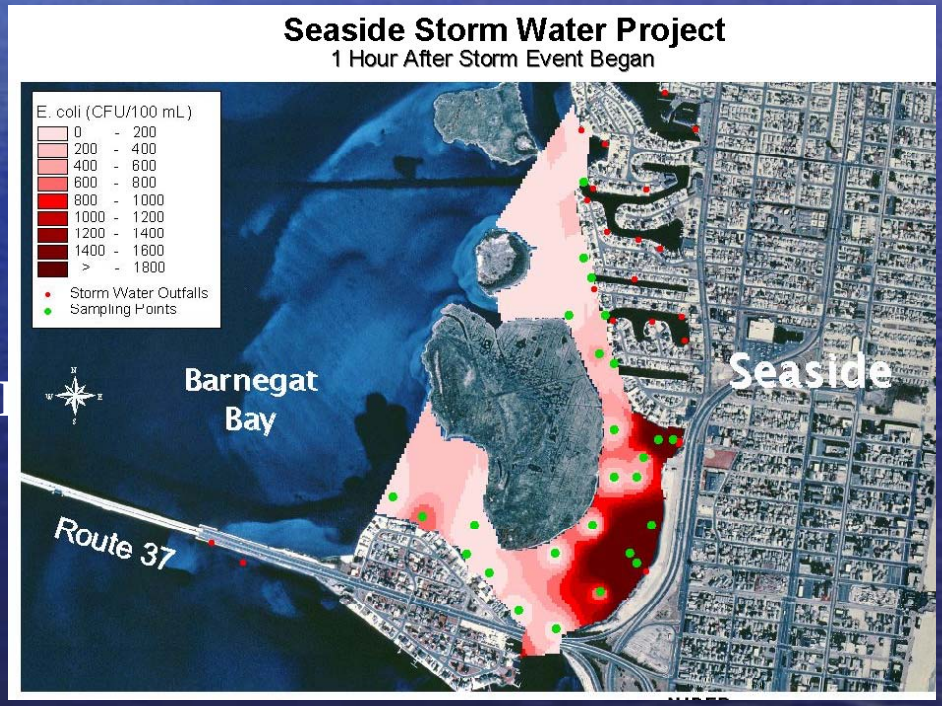
Seaside Storm Water Project

- Bacteria levels prior to rainfall
- Levels throughout the area are generally less than 100 fecal coliform per 100 mLs



Seaside Storm Water Project

- 1 Hour after storm event began
- Levels quickly rise - some areas with fecal coliform levels greater than 1000/100 mLs
- High values adjacent to two stormdrains in this area



Seaside Storm Water Project

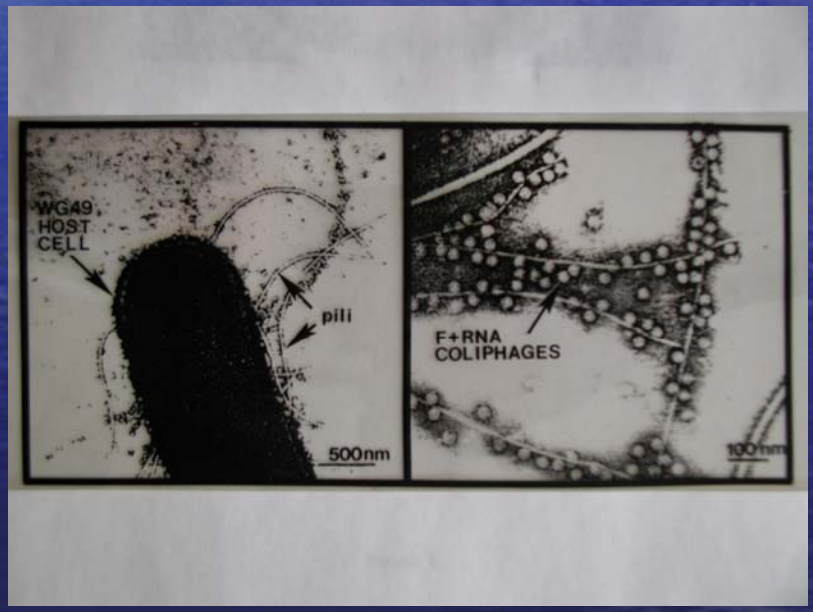
- 3 hours after storm event began
- Levels begin to subside
- High values continue to be adjacent to two of the numerous storm drains in the area

Seaside Storm Water Project

- Stormdrain - major contribution of bacterial loading
- Coliphage testing revealed source to be of human origin
- Demonstrates concept of prioritizing sources

F+ RNA Coliphages

- Viruses that infect bacterial cells
- Similar in size, shape and morphology to HEV including; HAV and Norwalk therefore: good viral pathogen indicator
- More resistant to chlorination than the conventional indicators
- Good wastewater effluent indicator



Coliphage - NJDEP Findings

- Monitoring at known fecal contaminated sites
  - point human - wasterwater discharge outfall
  - point animal - wildlife refuge discharge
  - non-point human - malfunctioning septic tank discharge
  - non-point animal - rural creek w/animal population

  - Findings:
    - coliphage are readily detectable in most fecal contaminated sites
    - serotyping (and now, genotyping) of the phages provides a promising system for distinguishing human and animal fecal contamination

Serotyping/Genotyping of coliphages

- Group I - Animal
- Group II - Human
- Group III - Human
- Group IV - Animal

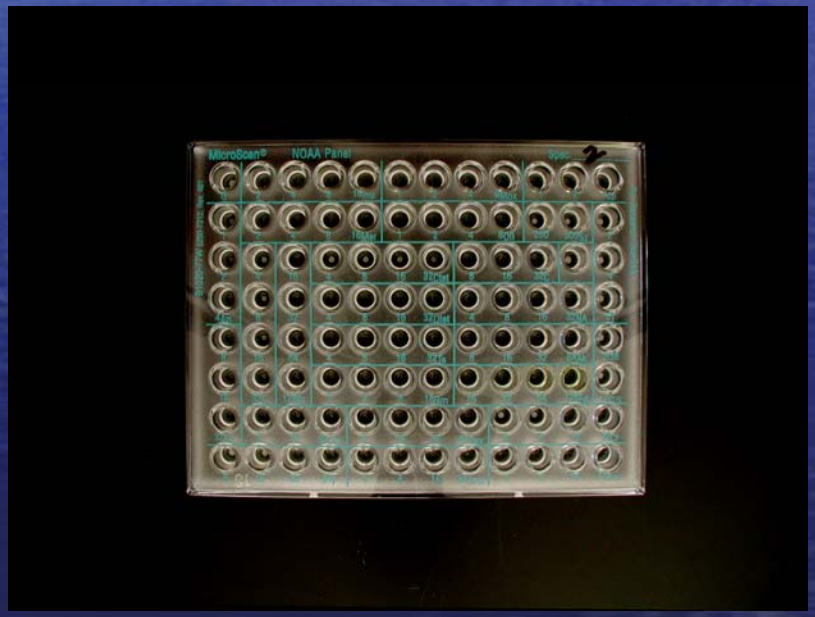
Techniques for Source ID

- **MAR - Multiple Antibiotic Resistance**
  - identifies *E. coli* that are resistant to antibiotics used to treat bacterial infections in humans. *E. coli* that is resistant to medicinal antibiotics are typically of human origin

- Used in conjunction with coliphage results
- Level of Discrimination: Human/Domesticated Animal/Wildlife

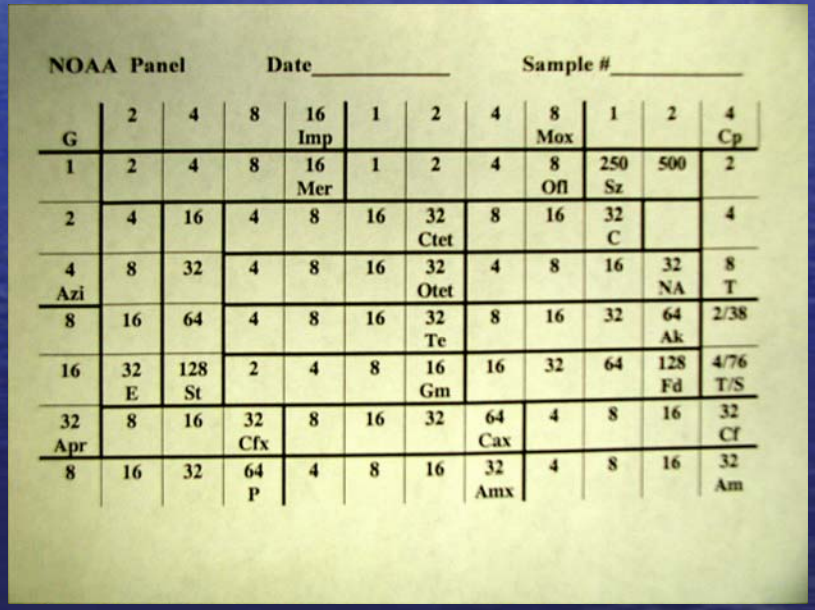
MAR Panel

- *E. coli* isolates from water samples are inoculated into 96 well panel
- Panel contains 26 antibiotics in 3-4 dilutions
- Growth denotes resistance
- Provides a consistent, standardized process



MAR Reporting Sheet

- Growth is recorded on a sheet which lists the antibiotics typically administered to humans and domestic animals
- Comparisons to a “reference library” is performed



NOAA Panel Date_____ Sample #_____

G	2	4	8	16 Imp	1	2	4	8 Mox	1	2	4 Cp
1	2	4	8	16 Mer	1	2	4	8 Ofl	250 Sz	500	2
2	4	16	4	8	16	32 Ctet	8	16	32 C		4
4 Azi	8	32	4	8	16	32 Otet	4	8	16	32 NA	8 T
8	16	64	4	8	16	32 Te	8	16	32	64 Ak	2/38
16	32 E	128 St	2	4	8	16 Gm	16	32	64	128 Fd	4/76 T/S
32 Apr	8	16	32 Cfx	8	16	32	64 Cax	4	8	16	32 Cf
8	16	32	64 P	4	8	16	32 Amx	4	8	16	32 Am

MST Reference Sites

- Wildlife - Wildlife Refuge
- Domesticated Animal - Cattle Farm
- Human - WWTP (chlorinated and unchlorinated effluent)

Legend

- Sampling Site
- Streams

N

Feet

0 300 600 1,200

NJDEP Bureau of Marine Water Monitoring


Sampling Site


AREA
CLOSED

WILDLIFE

NOAA Panel Date 3-21-06 Coll. Time 11:00 Sample # REFUGE ID # EAST GATE

G	2	4	8	16 Imp	1	2	4	8 Mox	1	2	4 Cp
1	2	4	8	16 Mer	1	2	4	8 Ofl	250 Sz	500	2
2	4	16					8	16	32 C		4
4 Azi	8	32	4	8	16	32 Otet	4	8	16	32 NA	8 T
8	16	64	4	8	16	32 Te	8	16	32	64 Ak	2/38
16	32 E	128 St	2	4	8	16 Gm	16	32	64	128 Fd	4/76 T/S
32 Apr	8	16	32 Cfx	8	16	32	64 Cax	4	8	16	32 Cf
8	16	32	64 P	4	8	16	32 Amx	4	8	16	32 Am

MODIFIED mTec

Vol.	Colony Count	CFU's/100mLs
30	12	40

Phage	PFU's/100mLs
–	<1

DOMESTICATED ANIMAL

NOAA Panel Date 3-2-04 Coll. Time _____ Sample # _____ ID # ALLDWAY

G	2	4	8	16 Imp	1	2	4	8 Mox	1	2	4 Cp
1	2	4	8	16 Mer	1	2	4	8 Ofl	250 Sz	500	2
2	4	16					8	16	32 C		4
4 Azi	8	32	4	8	16	32 Otet	4	8	16	32 NA	8 T
8	16	64	4	8	16	32 Te	8	16	32	64 Ak	2/38
16	32 E	128 St	2	4	8	16 Gm	16	32	64	128 Fd	4/76 T/S
32 Apr	8	16	32 Cfx	8	16	32	64 Cax	4	8	16	32 Cf
8	16	32	64 P	4	8	16	32 Amx	4	8	16	32 Am

MODIFIED mTec

Vol.	Colony Count	CFU's/100mLs
_____	_____	_____

Phage	PFU's/100mLs
_____	_____

HUMAN

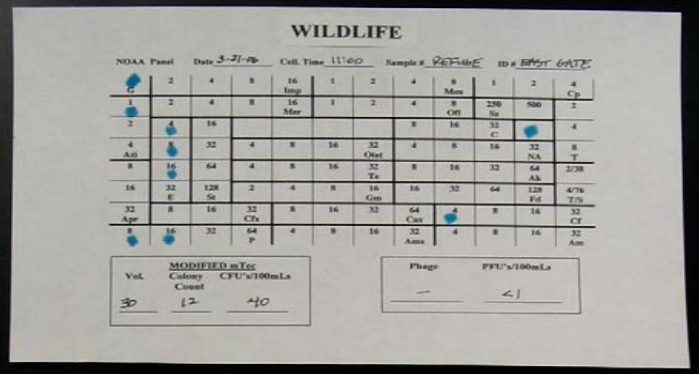
NOAA Panel Date 3-27-04 Coll. Time _____ Sample # ACUA ID # EFFLUENT

G	2	4	8	16 Imp	1	2	4	8 Mox	1	2	4 Cp
1	2	4	8	16 Mer	1	2	4	8 Ofl	250 Sz	500	2
2	4	16					8	16	32 C		4
4 Azi	8	32	4	8	16	32 Otet	4	8	16	32 NA	8 T
8	16	64	4	8	16	32 Te	8	16	32	64 Ak	2/38
16	32 E	128 St	2	4	8	16 Gm	16	32	64	128 Fd	4/76 T/S
32 Apr	8	16	32 Cfx	8	16	32	64 Cax	4	8	16	32 Cf
8	16	32	64 P	4	8	16	32 Amx	4	8	16	32 Am

MODIFIED mTec

Vol.	Colony Count	CFU's/100mLs
100	12	12

Phage	PFU's/100mLs
	11,280



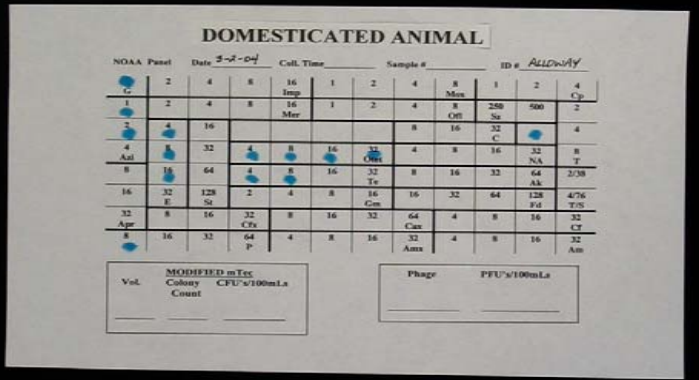
WILDLIFE

NOAA Panel Date 3-21-04 Coll. Time 11:00 Sample # REFUGE ID # EAST GATE

G	2	4	8	16 Imp	1	2	4	8 Mox	1	2	4 Cp
1	2	4	8	16 Mer	1	2	4	8 Off	250 Sz	500	2
2	4	16					8	16	32 C		4
4 Azi	8	32	4	8	16	32 Otet	4	8	16	32 NA	8 T
8	16	64	4	8	16	32 Te	8	16	32	64 Ak	2/38
16	32 E	128 St	2	4	8	16 Gm	16	32	64	128 Fd	4/76 T/S
32 Apr	8	16	32 CFx	8	16	32	64 Cax	4	8	16	32 CF
8	16	32	64 P	4	8	16	32 Amx	4	8	16	32 Am

Vol.	MODIFIED mTec Colony Count	CFU's/100mLs
30	12	40

Phage	PFU's/100mLs
—	<1



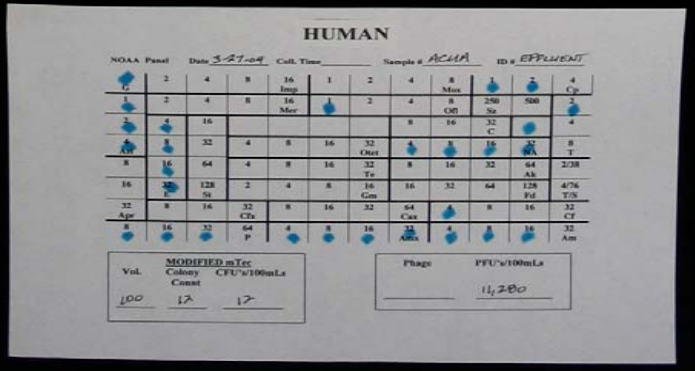
DOMESTICATED ANIMAL

NOAA Panel Date 3-21-04 Coll. Time _____ Sample # _____ ID # ALLOWAY

G	2	4	8	16 Imp	1	2	4	8 Mox	1	2	4 Cp
1	2	4	8	16 Mer	1	2	4	8 Off	250 Sz	500	2
2	4	16					8	16	32 C		4
4 Azi	8	32	4	8	16	32 Otet	4	8	16	32 NA	8 T
8	16	64	4	8	16	32 Te	8	16	32	64 Ak	2/38
16	32 E	128 St	2	4	8	16 Gm	16	32	64	128 Fd	4/76 T/S
32 Apr	8	16	32 CFx	8	16	32	64 Cax	4	8	16	32 CF
8	16	32	64 P	4	8	16	32 Amx	4	8	16	32 Am

Vol.	MODIFIED mTec Colony Count	CFU's/100mLs

Phage	PFU's/100mLs



HUMAN

NOAA Panel Date 3-21-04 Coll. Time _____ Sample # ACUA ID # EFFLUENT

G	2	4	8	16 Imp	1	2	4	8 Mox	1	2	4 Cp
1	2	4	8	16 Mer	1	2	4	8 Off	250 Sz	500	2
2	4	16					8	16	32 C		4
4 Azi	8	32	4	8	16	32 Otet	4	8	16	32 NA	8 T
8	16	64	4	8	16	32 Te	8	16	32	64 Ak	2/38
16	32 E	128 St	2	4	8	16 Gm	16	32	64	128 Fd	4/76 T/S
32 Apr	8	16	32 CFx	8	16	32	64 Cax	4	8	16	32 CF
8	16	32	64 P	4	8	16	32 Amx	4	8	16	32 Am

Vol.	MODIFIED mTec Colony Count	CFU's/100mLs
100	17	17

Phage	PFU's/100mLs
	11,200

MAR Results

Antibiotic	Waterfowl		Cattle		WWTP
Azithromycin					
Erythromycin					
Penicillin G or V					
Oxytetracycline					
Tetracycline					
Amoxicillin					
Ceftriaxone					
Ampicillin					

Resistance Intensity	Low		Med		High

Station	Intensity	ABs	Rank	E coli	Phage	Phage Type
PM003	0.86	18.00	0.88	4221	323	
96A	0.89	14.00	0.79	144	3	Human
PM002	0.78	14.00	0.74	5006	168	
96B	0.82	12.00	0.71	114	3	Human
SMITH POND	0.90	10.00	0.70	902	< 1	
98	0.92	9.00	0.68	54	< 1	
92	0.88	9.00	0.67	160	313	
100	0.83	9.00	0.64	68	< 1	
87	0.66	11.00	0.61	1542	33	
107	0.82	8.00	0.61	85	10	
ACUACHLEFF	0.78	8.00	0.59	12	13640	
M.R.1-4	0.88	7.00	0.61			
95	0.62	9.00	0.54	97	4	Human
33	0.79	7.00	0.57	112	2	Human
HC-3	0.69	8.00	0.54	10		
97	0.68	8.00	0.54	148	1	Animal
105	0.68	8.00	0.54	568	182	
67	0.67	8.00	0.53	58	< 1	
M.R.-24	0.76	7.00	0.55	347	< 1	
REFUGE	0.75	7.00	0.55	35		
M.R.3-4	0.81	6.00	0.55			
HC-4	0.73	6.00	0.52	370		

Intensity = ave. Level of resistance where 1.00 means resistant to all ABs at the highest conc

ABs means # of antibiotics that E. coli were resistant to.

Rank = $\frac{(AB/20 + Intensity)}{2}$

MAR Patterns

- Fecal coliform isolates from humans were more resistant to ampicillin and amoxicillin than were animal isolates
- Fecal coliform isolates from animals were more resistant to tetracycline (oxytetracycline), erthromycin, and streptomycin than isolates from humans

- *From: Harwood, University of South Florida*

BACTERIOPHAGE METHOD

MAR METHOD

Use of Alternate Indicators in MST

- There is no “Silver Bullet” - All microbiological methods have limitations (including fecal coliform and Enterococcus).
- Design your monitoring program to use best indicators and preferably multiple indicators.
- Combine these results with routine monitoring data and a thorough pollution source survey to develop a “weight of evidence” approach.

Contact Information

- Eric Feerst, Section Chief - NJDEP Bureau of Marine Water Monitoring

- Eric.Feerst@dep.state.nj.us
- 609- 748-2000

- http://www.nj.gov/dep/bmw/