3 Field Studies Offering Information Applicable to Use of MSC in the NSSP

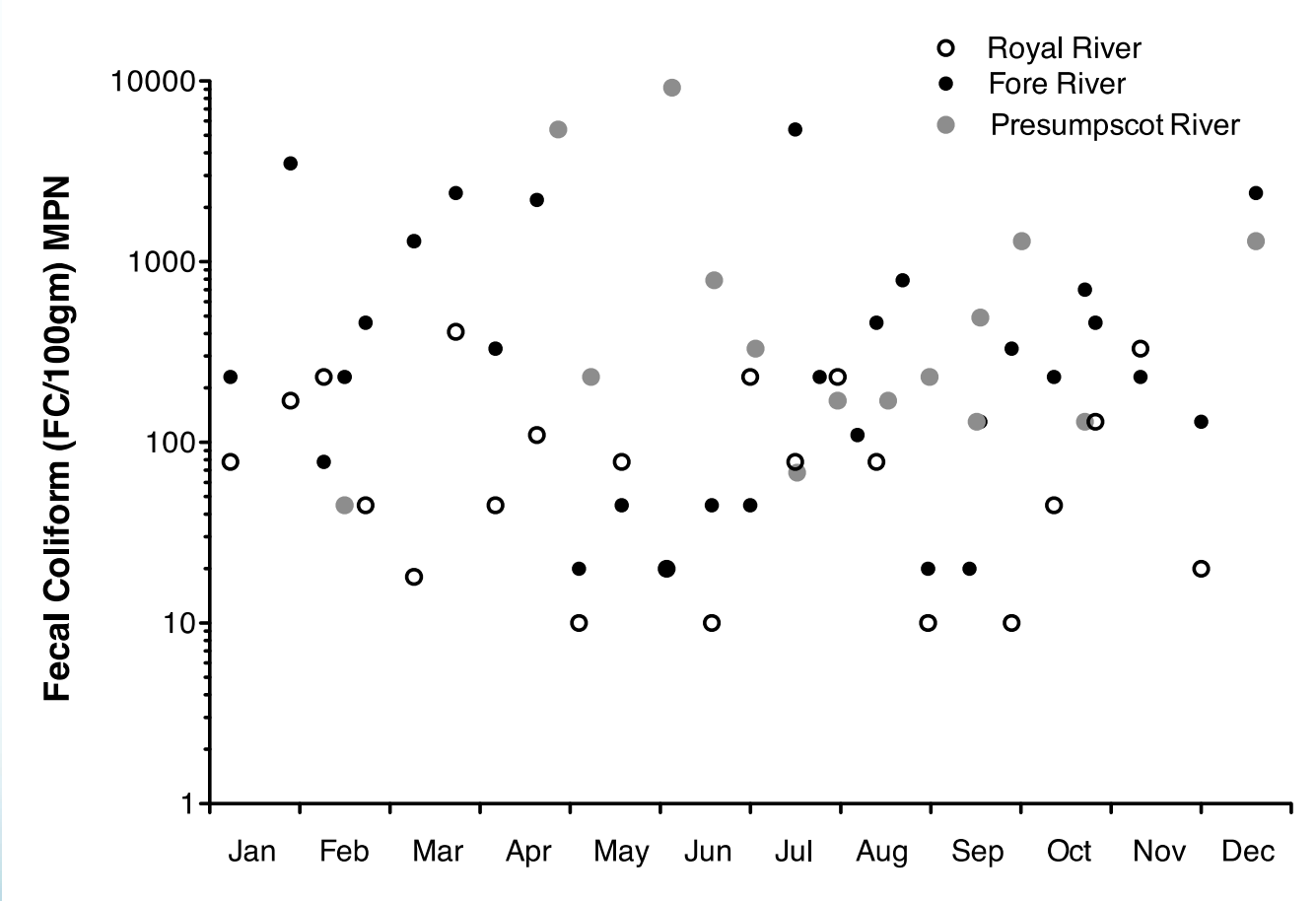
Thomas Howell, Spinney Creek Shellfish, Inc. Eliot, ME
MSC Information Meeting August, 2014

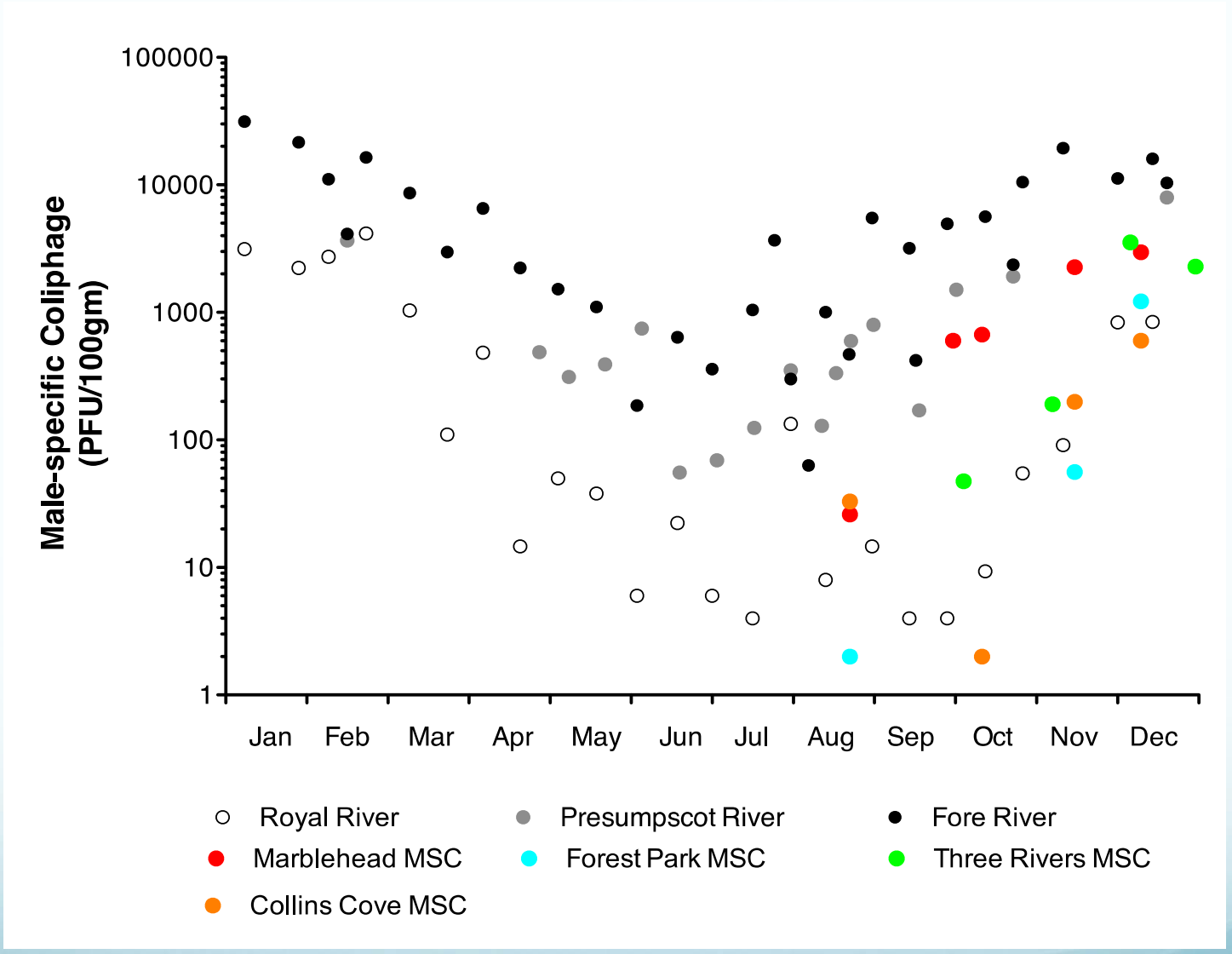
1. Seasonal Persistence and Contaminant Reduction Studies with Soft-shelled Clams (2010 – 2014 ongoing)

Purpose – To investigate the seasonal persistence and reduction rates of FC, MSC, NoV, and AdV in soft-shelled clams from various Maine and Massachusetts growing areas

Multi-year collaboration with Spinney Creek Shellfish, FDA Gulf Coast Shellfish Lab, Maine Department of Marine Resources, and Massachusetts Division of Marine Fisheries

FC in Soft-shelled Clams verses Month




Male-specific Coliphage
(PFU/100gm)
100000
10000
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10
1
Jan
Feb
Mar
Apr
May
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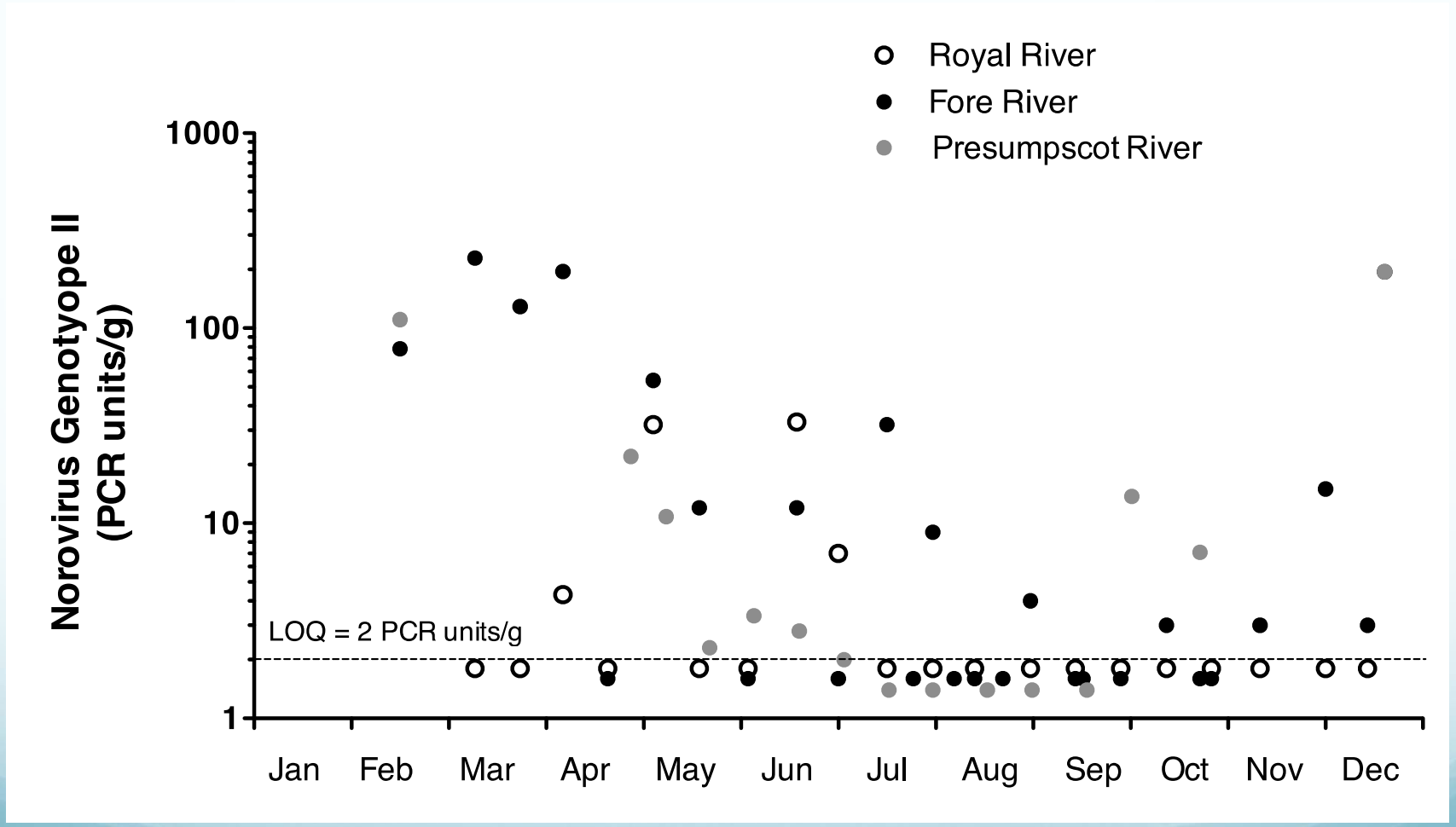
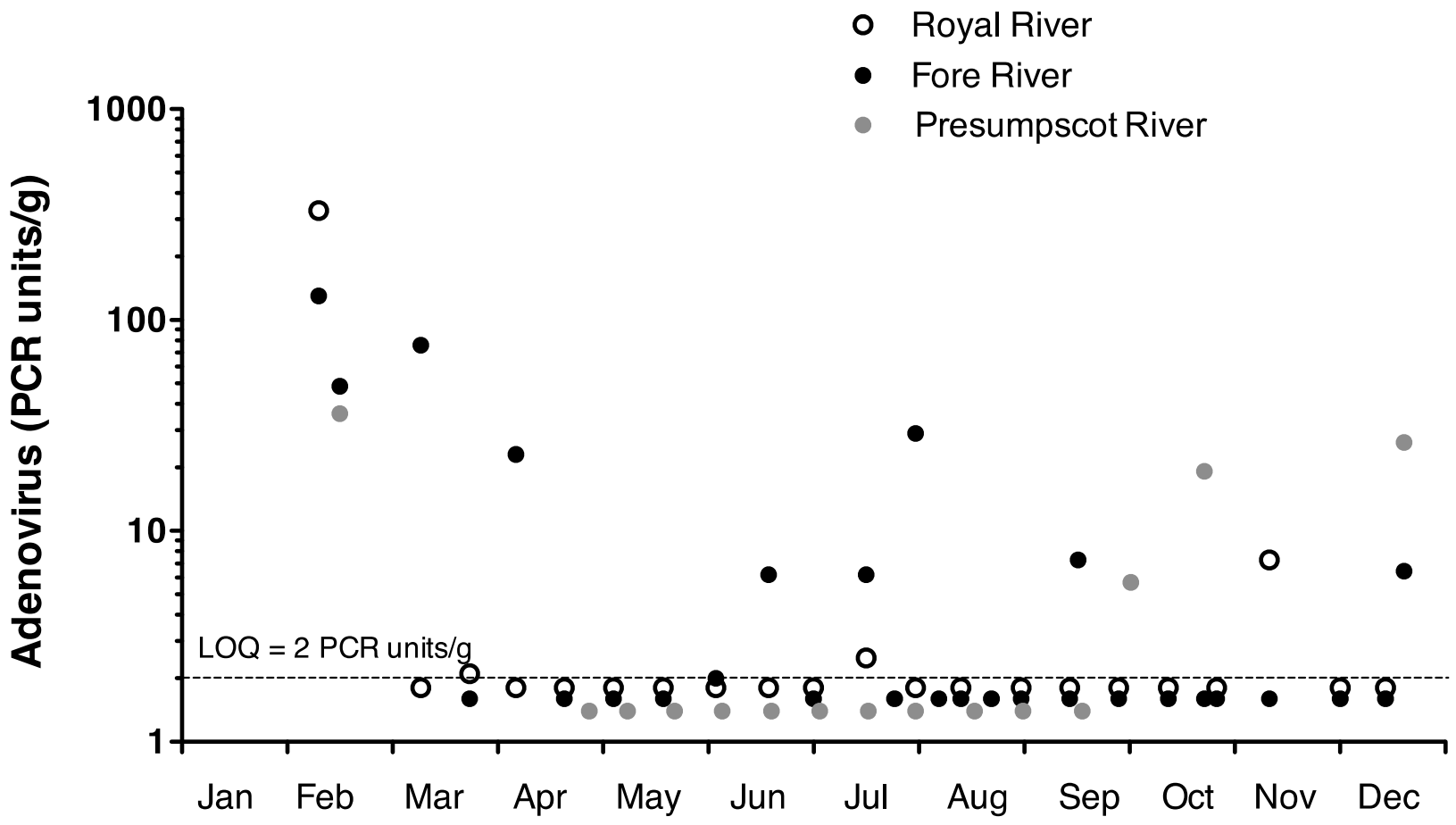
Jul
Aug
Sep
Oct
Nov
Dec
Royal River
Presumpscot River
Fore River
Marblehead MSC
Forest Park MSC
Three Rivers MSC
Collins Cove MSC

NoV GII in Soft-shelled Clams verses Month



AdV in Soft-shelled Clams verses Month

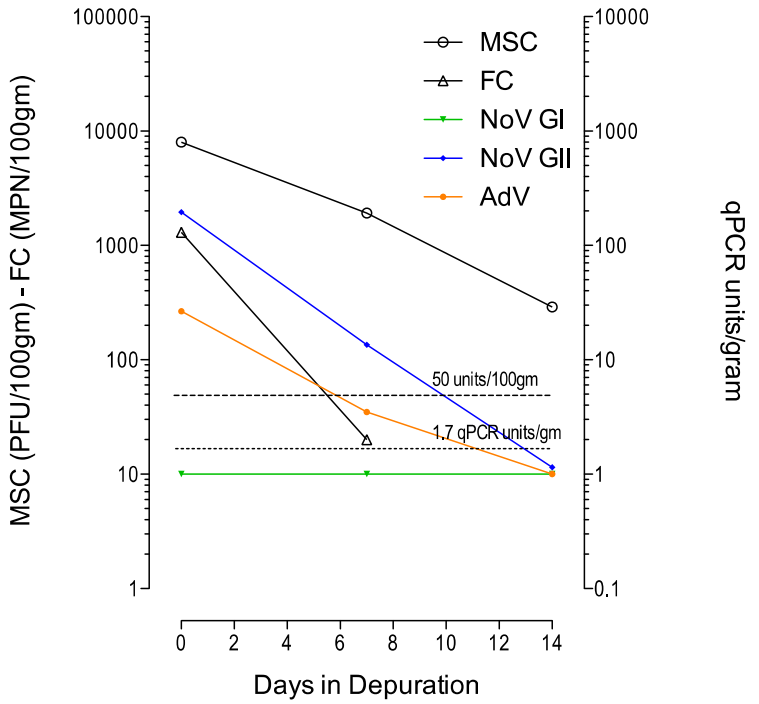


Seasonal Persistence of Viruses in Soft-shelled Clams

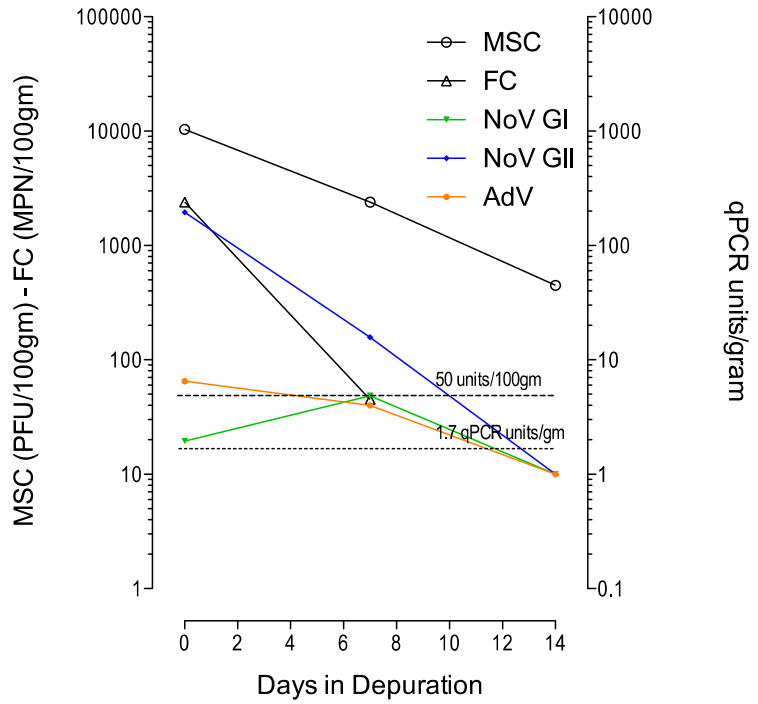
- MSC shows 2 to 3 log seasonal variation
- NoV GII and AdV suggest similar seasonality
- Pathogenic viruses are intermittent in wastewater influent
- MSC is consistently present in high numbers in sewage
- MSC is an appropriate indicator to assess WTP impact on shellfish beds adjacent to the outfall

Contaminant Reduction Trials

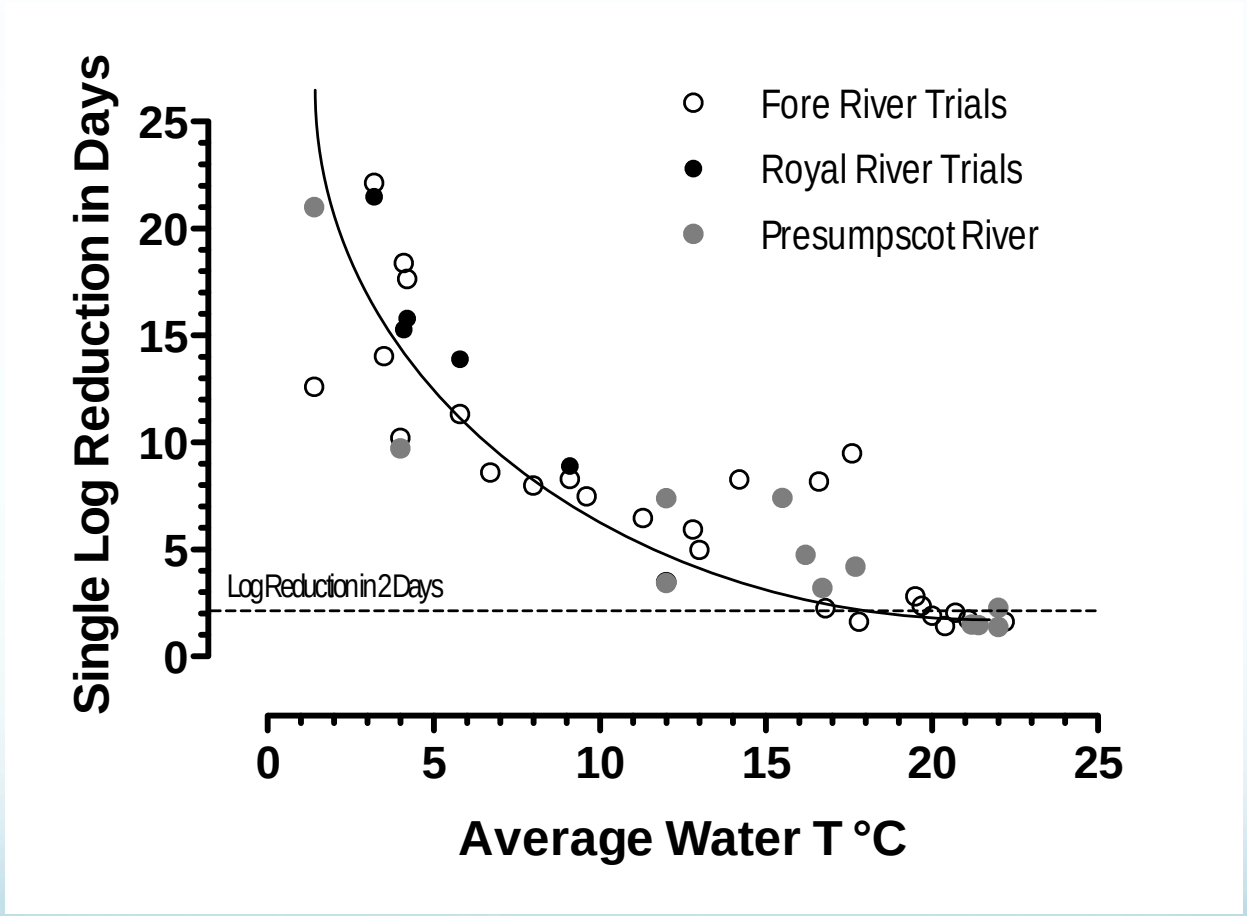
2012 Field Trial 16
Presumpscot River
Harvested 12/19/13
Process water 4.0°C ± 1.4°C



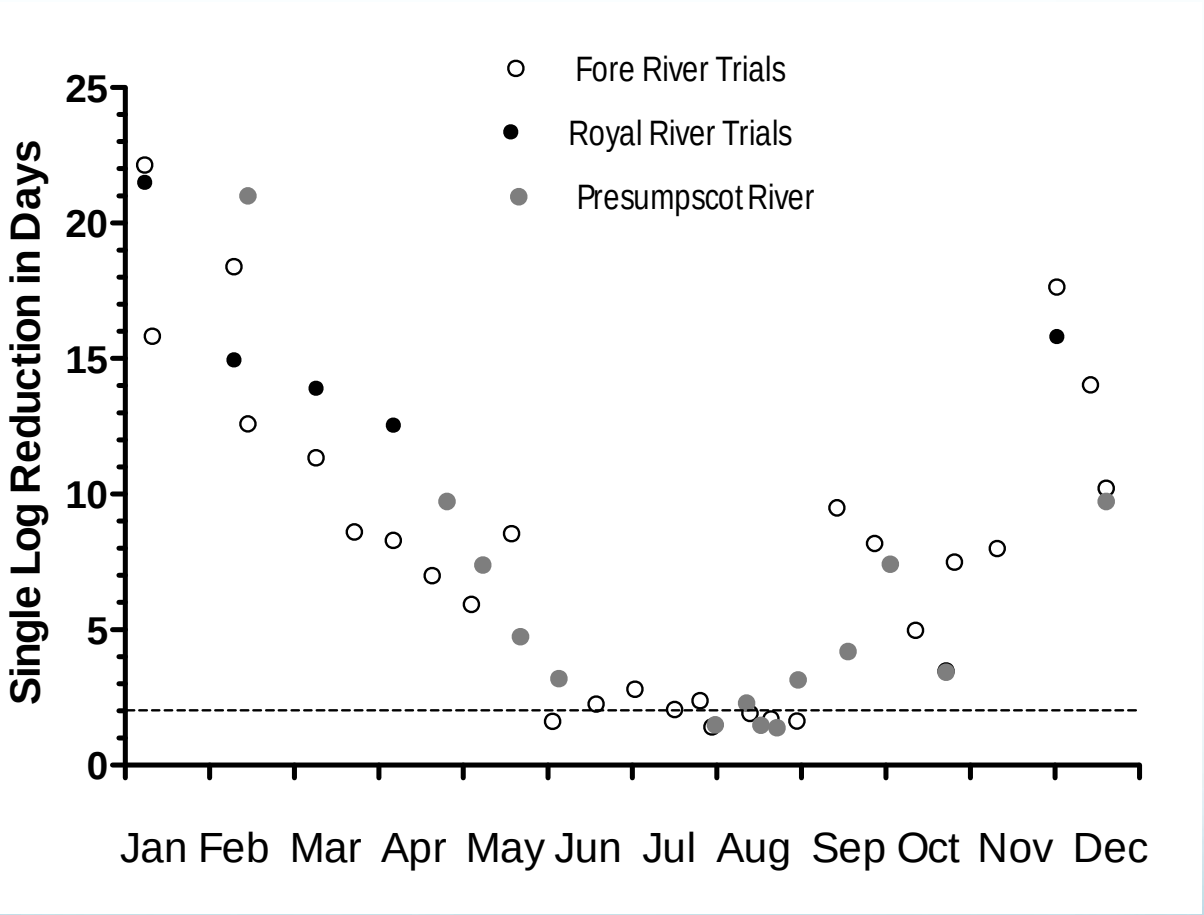
2012 Field Trial 16A
Fore River
Harvested 12/19/13
Process water 4.0°C ± 1.4°C



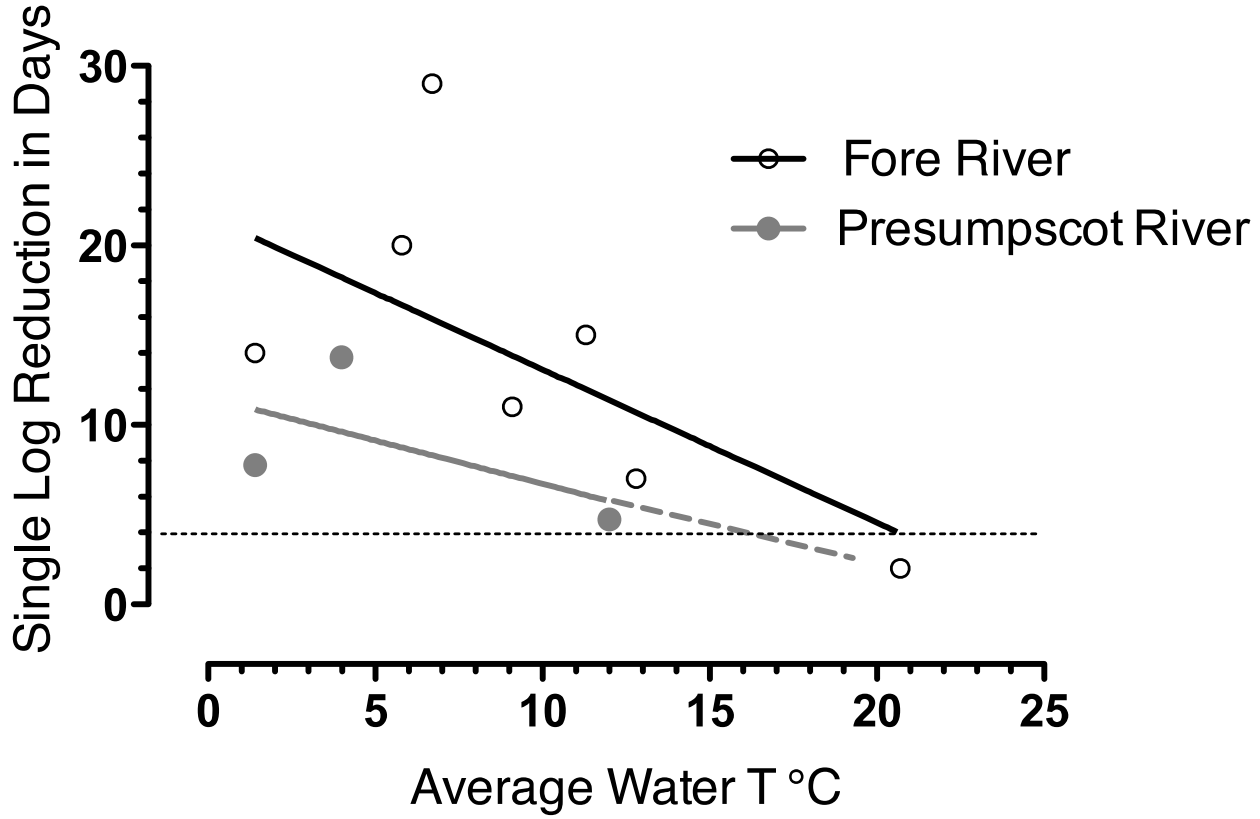
Temperature Dependent MSC Reduction Rate



Seasonal MSC Reduction Rate



Temperature Dependent NoV GII Reduction Rate



Conclusions from Contaminant Reduction Studies for Soft-shelled Clams in New England

MSC and NV demonstrate a similar persistence pattern; *Low in late Spring and Summer and 2 to 3 logs higher in Winter Months*.

MSC and NV depuration rates are similarly temperature and season dependent; *Consistently 1-log/2-days from June through September when ambient process water exceeds 18°C.*

Seasonal depuration and relay strategies **work well** in the summer months when viral persistence is low and depuration rate is high.

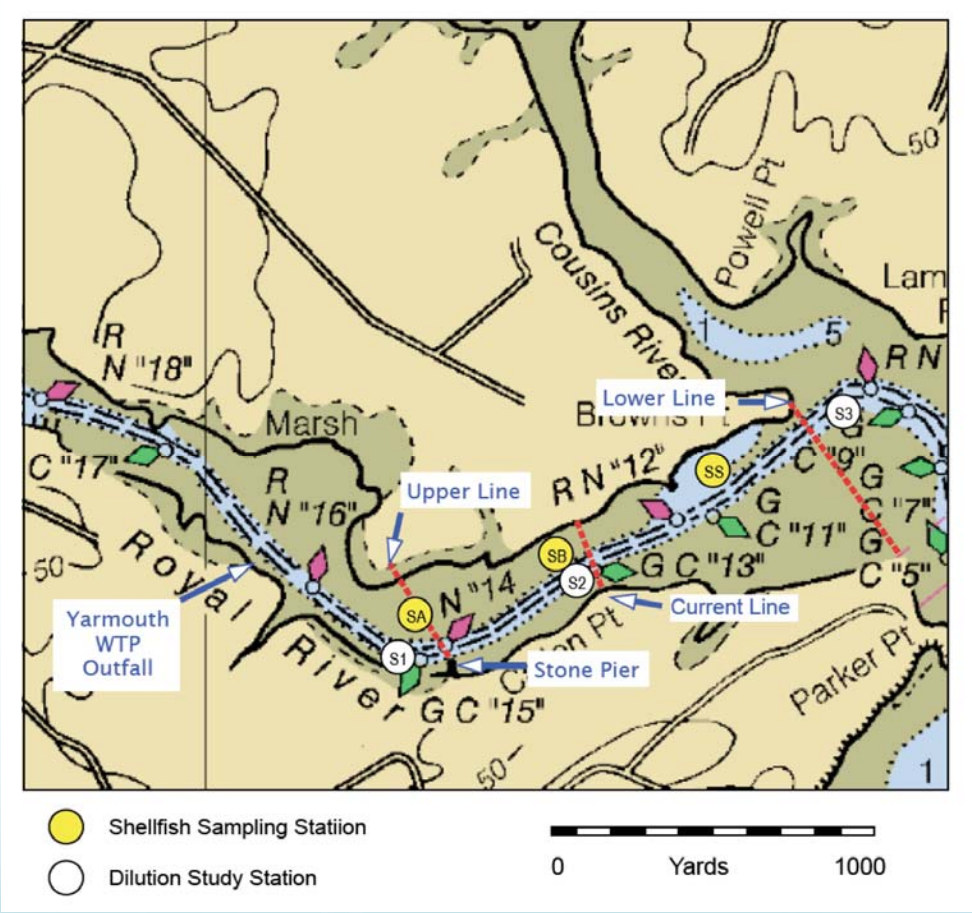
Depuration and relay strategies **work poorly** in the **winter months** when viral persistence peaks and viral depuration rates approach 1-log/21-days.

2. Royal River Spatial Variation Studies and the Dilution Model (2010 – 2012)

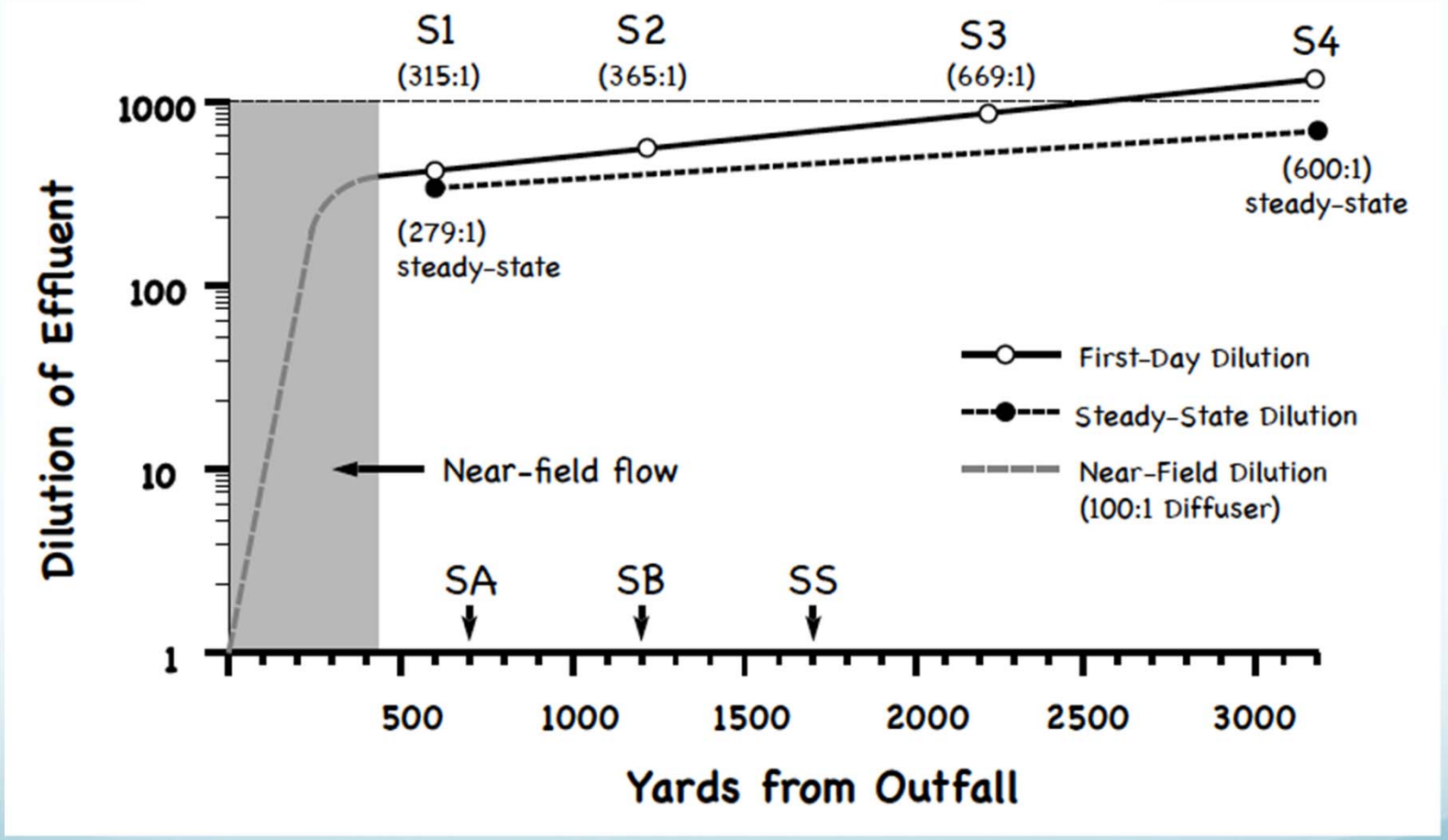
Purpose – To investigate how MSC levels in soft-shelled clams as a function of distance from the WTP outfall compare to the dilution model

Collaboration with Spinney Creek Shellfish, FDA Gulf Coast Shellfish Lab and Greg Goblick's Dye Study Group, Maine Department of Marine Resources

Spatial Variation of MSC, NoV, and AdV in Soft-shelled Clams in the Royal River



Dilution Model for Royal River

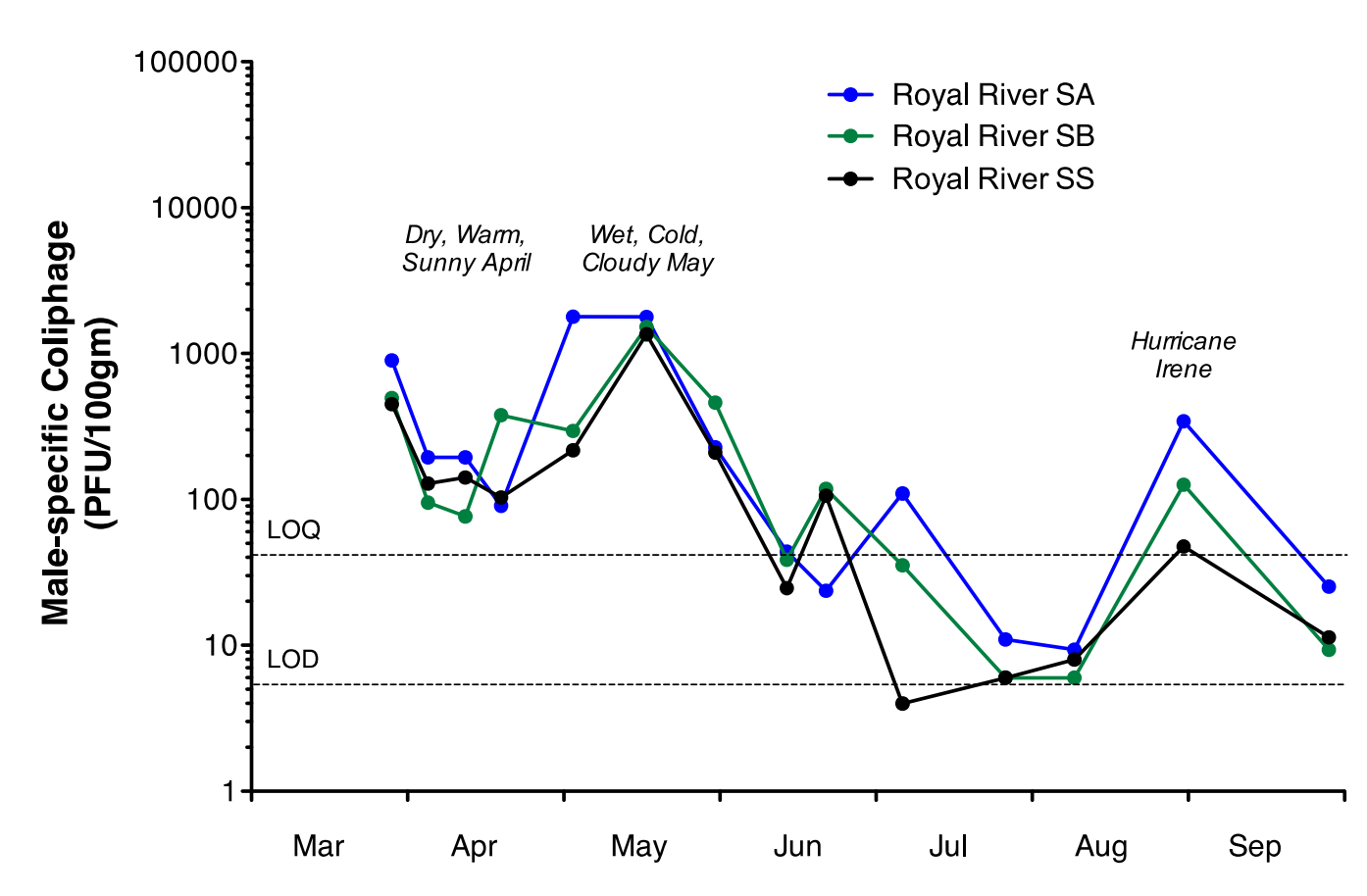


Royal River
Sampling Station Statistics

Station	Yards from Outfall	SS Dilution	Mean MSC Level
SA	700 yards	290:1	482 PFU/100gm
SB	1200 yards	350:1	262 PFU/100gm
SS	1700 yards	450:1	201 PFU/100gm

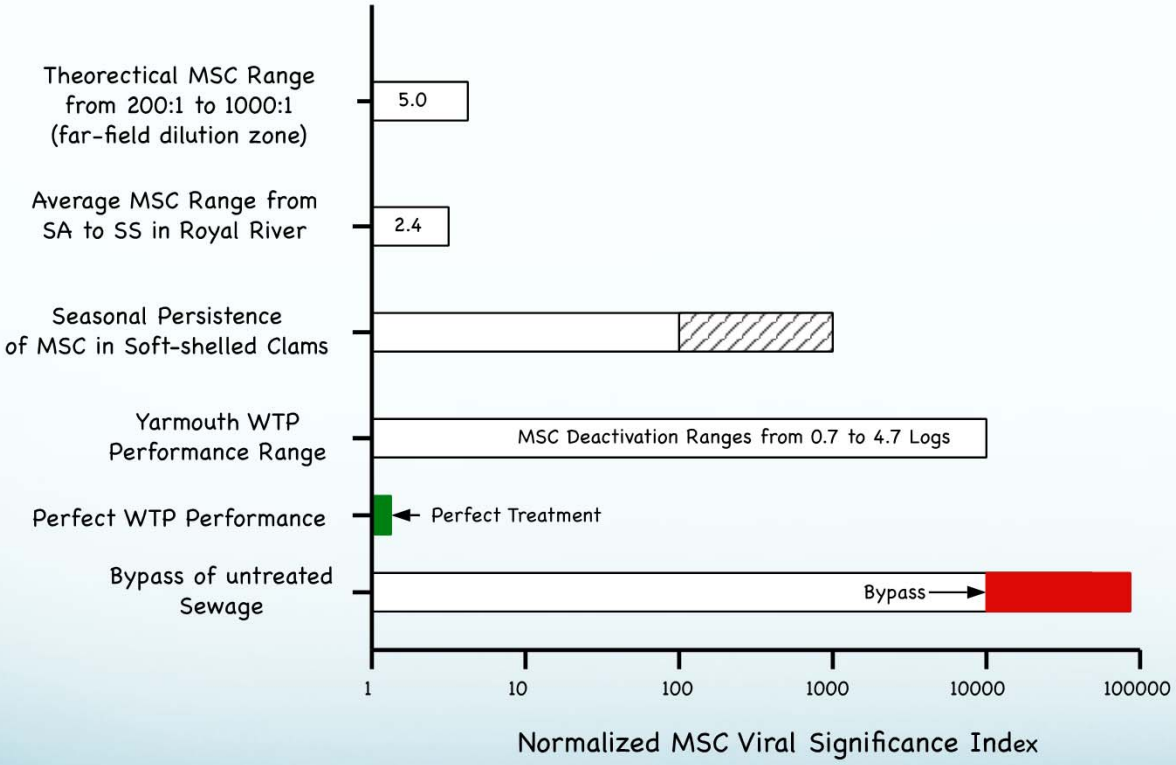
Approximates an Inverted Linear Relationship in the Far-Field, where
Average MSC levels are 2.4 times higher at SA than SS,
Average MSC levels are 1.3 times higher at SB than SS

2011 Spatial Variation Study Shows that Dilution is Not the Most Important Thing



MSC Normalized, **Magnitude of Variables Analyses**;

1) Viral Plant Performance (up to 5 logs),
2) Seasonal Viral Persistence (2 to 3 logs), and
3) Dilution in the Far-Field Dilution Zone (<1 log)



Suggested “up-dated” criteria for sizing prohibited growing area adjacent to WTP Outfall includes

(b) The determination of the size of the area to be classified as prohibited adjacent to each outfall shall include the following minimum criteria:

1) Viral performance of the wastewater treatment plant and viral quality of the effluent;

2) Species-specific, seasonal persistence of viruses in the shellfish;

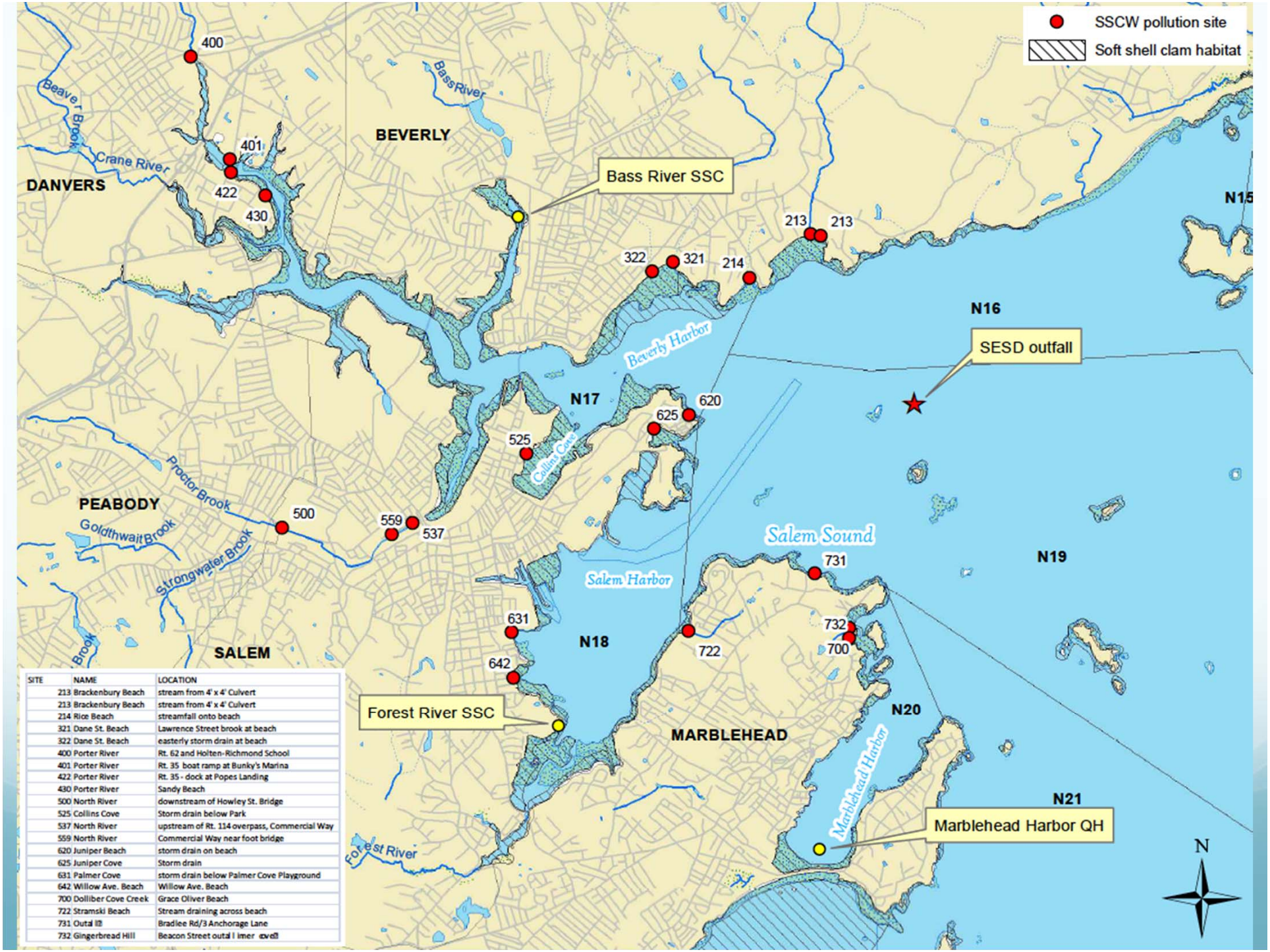
3) The wastewater's dispersion and dilution, and the time of waste transport to the area where shellstock may be harvested; and

4) Map: The location of the shellfish resources, location of discharge, classification of adjacent waters and identifiable landmarks or boundaries.

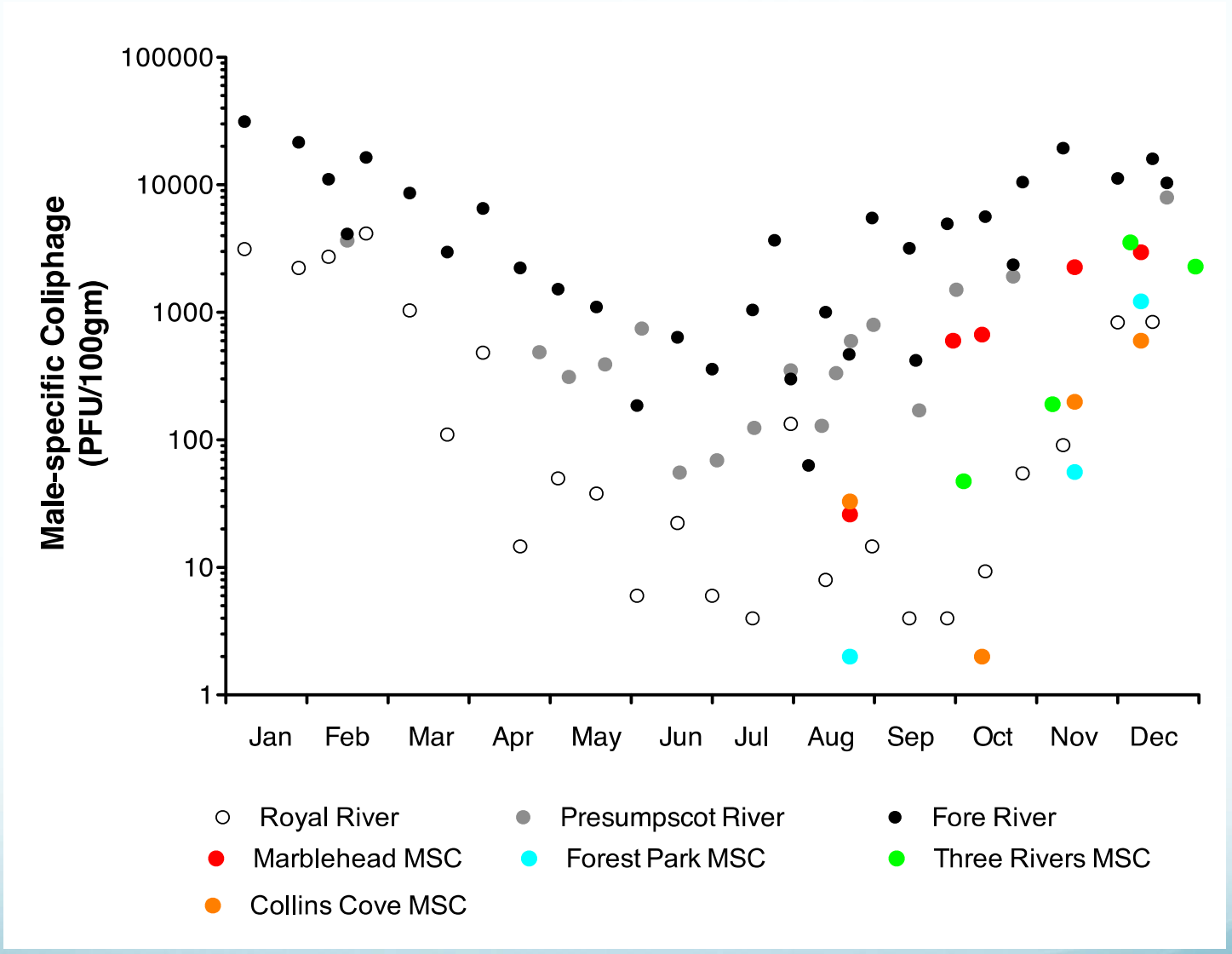
3. Species-specific Bio-accumulation Studies using FC and MSC 2013

Purpose – To investigate species-specific bio-accumulation and seasonal persistence using FC and MSC in American oysters and quahogs

Collaboration with Spinney Creek Shellfish, Massachusetts Department of Marine Fisheries, UNH Sea Grant, FDA Gulf Coast Shellfish Lab, and Maine Department of Marine Resources



SITE	NAME	LOCATION
213	Brackenbury Beach	stream from 4' x 4' Culvert
213	Brackenbury Beach	stream from 4' x 4' Culvert
214	Rice Beach	streamfall onto beach
321	Dane St. Beach	Lawrence Street brook at beach
322	Dane St. Beach	easterly storm drain at beach
400	Porter River	Rt. 62 and Holten-Richmond School
401	Porter River	Rt. 35 boat ramp at Bunky's Marina
422	Porter River	Rt. 35 - dock at Popes Landing
430	Porter River	Sandy Beach
500	North River	downstream of Howley St. Bridge
525	Collins Cove	Storm drain below Park
537	North River	upstream of Rt. 114 overpass, Commercial Way
559	North River	Commercial Way near foot bridge
620	Juniper Beach	storm drain on beach
625	Juniper Cove	Storm drain
631	Palmer Cove	storm drain below Palmer Cove Playground
642	Willow Ave. Beach	Willow Ave. Beach
700	Dolliber Cove Creek	Grace Oliver Beach
722	Stramski Beach	Stream draining across beach
731	Outal ll	Bradlee Rd/3 Anchorage Lane
732	Gingerbread Hill	Beacon Street outal l imer cove


Male-specific Coliphage
(PFU/100gm)
100000
10000
1000
100
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1
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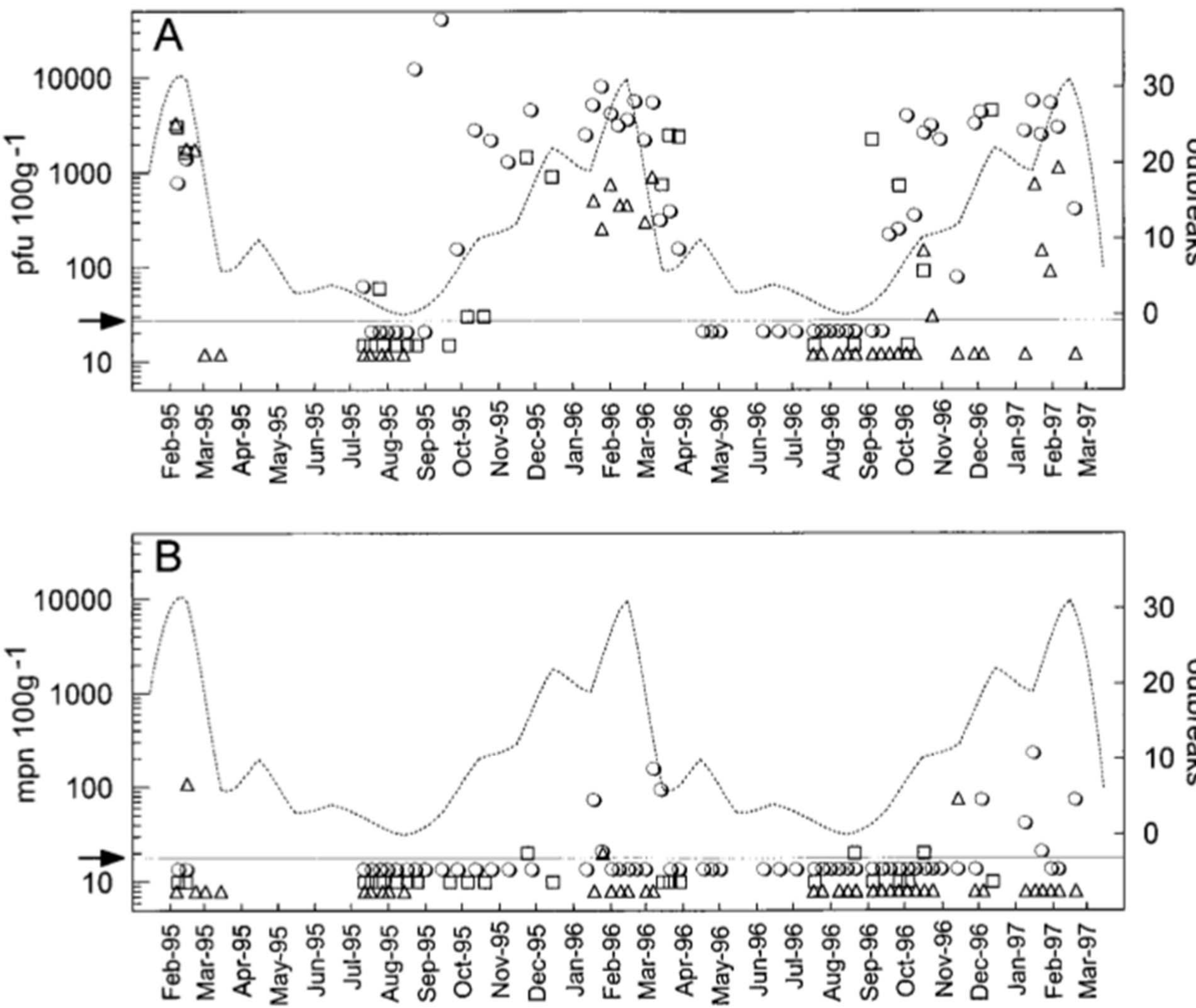
Oct
Nov
Dec
Royal River
Presumpscot River
Fore River
Marblehead MSC
Forest Park MSC
Three Rivers MSC
Collins Cove MSC


A
B
pfu 100g -1
mpn 100g -1
outbreaks
10000
1000
100
10
30
20
10
0
Feb-95
Mar-95
Apr-95
May-95
Jun-95
Jul-95
Aug-95
Sep-95
Oct-95
Nov-95
Dec-95
Jan-96
Feb-96
Mar-96
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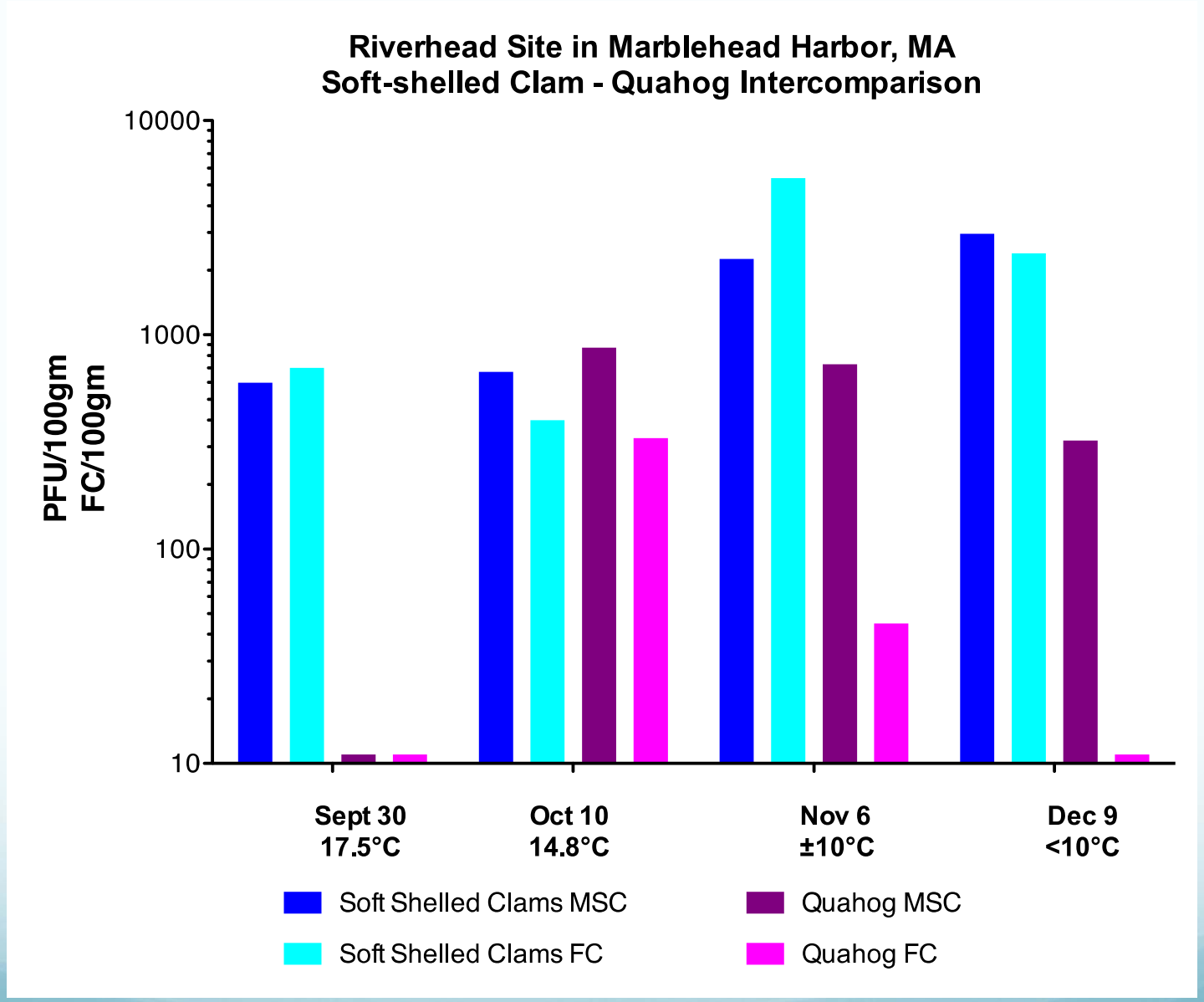
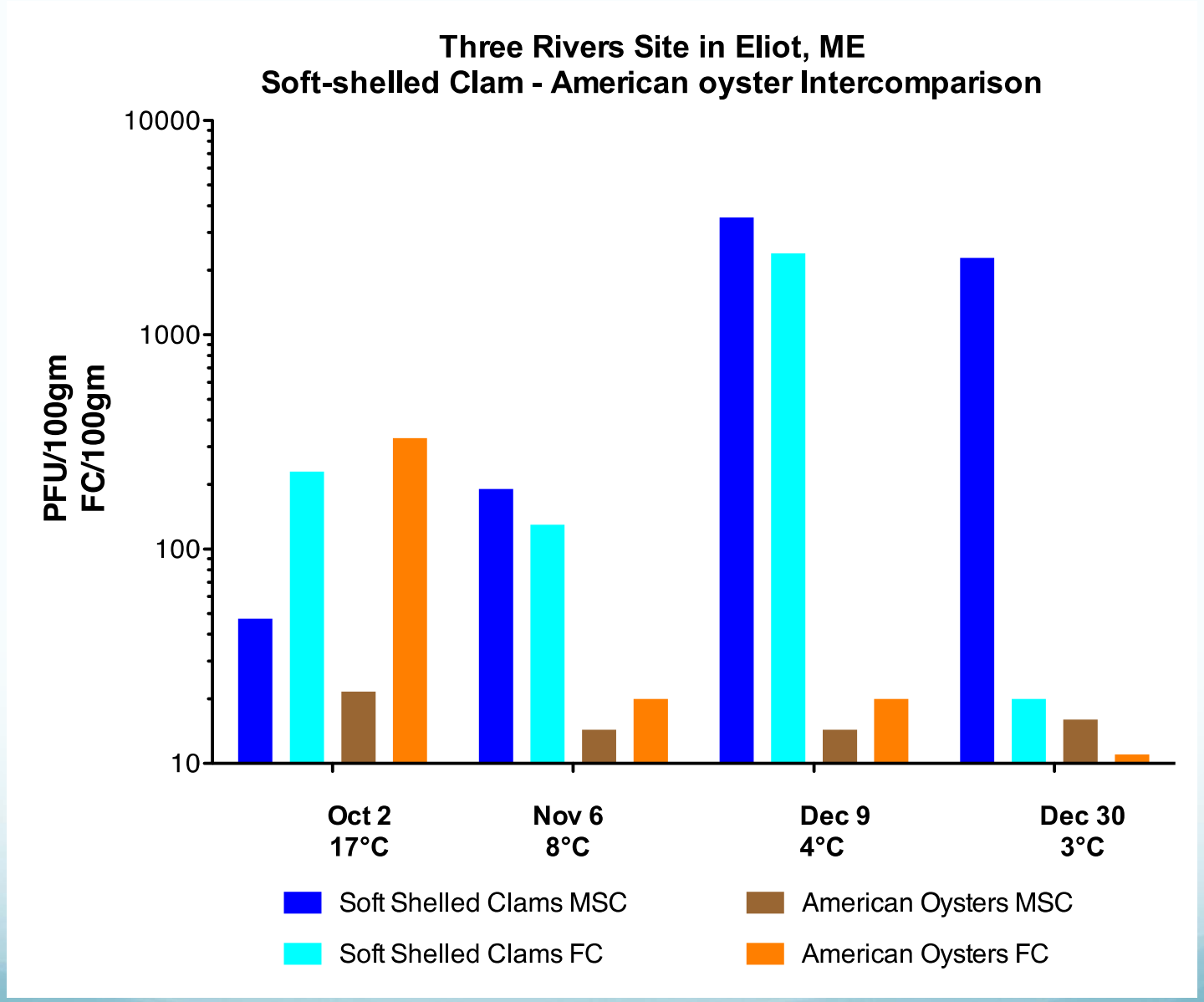
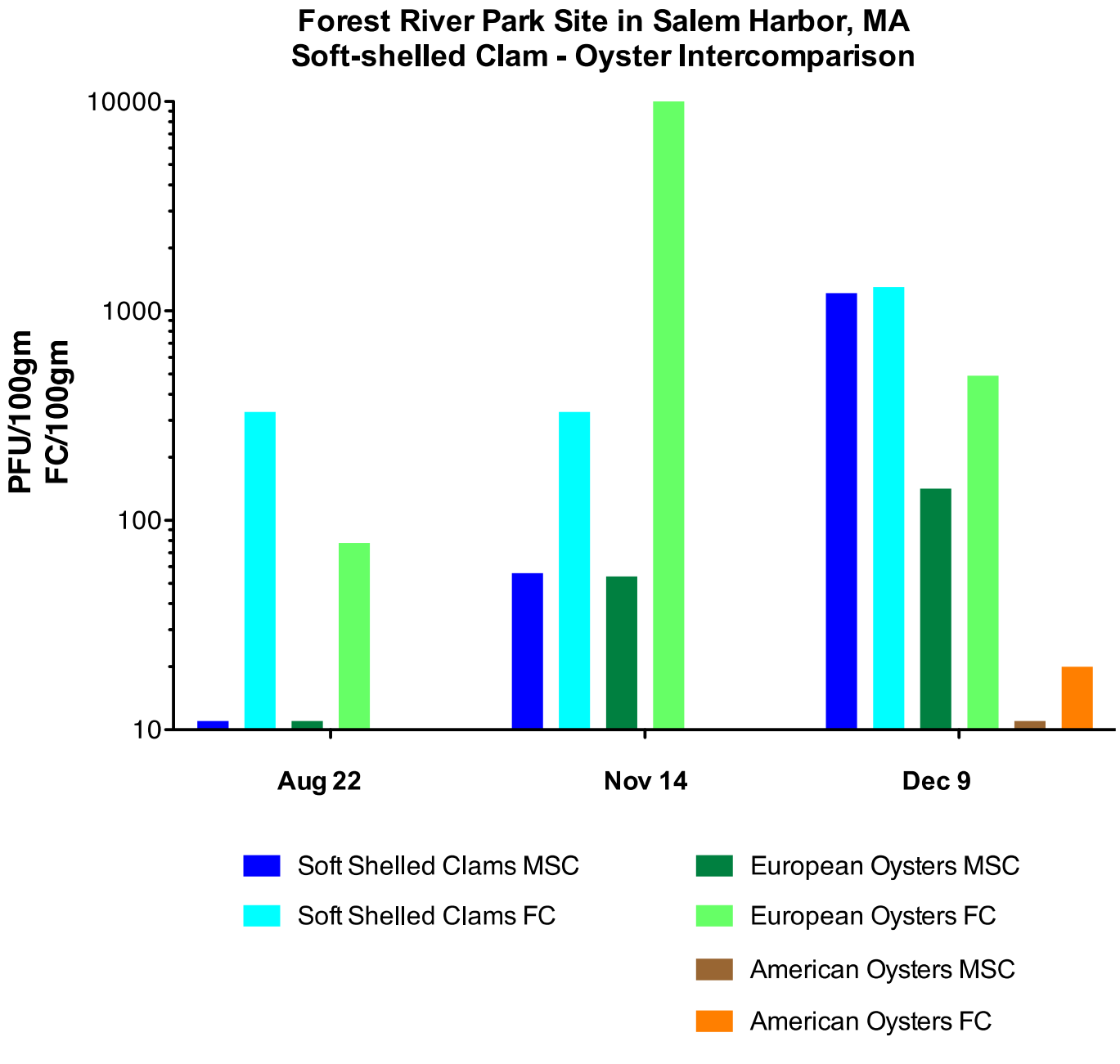
Nov-96
Dec-96
Jan-97
Feb-97
Mar-97


Riverhead Site in Marblehead Harbor, MA
Soft-shelled Clam - Quahog Intercomparison
PFU/100gm
FC/100gm
10000
1000
100
10
Sept 30
17.5°C
Oct 10
14.8°C
Nov 6
±10°C
Dec 9
<10°C
Soft Shelled Clams MSC
Soft Shelled Clams FC
Quahog MSC
Quahog FC


Three Rivers Site in Eliot, ME
Soft-shelled Clam - American oyster Intercomparison
PFU/100gm
FC/100gm
10000
1000
100
10
Oct 2
17°C
Nov 6
8°C
Dec 9
4°C
Dec 30
3°C
Soft Shelled Clams MSC
Soft Shelled Clams FC
American Oysters MSC
American Oysters FC


Forest River Park Site in Salem Harbor, MA
Soft-shelled Clam - Oyster Intercomparison
PFU/100gm
FC/100gm
10000
1000
100
10
Aug 22
Nov 14
Dec 9
Soft Shelled Clams MSC
Soft Shelled Clams FC
European Oysters MSC
European Oysters FC
American Oysters MSC
American Oysters FC

Interim Conclusions of Our Study Comparing with Other Studies

- Cold-water adapted species such as soft-shelled clams, Pacific oysters, and European oysters demonstrate strong seasonal MSC patterns (probably mussels as well)
- Non cold-water adapted species such as American oysters and quahogs are anomalous because they stop pumping at water temperatures below 10°C
- American oysters and quahogs demonstrate similar seasonal MSC as cold-water adapted species in southern waters where water temperatures do not drop below 10°C
- American oysters and quahogs can trap MSC for the winter months if significant MSC contamination is present in the environment prior to when water temperature fall below 10°C
- FC indicators die-off when American oysters and quahogs stop pumping over the winter period

Housatonic River Study (Fall 2014 – 2015)

- Contaminant reduction studies using FC, MSC, NoV, and AdV to assess viral relay strategies with American oysters
- Assist the State of Connecticut to develop a viral relay protocol so that a portion of Housatonic River can be reclassified to restricted
- Increase scientific basis for using MSC as a viral indicator of sewage contamination, relay and depuration strategies with American oysters