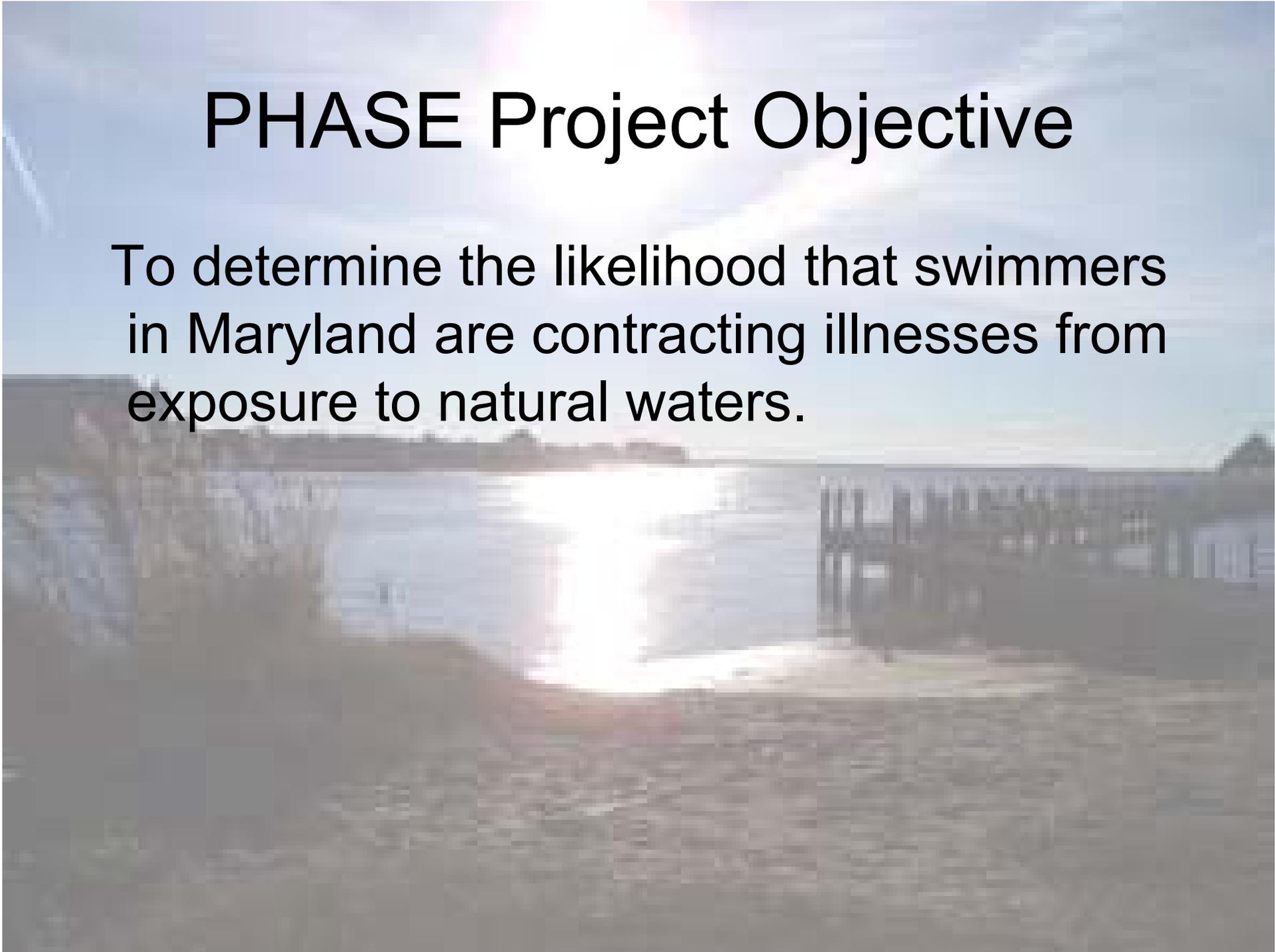


Incidence of Illness Associated with Recreational Water Contact: Evaluating a Potential Public Health Problem

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PHASE Project Objective

To determine the likelihood that swimmers in Maryland are contracting illnesses from exposure to natural waters.



Background

- Disease Classification
 - Pathogenic agents: bacterial, viral, parasitic and fungal
 - Mode of infection: skin contact, ingestion of contaminated water

Bacteria	Disease	Symptoms	Reservoir	Method of Transmission
Salmonella	Typhoid, ParaTyphoid fever, Salmonellosis	acute enterocolitis--fever, headache, nausea, vomiting	Domestic and wild animals--animals and birds=chronic carriers	Ingestion of contaminated food or water
Shigella (Plesiomonas shigelloides)	Bacillary Dysentery/Shigellosis; acute GI illness	diarrhea (bloody stool), fever, nausea, toxemia, vomiting	humans	Direct or Indirect Fecal oral transmission
E. Coli (O157:H7, O121)	gastroenteritis, HUS (hemolytic uremic syndrome)	Diarrhea, with or without bloody stool	cattle, humans, deer	Ingestion of contaminated food or ingesting or swimming in contaminated water
Yersinia enterocolitica	Intestinal/Extraintestinal Yersiniosis	acute febrile diarrhea, enterocolitis, acute mesenteric lymphadenitis	pigs	fecal-oral transmission by ingestion of contaminated food or water; found in natural waters in absence of E. Coli
Staphylococcus aureus		vomiting, diarrhea, abdominal cramps, nausea, prostration	humans, animals	dust, sewage, water
Pseudomonas aeruginosa	otitis externa	ear pain; may also be asymptomatic	humans, animals	water and soil especially when contaminated with human or animal waste
Clostridium perfringens (C. welchii)	Enteritis	sudden colic, diarrhea, nausea	soil; GI tract of humans and animals (cattle, poultry, fish)	usually associated with ingestion of food contaminated with soil or feces. Levels of organism detected in water quality studies.
Legionella	Legionellosis	muscle ache, headache, cough, fever, chills, diarrhea	Natural waters	Airborne
Leptospira interrogans	Leptospirosis	Sudden fever, headache, chills, severe myalgia and conjunctival suffusion	Wild and domestic animals; rats, pigs, dogs, raccoons, cattle	Contact of skin or mucus membranes with water, moist soil or vegetation; swimming, direct contact with infected tissues, inhalation
Vibrio cholera	Cholera	sudden watery stools, nausea and vomiting	Humans, environmental (zooplankton, etc.)	Ingestion of contaminated food or water; US outbreaks involve eating seafood

Virus	Disease	Symptoms	Reservoir	Method of Transmission
Coxsackievirus A	Non-paralytic enterovirus	enteritis	variable	fecal-oral route; outbreaks related to swimming
Coxsackievirus B	Non-paralytic enterovirus	enteritis	variable	fecal-oral route; outbreaks related to swimming
Echoviruses	viral meningitis, mild respiratory disorders, diarrhea (infants)	respiratory symptoms, diarrhea	variable	fecal-oral route; outbreaks related to swimming
Adenoviruses	respiratory infection, conjunctivitis	respiratory symptoms, pinkeye	variable	fecal-oral route; outbreaks related to swimming
Reoviruses	Rotavirus, etc.	mild upper respiratory symptoms; diarrhea, vomiting, fever	variable; Rotavirus (mammals)	variable; Rotavirus (fecal-oral route)
Hepatitis A	Infectious Hepatitis	fever, abdominal cramps, anorexia, weakness, jaundice; may have vomiting or diarrhea	humans	fecal-oral transmission
Norovirus	Enteritis	nausea, vomiting, diarrhea, abdominal cramps, mild fever and headache	humans	Freshwater
Poliovirus	poliomyelitis	asymptomatic; abortive (fever, nausea, sore throat, abdominal pain); non-paralytic (severe headache, nausea, vomiting); paralytic (muscle weakness, wasting, difficulty breathing, paralysis)	humans	fecal-oral route

Parasite	Disease	Symptoms	Reservoir	Method of Transmission
Cryptosporidium parvum (coccidian protozoa)	cryptosporidiosis	watery diarrhea, anorexia, vomiting	humans, cattle, domestic animals	fecal-oral (person to person, animal to person, foodborne and waterborne); outbreaks associated with water injection and water recreation (pools and lakes)
Cyclospora cayetanensis (coccidian protozoa)	Cyclosporiasis	watery diarrhea, anorexia, nausea, vomiting, cramping, fatigue, weight loss	humans	Drinking or swimming in contaminated water
Naegleria fowleri (free-living ameba)	Naegleriasis/Acanthamebiasis Primary amebic meningoencephalitis	sore throat, severe headache, fever, nuchal rigidity, somnolence, death	free living in aquatic and soil habitats	Exposure of nasal passages to contaminated water; diving or swimming in fresh water (stagnant ponds or lakes in summer, thermal springs, waters warmed by industrial effluents)
Entamoeba histolytica	Amoebic Dysentery; Amoebiasis	most asymptomatic; intestinal or extraintestinal disease	humans-chronically ill or asymptomatic cyst passer	Ingestion of fecally contaminated food or water
Giardia intestinalis	Giardiasis	GI distress	birds, flies, cockroaches; infects dogs, cats, humans, other animals	Ingestion of fecally contaminated food or water
Schistosoma (trematode); Cercaria (free-swimming trematode larva)	Schistosomiasis /Swimmers itch ; Cercarial Dermatitis	Eggs produce granulomata and scars in organs where they lodge; symptoms relate to number and location of eggs	Humans, wild and domestic animals	Water containing free swimming larval forms (cercariae); miracidia-stage organisms contained in urine and feces, reinfect new host in cercariae stage after maturing in snails
Acanthamoeba	Granulomatous Amebic Encephalitis (GAE)	chronic skin lesions, conjunctivitis, keratoconjunctivitis	free living in aquatic and soil habitats	infection through respiratory tract, breaks in the skin or water uptake in the nostrils with spread to nervous system
Ascaris lumbricoides	Ascariasis	asymptomatic; mild (worms in stool, loss of appetite, fever, wheezing); severe (vomiting, abdominal distension, intestinal or biliary tract blockage)	soil; human feces	Ingestion of fecally contaminated food, water or soil

Fungus	Disease	Symptoms	Reservoir	Method of Transmission
Blastomyces dermatitidis	Blastomycosis	granulomatous mycosis of lungs and skin; sudden fever, cough and pulmonary infiltrate on x-ray; skin lesions may become crusted, ulcerated and spread	moist soil in wooded areas and along water ways	Inhaled spores
Candida albicans	Candidiasis (Thrush)	infects skin and mucosal surfaces; pneumonia, septicemia, endocarditis	humans	Resident in human mouth and gut; infection determined by host factors
Aspergillus niger	Otomycosis	external ear infection; scaling, itching, pain	decaying vegetation in nature; all seasons	Inhaled spores

Background (2)

- Contamination Measures
 - Total Coliforms (TC): total number of microscopic agents in a sample of water
 - Fecal Coliforms (FC): includes fecal contaminants from humans and other warm-blooded animals
 - Enterococci (ENT): human enterococci; associated with diarrhea in swimmers
 - E. coli
 - Streptococci

Background (3)

- Federal Guidelines for water safety
 - Guidelines implemented at state level
 - Maryland marine waters:
 - Monthly geometric mean: ≤ 35 enterococci/100ml
 - Single samples: ≤ 104 enterococci/100ml
 - Maryland fresh water:
 - Monthly geometric mean: ≤ 126 E. coli/100 ml
 - Single sample: ≤ 235 E. coli/100ml

Background (4)

- Potential contamination Sources
 - Sewage effluents: sewer overflows
 - Recreational population (shedding or defecation)
 - Industrial processes
 - Live stock
 - Farming activities
 - Domestic animals
 - Wildlife

Data Sources and Accessibility

- Potential Data Sources
 - Drug (prescription, OTC) sales
 - Ambulatory care databases
 - Hospital discharge data
 - Patient diagnostic (ICD-9) codes
 - Outbreak data
 - Weather data
 - Reportable disease data
 - Water quality data
 - Beach surveys

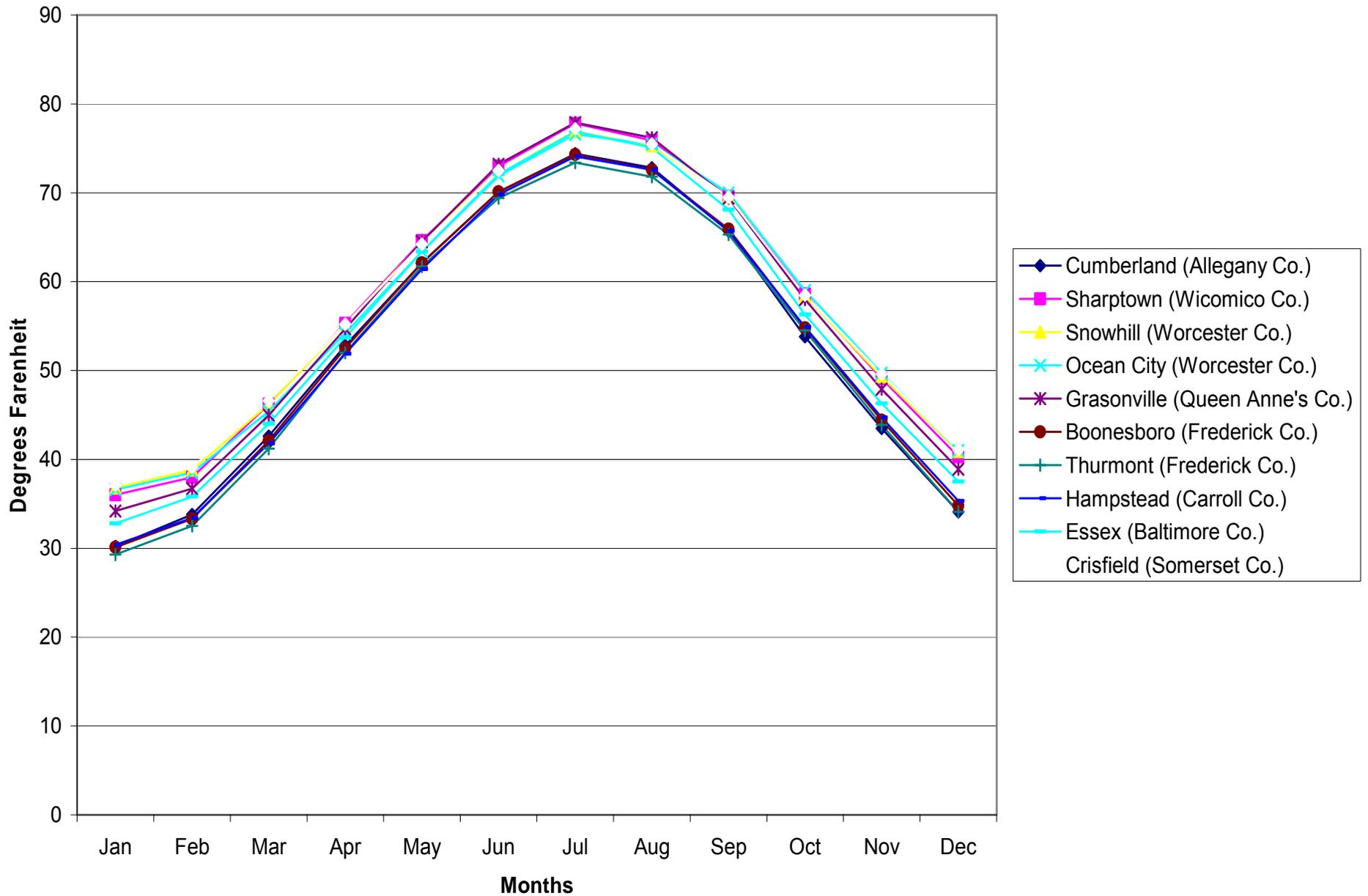
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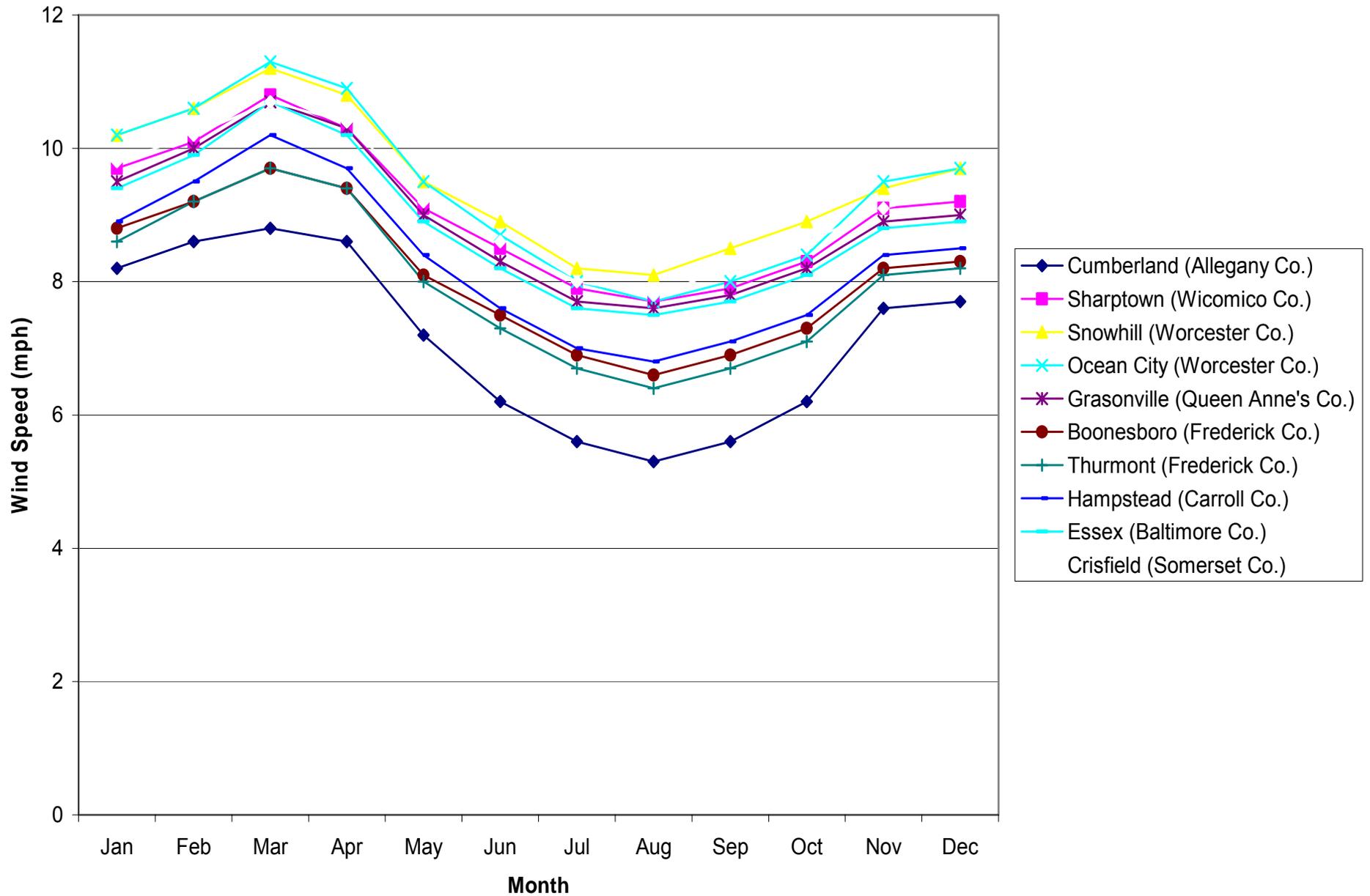
Data Analysis: Weather

- Temperature patterns: May-September
- Wind speed patterns: May-September
- Precipitation patterns: variable

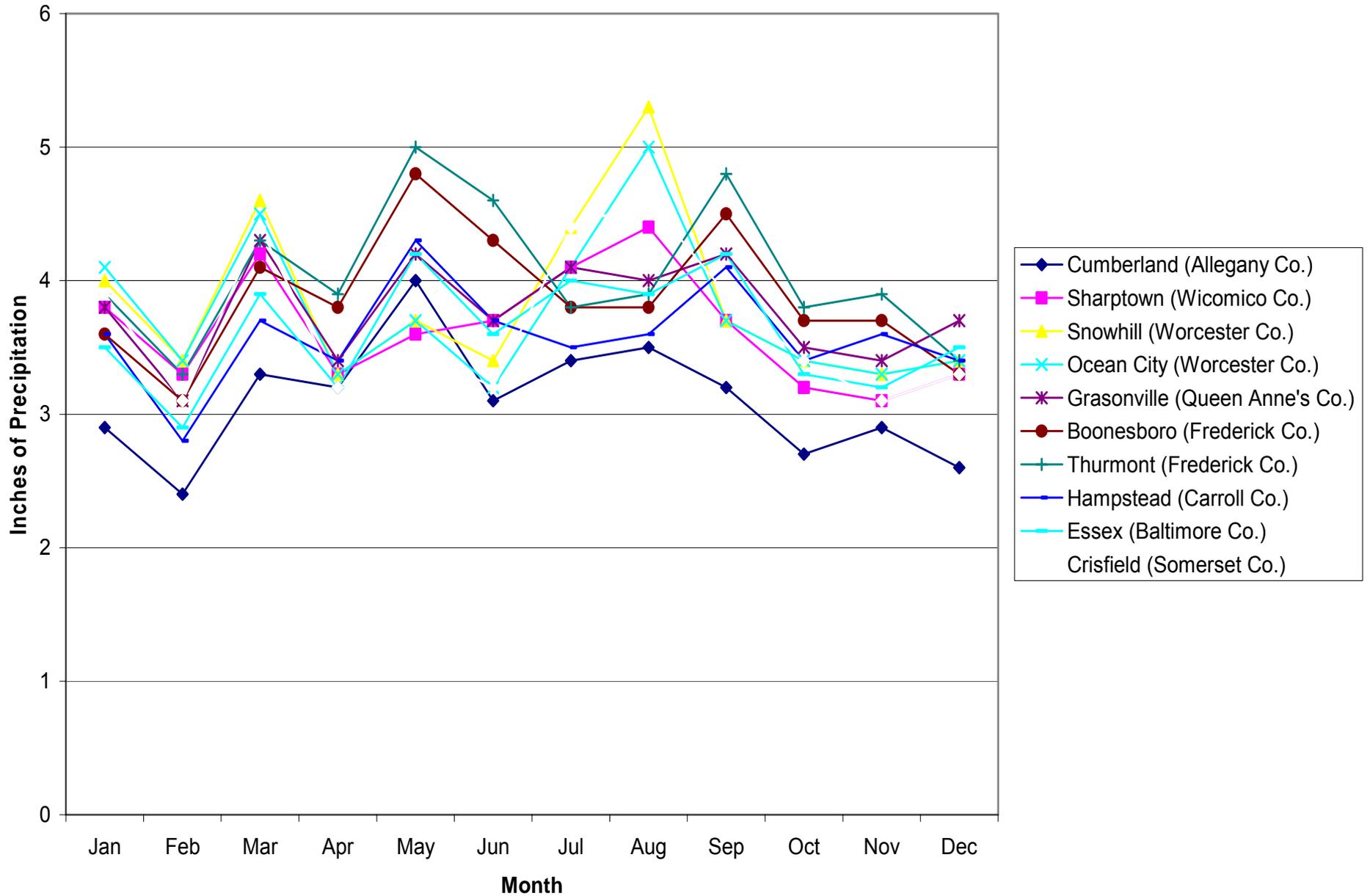
Average Temperature by Beach Location



Average Wind Speed in Areas Surrounding Beach Locations



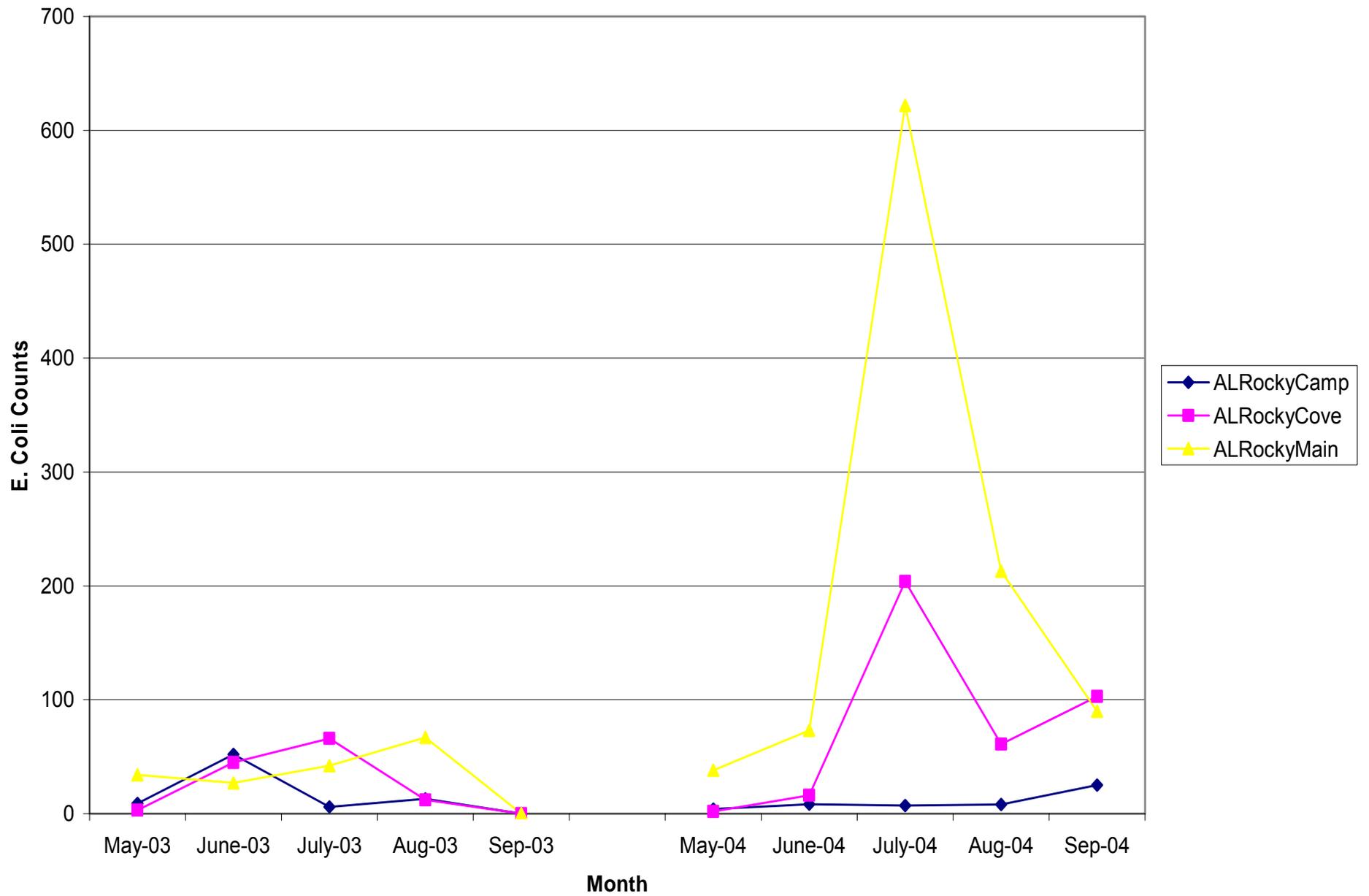
Average Precipitation by Beach Location



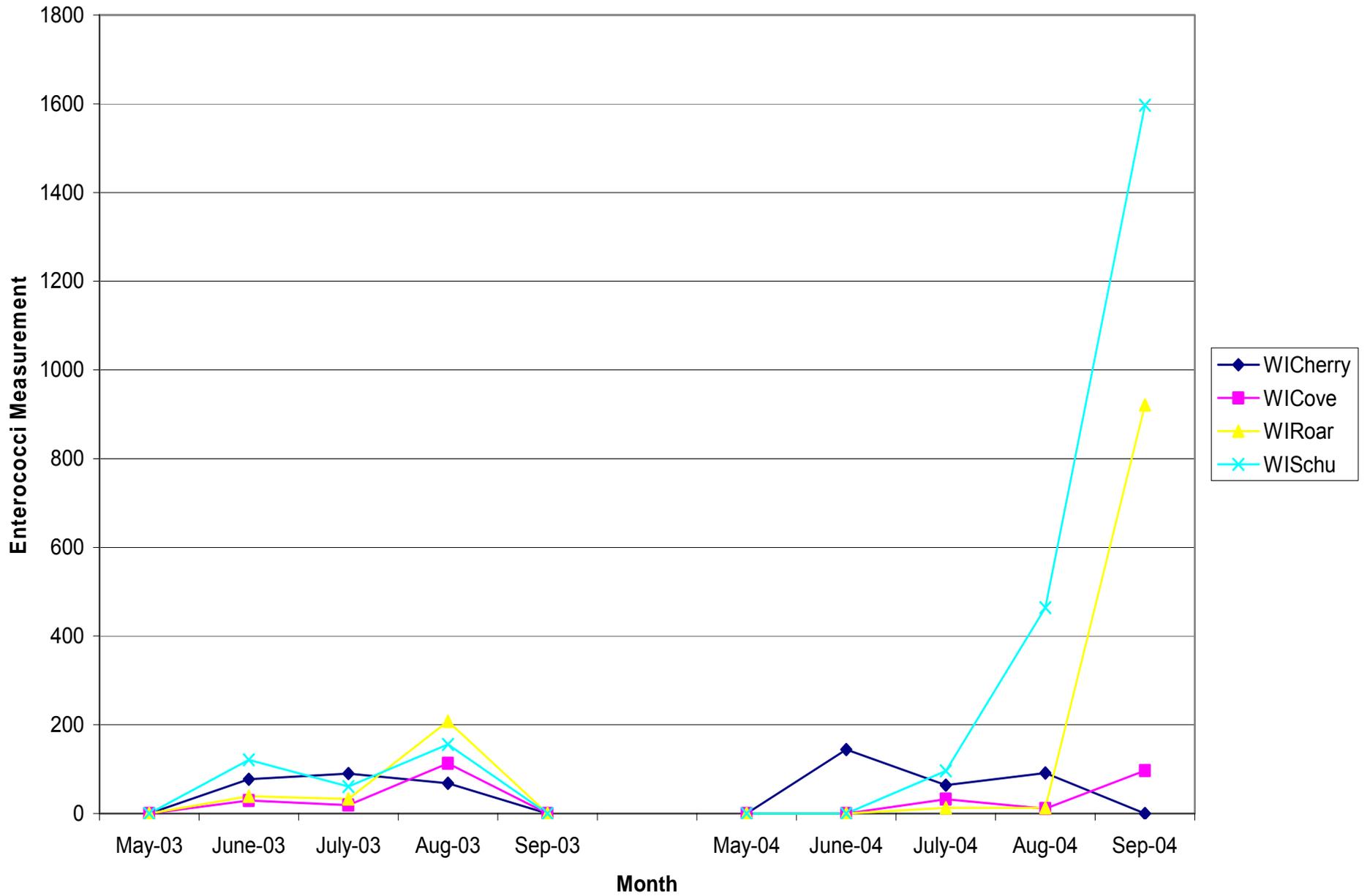
Data Analysis: Water Quality Indicators

- Variation in Measurements
 - Area and depth of water
 - day/time of day measurements taken
 - variations in weather conditions
- ENT/E. coli counts peaks in June/July
 - Coincident with peak swim season
- Counts sometimes exceed EPA standards
 - Beaches closed 7 times in 2003 and 12 times in 2004 for exceeding safety standards

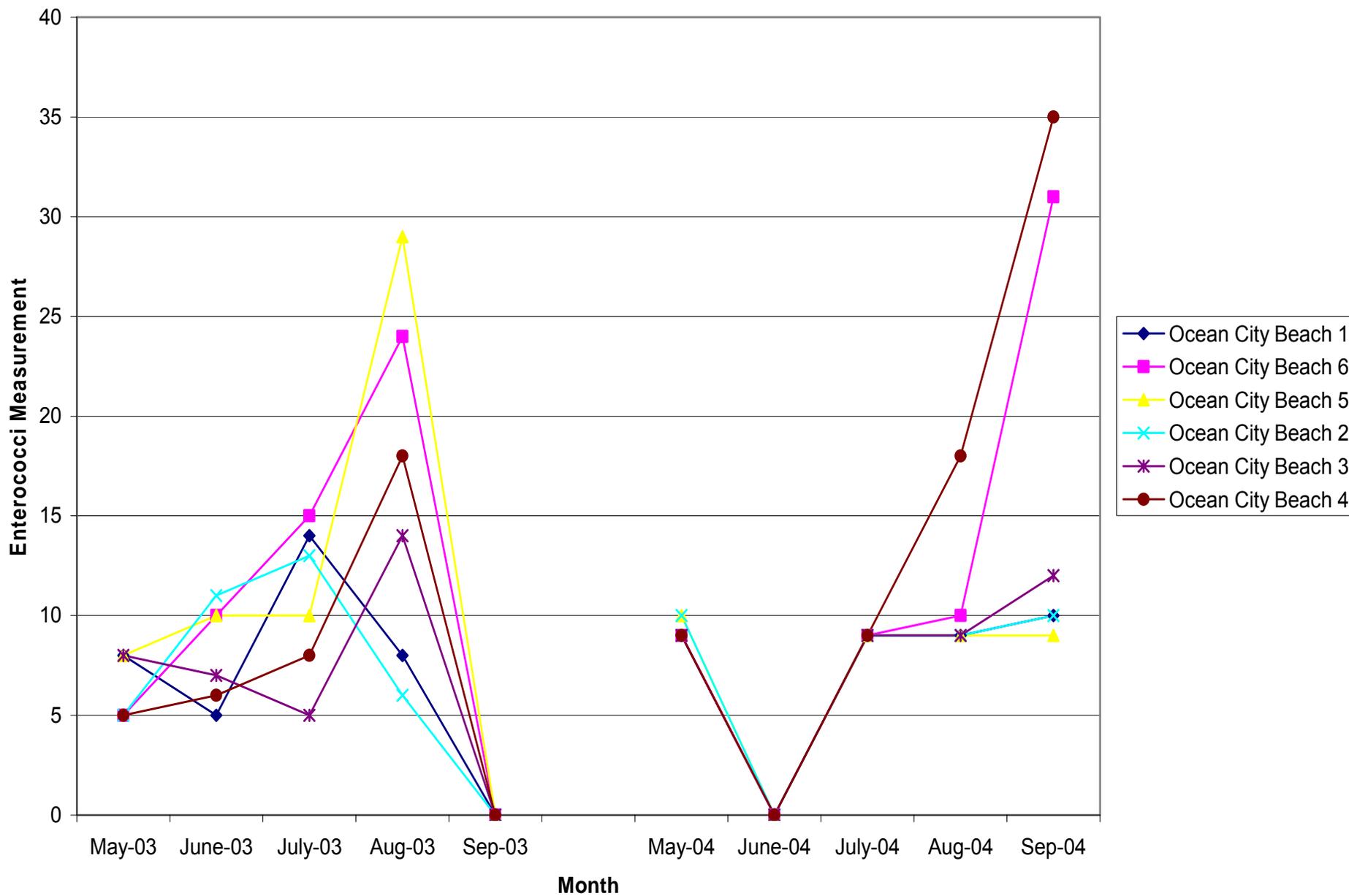
Allegheny County Average E. Coli Measurements by Station (2003-2004)



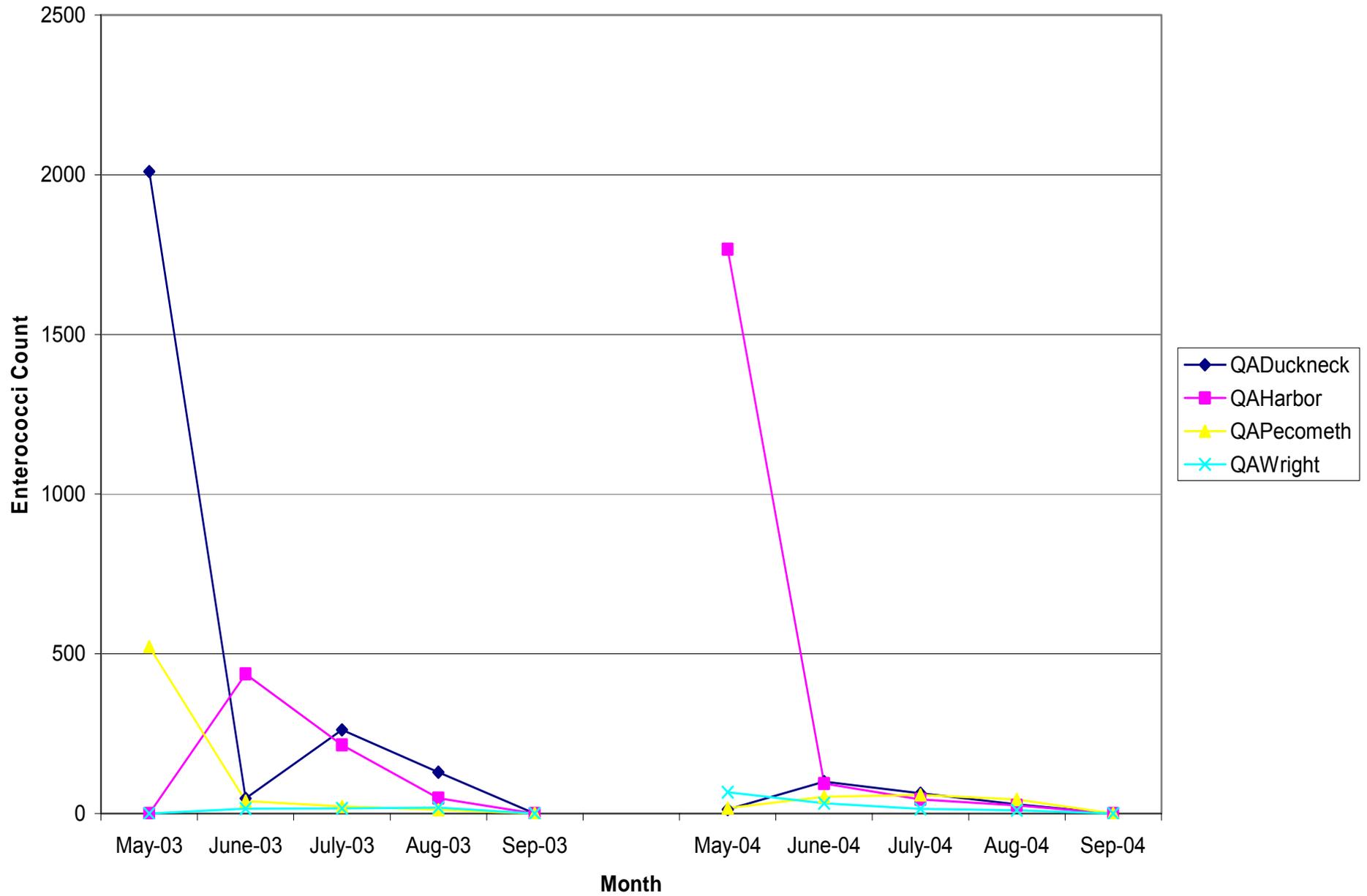
Wicomico County Average Enterococci Measurements by Station ID (2003-2004)



Worcester County Average Enterococci Measurements by Station (2003-2004)



Queen Anne's County Average Enterococci Measurements by Station (2003-2004)



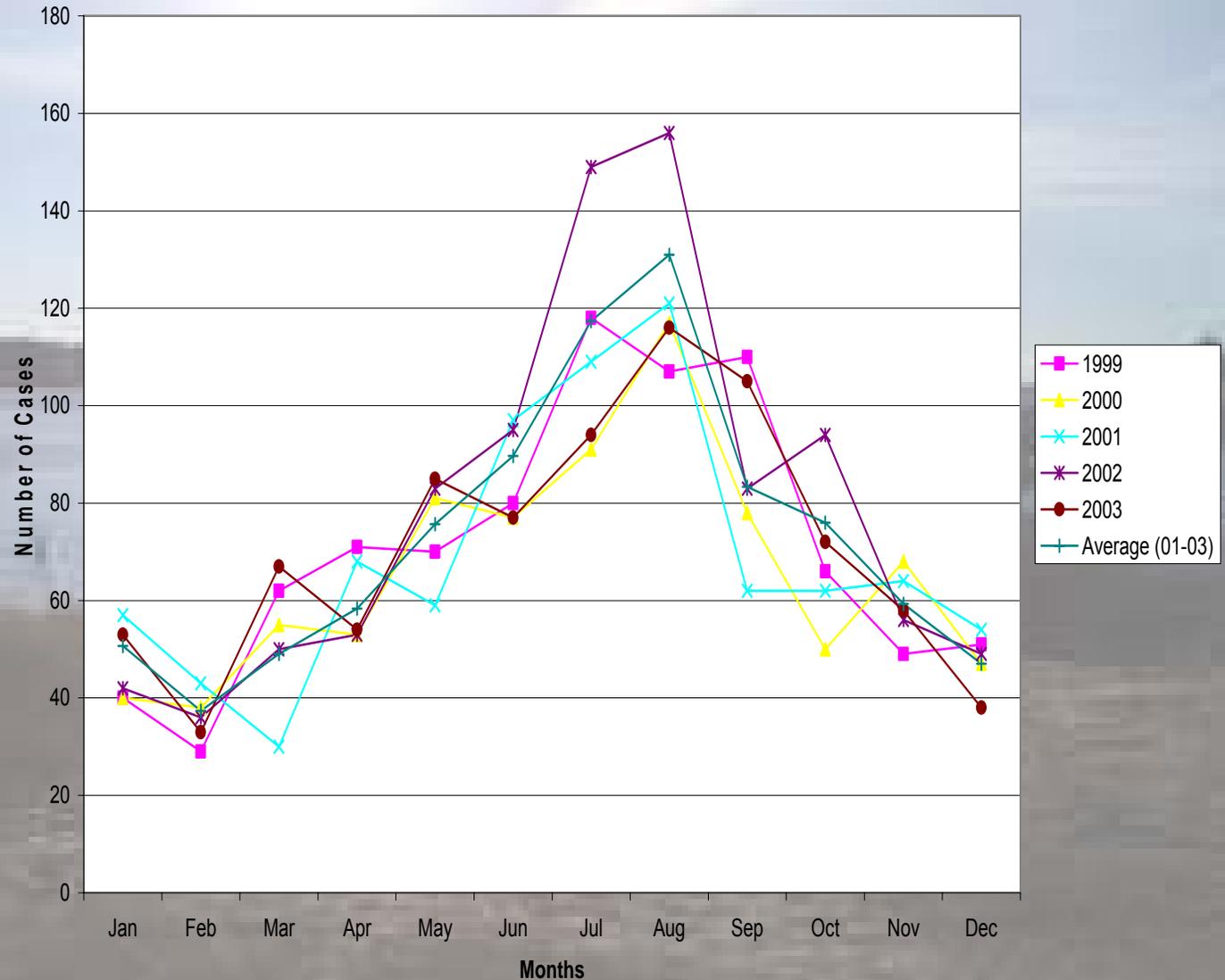
Analysis: Seasonal Trends

- Methods: Number of cases tabulated and plotted by month and year (1999-2003).
- 12 diseases matched both the disease matrix and the list of Reportable Diseases.
 - Amebiasis, Cryptosporidiosis, Cyclospora, E. coli, Giardiasis, Hepatitis A, Legionellosis, Leptospirosis, Meningococcal Bacteremia, Salmonella, Shigella and Yersinia enterocolitica

Analysis: Seasonal Trends (2)

Salmonella Cases (1999-2003)

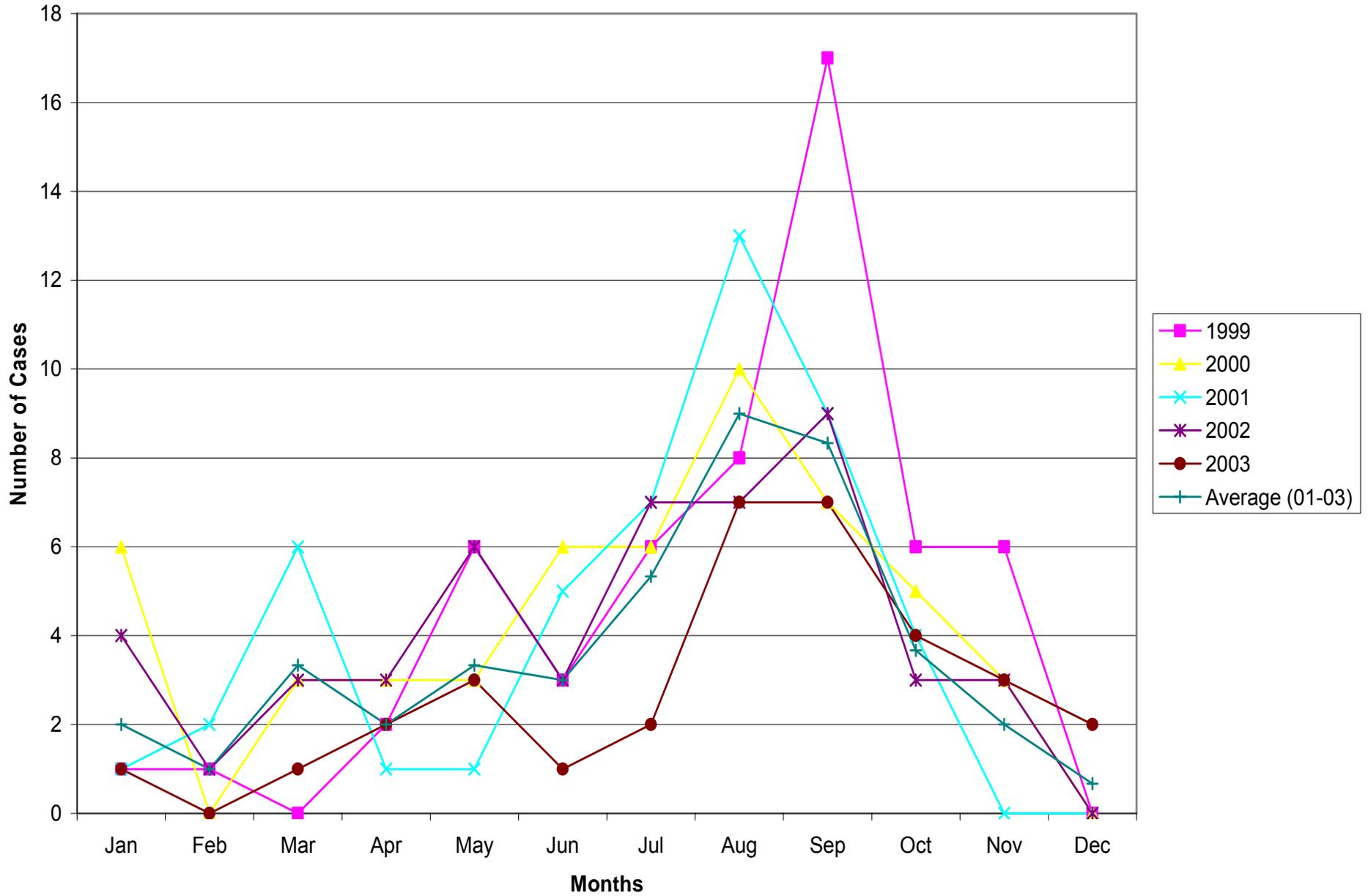
- Results:
 - Salmonella showed the strongest correlation with swimming season



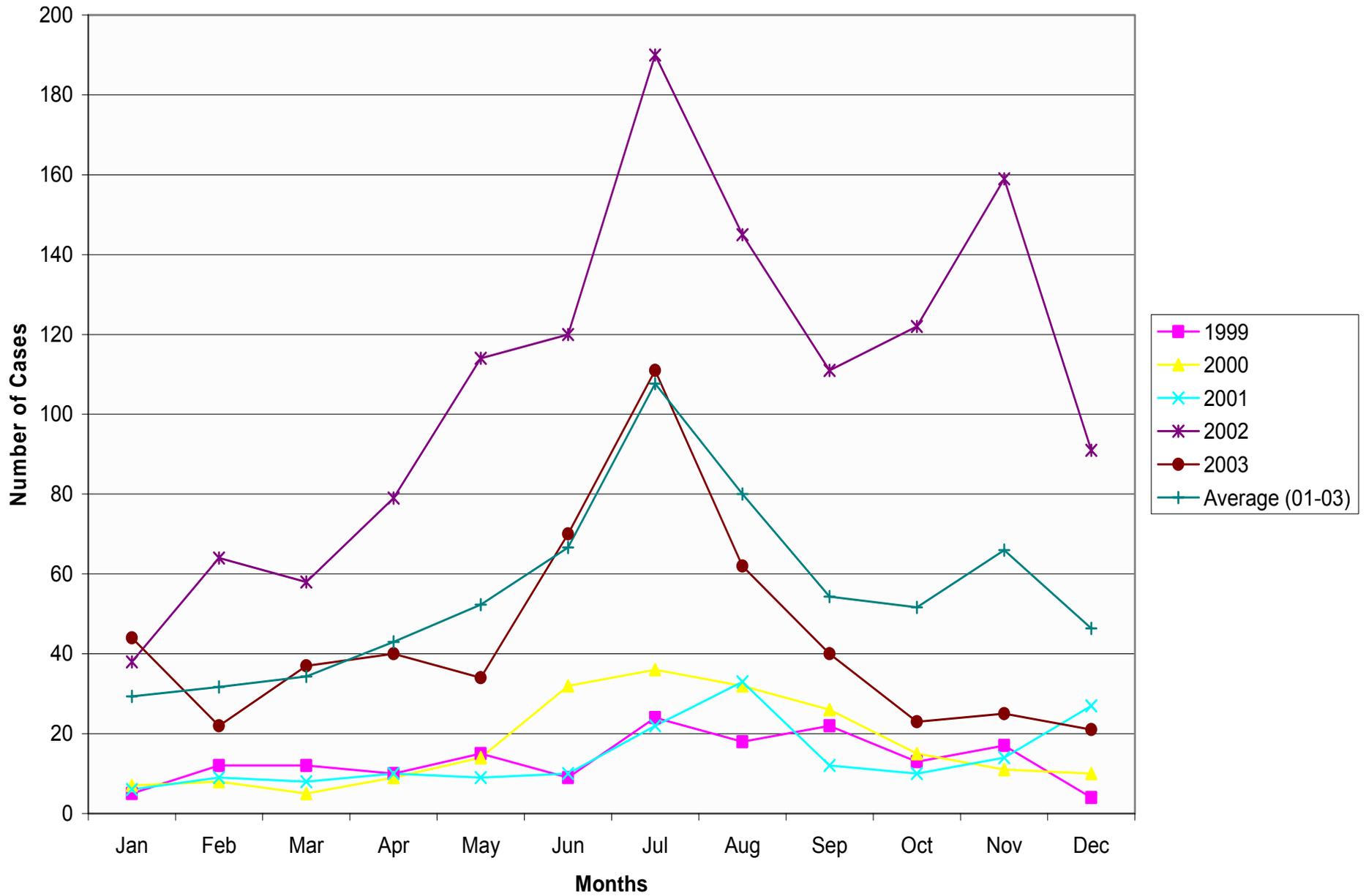
Analysis: Seasonal Trends (3)

- Results:
 - Numbers of reported E. coli, Shigella and Legionella cases also showed promising correlations with warm temperature trends
 - Remaining eight reportable diseases, showed no significant seasonal trends
 - Underreporting, physician misdiagnosis, mild or self-resolving treated with OTC drugs, home remedies or gone untreated.
 - Endemic disease levels also create “noisy” data making it more difficult to see seasonal trends

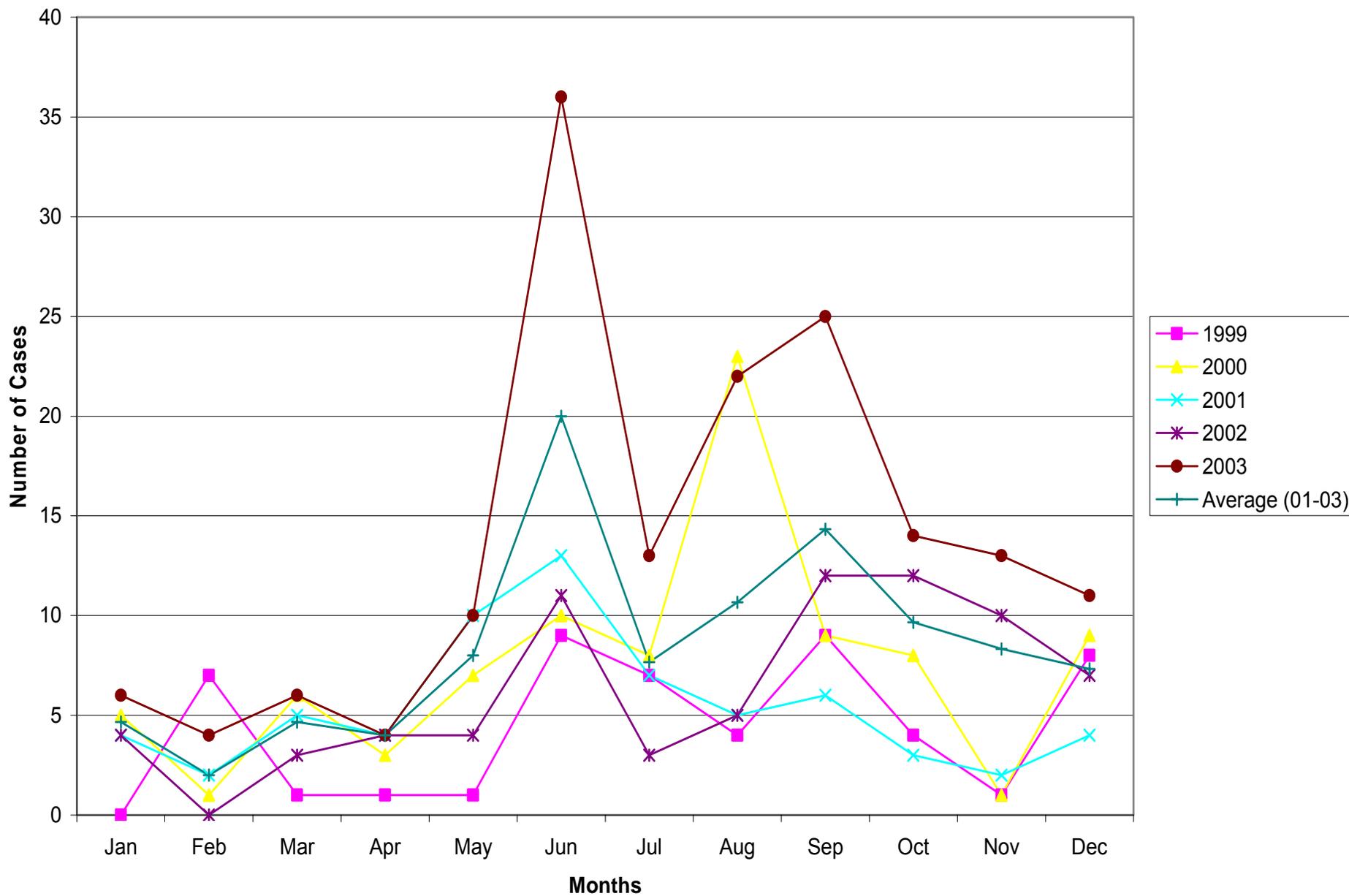
E. Coli Cases (1999-2003)



Shigella Cases (1999-2003)



Legionella Cases (1999-2003)



Analysis: Seasonal Trends (4)

- Methodology:
 - Difficulty with plotting cases against time
- Cannot calculate risk estimates (Incidence rates, relative risk, odds ratios)
- Cannot see increase or decrease in risk over time (rate of change)
 - Difficult to correlate disease rate fluctuations with similar changes in weather or dramatic events
- The result is a weak statistical argument for a “likely” association between swimming and disease

Recommendations

- Further research
 - Observational studies (cohort, case-control designs), randomized trial
- Focus research
 - most probable pathogens
 - broad scope of diseases
 - GI
 - non-enteric illnesses
- Fill-in existing data “gaps”

Recommendations (2)

- Filling in the “gaps” and more:
 - Demographics
 - parameters of population at risk for illness from swimming
 - Improve reporting
 - Underreporting is a potentially large problem (self-resolving, self-treated infections)
 - Cases not being reported to medical or PH services
 - Many potential diseases not “reportable”
 - Improve data access
 - Look for project coordination and information sharing opportunities
 - Lack of financial and time resources limit data accessibility
 - Legal agreements protect against third-party use

Recommendations (3)

- Filling in the “gaps” and more (con’t):
 - More research
 - Non-swimming risk factors for disease higher in swimmers (Fleisher et al. study)
 - Collaborate to reduce costs
 - Potential interventions
 - Physician Education Program
 - Partner with the Health Dept. to alert physicians to dangers of water recreation
 - Help physicians ask ALL the right questions of their patients to determine disease etiology
 - May improve reporting and help more accurately assess association between swimming and illness
 - Public Education Program
 - Make swimmers aware of specific potential dangers (disease symptoms, etc.)
 - Public awareness greatest reporting tool

Lessons Learned

- Need more information:
 - Demographic and other data needed to determine correlation between illness and proximity to swimming areas
- Poor water quality is a likely threat to swimmer health:
 - Seasonal correlation between swimming and four (4) potential swimmer illnesses (E. Coli, Salmonella, Shigella and Legionella).
 - Factor in determining resource allocation
 - Launching point for further research, study or continued observation (fill-in “gaps”)
 - Mathematical Modeling?
 - Weather data, water quality info and cases of illness in swimmers
 - Better method of predicting beach closures? (Turbow et al.)
- Invest in clean-up activities:
 - Water quality measures are improving but unreliable
 - Safeguard swimmer health by improving water conditions

Any Questions?

DANGER



Polluted Water

NO SWIMMING

By Order Of
Hammond Board of Health



Back-Up Slides

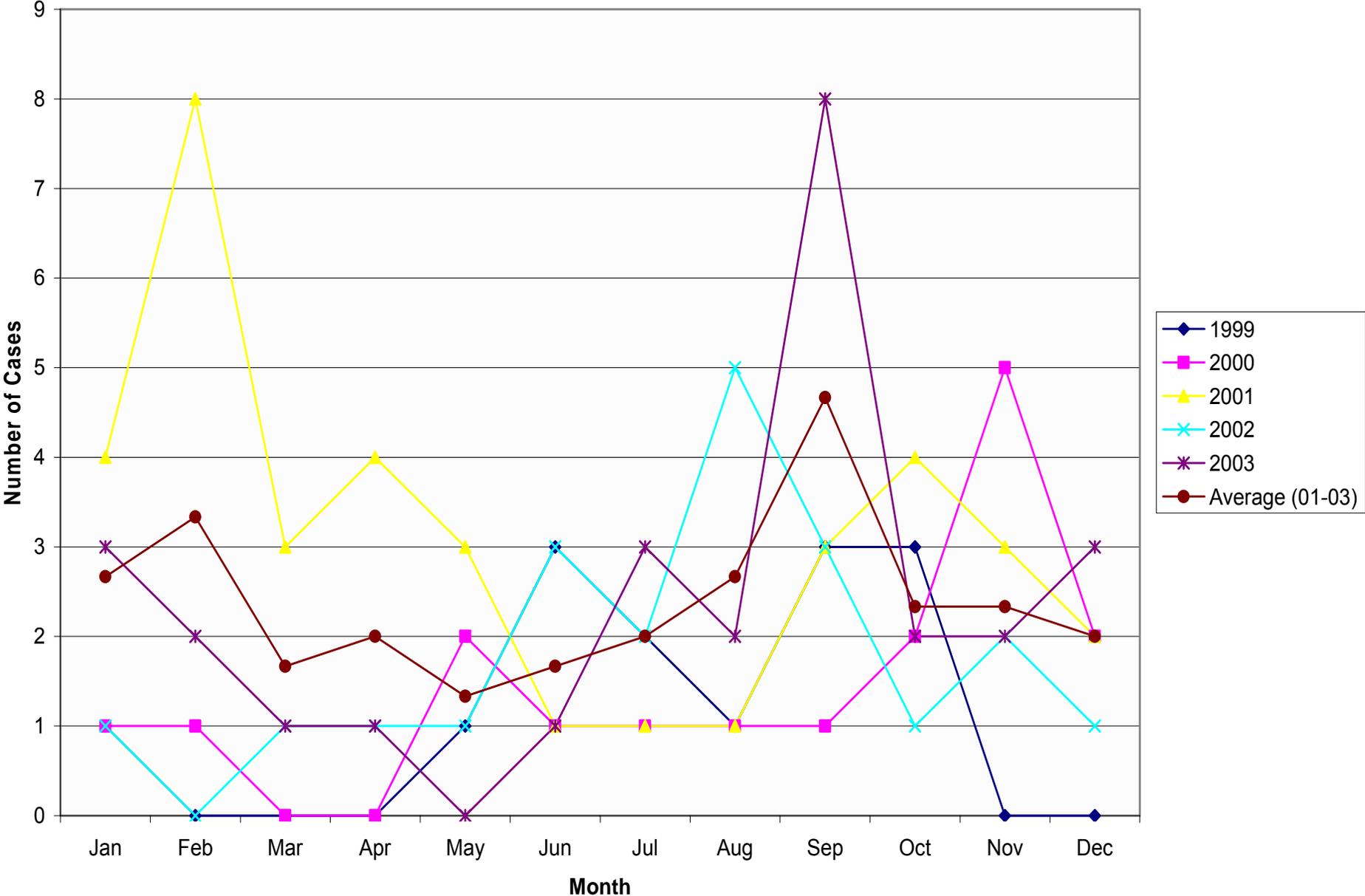
Data Accessibility Issues

- Drug sales and patient diagnostic codes are guarded by HMOs
- Military-owned patient data
 - Contractor controlled
 - Legally protected from third-party access
- Ambulatory care databases, hospital discharge data and ICD-9 diagnostic code databases
 - Designed to track services for billing purposes, not detect illnesses associated with swimming
- Data “Gaps”
 - Lack of appropriate data points makes thorough analysis difficult
 - Demographic data
 - Precise geographic “matching” of cases to population
- Note: Data owners are looking at how to integrate disease incidence due to swimming into their surveillance systems

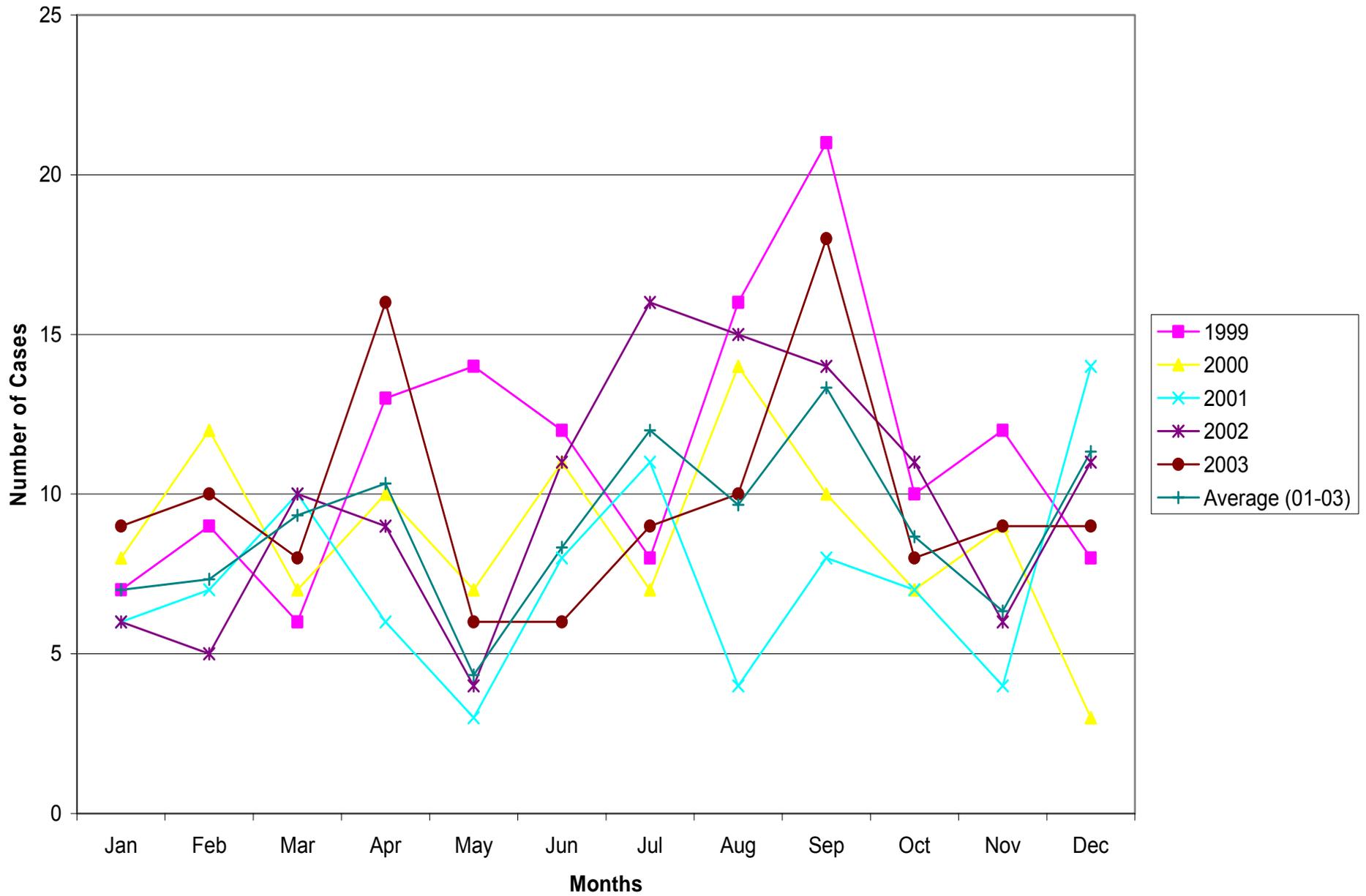
Beach Closed 2003	EPA Beach ID	Closure/advisory start	Closure/Advisory Stop	Reason
North Beach	MD248424	6/12/2003	6/26/2003	Sewage spill
North Beach	MD248424	8/25/2003	9/30/2003	Sewage spill
Brownie's Beach	MD141418	8/25/2003	9/30/2003	Sewage spill
Oyster Harbor	MD143211	7/21/2003	7/25/2003	Sewage spill
Oyster Harbor	MD143211	8/3/2003	8/5/2003	Sewage spill
Greenbrier SP	N/A	8/8/2003	end of season	illness outbreak
Hunting Creek Lake CFSP	N/A	8/14/2003	8/21/2003	High Indicator Counts

Beach Closed 2004	County	Date Start	Date Stop	Activity	Reason
Carpenters Point Beach	CE	6/9/04 12:00 AM	6/11/04 12:00 AM	closure	WQ Criteria exceeded
Holloway Beach	CE	6/9/04 12:00 AM	6/11/04 12:00 AM	closure	WQ Criteria exceeded
Red Point Beach	CE	6/9/04 12:00 AM	6/11/04 12:00 AM	closure	WQ Criteria exceeded
Elk Neck State Park North East River	CE	6/9/04 12:00 AM	6/11/04 12:00 AM	closure	WQ Criteria exceeded
Charlestown Manor	CE	6/9/04 12:00 AM	6/11/04 12:00 AM	closure	WQ Criteria exceeded
Elk Neck State Park North East River	CE	6/16/04 12:00 AM	6/23/04 12:00 AM	closure	WQ Criteria exceeded
Carpenters Point Beach	CE	6/16/04 12:00 AM	6/23/04 12:00 AM	closure	WQ Criteria exceeded
Red Point Beach	CE	6/16/04 12:00 AM	6/23/04 12:00 AM	closure	WQ Criteria exceeded
Hacks Point	CE	6/17/04 12:00 AM	6/24/04 12:00 AM	closure	WQ Criteria exceeded
Elkview Shores	CE	6/24/04 12:00 AM	7/1/04 12:00 AM	closure	WQ Criteria exceeded
Elk Neck State Park North East River	CE	8/4/04 12:00 AM	8/11/04 12:00 AM	closure	WQ Criteria exceeded
Betterton Beach	KE	8/12/04 12:00 AM	8/29/04 12:00 AM	closure	WQ Criteria exceeded

Cryptosporidium Cases (1999-2003)



Giardiasis Cases (1999-2003)



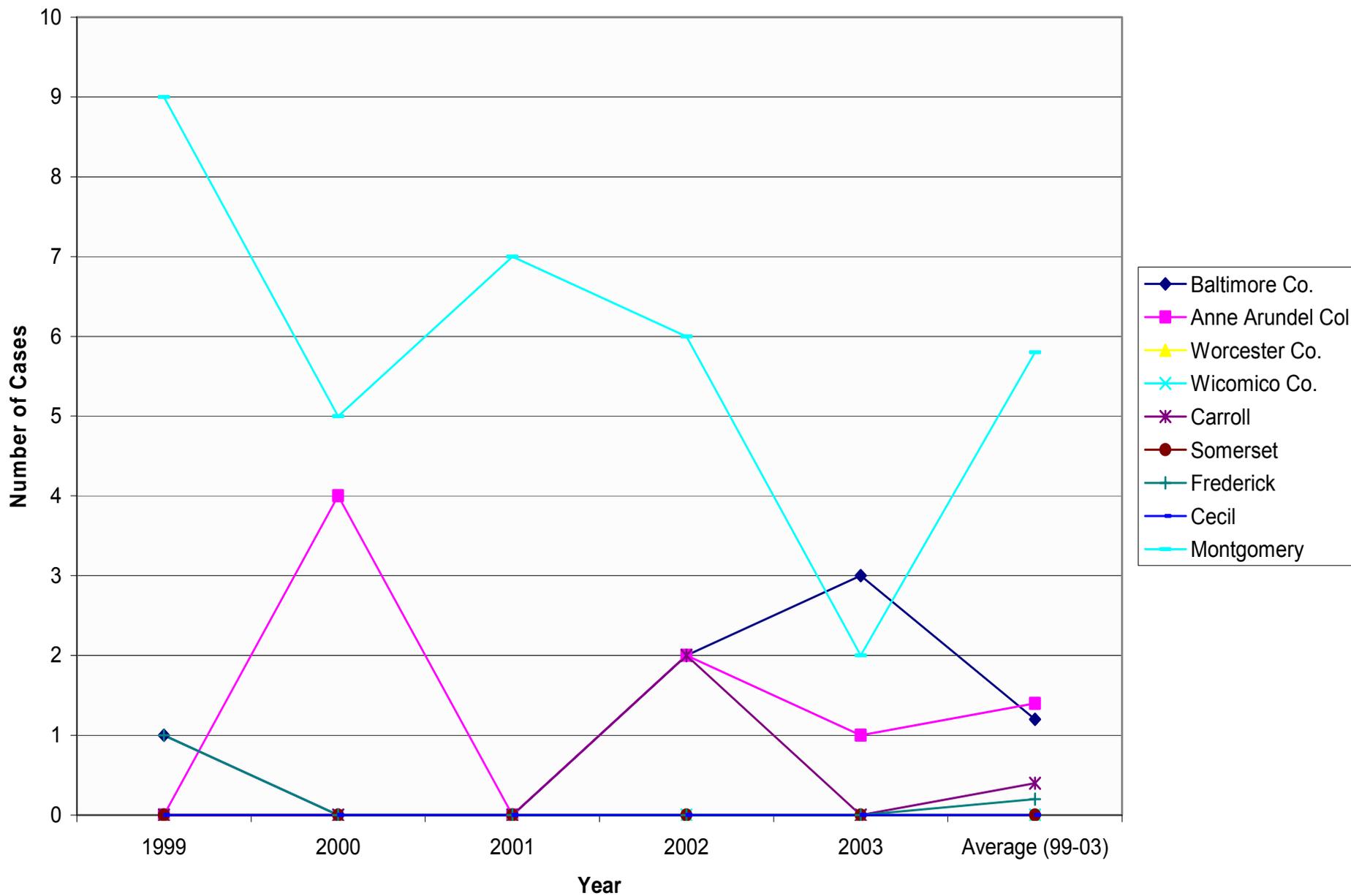
Analysis: Geographic Trends

- Reportable disease, water quality, beach surveys and weather data all “matched” by county
- Plotted total number of disease cases per year per county
- Graphs subdivided into counties with beaches within the borders and counties without beaches
- Results varied

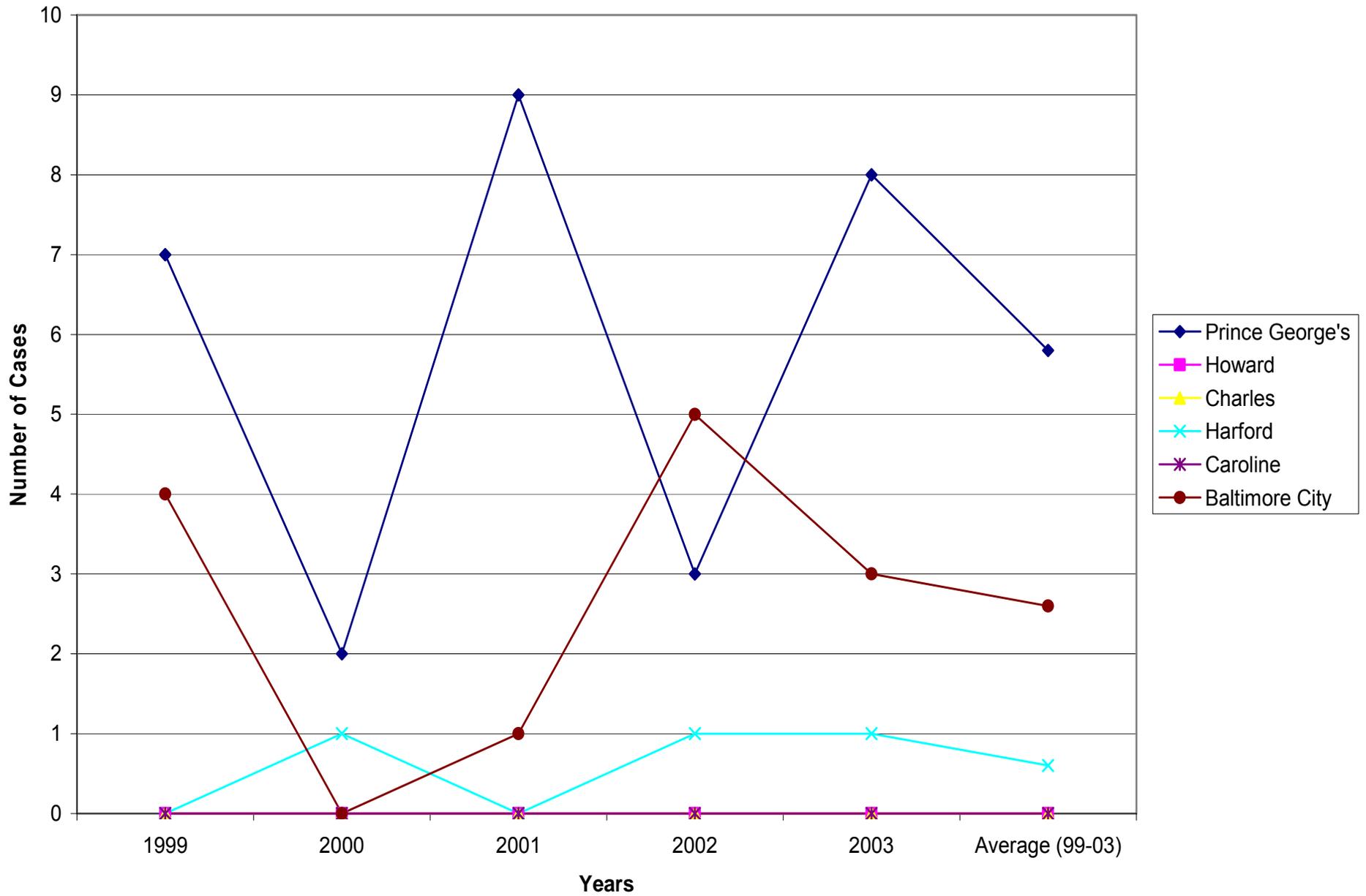
Analysis: Geographic Trends (2)

- Results:
 - Amebiasis in both beach and non-beach counties showed a range of 0-9 cases from 1999-2003
 - E. coli beach county cases ranged from 0-13, while the range for non-beach counties was 0-8 over the same time period
 - supports data analysis for seasonal trends and may suggest swimming is a risk factor of disease

Amebiasis Cases by Beach Counties (1999-2003)



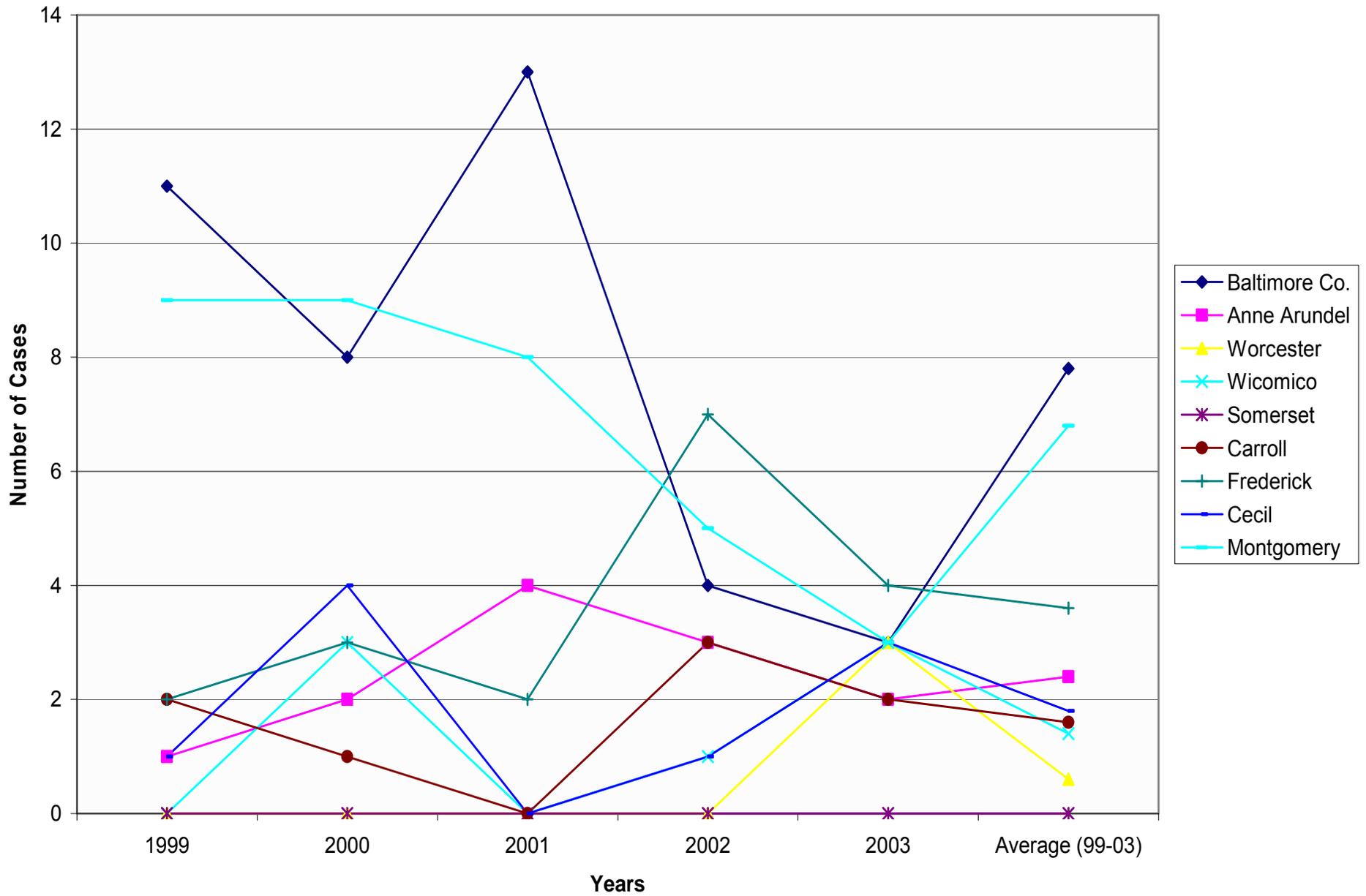
Amebiasis Cases by Non-Beach County (1999-2003)



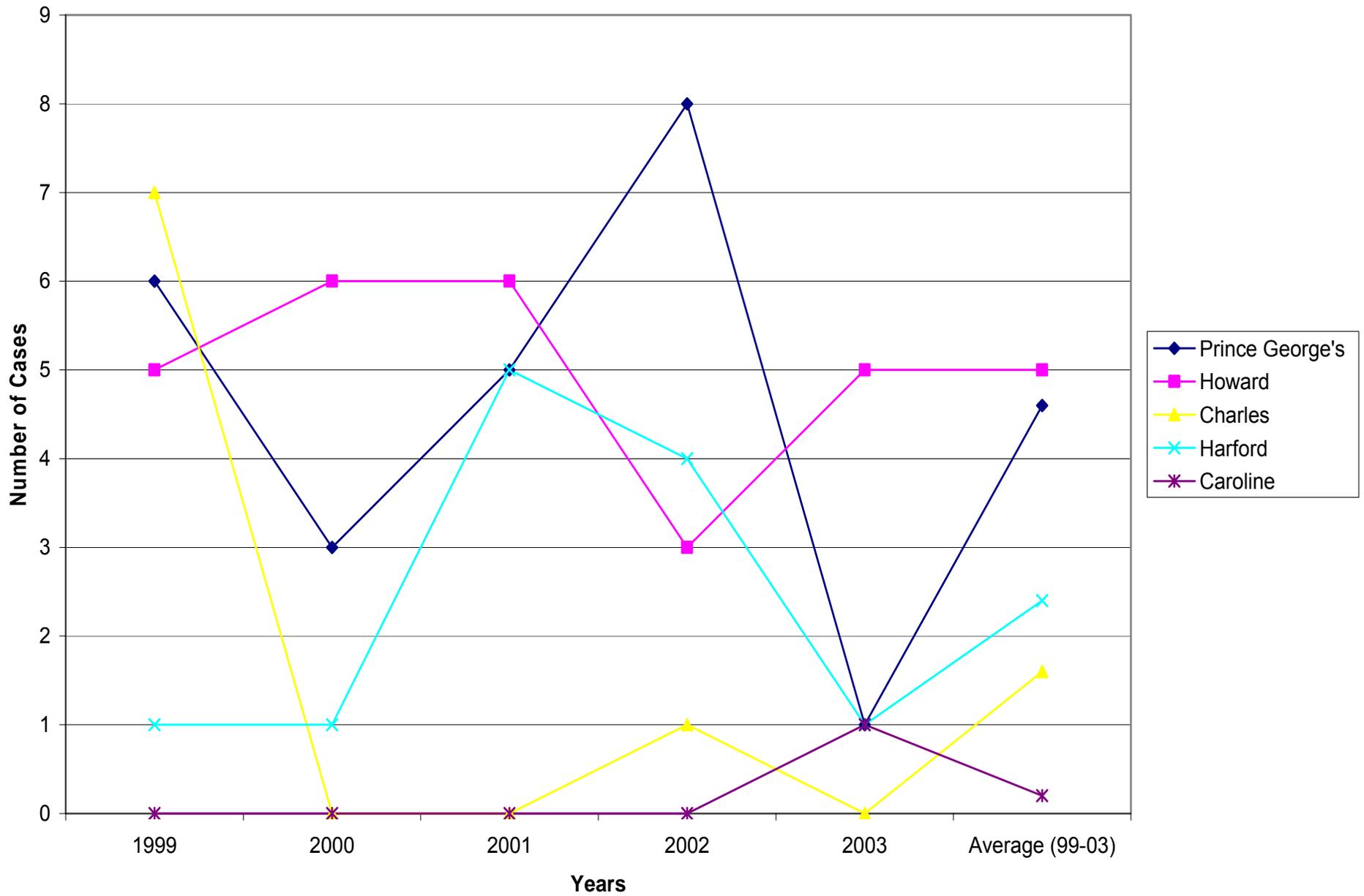
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E. Coli Cases by Beach Counties (1999-2003)



E. Coli Cases by Non-Beach Counties (1999-2003)



Analysis: Geographic Trends (3)

- Results:
 - Cannot draw conclusions about whether or not geographic proximity to natural water sources is a risk factor of any of the reportable diseases
 - Some counties have consistently higher reporting than others. But higher reporting occurs in *both* beach and non-beach counties (Baltimore Co, Montgomery, PG).
 - Likely that non-water related risk factors are approximately the same for each county
 - Risk of illness from swimming in natural waters *may* be greater for those with greatest ease of access