South Puget Sound Dissolved Oxygen Study

Technical Advisory Committee

March 17, 2008

Andrew Kolosseus

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www.ecy.wa.gov/puget_sound/dissolved_oxygen_study.html

Agenda

1:10	WWTP & tributary data updates
2:00	Marine data update
2:40	Modeling, Sediment Flux
2:50	Your review of data report (April)
2:55	Set next meeting, etc

Questions or Concerns?

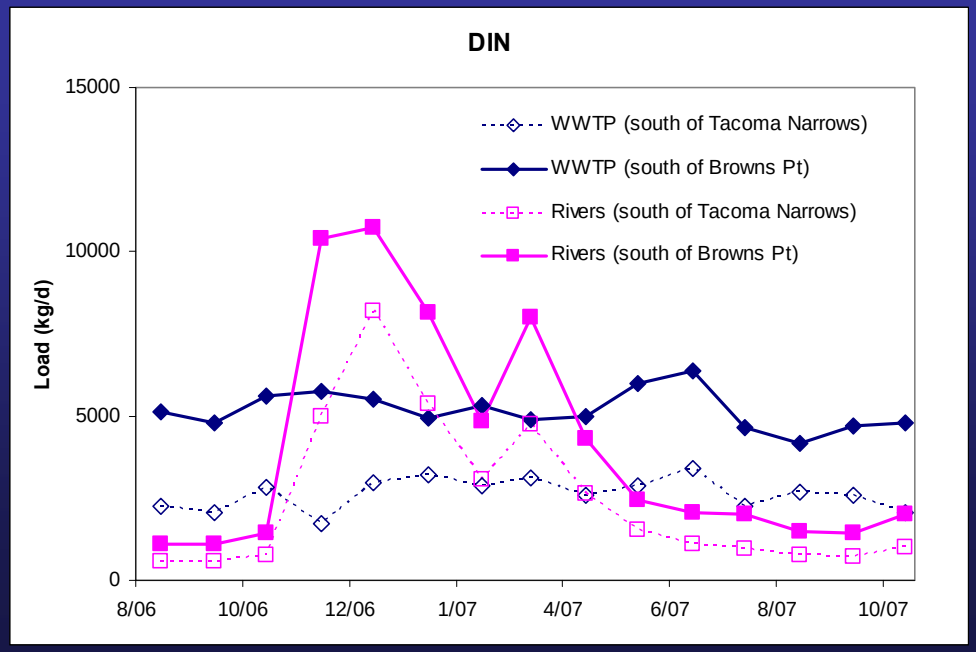
If you or your organization has concerns or would like an individual briefing, please contact Andrew Kolosseus

South Puget Sound Monitoring and Modeling

Mindy Roberts
Technical Advisory Committee
March 17, 2008

Presentation overview

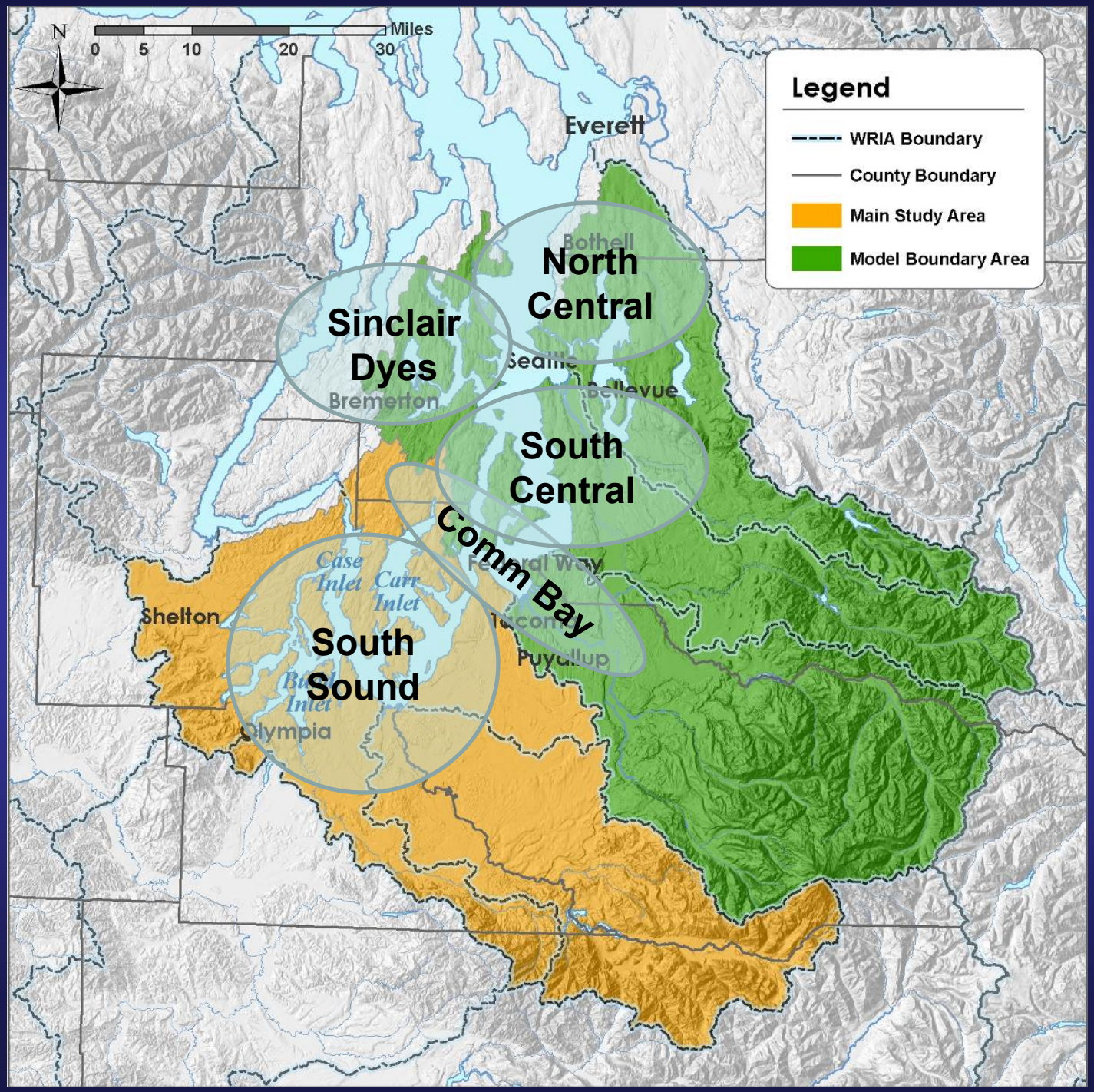
- Data status
- WWTP concentrations
- Tributary concentrations
- Load estimates
- Sediment flux study
- Lost ADCP…
- Modeling status



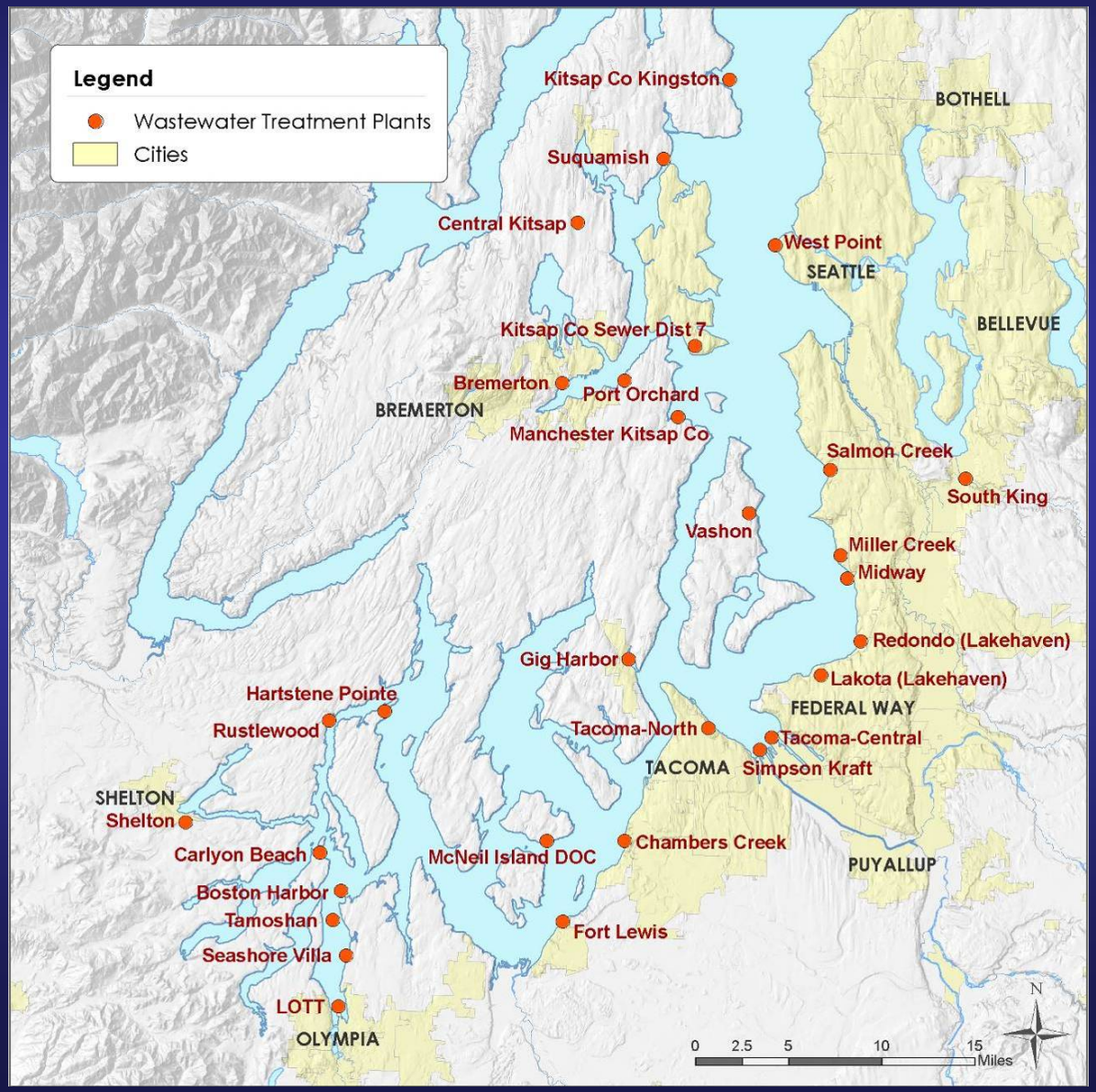
Status

- Data in EIM
- 90% complete
- No QA/QC problems
  - Dissolved total nitrogen and dissolved total phosphorus issue in large rivers
- Instantaneous loads complete

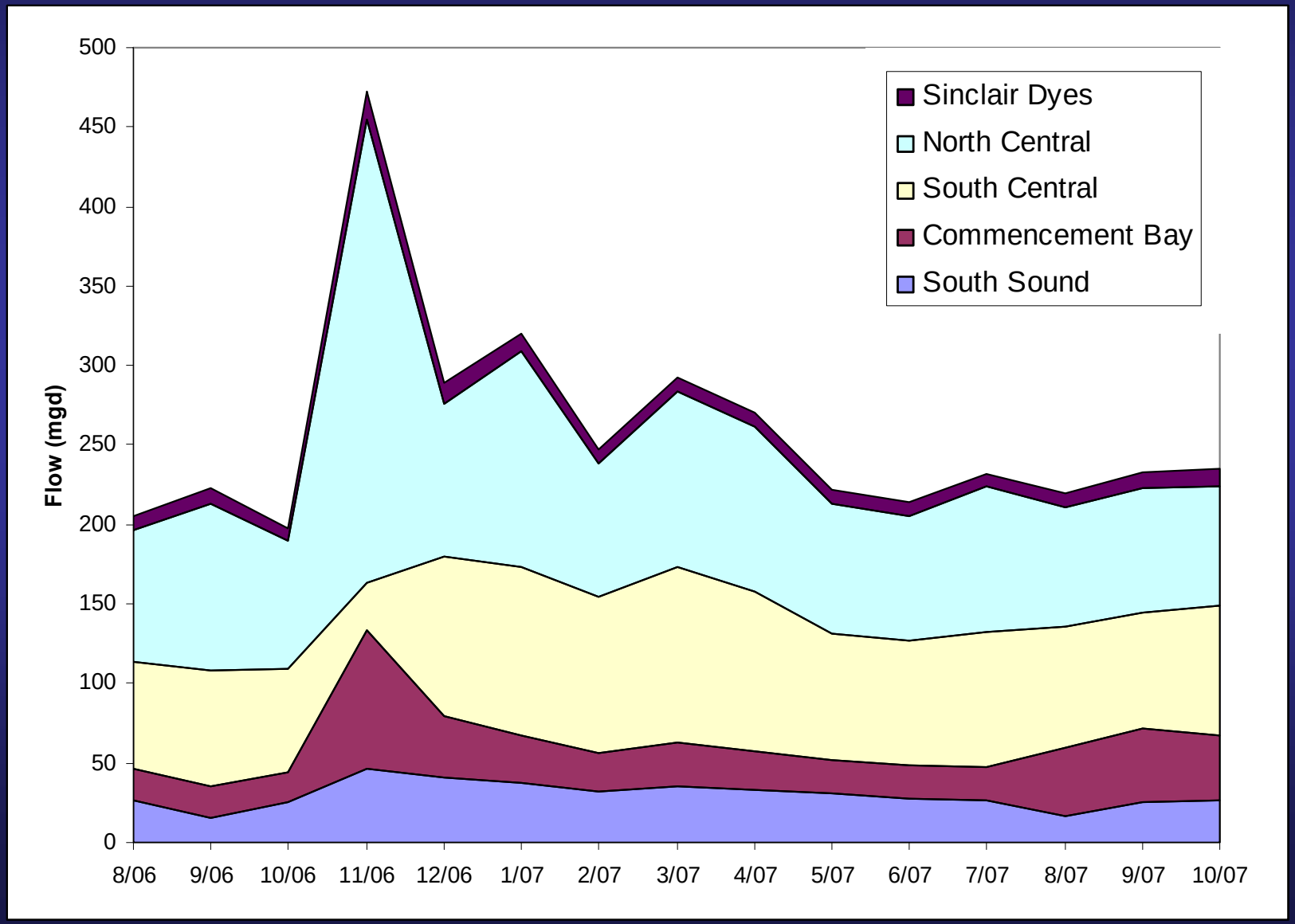
Regions


N
0 5 10 20 30 Miles
Legend
WRIA Boundary
County Boundary
Main Study Area
Model Boundary Area
Everett
Bothell
North Central
Sinclair Dyes
Bremerton
South Central
Comm Bay
Case Inlet
Carr Inlet
Shelton
South Sound
Puyallup
Olympia

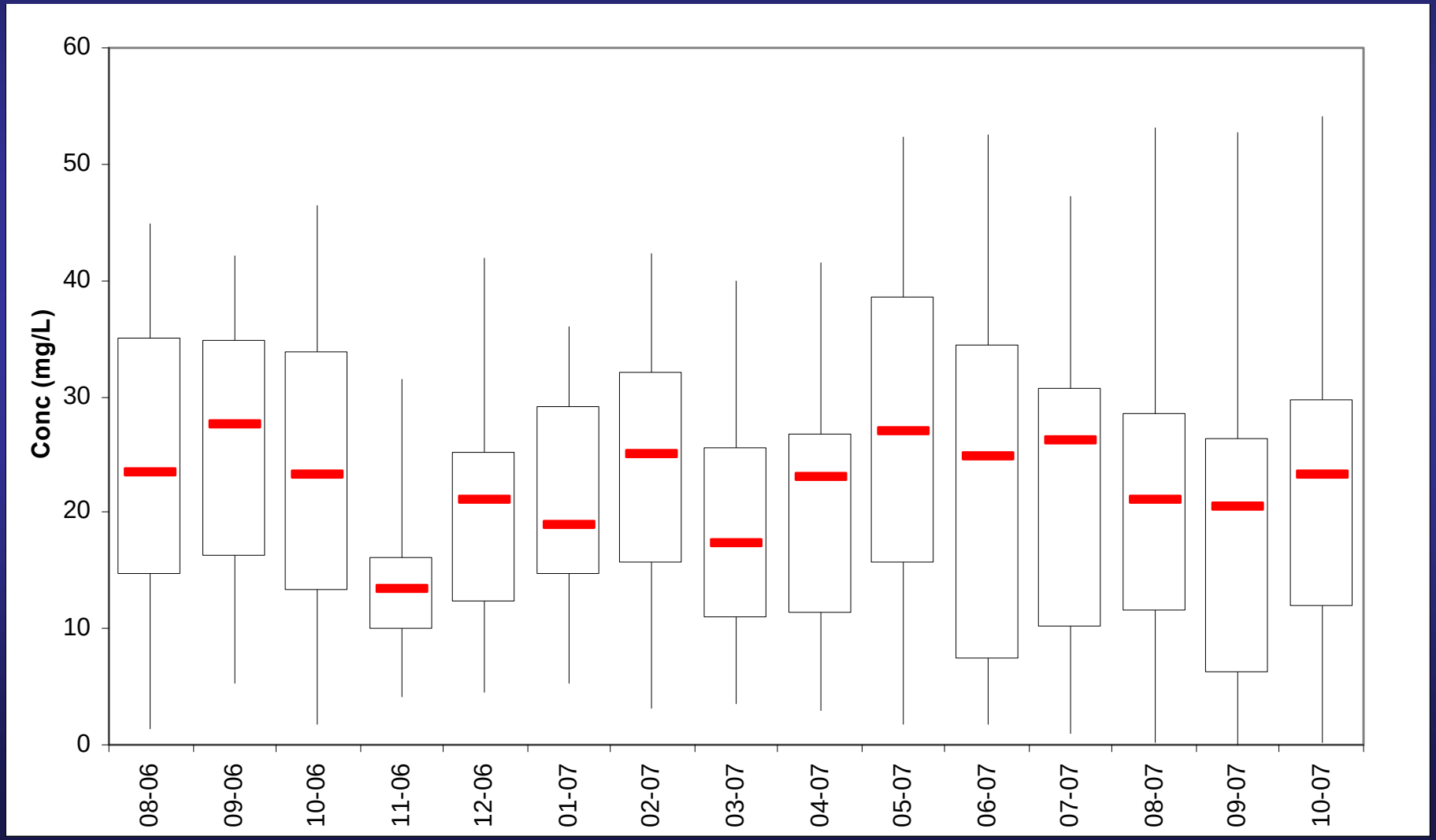
WWTP locations



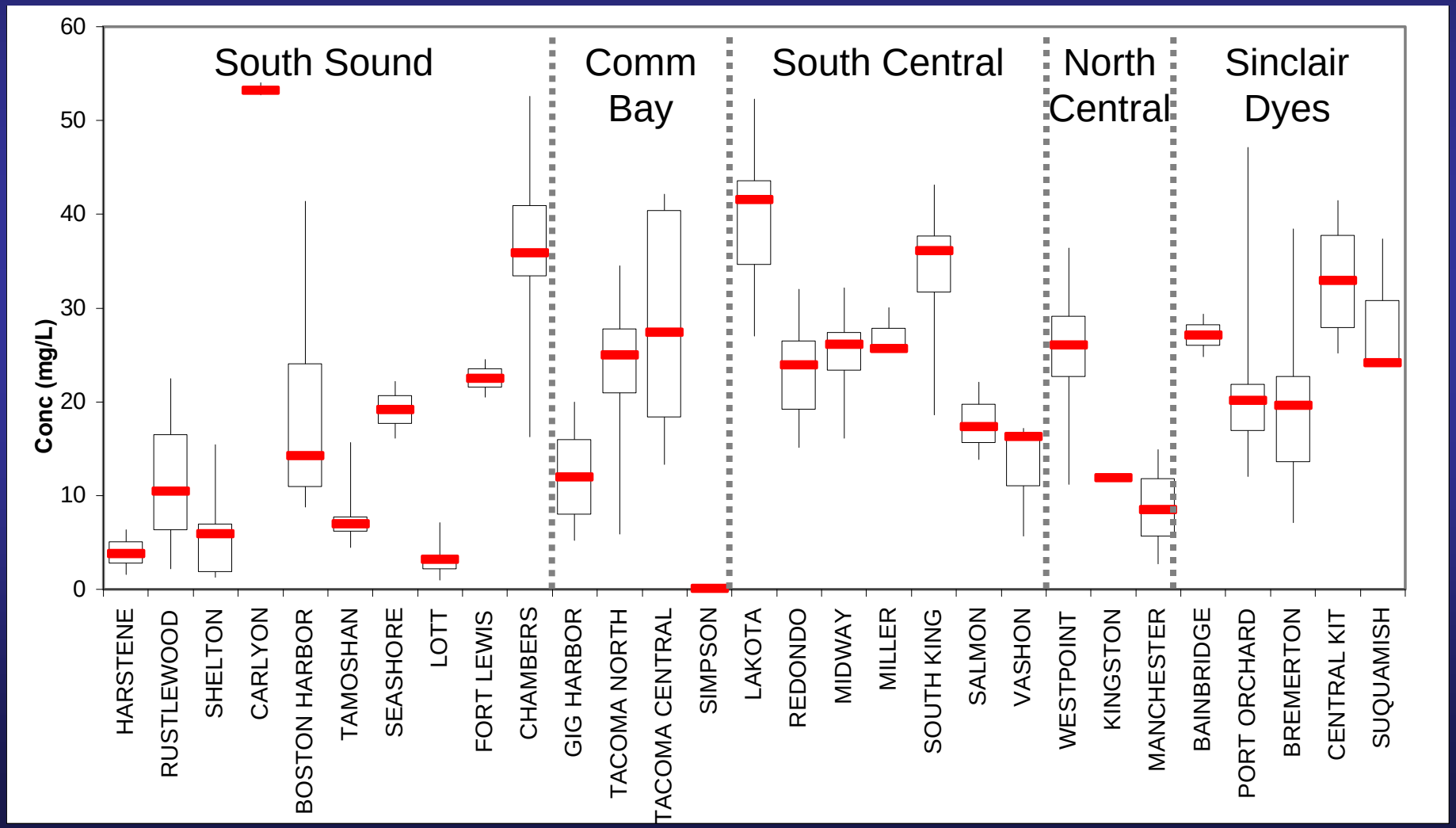
WWTP discharge by region

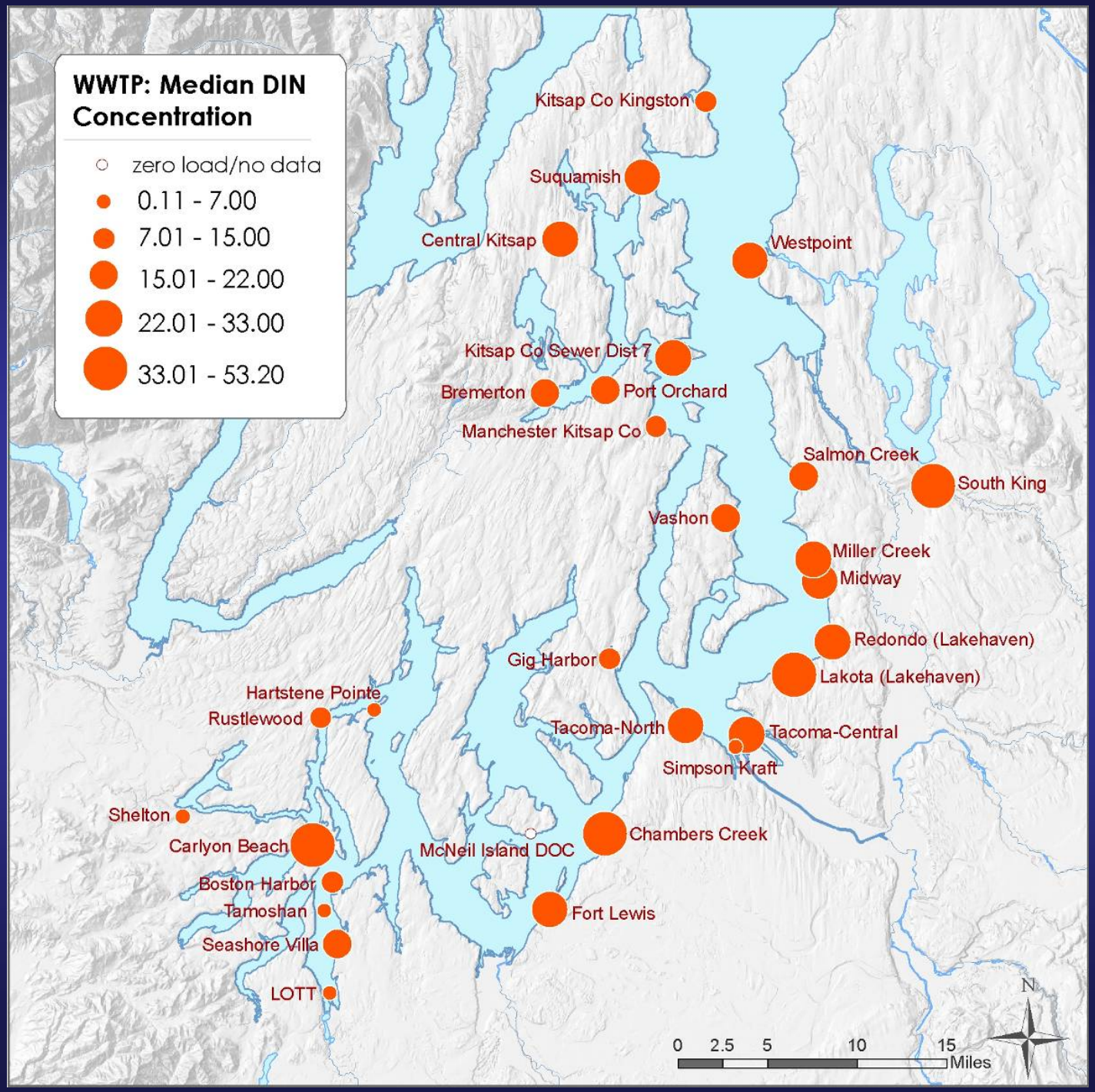


WWTP DIN concentrations

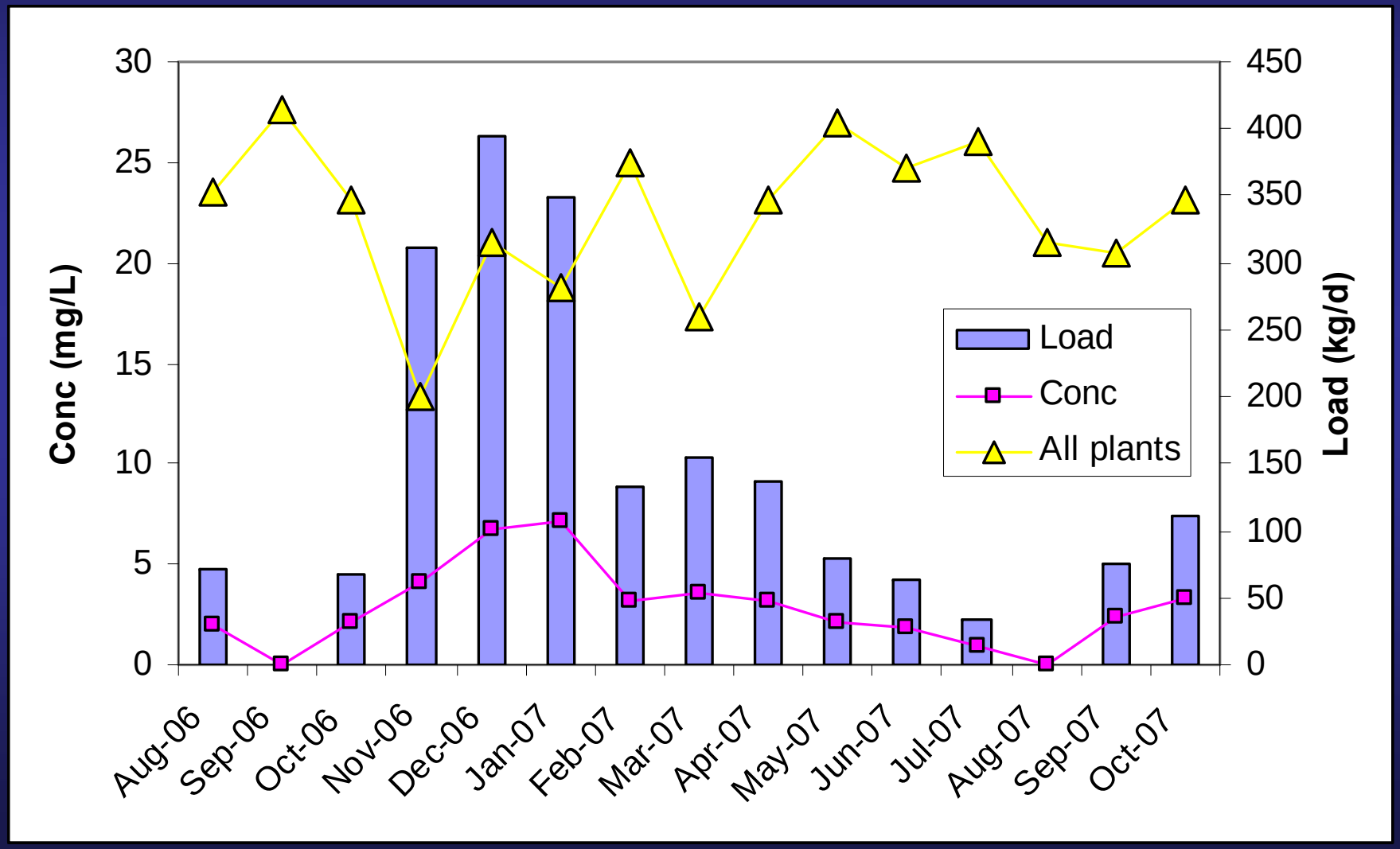


WWTP DIN concentrations

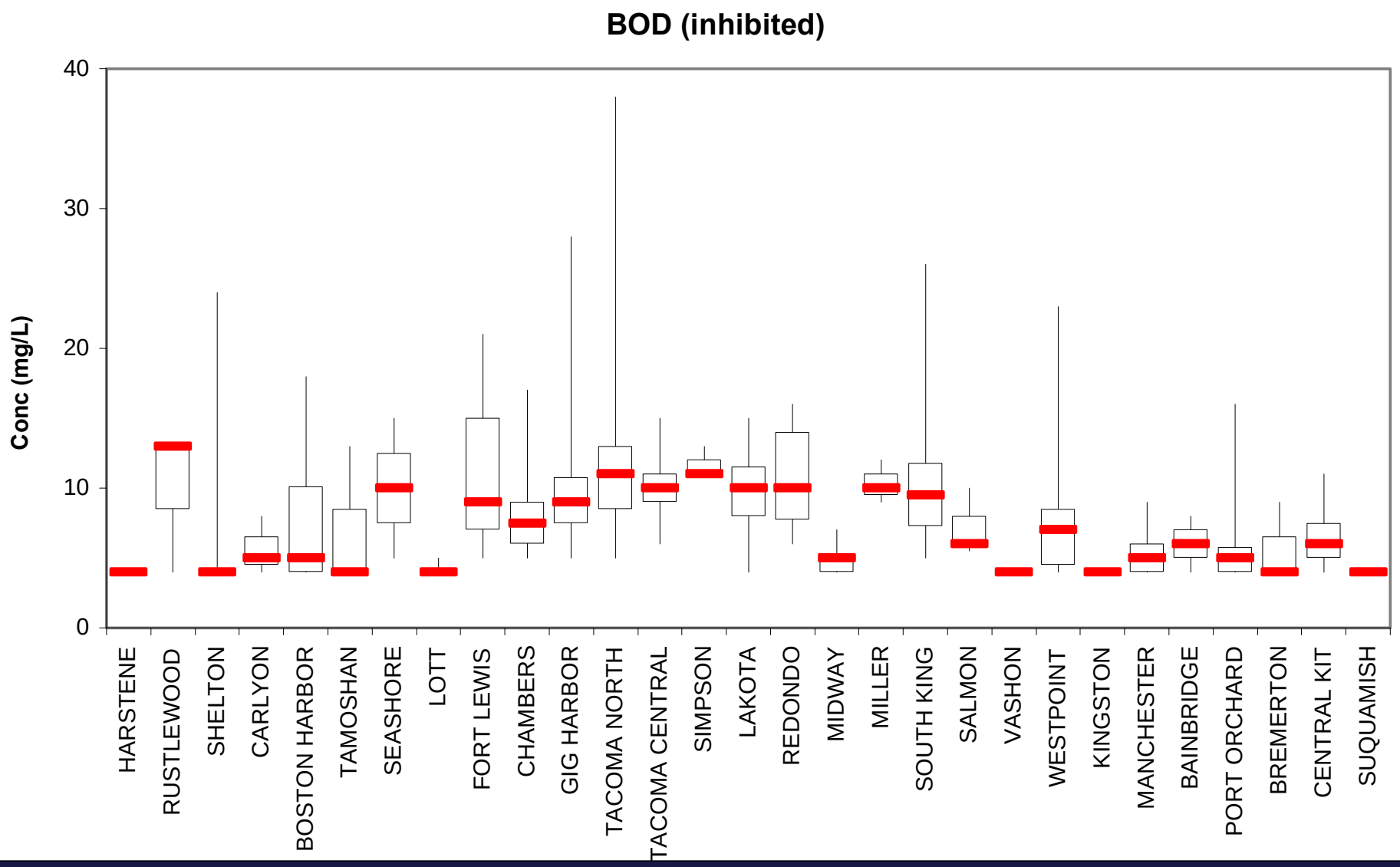



WWTP: Median DIN Concentration
zero load/no data
0.11 - 7.00
7.01 - 15.00
15.01 - 22.00
22.01 - 33.00
33.01 - 53.20
Kitsap Co Kingston
Suquamish
Central Kitsap
Westpoint
Kitsap Co Sewer Dist 7
Bremerton
Port Orchard
Manchester Kitsap Co
Salmon Creek
South King
Vashon
Miller Creek
Midway
Redondo (Lakehaven)
Gig Harbor
Lakota (Lakehaven)
Hartstene Pointe
Rustlewood
Tacoma-North
Tacoma-Central
Simpson Kraft
Shelton
Carlyon Beach
McNeil Island DOC
Chambers Creek
Boston Harbor
Tamoshan
Fort Lewis
Seashore Villa
LOTT
0 2.5 5 10 15
Miles
N

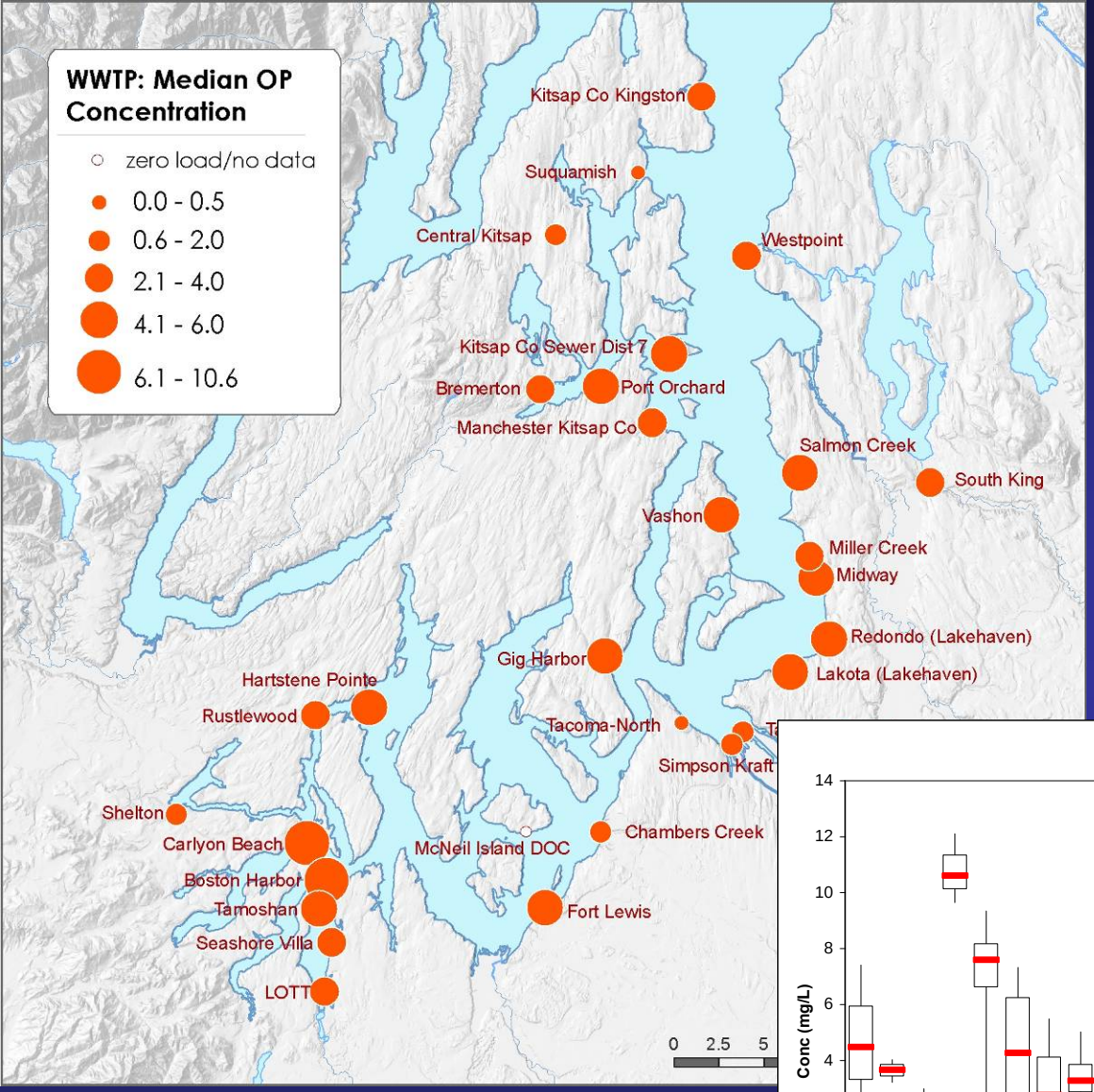
LOTT denitrification

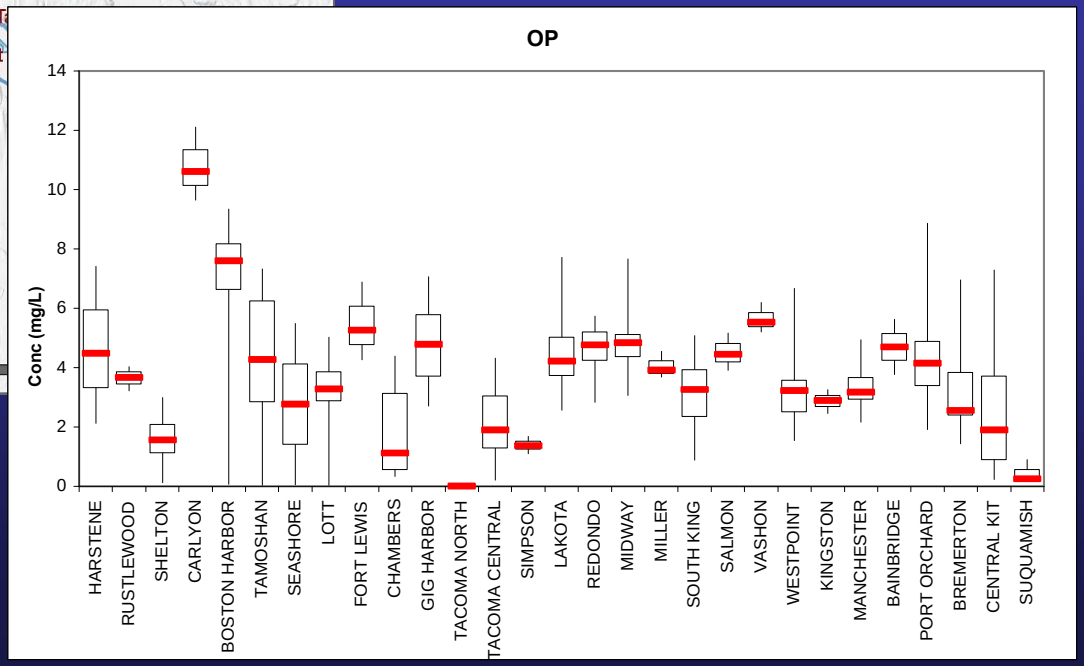


BODinh

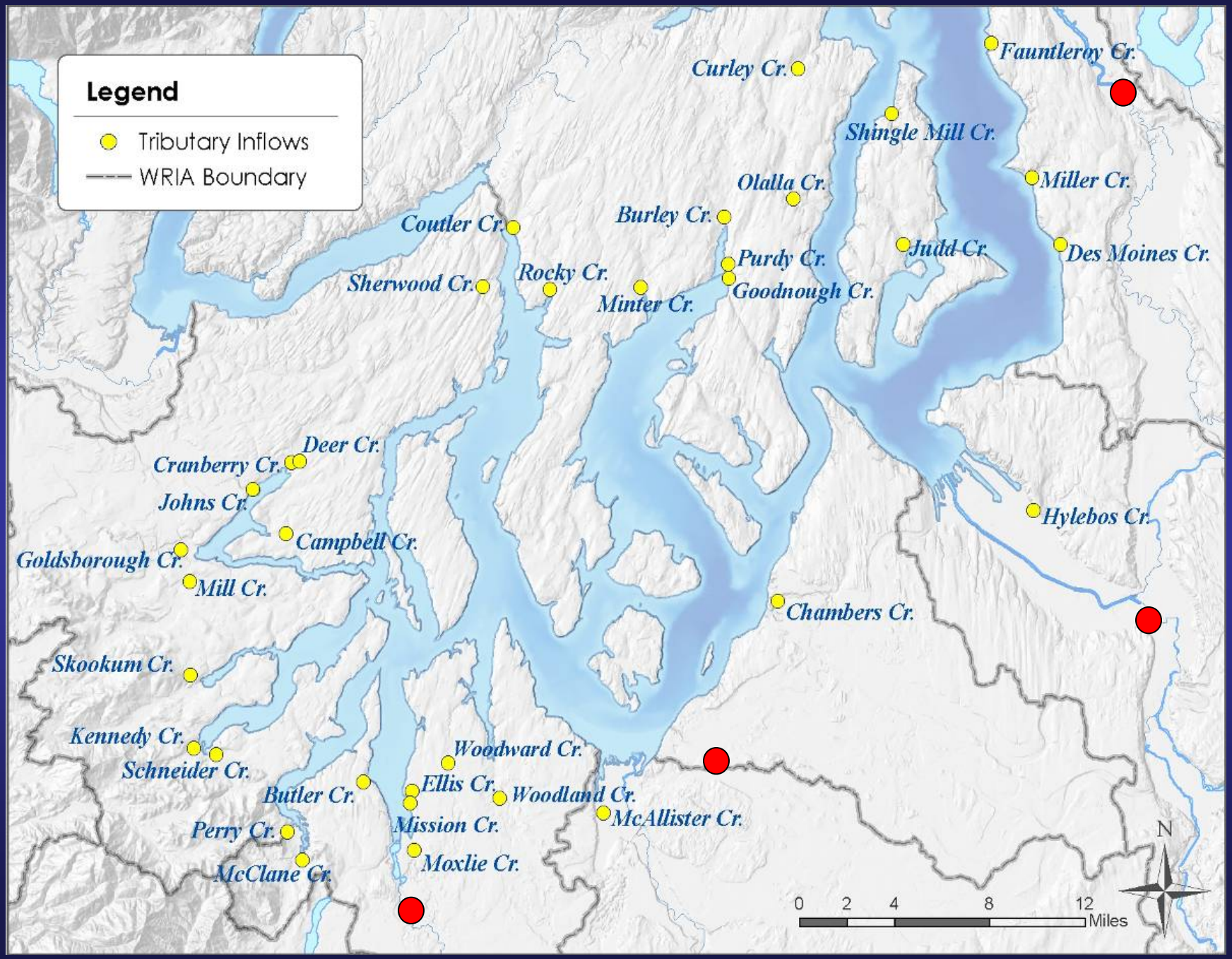

BOD (inhibited)
Conc (mg/L)
40
30
20
10
0
HARSTENE
RUSTLEWOOD
SHELTON
CARLYON
BOSTON HARBOR
TAMOSHAN
SEASHORE
LOTT
FORT LEWIS
CHAMBERS
GIG HARBOR
TACOMA NORTH
TACOMA CENTRAL
SIMPSON
LAKOTA
REDONDO
MIDWAY
MILLER
SOUTH KING
SALMON
VASHON
WESTPOINT
KINGSTON
MANCHESTER
BAINBRIDGE
PORT ORCHARD
BREMERTON
CENTRAL KIT
SUQUAMISH

WWTP OP conc

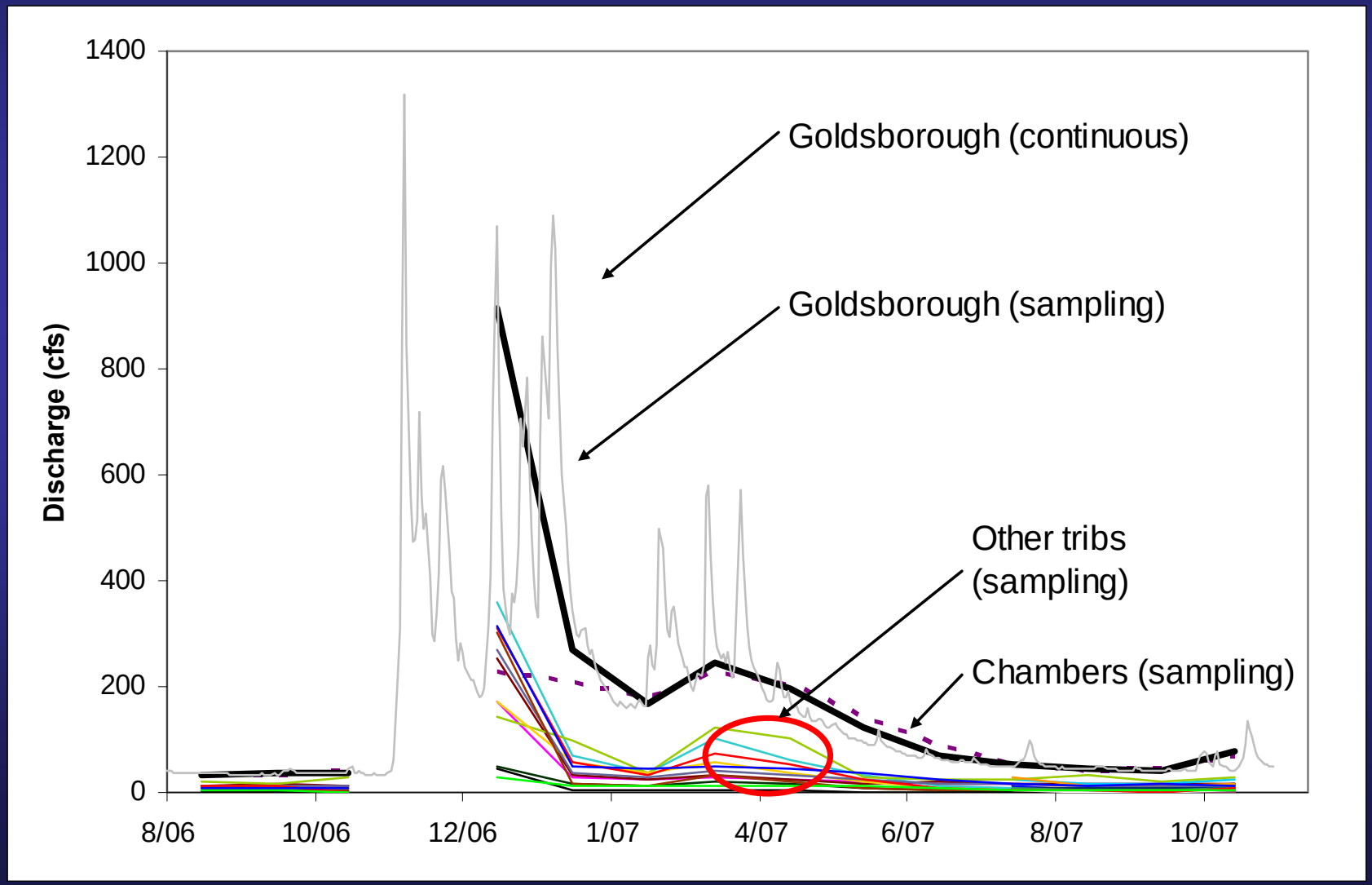

WWTP: Median OP Concentration
zero load/no data
0.0 - 0.5
0.6 - 2.0
2.1 - 4.0
4.1 - 6.0
6.1 - 10.6
Kitsap Co Kingston
Suquamish
Central Kitsap
Westpoint
Kitsap Co Sewer Dist 7
Bremerton
Port Orchard
Manchester Kitsap Co
Salmon Creek
South King
Vashon
Miller Creek
Midway
Redondo (Lakehaven)
Lakota (Lakehaven)
Gig Harbor
Hartstene Pointe
Rustlewood
Tacoma-North
Simpson Kraft
Shelton
Carlyon Beach
Boston Harbor
Tamoshan
Seashore Villa
LOTT
McNeil Island DOC
Chambers Creek
Fort Lewis
0 2.5 5


OP
Conc (mg/L)
0
2
4
6
8
10
12
14
HARSTENE
RUSTLEWOOD
SHELTON
CARLYON
BOSTON HARBOR
TAMOSHAN
SEASHORE
LOTT
FORT LEWIS
CHAMBERS
GIG HARBOR
TACOMA NORTH
TACOMA CENTRAL
SIMPSON
LAKOTA
REDONDO
MIDWAY
MILLER
SOUTH KING
SALMON
VASHON
WESTPOINT
KINGSTON
MANCHESTER
BAINBRIDGE
PORT ORCHARD
BREMERTON
CENTRAL KIT
SUQUAMISH

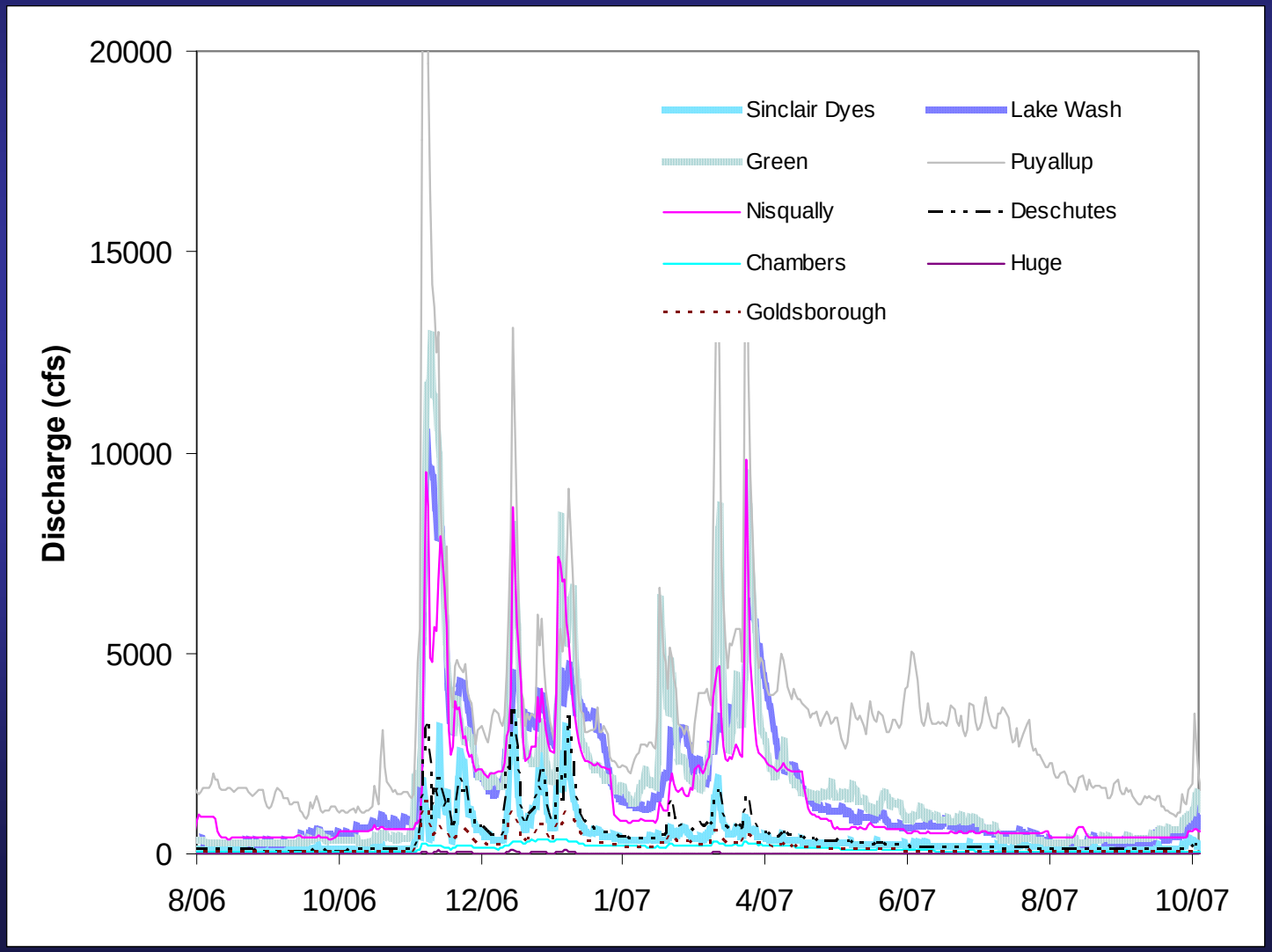
Tributaries


Legend
Tributary Inflows
WRIA Boundary
Fauntleroy Cr.
Curley Cr.
Shingle Mill Cr.
Miller Cr.
Olalla Cr.
Burley Cr.
Coutler Cr.
Judd Cr.
Des Moines Cr.
Purdy Cr.
Rocky Cr.
Sherwood Cr.
Goodnough Cr.
Minter Cr.
Deer Cr.
Cranberry Cr.
Johns Cr.
Hylebos Cr.
Campbell Cr.
Goldsborough Cr.
Mill Cr.
Chambers Cr.
Skookum Cr.
Kennedy Cr.
Schneider Cr.
Woodward Cr.
Ellis Cr.
Woodland Cr.
Butler Cr.
McAllister Cr.
Mission Cr.
Perry Cr.
Moxlie Cr.
McClane Cr.
N
0 2 4 8 12
Miles

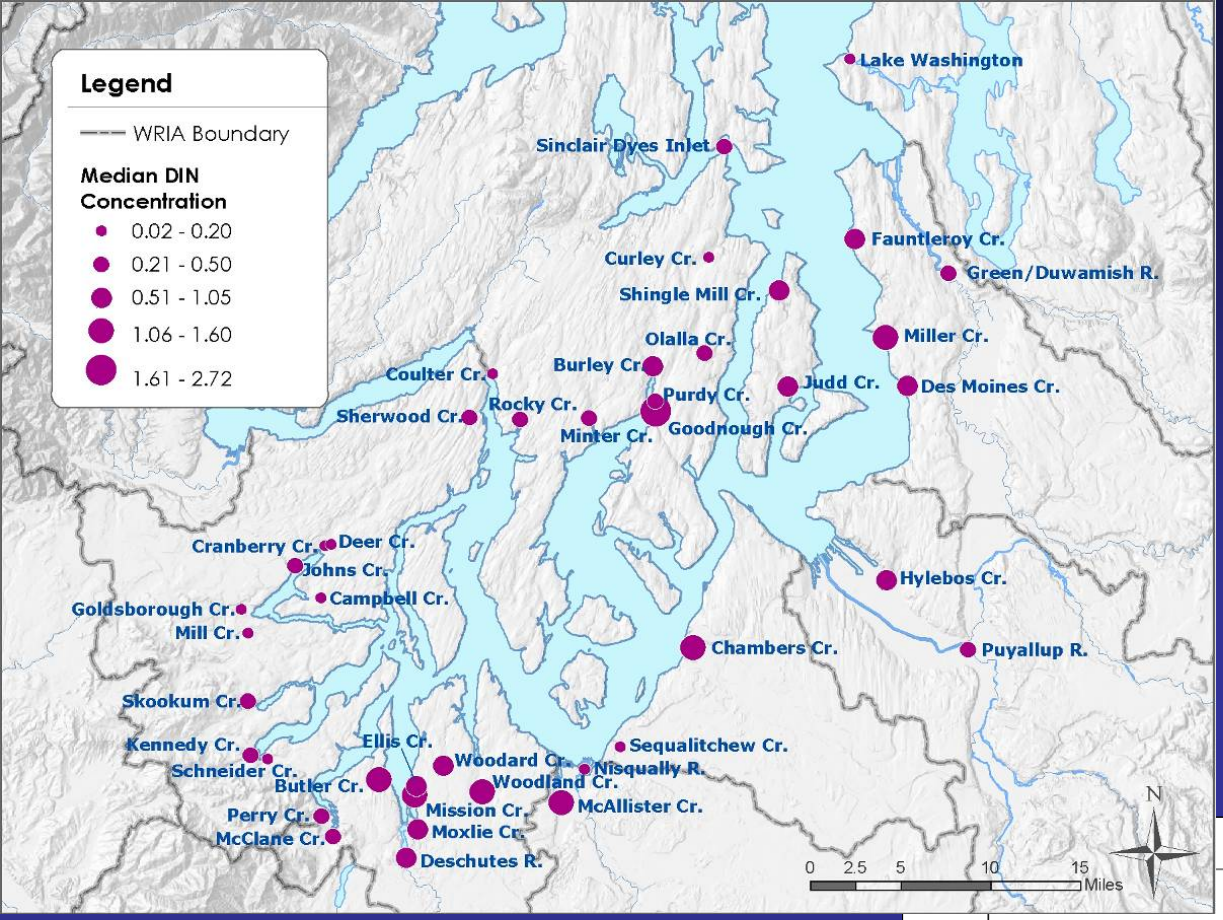
Seasonal flows represented

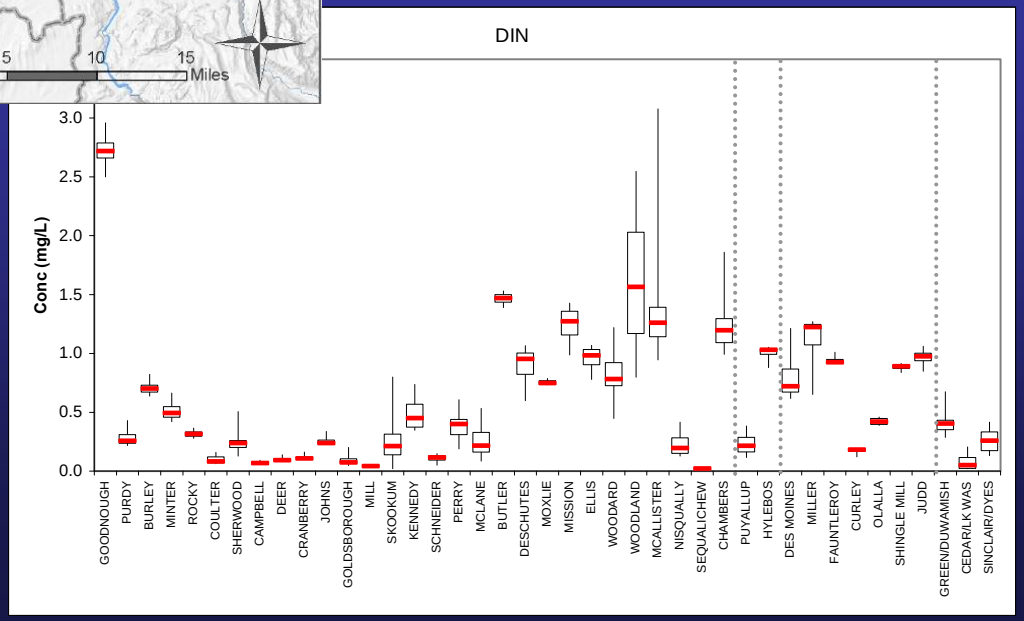


Discharge

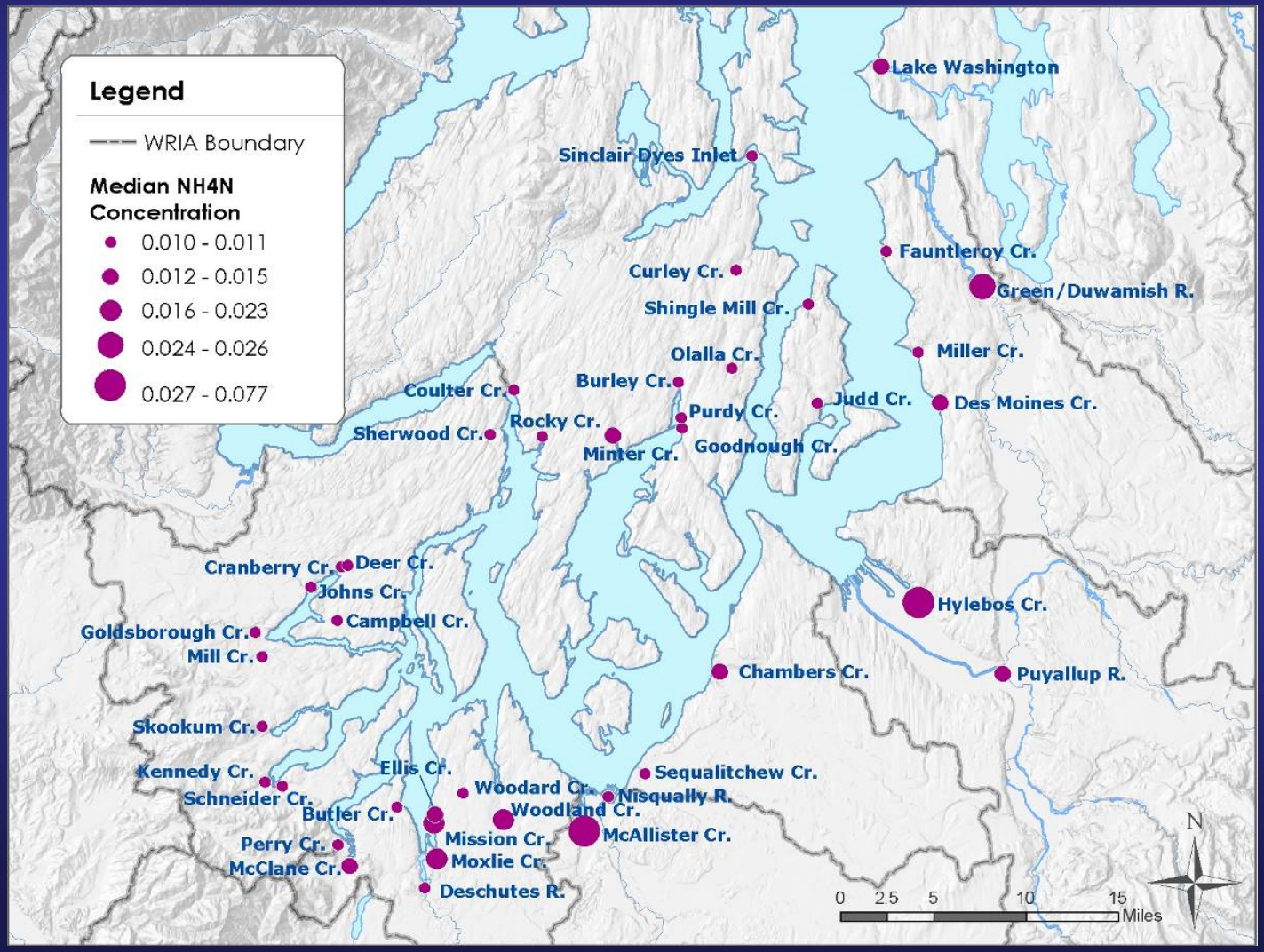

Discharge (cfs)
20000
15000
10000
5000
0
8/06
10/06
12/06
1/07
4/07
6/07
8/07
10/07
Sinclair Dyes
Lake Wash
Green
Puyallup
Nisqually
Deschutes
Chambers
Huge
Goldsborough

Trib DIN conc

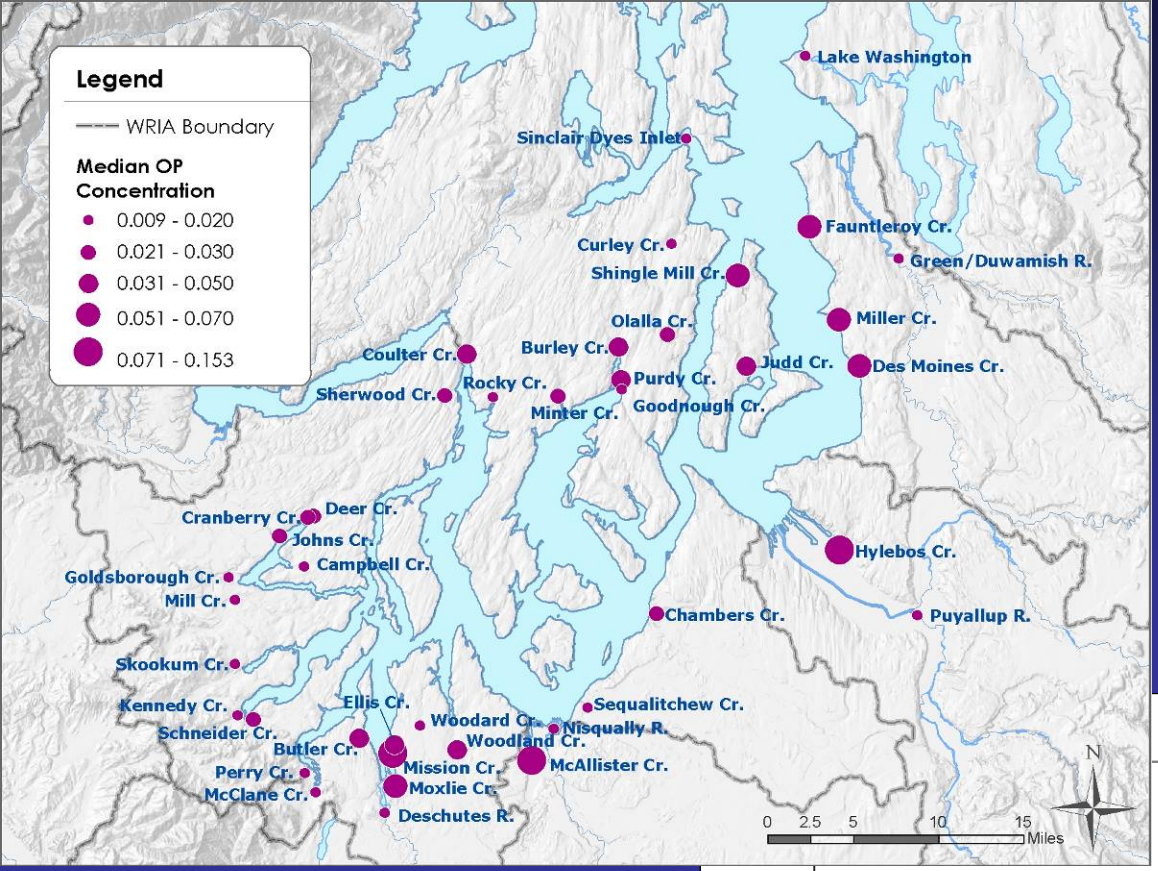


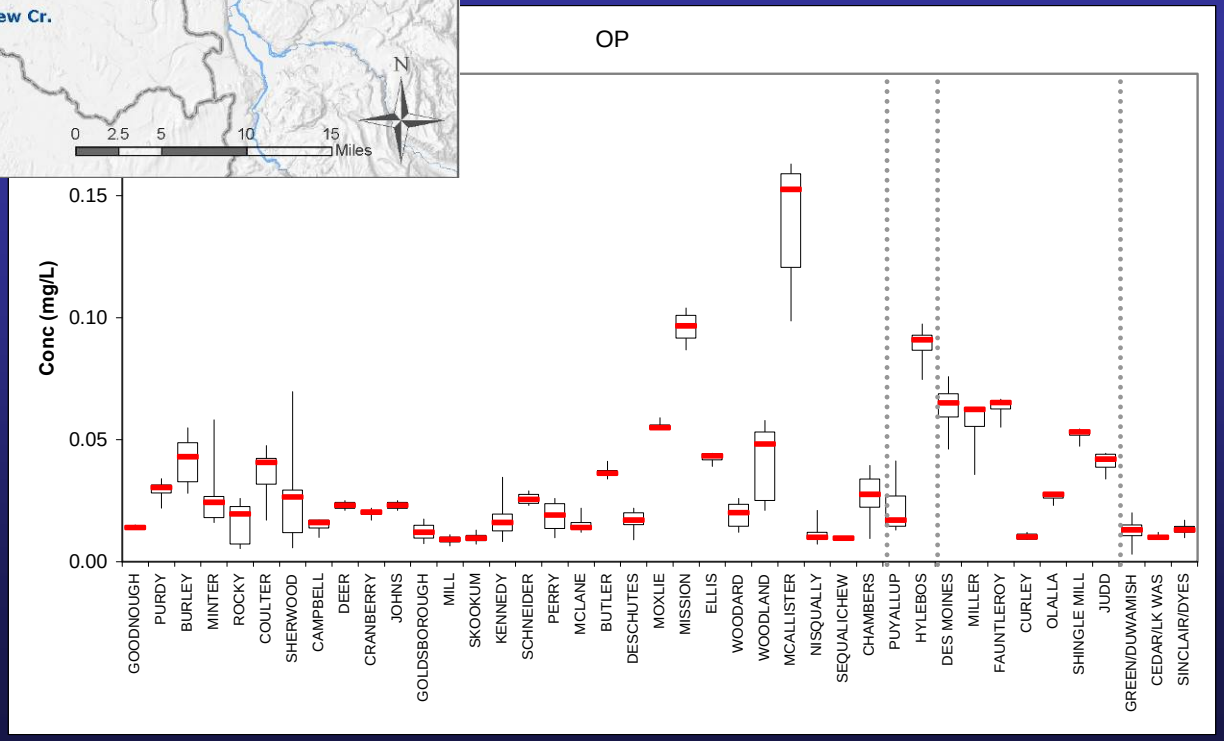


Trib ammonia concentration

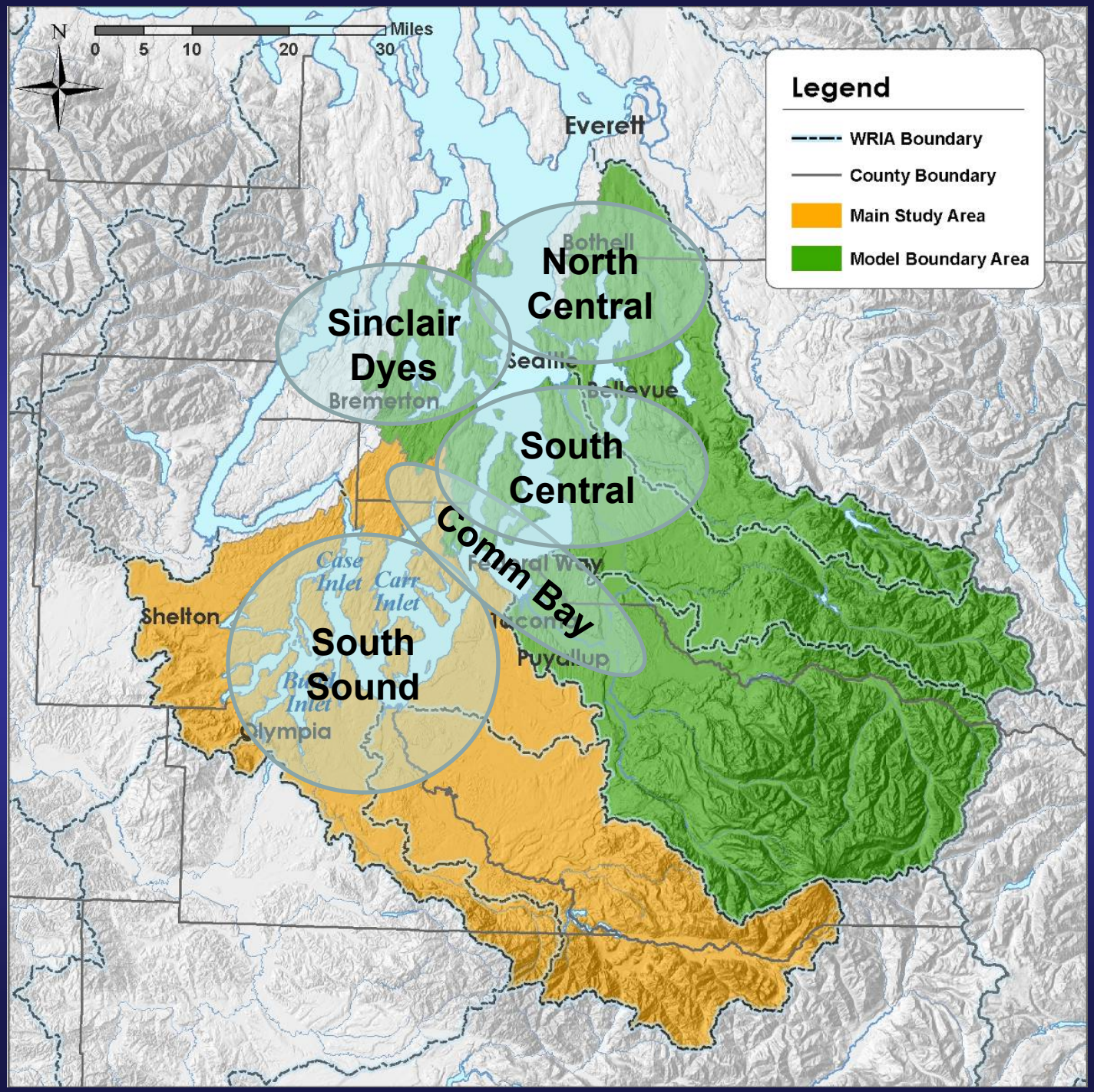


Trib OP conc

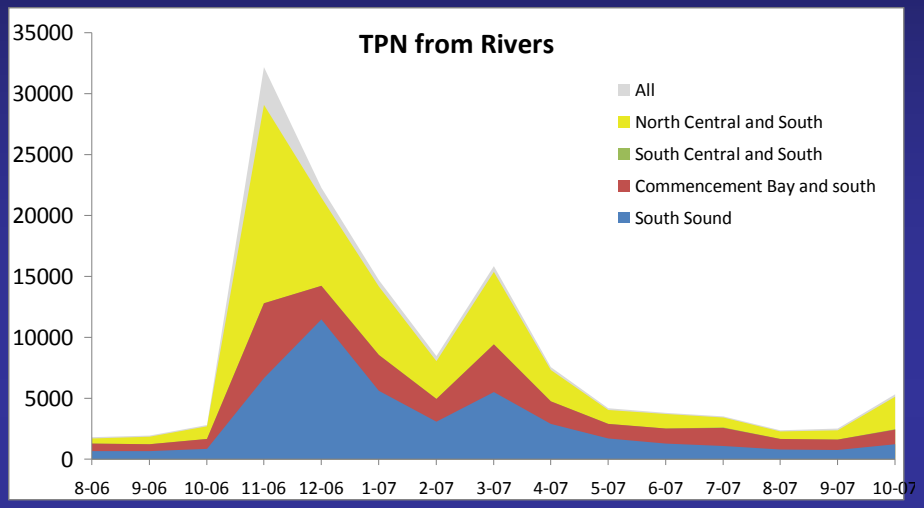

Legend
WRIA Boundary
Median OP Concentration
0.009 - 0.020
0.021 - 0.030
0.031 - 0.050
0.051 - 0.070
0.071 - 0.153
Lake Washington
Sinclair Dyes Inlet
Fauntleroy Cr.
Green/Duwamish R.
Curley Cr.
Shingle Mill Cr.
Miller Cr.
Olalla Cr.
Burley Cr.
Coulter Cr.
Judd Cr.
Des Moines Cr.
Rocky Cr.
Purdy Cr.
Sherwood Cr.
Minter Cr.
Goodnough Cr.
Cranberry Cr.
Deer Cr.
Johns Cr.
Hylebos Cr.
Campbell Cr.
Goldsborough Cr.
Mill Cr.
Chambers Cr.
Puyallup R.
Skookum Cr.
Kennedy Cr.
Ellis Cr.
Sequalitchew Cr.
Schneider Cr.
Woodard Cr.
Nisqually R.
Butler Cr.
Woodland Cr.
Perry Cr.
Mission Cr.
McAllister Cr.
McClane Cr.
Moxlie Cr.
Deschutes R.
0 2.5 5 10 15 Miles
N

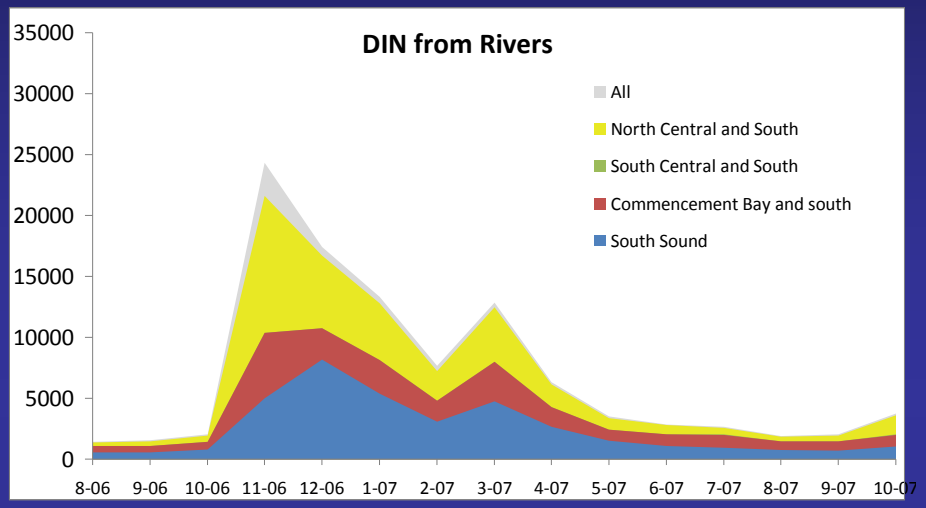

OP
Conc (mg/L)
0.15
0.10
0.05
0.00
GOODNOUGH
PURDY
BURLEY
MINTER
ROCKY
COULTER
SHERWOOD
CAMPBELL
DEER
CRANBERRY
JOHNS
GOLDSBOROUGH
MILL
SKOOKUM
KENNEDY
SCHNEIDER
PERRY
MCLANE
BUTLER
DESCHUTES
MOXLIE
MISSION
ELLIS
WOODARD
WOODLAND
MCALLISTER
NISQUALLY
SEQUALICHEW
CHAMBERS
PUYALLUP
HYLEBOS
DES MOINES
MILLER
FAUNTLEROY
CURLEY
OLALLA
SHINGLE MILL
JUDD
GREEN/DUWAMISH
CEDAR/LK WAS
SINCLAIR/DYES

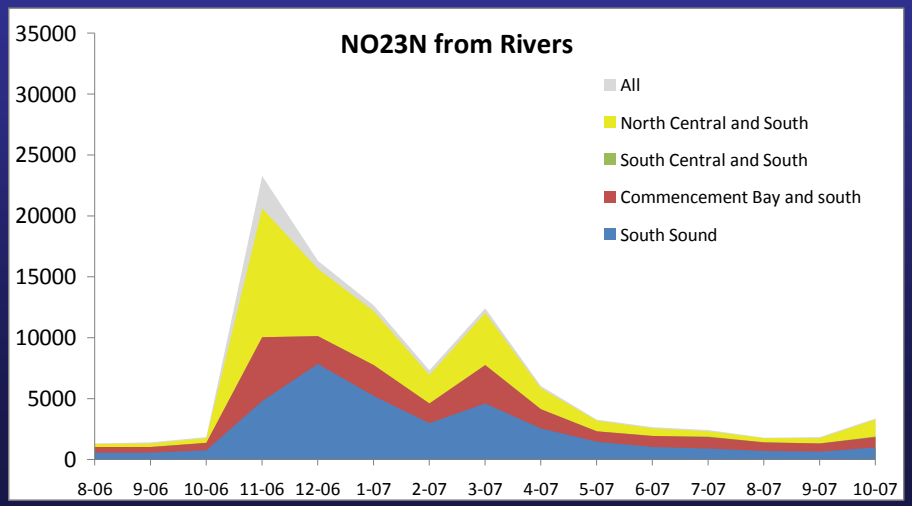
Regions

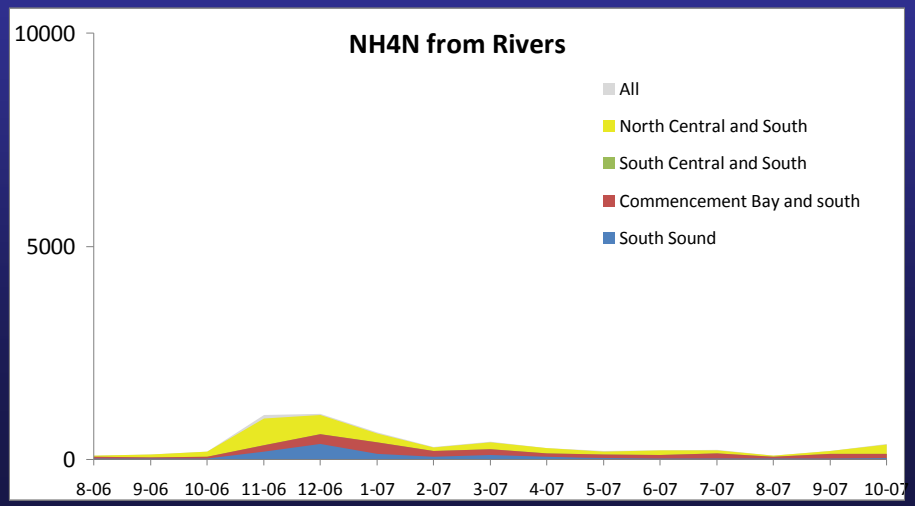

N
0 5 10 20 30 Miles
Legend
WRIA Boundary
County Boundary
Main Study Area
Model Boundary Area
Everett
Bothell
North Central
Sinclair Dyes
Bremerton
South Central
Comm Bay
Case Inlet
Carr Inlet
Shelton
South Sound
Puyallup
Olympia

Nitrogen loads from rivers

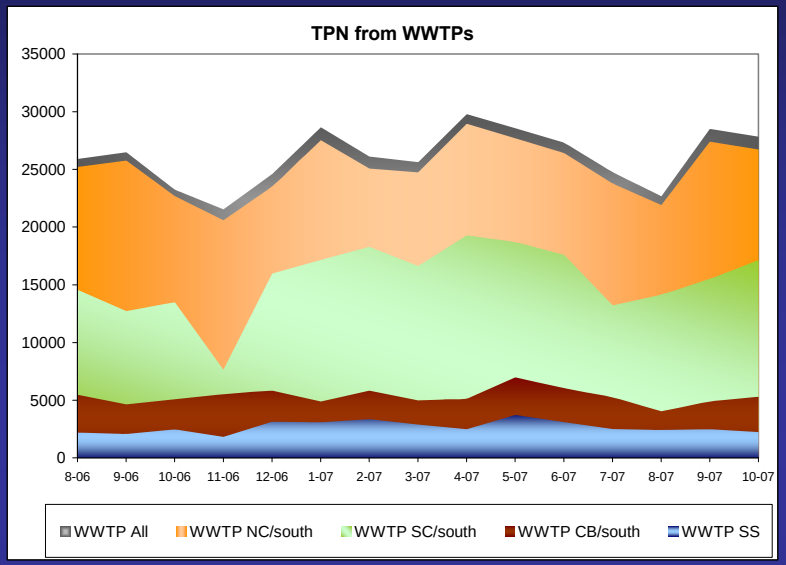


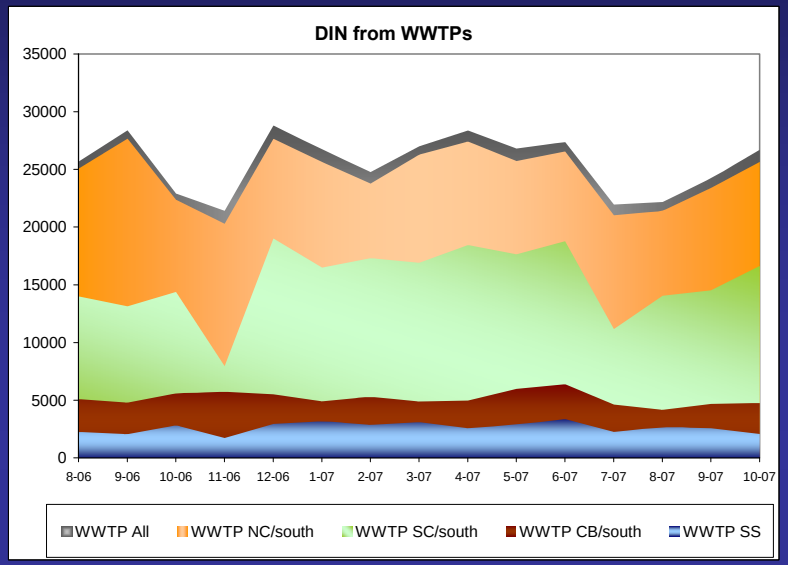


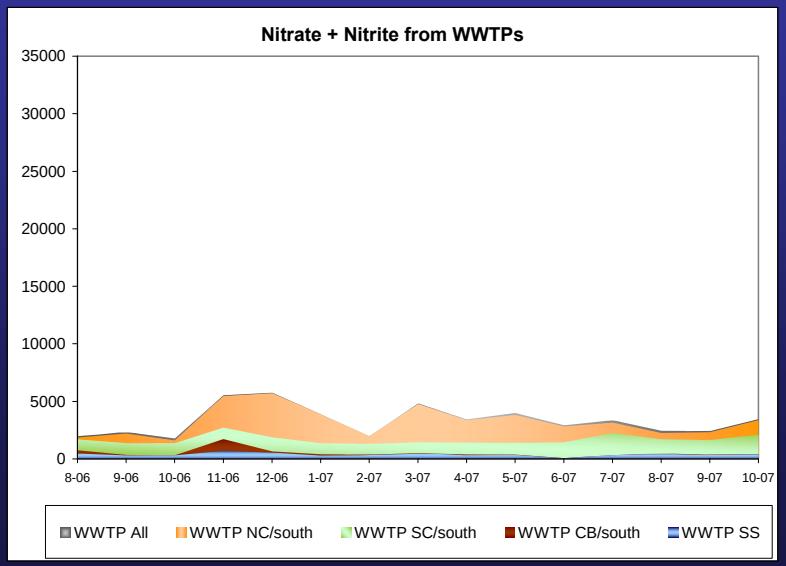


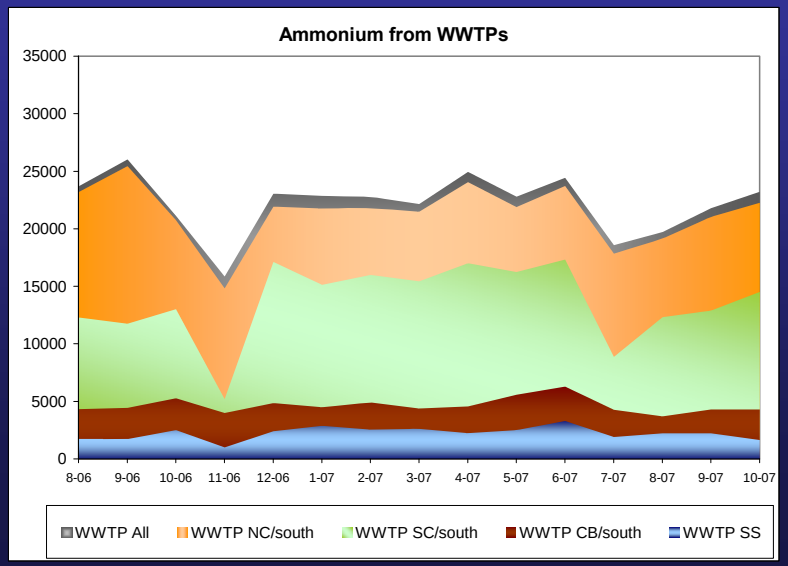


Nitrogen loads from WWTPs

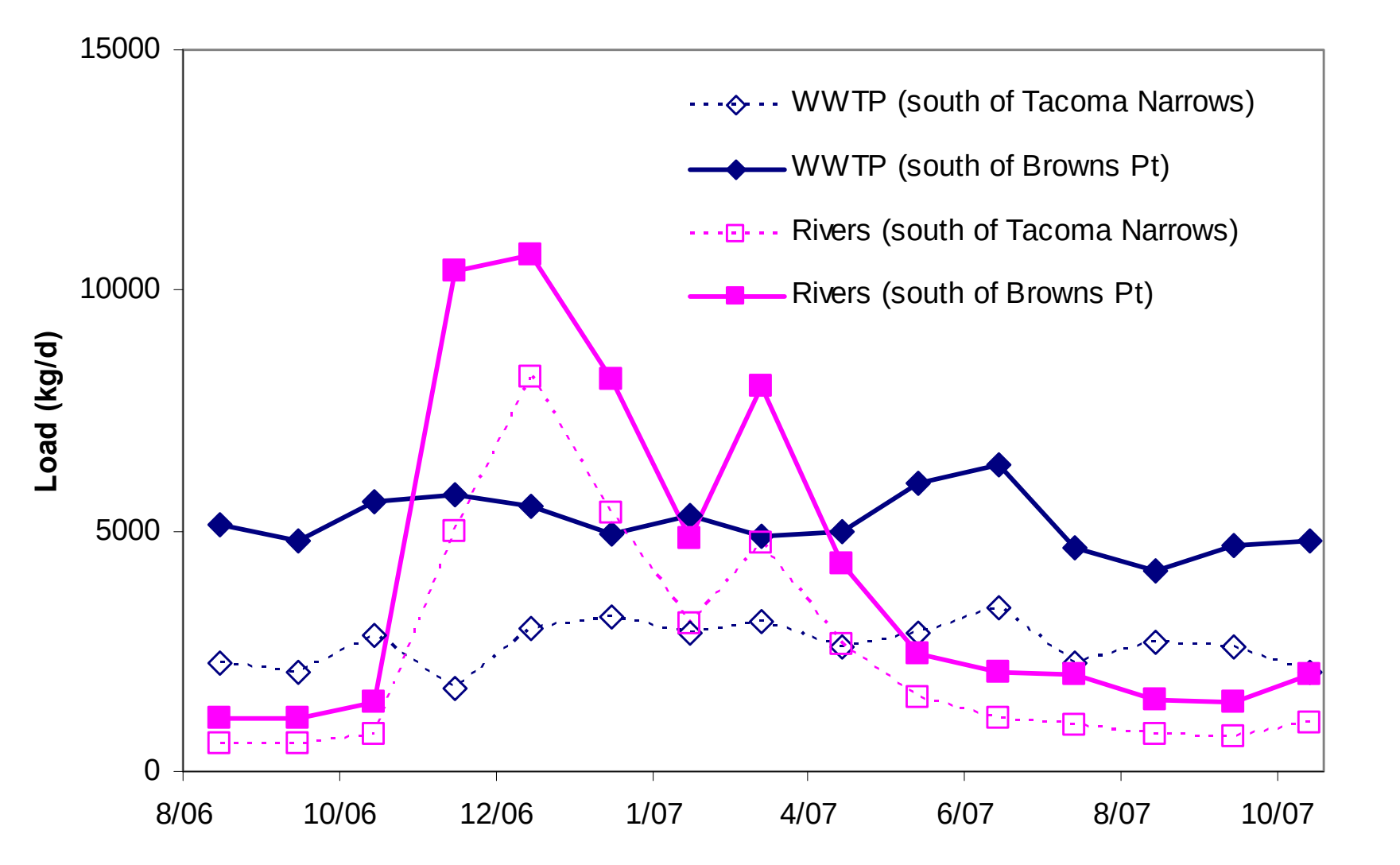


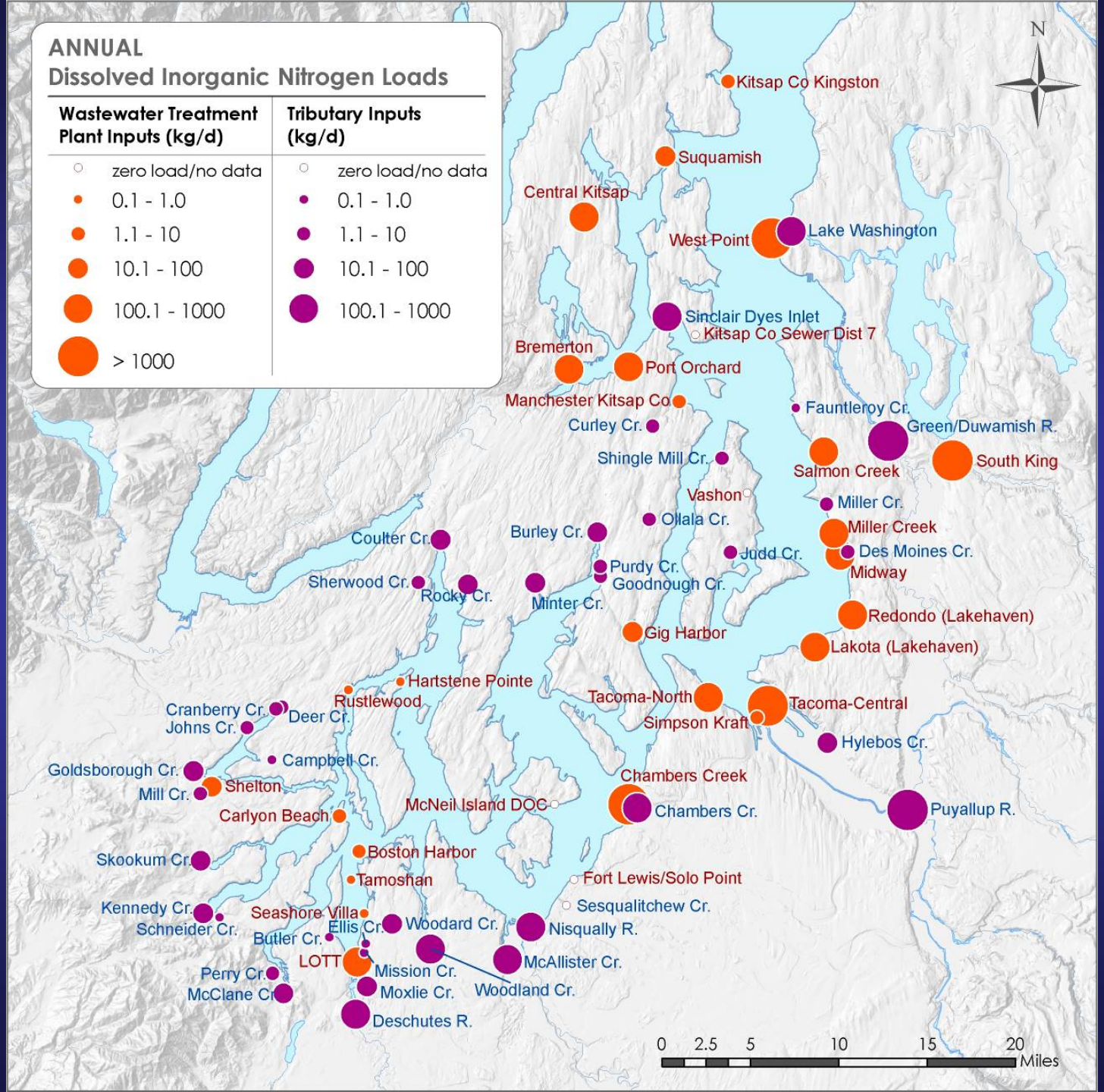


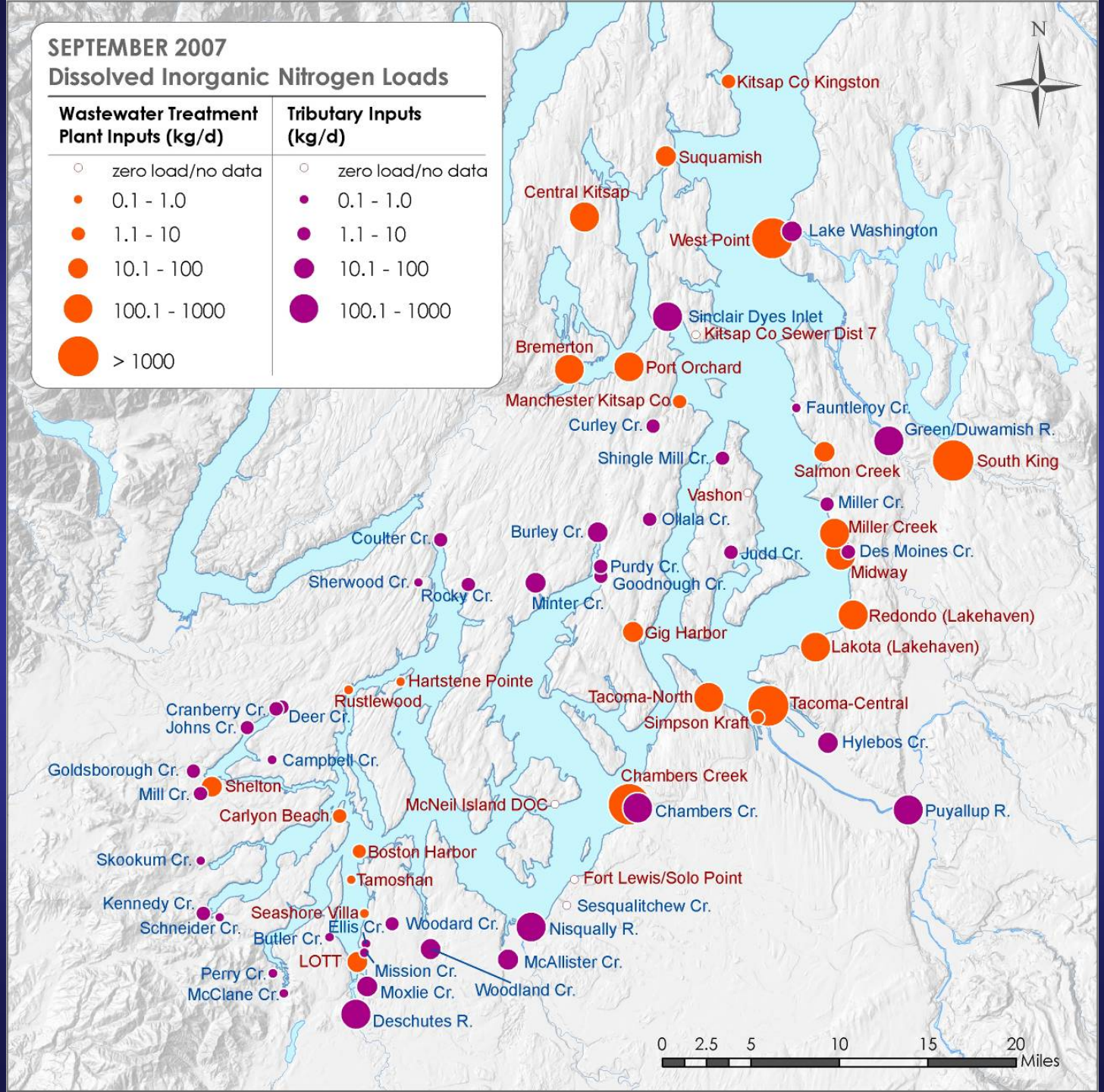




Rivers and WWTPs



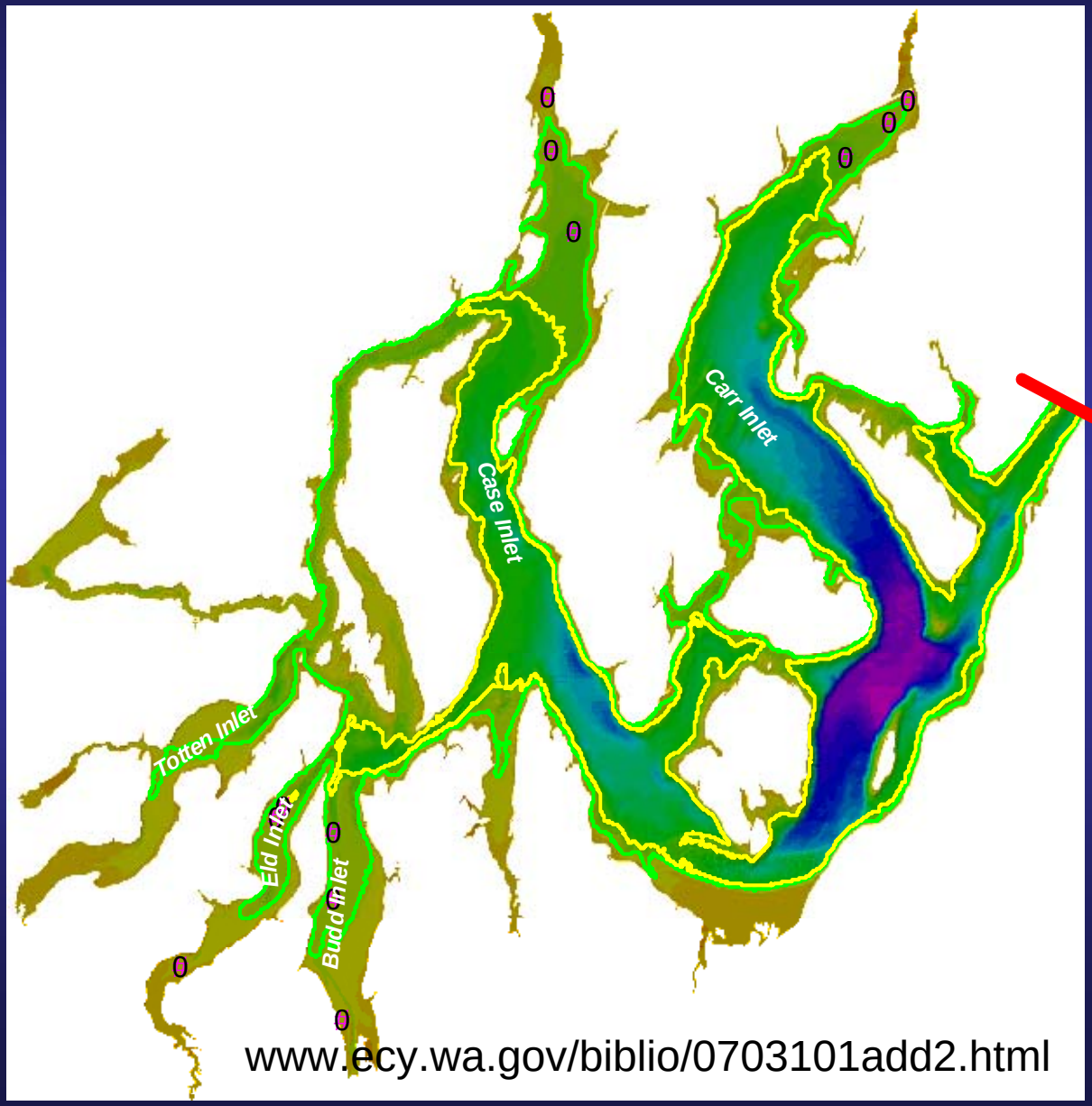

ANNUAL
Dissolved Inorganic Nitrogen Loads
Wastewater Treatment Plant Inputs (kg/d)
zero load/no data
0.1 - 1.0
1.1 - 10
10.1 - 100
100.1 - 1000
> 1000
Tributary Inputs (kg/d)
zero load/no data
0.1 - 1.0
1.1 - 10
10.1 - 100
100.1 - 1000
N
Kitsap Co Kingston
Suquamish
Central Kitsap
West Point
Lake Washington
Sinclair Dyes Inlet
Kitsap Co Sewer Dist 7
Bremerton
Port Orchard
Manchester Kitsap Co
Fauntleroy Cr.
Curley Cr.
Green/Duwamish R.
Shingle Mill Cr.
Salmon Creek
South King
Vashon
Miller Cr.
Ollala Cr.
Miller Creek
Coulter Cr.
Burley Cr.
Judd Cr.
Des Moines Cr.
Purdy Cr.
Midway
Sherwood Cr.
Goodnough Cr.
Rocky Cr.
Minter Cr.
Redondo (Lakehaven)
Gig Harbor
Lakota (Lakehaven)
Hartstene Pointe
Rustlewood
Tacoma-North
Tacoma-Central
Cranberry Cr.
Deer Cr.
Johns Cr.
Simpson Kraft
Hylebos Cr.
Campbell Cr.
Goldsborough Cr.
Shelton
Mill Cr.
Chambers Creek
McNeil Island DOC
Chambers Cr.
Puyallup R.
Carlyon Beach
Boston Harbor
Skookum Cr.
Tamoshan
Fort Lewis/Solo Point
Sesqualitchew Cr.
Kennedy Cr.
Seashore Villa
Schneider Cr.
Ellis Cr.
Woodard Cr.
Nisqually R.
Butler Cr.
LOTT
McAllister Cr.
Mission Cr.
Perry Cr.
Moxlie Cr.
Woodland Cr.
McClane Cr.
Deschutes R.
0 2.5 5 10 15 20
Miles


SEPTEMBER 2007
Dissolved Inorganic Nitrogen Loads
Wastewater Treatment Plant Inputs (kg/d)
zero load/no data
0.1 - 1.0
1.1 - 10
10.1 - 100
100.1 - 1000
> 1000
Tributary Inputs (kg/d)
zero load/no data
0.1 - 1.0
1.1 - 10
10.1 - 100
100.1 - 1000
N
Kitsap Co Kingston
Suquamish
Central Kitsap
West Point
Lake Washington
Sinclair Dyes Inlet
Kitsap Co Sewer Dist 7
Bremerton
Port Orchard
Manchester Kitsap Co
Fauntleroy Cr.
Curley Cr.
Green/Duwamish R.
Shingle Mill Cr.
Salmon Creek
South King
Vashon
Miller Cr.
Ollala Cr.
Miller Creek
Burley Cr.
Coulter Cr.
Judd Cr.
Des Moines Cr.
Purdy Cr.
Midway
Sherwood Cr.
Goodnough Cr.
Rocky Cr.
Minter Cr.
Redondo (Lakehaven)
Gig Harbor
Lakota (Lakehaven)
Hartstene Pointe
Rustlewood
Tacoma-North
Tacoma-Central
Cranberry Cr.
Deer Cr.
Johns Cr.
Simpson Kraft
Hylebos Cr.
Campbell Cr.
Goldsborough Cr.
Shelton
Mill Cr.
Chambers Creek
McNeil Island DOC
Chambers Cr.
Puyallup R.
Carlyon Beach
Boston Harbor
Skookum Cr.
Tamoshan
Fort Lewis/Solo Point
Sesqualitchew Cr.
Kennedy Cr.
Seashore Villa
Schneider Cr.
Ellis Cr.
Woodard Cr.
Nisqually R.
Butler Cr.
LOTT
McAllister Cr.
Mission Cr.
Perry Cr.
Woodland Cr.
McClane Cr.
Moxlie Cr.
Deschutes R.
0 2.5 5 10 15 20
Miles

Trib and WWTP tasks

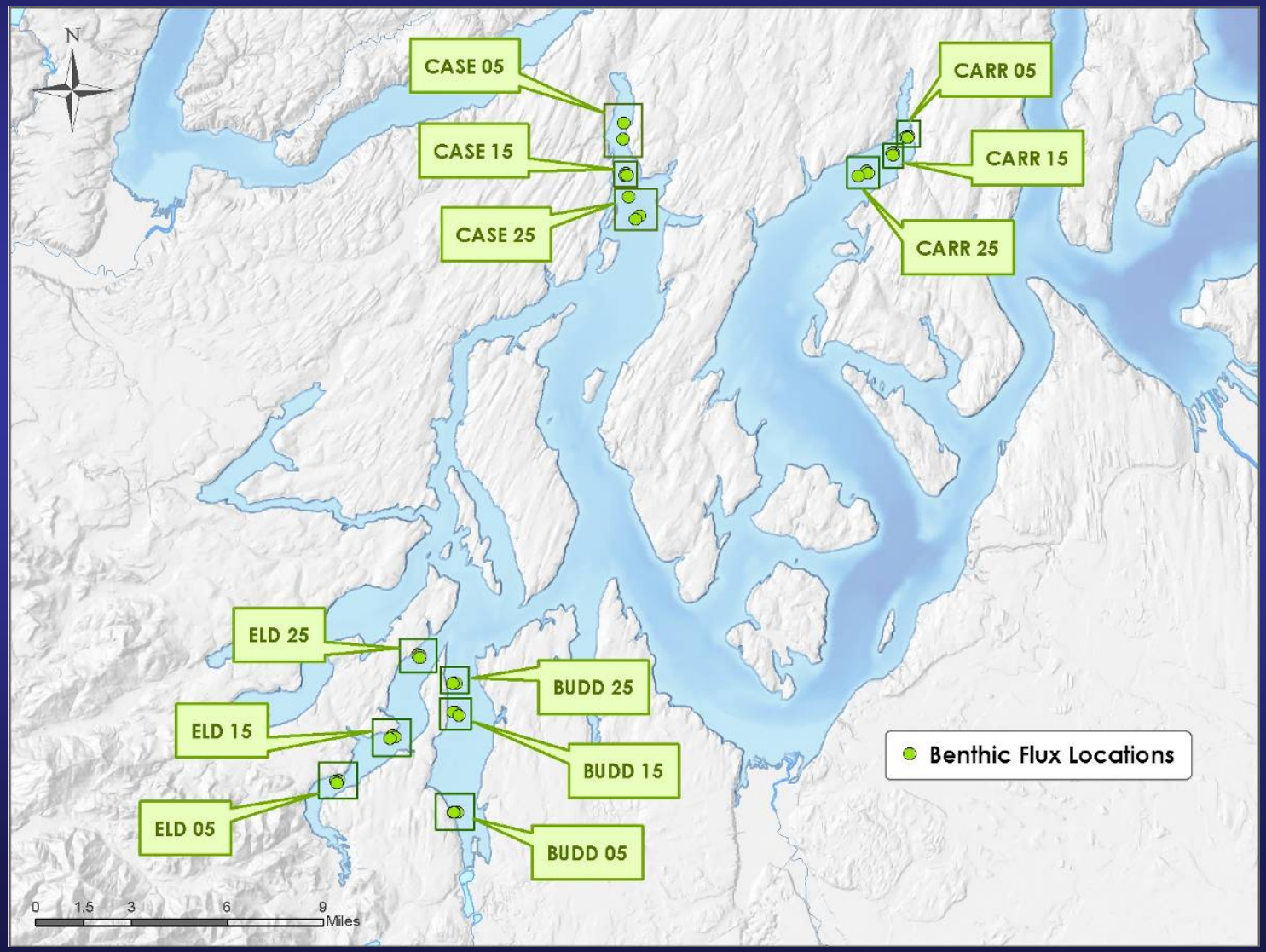
- Develop trib load time series for model
  - Estimated daily flows
  - Account for entire watershed
- Develop WWTP time series for model
  - Have electronic daily flows from 25 plants
  - Sludge dewatering not as variable
  - Method to extrapolate from measured data

Sediment Flux Study

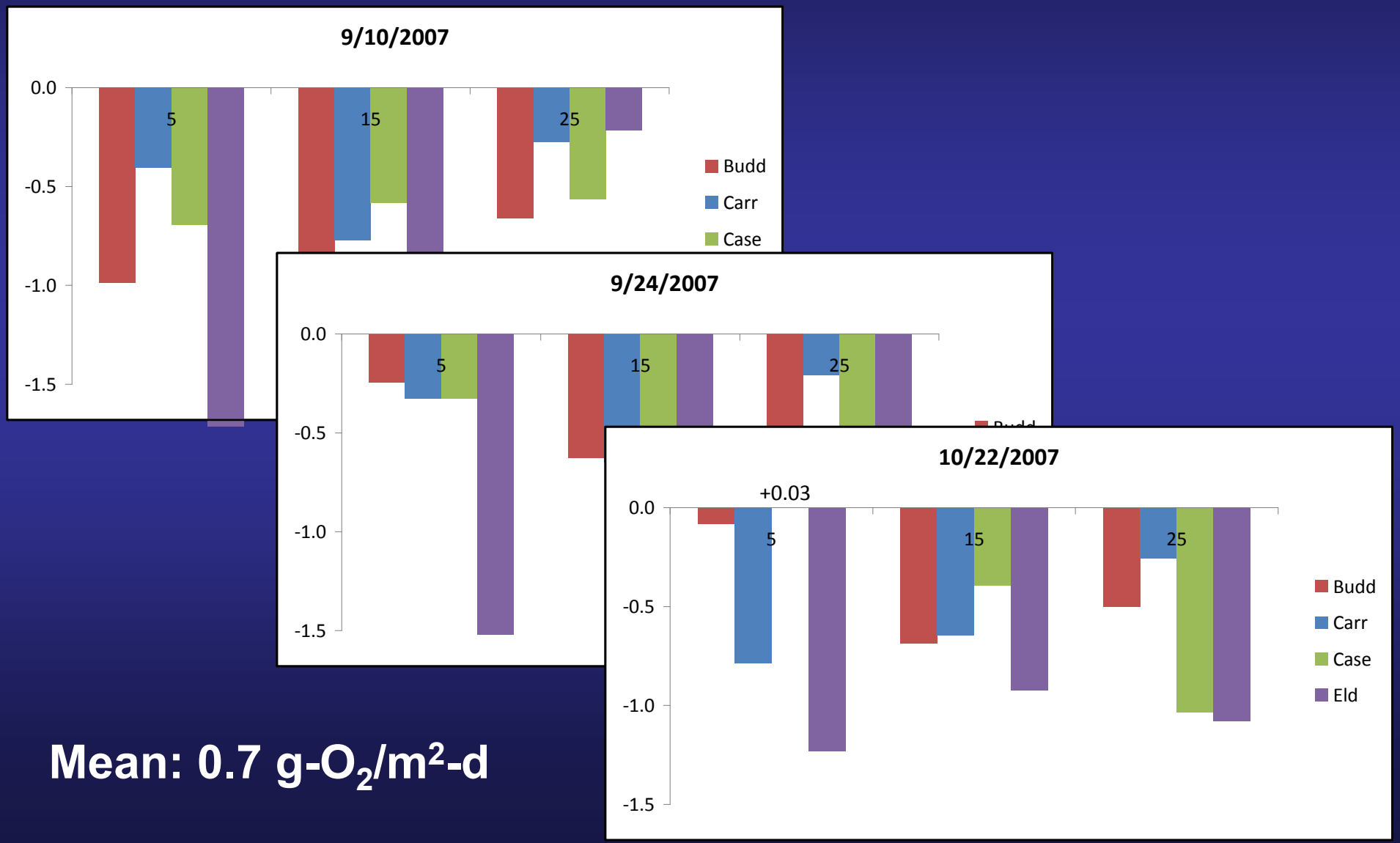


- Four inlets
- Three depths
- Three events
  - 9/10/07
  - 9/24/07
  - 10/22/07
- EPA $100k
  - Evans-Hamilton

Sediment flux locations

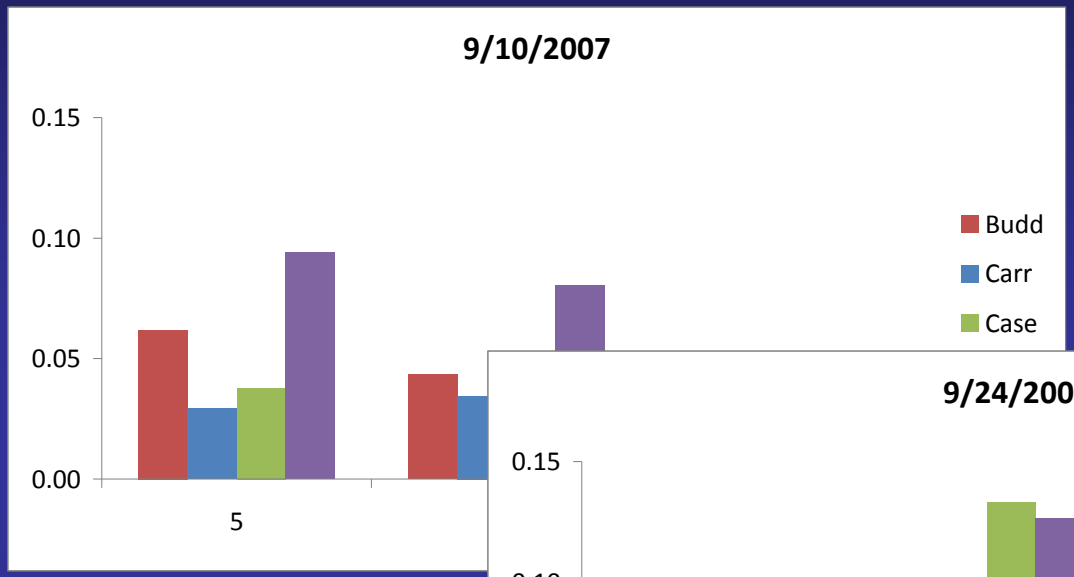


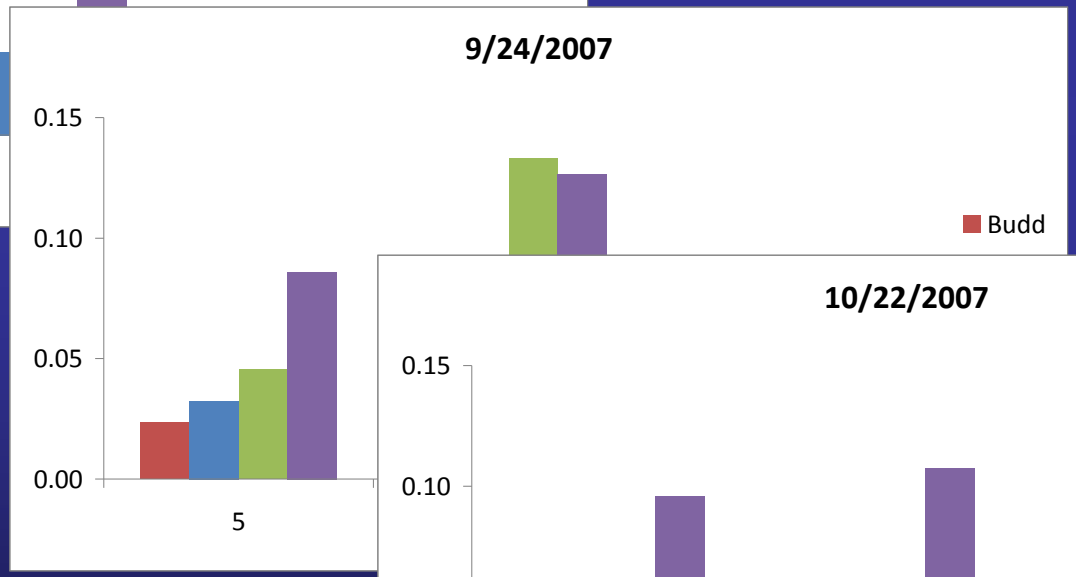
Sediment oxygen demand

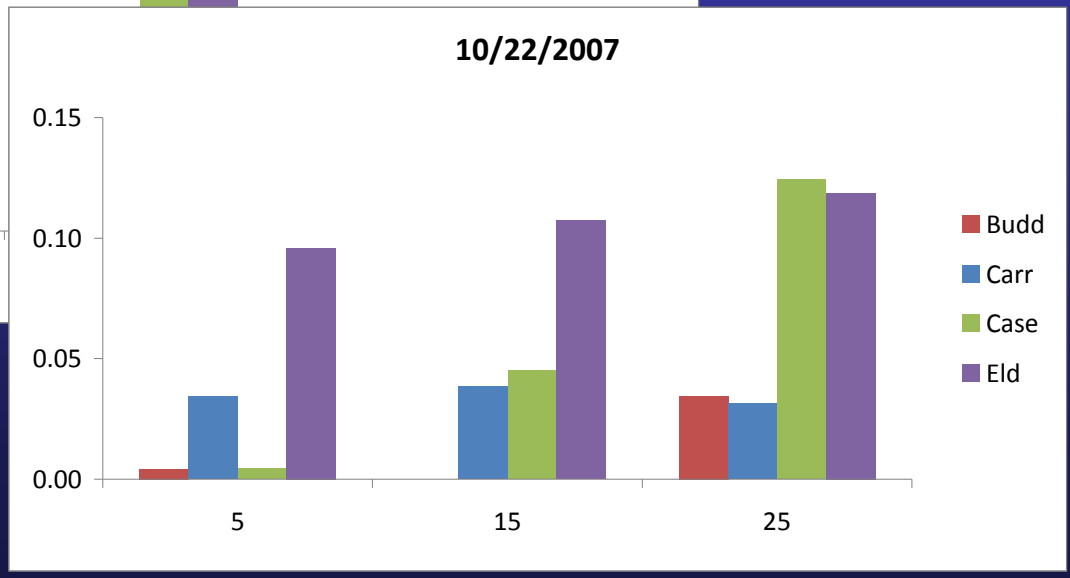


Mean: 0.7 g-O_2/m^2-d

Sediment DIN loads







Sediments = Reservoir

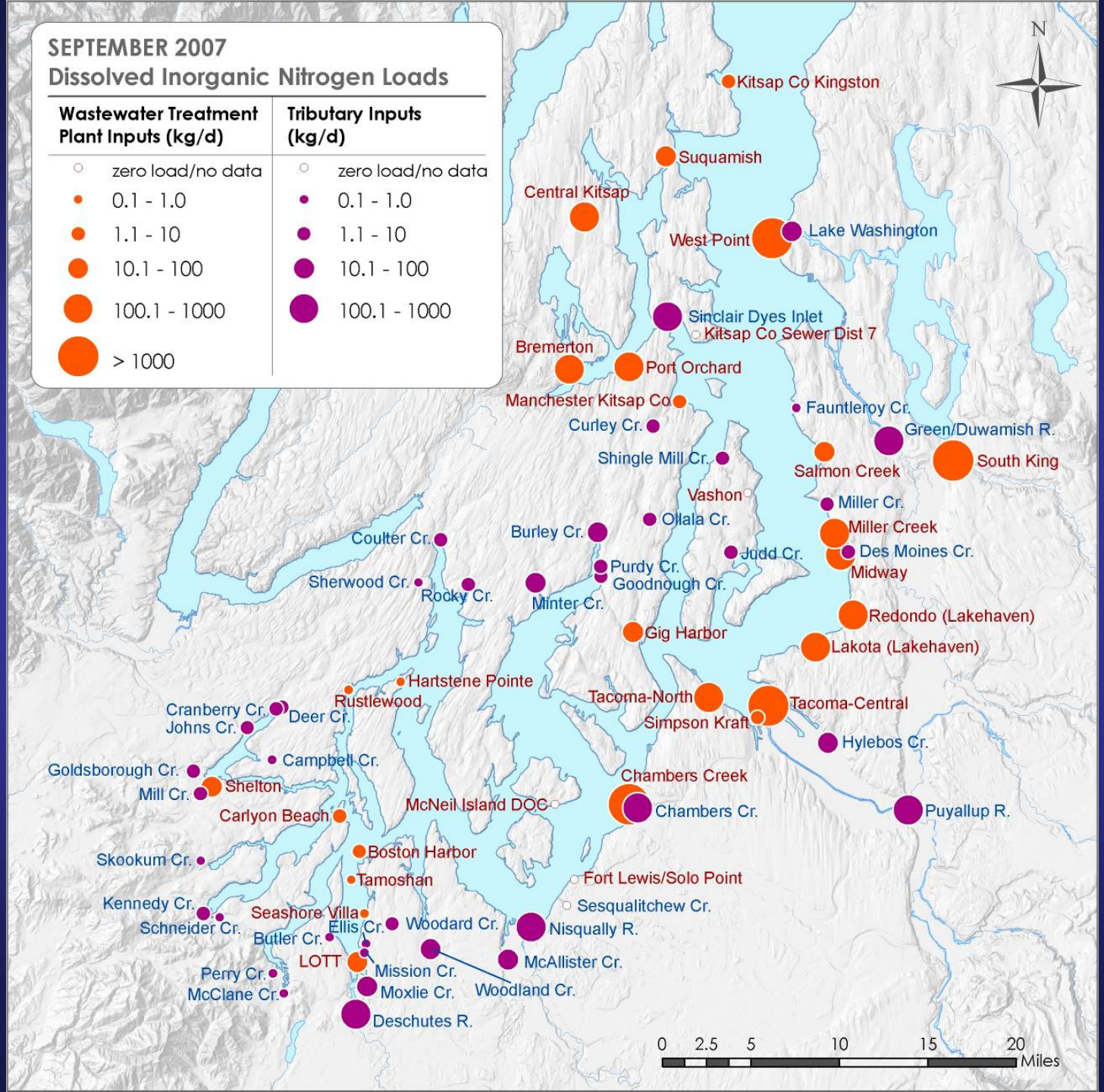
Mean: 0.052 g-N/m^2-d

Sediment DIN flux

- World Flux Database
  - Mean: 0.040 g-N/m^2-d (NH4)
- Chesapeake Bay
  - Mean: 0.064 g-N/m^2-d (DIN)
- Budd Inlet Scientific Study

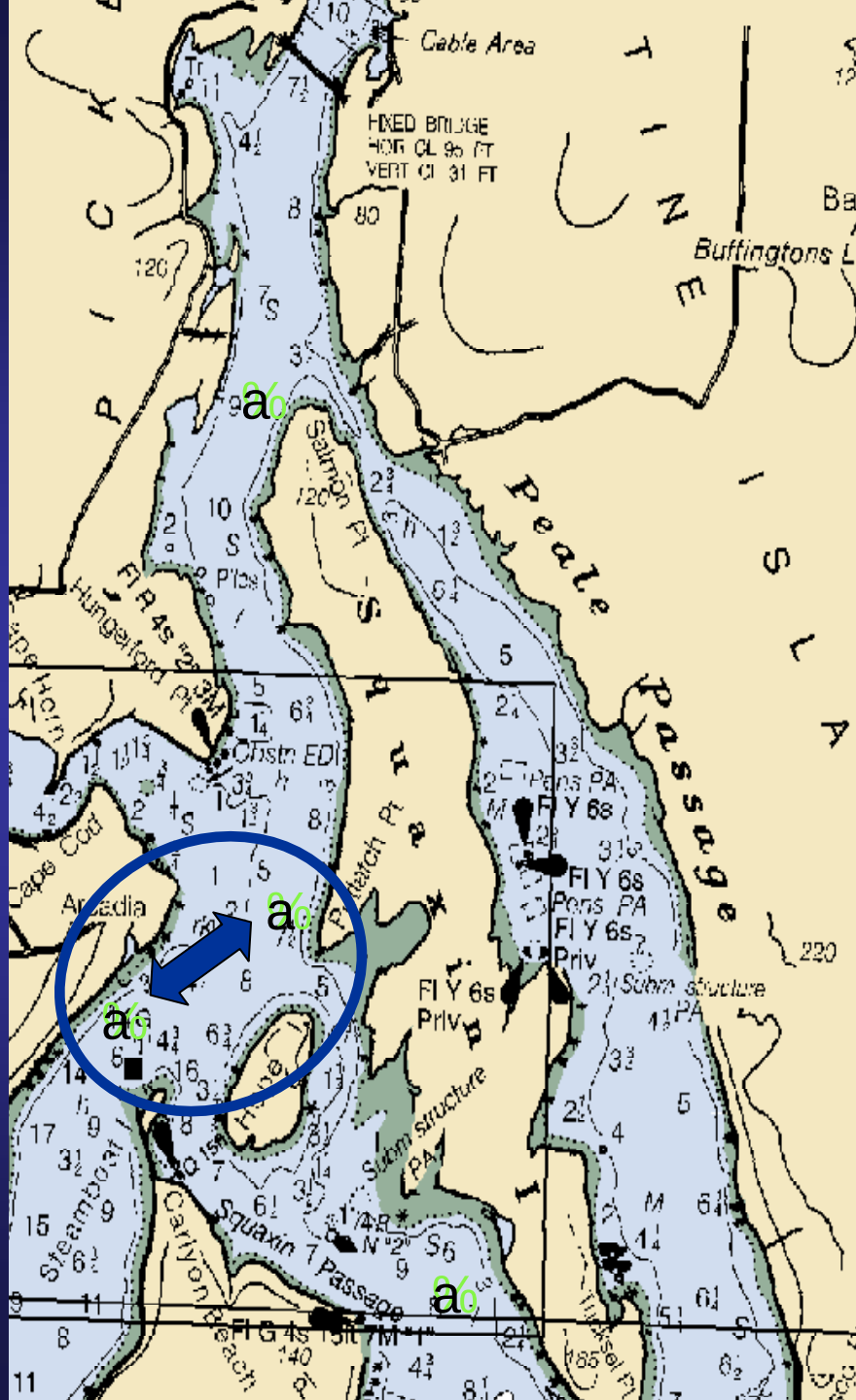
Sediment flux estimates

- Budd Inlet
  - 1998 Budd Inlet Scientific Study (annual and seasonal)
    - Annual: 326 metric tons-N/yr or 890 kg-N/d
    - Late summer: 2400 kg-N/d
  - Present study
    - Late summer: 1100 kg-N/d (Budd Inlet)
    - WWTPs: 2800 kg-N/d (South Sound)
    - Tribs: 2700 kg-N/d (South Sound)
  - *Sediments are an important nutrient reservoir*


SEPTEMBER 2007
Dissolved Inorganic Nitrogen Loads
Wastewater Treatment Plant Inputs (kg/d)
zero load/no data
0.1 - 1.0
1.1 - 10
10.1 - 100
100.1 - 1000
> 1000
Tributary Inputs (kg/d)
zero load/no data
0.1 - 1.0
1.1 - 10
10.1 - 100
100.1 - 1000
N
Kitsap Co Kingston
Suquamish
Central Kitsap
West Point
Lake Washington
Sinclair Dyes Inlet
Kitsap Co Sewer Dist 7
Bremerton
Port Orchard
Manchester Kitsap Co
Fauntleroy Cr.
Curley Cr.
Green/Duwamish R.
Shingle Mill Cr.
Salmon Creek
South King
Vashon
Miller Cr.
Ollala Cr.
Miller Creek
Burley Cr.
Coulter Cr.
Judd Cr.
Des Moines Cr.
Purdy Cr.
Midway
Sherwood Cr.
Goodnough Cr.
Rocky Cr.
Minter Cr.
Redondo (Lakehaven)
Gig Harbor
Lakota (Lakehaven)
Hartstene Pointe
Rustlewood
Tacoma-North
Tacoma-Central
Cranberry Cr.
Deer Cr.
Johns Cr.
Simpson Kraft
Hylebos Cr.
Campbell Cr.
Goldsborough Cr.
Shelton
Mill Cr.
Chambers Creek
McNeil Island DOC
Chambers Cr.
Puyallup R.
Carlyon Beach
Boston Harbor
Skookum Cr.
Tamoshan
Fort Lewis/Solo Point
Sesqualitchew Cr.
Kennedy Cr.
Seashore Villa
Schneider Cr.
Ellis Cr.
Woodard Cr.
Nisqually R.
Butler Cr.
LOTT
McAllister Cr.
Mission Cr.
Perry Cr.
Woodland Cr.
McClane Cr.
Moxlie Cr.
Deschutes R.
0 2.5 5 10 15 20
Miles

Hope Island patterns

- Missing ADCP in Squaxin Passage
- **Ask around**
- Data summary in report



Marine modeling status

- Finalized grid
- Compiled input time series Jun06-Oct07
  - Meteorology
  - River inputs (flow)
  - Boundary conditions
- Compiled output data for comparison
- Model runs spring

Hydrodynamic model tasks

- Calibration
- Validation/confirmation/verification/checking/ comparison
- Boundary condition
  - Sensitivity
  - Particle tracking experiments
  - Recommend boundary location for water quality model development

Upcoming Dates

• Data report	Apr08
• Hydrodynamic report	Spr08
• Water quality modeling	2008-09
• Technical report development	2009

Questions?

www.ecy.wa.gov/puget_sound/dissolved_oxygen_study.html

mrob461@ecy.wa.gov

South Puget Sound Dissolved Oxygen Study

Technical Advisory Committee

March 17, 2008

Julia Bos

360-407-6674

jbos461@ecy.wa.gov

www.ecy.wa.gov/puget_sound/dissolved_oxygen_study.html

Field & Lab Data Collection

- 16 Central Sound Boundary Station "Liberty" cruises (July 06 – Oct 07)
- 10 condensed South Sound "Skookum" cruises (Aug 06 – Oct 07)
- 6 intensive Quarterly South Sound "Barnes" cruises

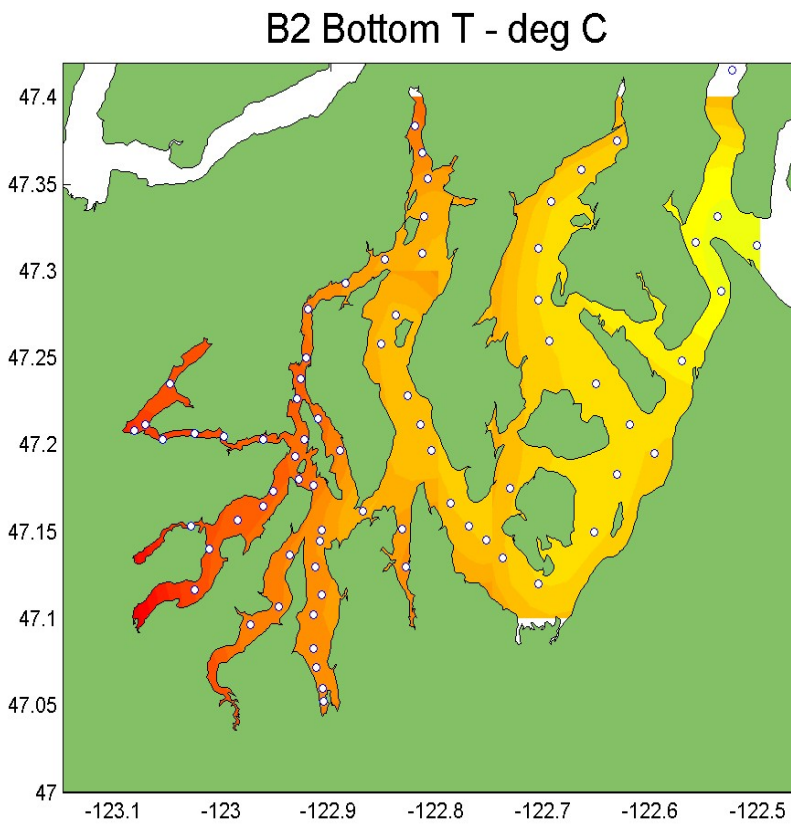
Cruise Type	Number of Stations	Number of Cruises (Events)	Average # of Depths Sampled for Discrete Samples	Average # of CTD Casts Per Cruise	Total Count of *Final* CTD Scans	Total Count of Discrete Samples	Total # of Measure-ments
Barnes	80	6	200	82	1286149	6638	1292787
PRISM	13	3	91	13	UW data	1404	1404
Skookum	41	10	30	42	426787	2350	429137
Liberty	5	16	40	5	285494	5360	290854
Total Data Points:					***1998430***	***15752***	***2014182***

	Max Chla		Max DIN		Max NH4		Max TN		Max TP		Min Bottom DO		Max Stratifi-cation		Max Bottom Temp	
Location	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Edmonds	=			X	X			X		X	X			E/W	x	
Alki	=			X	X			X		X	X			x	x	
Tacoma Narrows	=			=	X			X		X	x		X		x	
Nisqually		X	X		=			X		X	=			=	x	
Carr		X	=		X			X		=	=		X		x	
North Carr		nd	X		X			X		=	x			=	x	
Case		X	X		X(z)			X		X	x			=	x	
North Case		X	X		X			X		=	x			=	x	
Dana/ Henderson		X		X		=		X		X	x			=	x	
Budd	*	*		X		X		X		=*	x			X	x	
Eld		X		X		X		X		X		x		=	x	
Totten		X		X		X		X		X		x		=	x	
Hammersley/ Oakland		=	X			X		X		X		x		=	x	
Pickering		X	X		X			X		X		=		=	x	

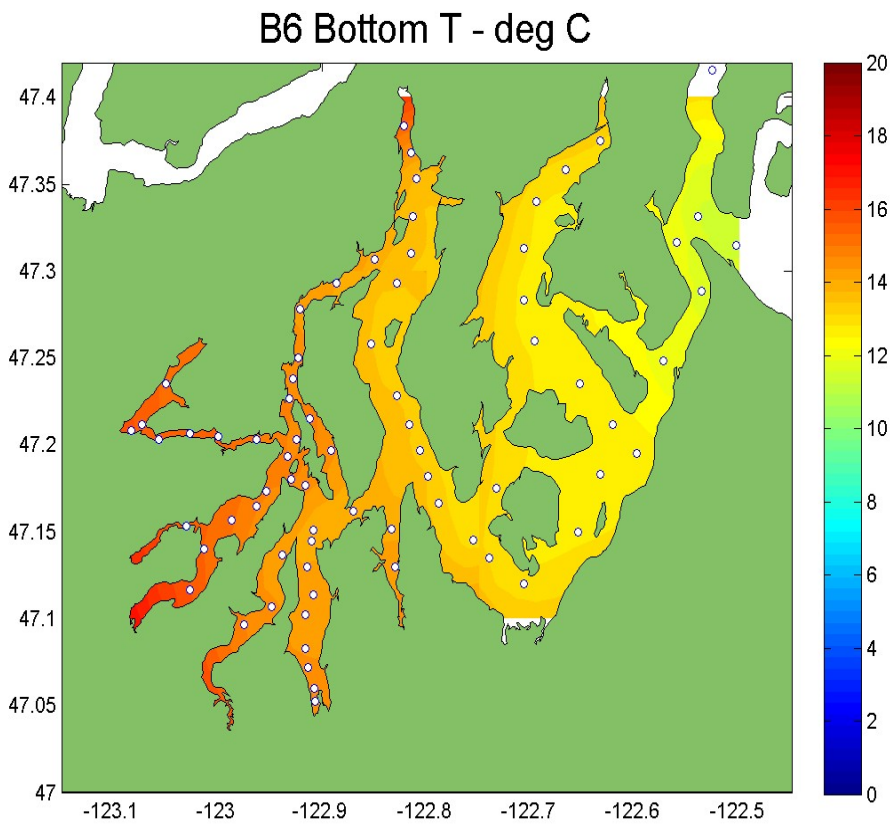
	Max Chla		Max DIN		Max NH4		Max TN		Max TP		Min Bottom DO		Max Stratifi-cation		Max Bottom Temp	
Location	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Edmonds	=			X	X			X		X	X			E/W	x	
Alki	=			X	X			X		X	X			x	x	
Tacoma Narrows	=			=	X			X		X	x		X		x	
Nisqually		X	X		=			X		X	=			=	x	
Carr		X	=		X			X		=	=		X		x	
North Carr		nd	X		X			X		=	x			=	x	
Case		X	X		X(z)			X		X	x			=	x	
North Case		X	X		X			X		=	x			=	x	
Dana/ Henderson		X		X		=		X		X	x			=	x	
Budd	*	*		X		X		X		=*	x			X	x	
Eld		X		X		X		X		X		x		=	x	
Totten		X		X		X		X		X		x		=	x	
Hammersley/ Oakland		=	X			X		X		X		x		=	x	
Pickering		X	X		X			X		X		=		=	x	

Sept. Bottom Temperature

2006



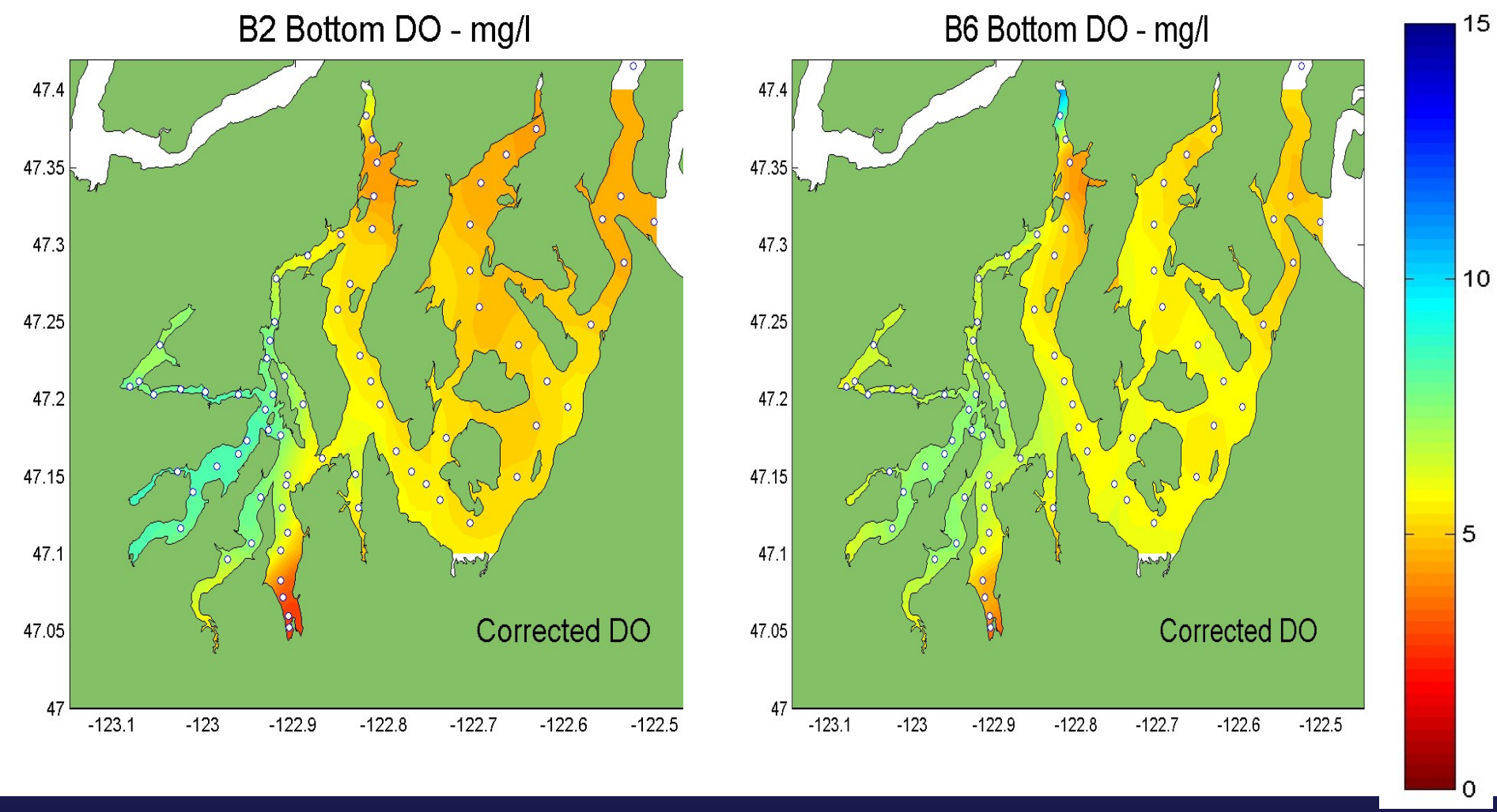
2007



Albertson 2008

Sept. Bottom Oxygen

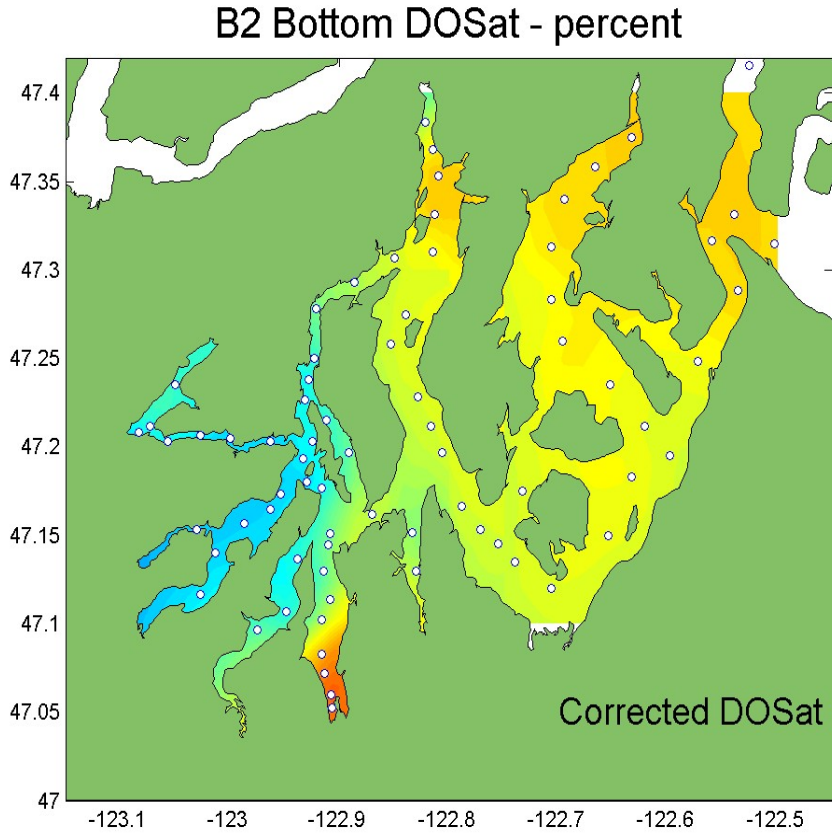
2006 **2007**

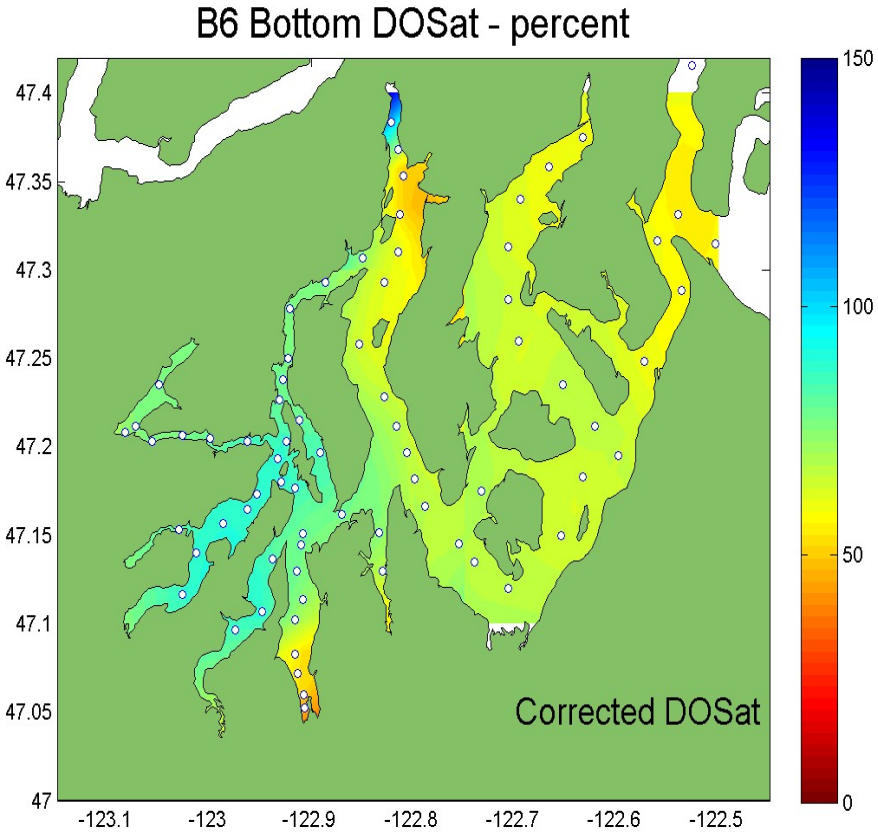


Albertson, Bos 2007

Sept. Bottom DO Saturation (%)

2006 **2007**

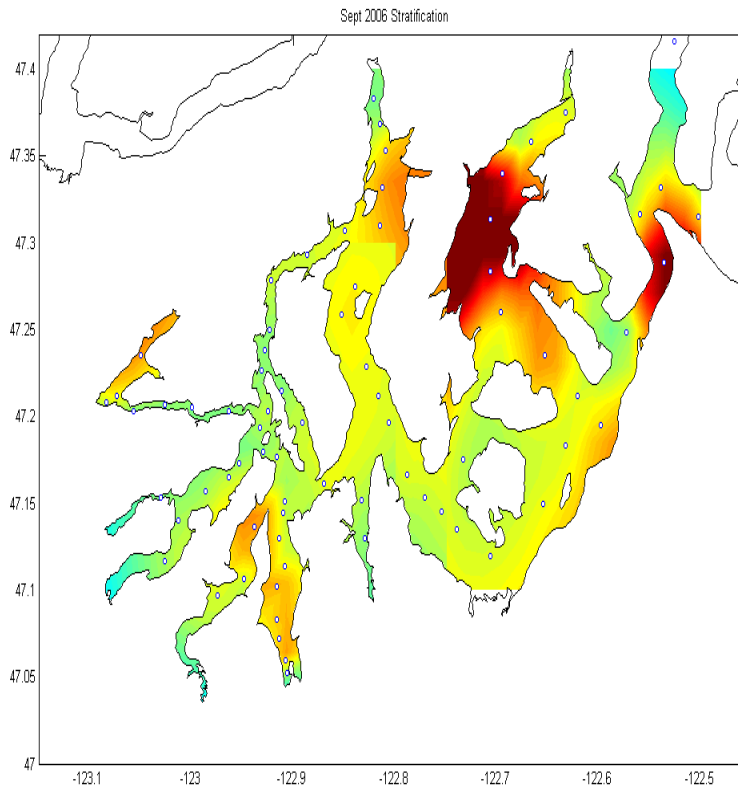


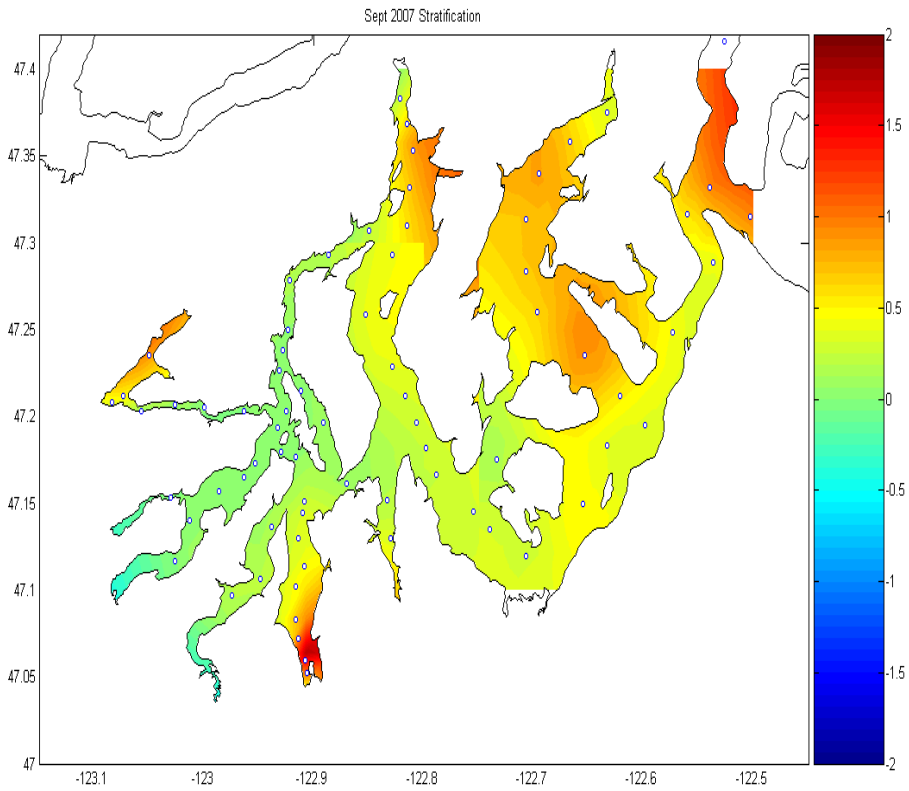


Albertson 2008

Sept. Stratification

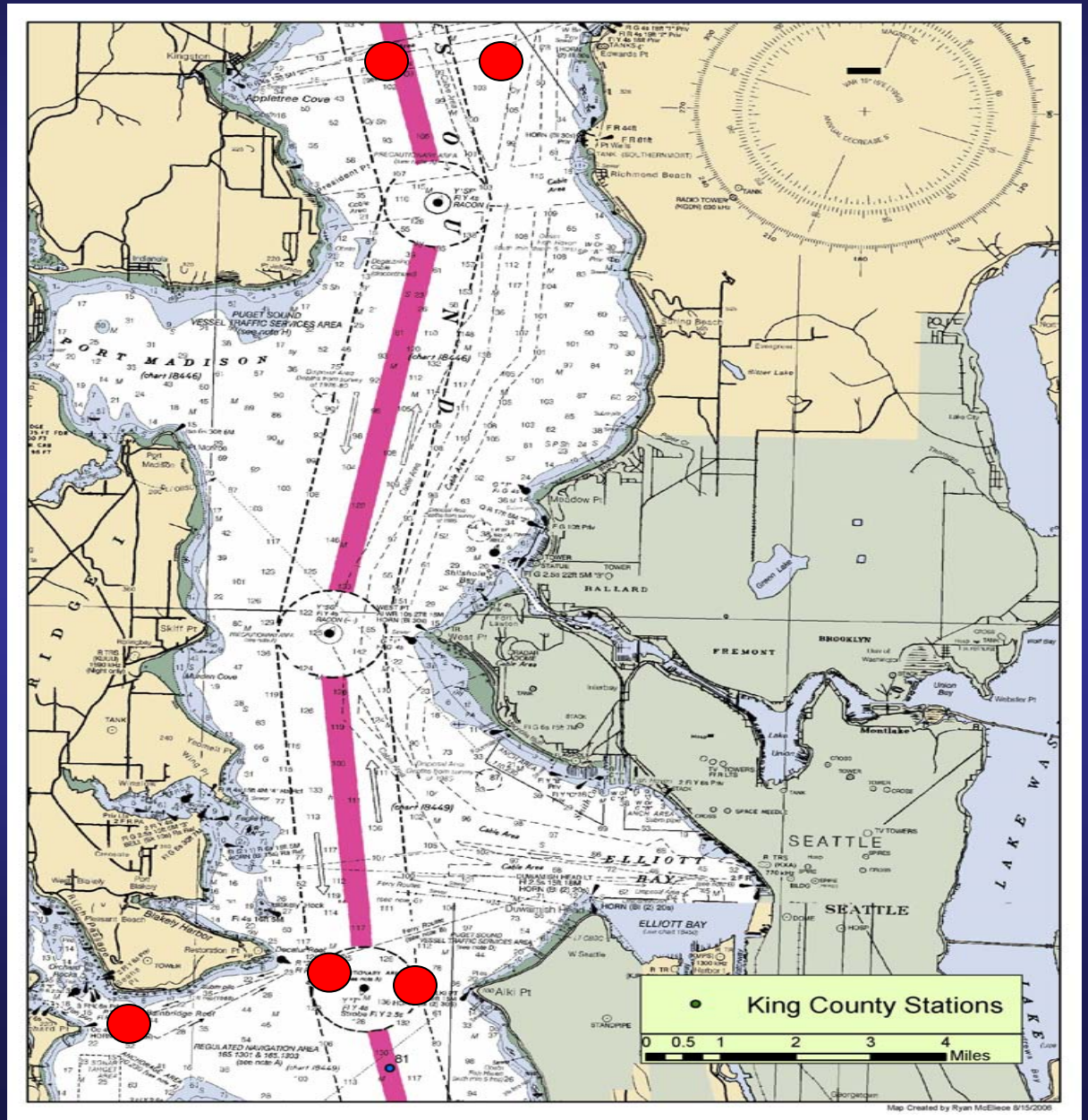
2006 **2007**

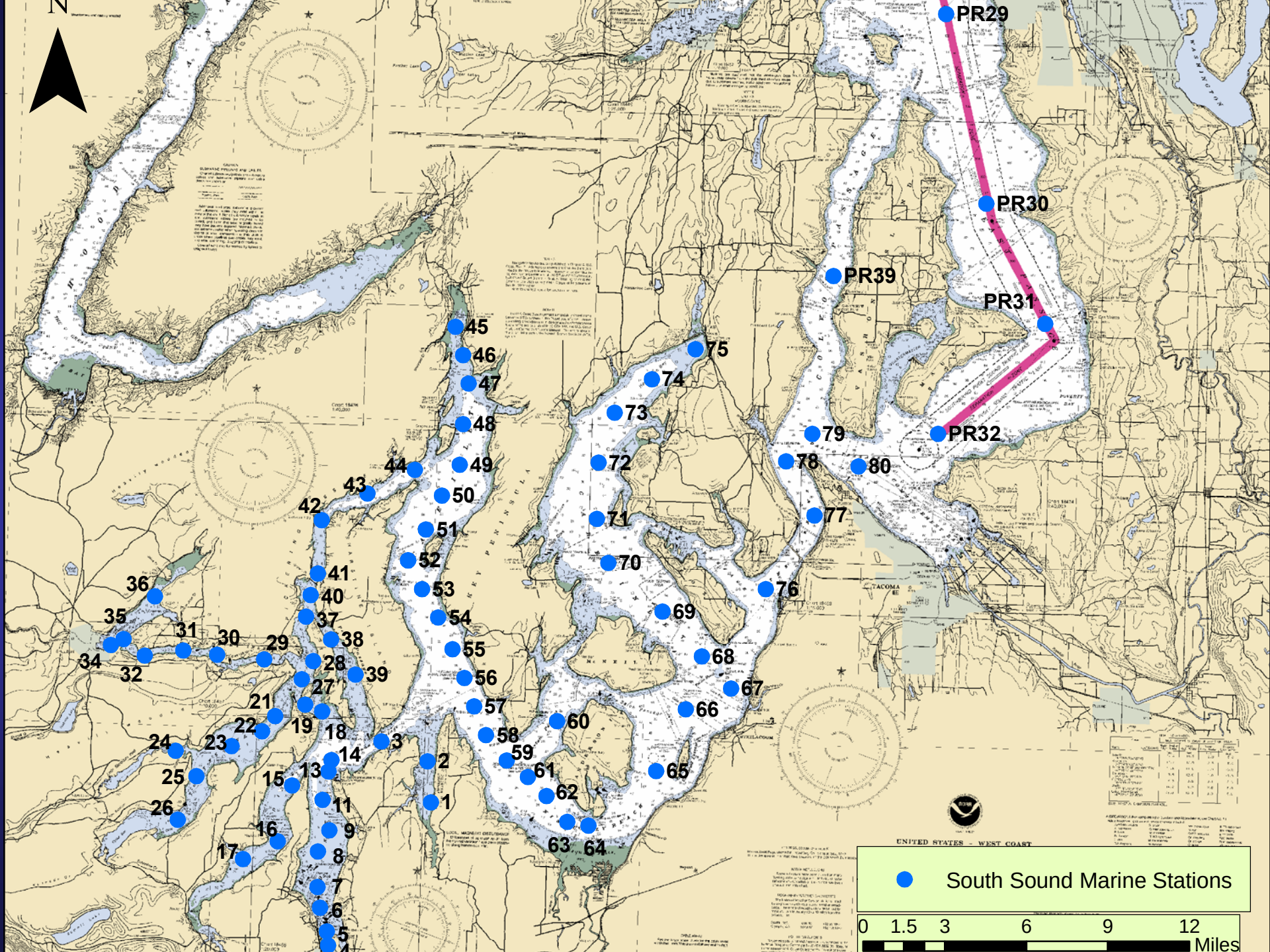




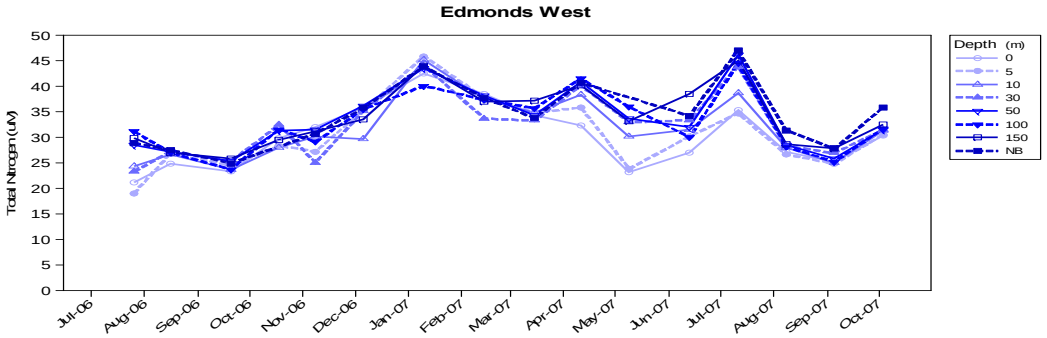
Bos 2008

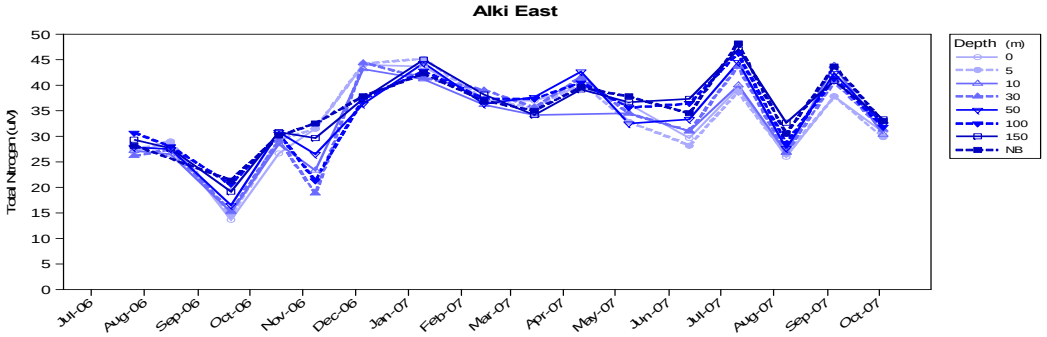
Central Basin Boundary Stations

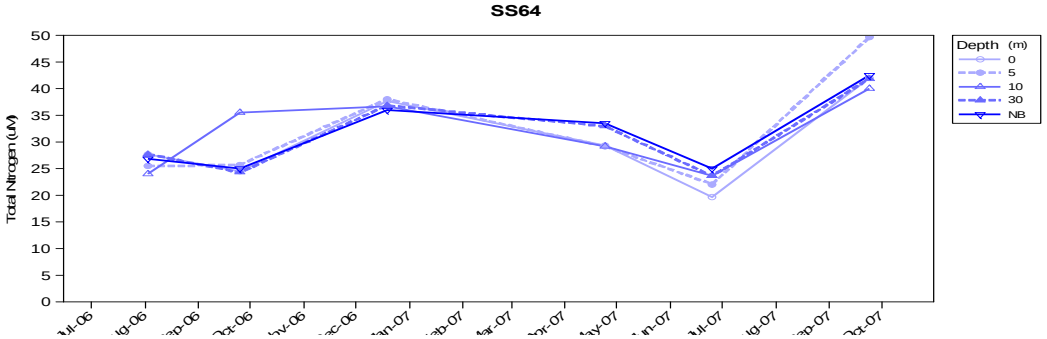


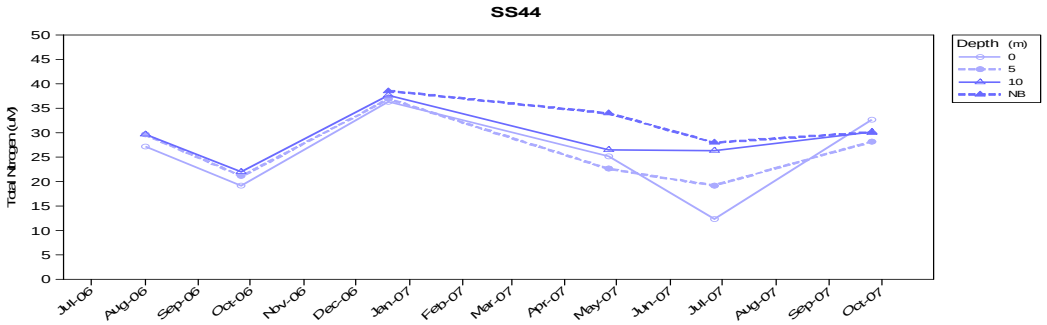

N
PR29
PR30
PR31
PR32
PR39
South Sound Marine Stations
0 1.5 3 6 9 12
Miles
UNITED STATES - WEST COAST

	Max TN	
Location	**2006**	**2007**
Edmonds		**x**
Alki		**x**
Tacoma Narrows		**x**
Nisqually		**x**
Carr		**x**
North Carr		**x**
Case		**x**
North Case		**x**
Dana/ Henderson		**x**
Budd		**x**
Eld		**x**
Totten		**x**
Hammersley/ Oakland		**x**
Pickering		**x**

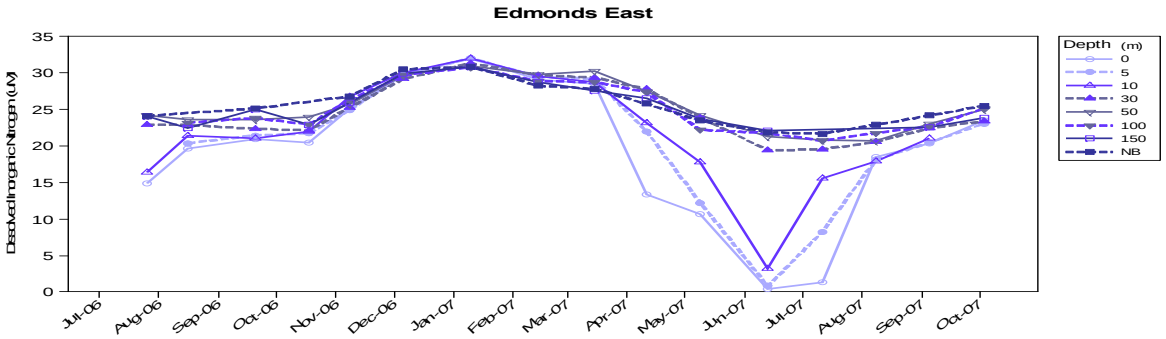


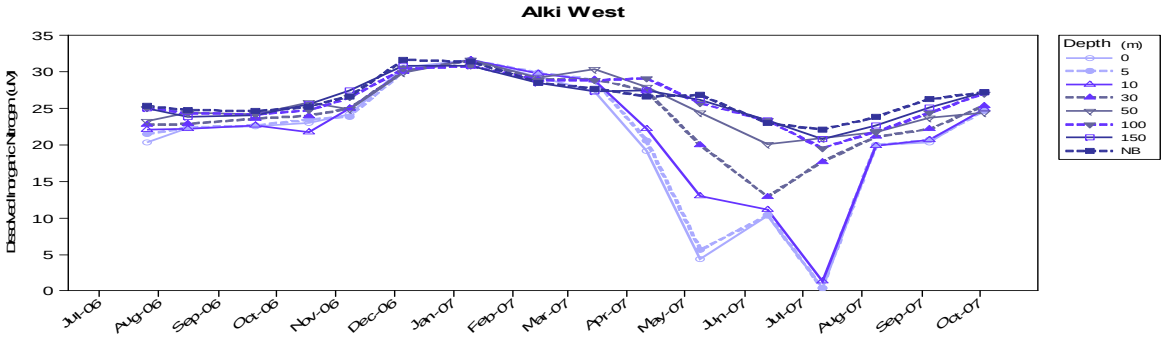


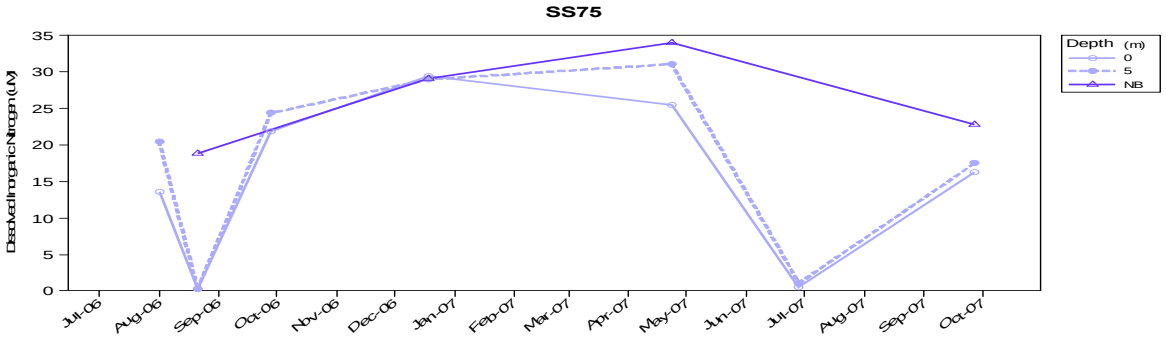


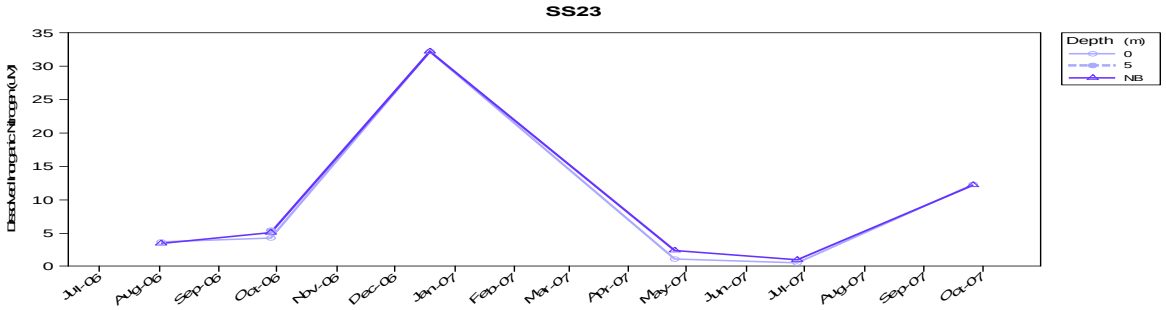


	Max DIN	
Location	2006	2007
Edmonds		x
Alki		x
Tacoma Narrows		=
Nisqually	x	
Carr	=	
North Carr	x	
Case	x	
North Case	x	
Dana/ Henderson		x
Budd		x
Eld		x
Totten		x
Hammersley/ Oakland	x	
Pickering	x	

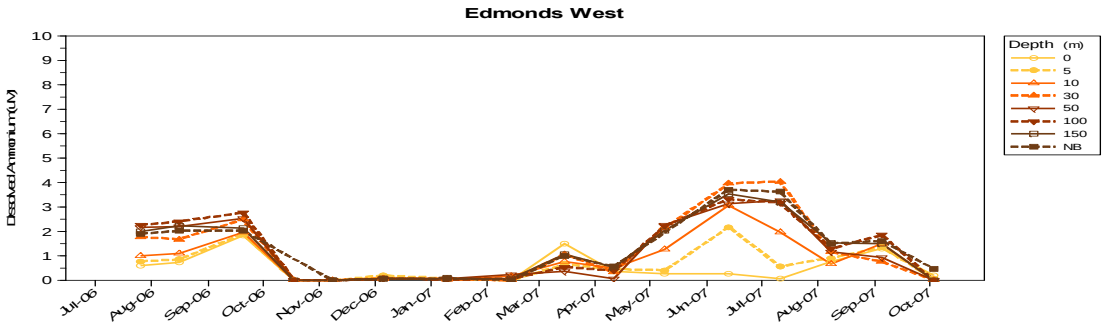


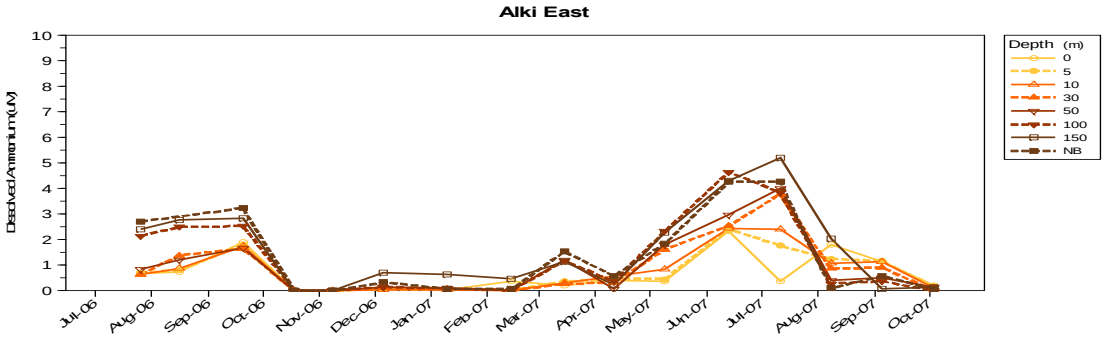


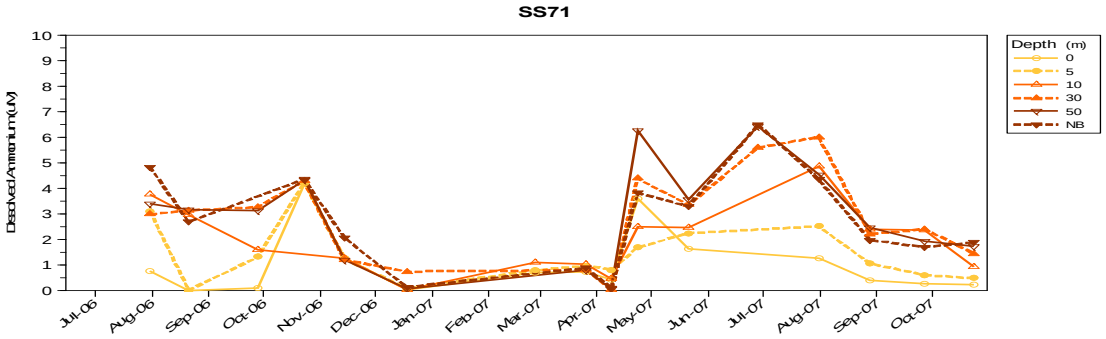


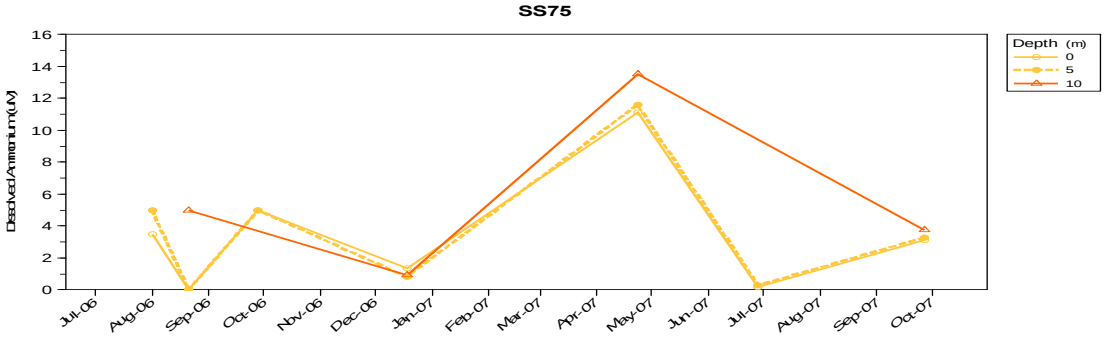


	Max NH4	
Location	2006	2007
Edmonds	X	
Alki	X	
Tacoma Narrows	X	
Nisqually	=	
Carr	=(z)	
North Carr	X	
Case	=(z)	
North Case	X	
Dana/ Henderson		=
Budd		X
Eld		X
Totten		X
Hammersley/ Oakland		X
Pickering	X	

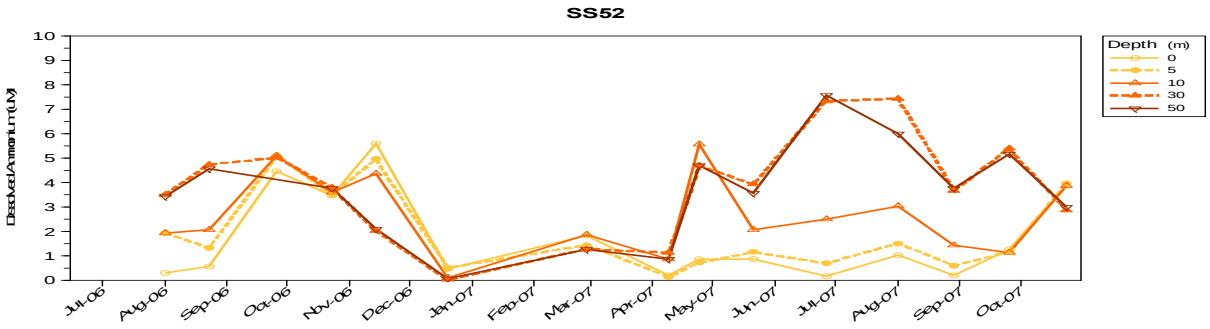


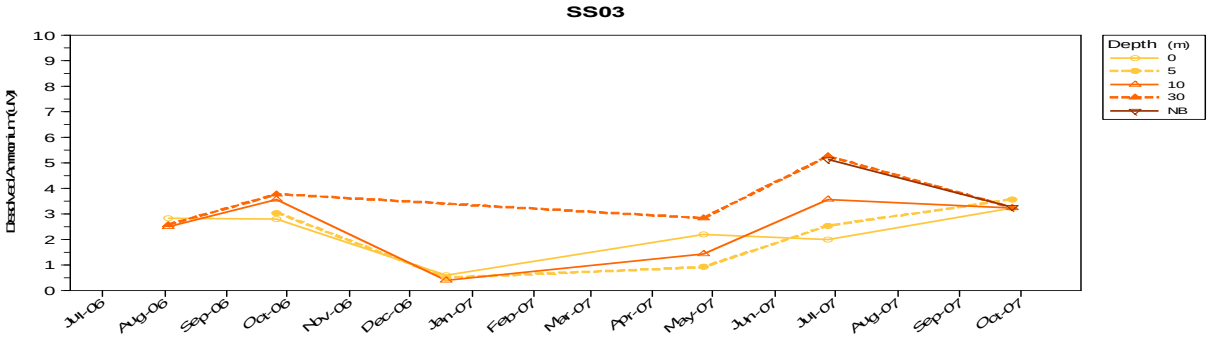


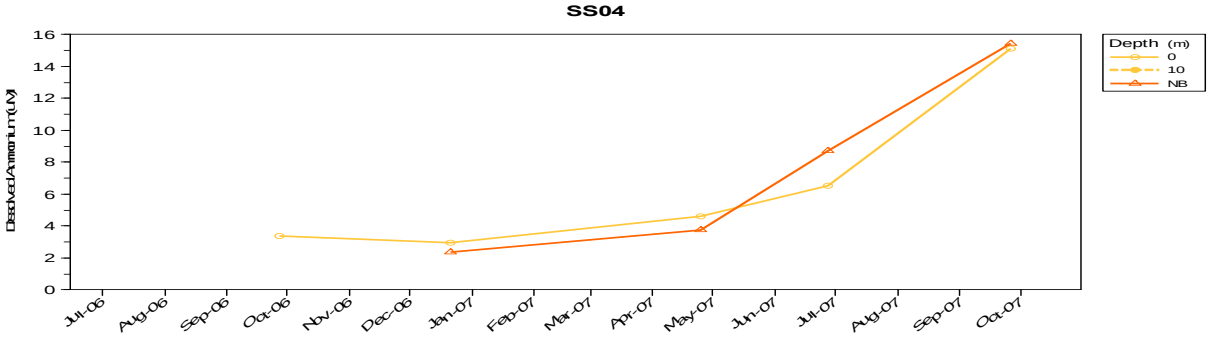


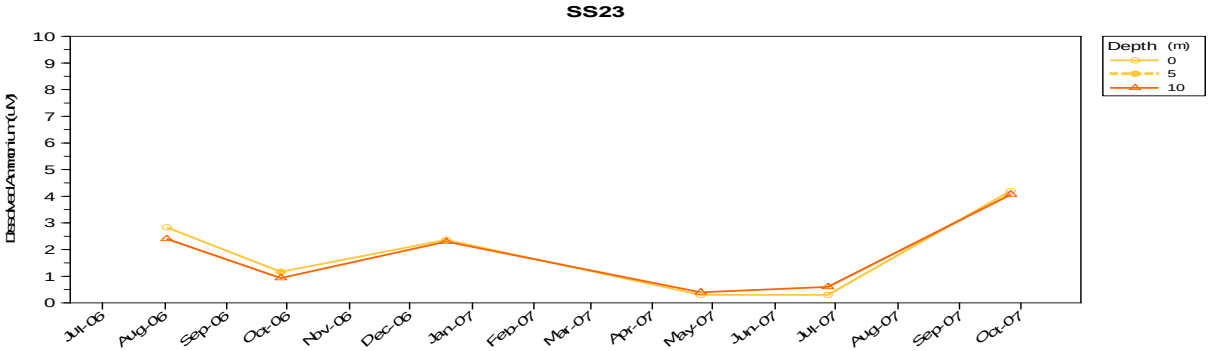


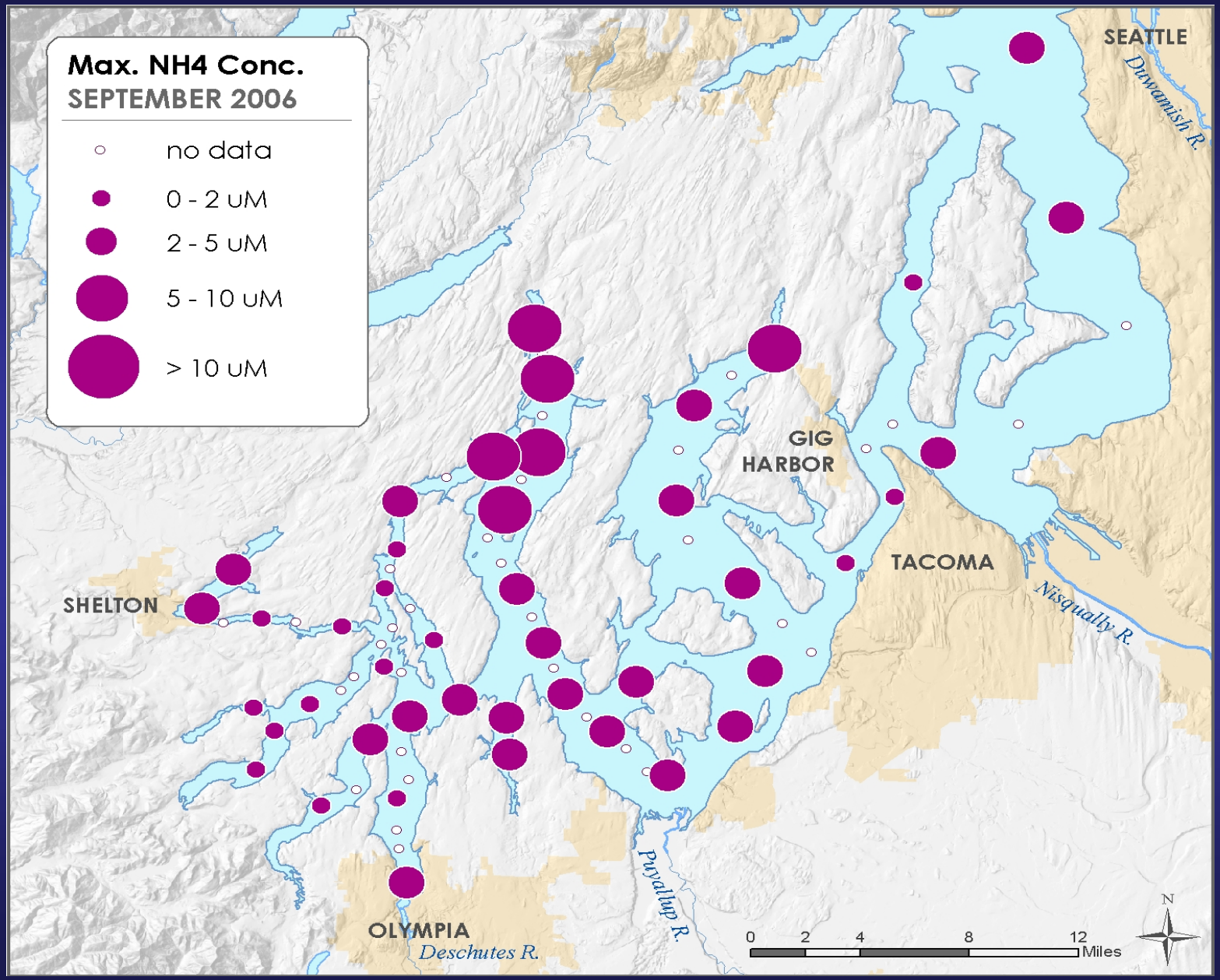
	Max NH4	
Location	2006	2007
Edmonds	X	
Alki	X	
Tacoma Narrows	X	
Nisqually	=	
Carr	=(z)	
North Carr	X	
Case	=(z)	
North Case	X	
Dana/ Henderson		=
Budd		X
Eld		X
Totten		X
Hammersley/ Oakland		X
Pickering	X	

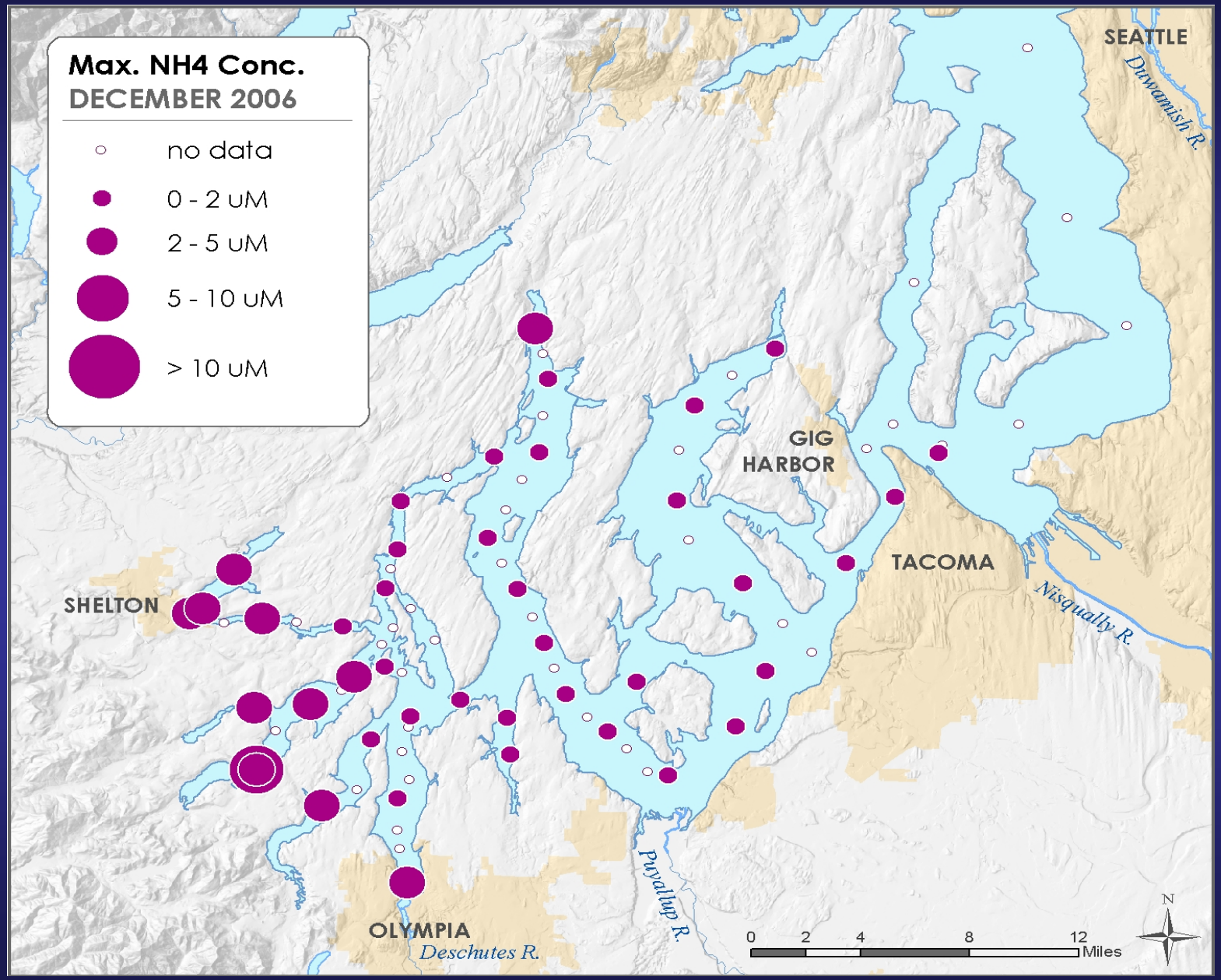


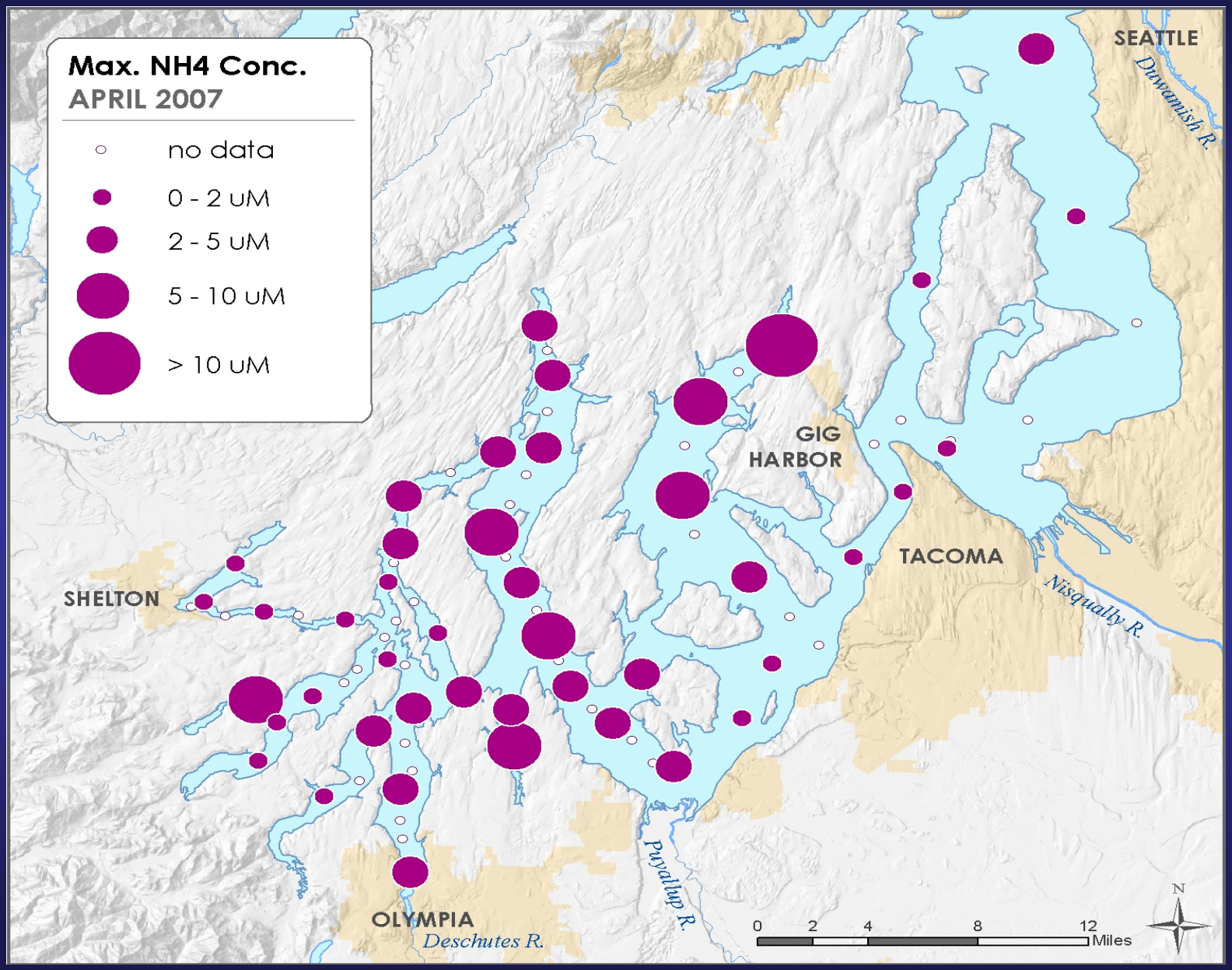


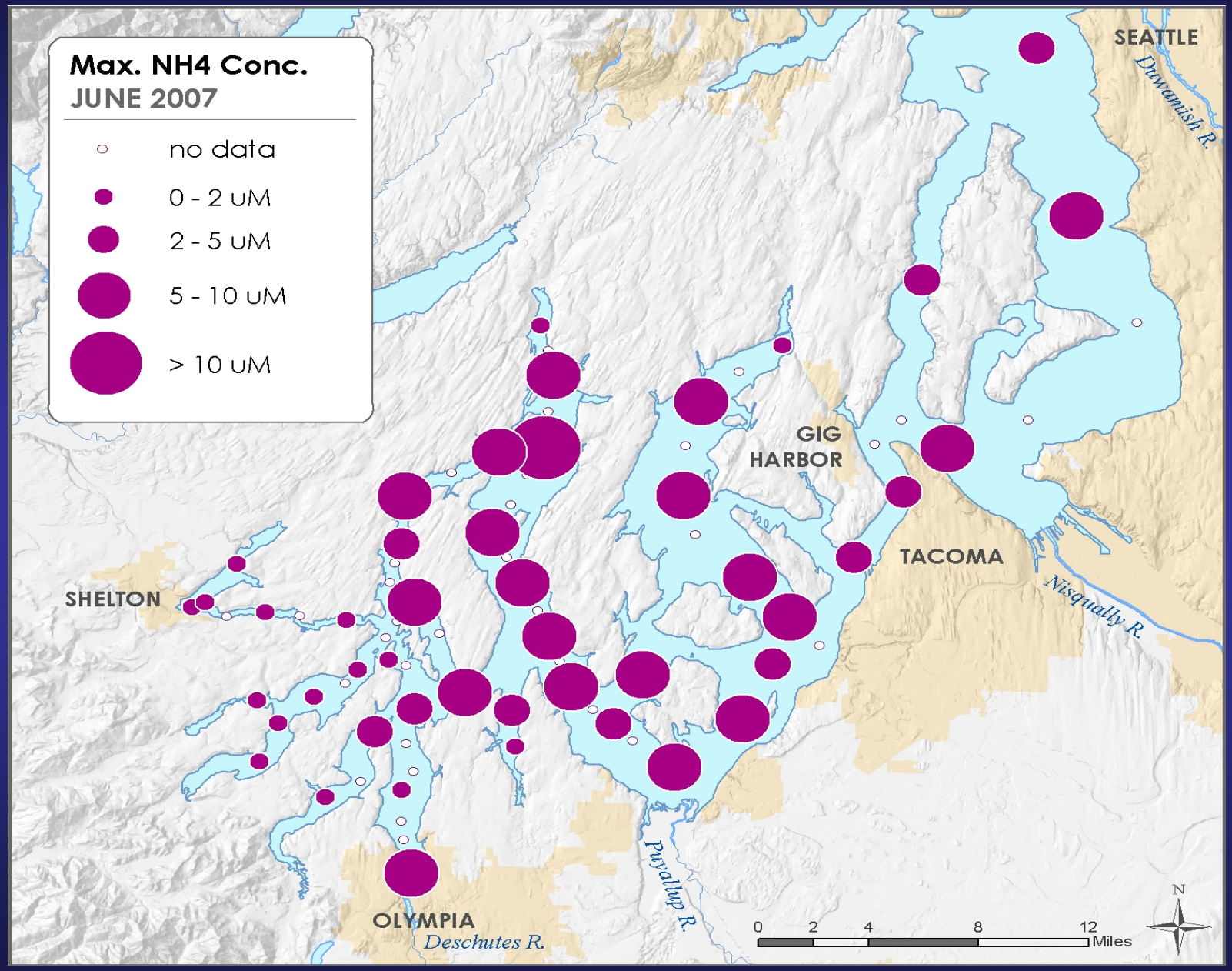


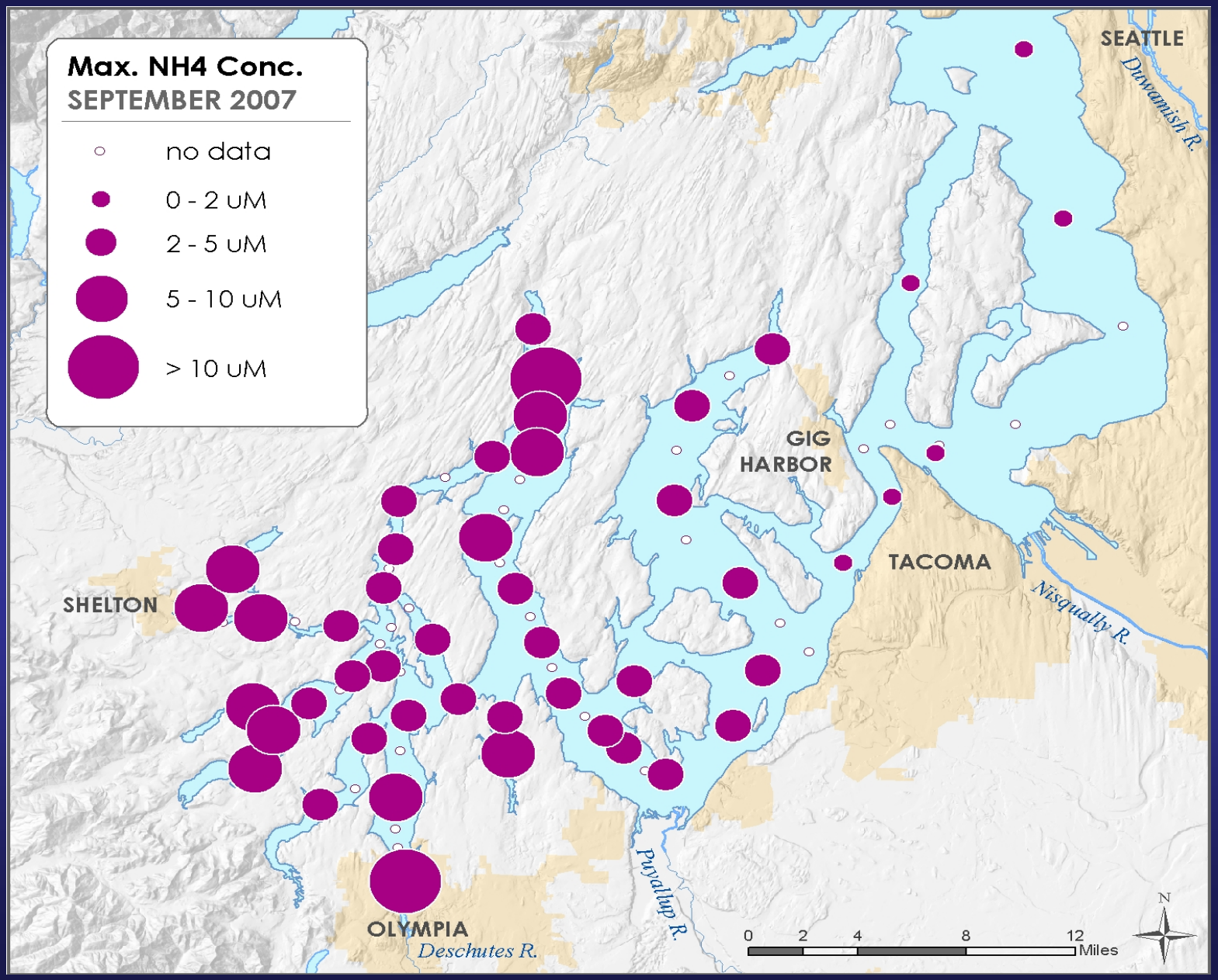



Max. NH4 Conc.
SEPTEMBER 2006
no data
0 - 2 uM
2 - 5 uM
5 - 10 uM
> 10 uM
SEATTLE
Duwamish R.
GIG HARBOR
TACOMA
Nisqually R.
SHELTON
Puyallup R.
OLYMPIA
Deschutes R.
0 2 4 8 12 Miles
N


Max. NH4 Conc.
DECEMBER 2006
no data
0 - 2 uM
2 - 5 uM
5 - 10 uM
> 10 uM
SEATTLE
Duwamish R.
GIG HARBOR
TACOMA
Nisqually R.
SHELTON
Puyallup R.
OLYMPIA
Deschutes R.
0 2 4 8 12
Miles
N

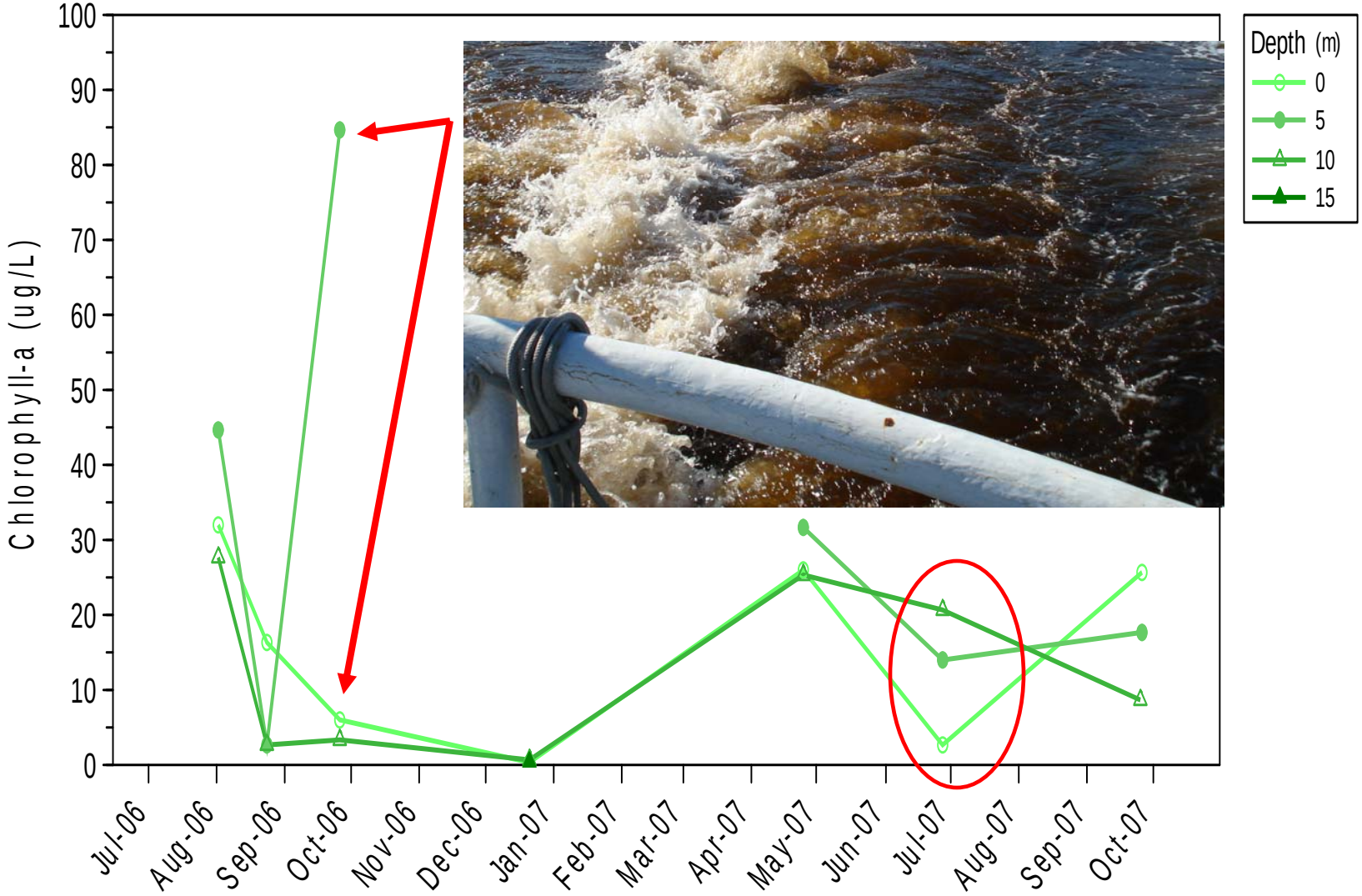

Max. NH4 Conc.
APRIL 2007
no data
0 - 2 uM
2 - 5 uM
5 - 10 uM
> 10 uM
SEATTLE
Duwamish R.
GIG HARBOR
TACOMA
Nisqually R.
SHELTON
Puyallup R.
OLYMPIA
Deschutes R.
0 2 4 8 12
Miles
N

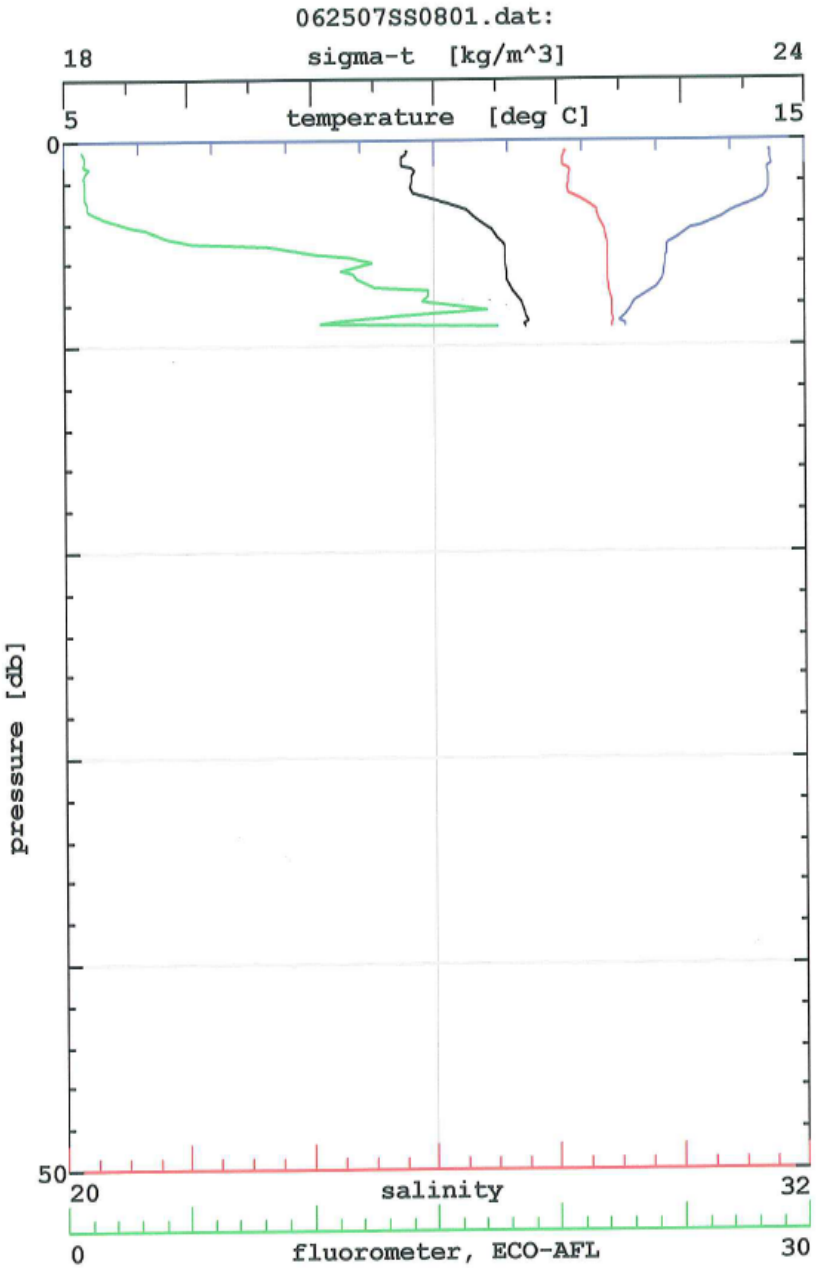

Max. NH4 Conc.
JUNE 2007
no data
0 - 2 uM
2 - 5 uM
5 - 10 uM
> 10 uM
SEATTLE
Duwamish R.
GIG HARBOR
TACOMA
Nisqually R.
SHELTON
Puyallup R.
OLYMPIA
Deschutes R.
0 2 4 8 12 Miles
N

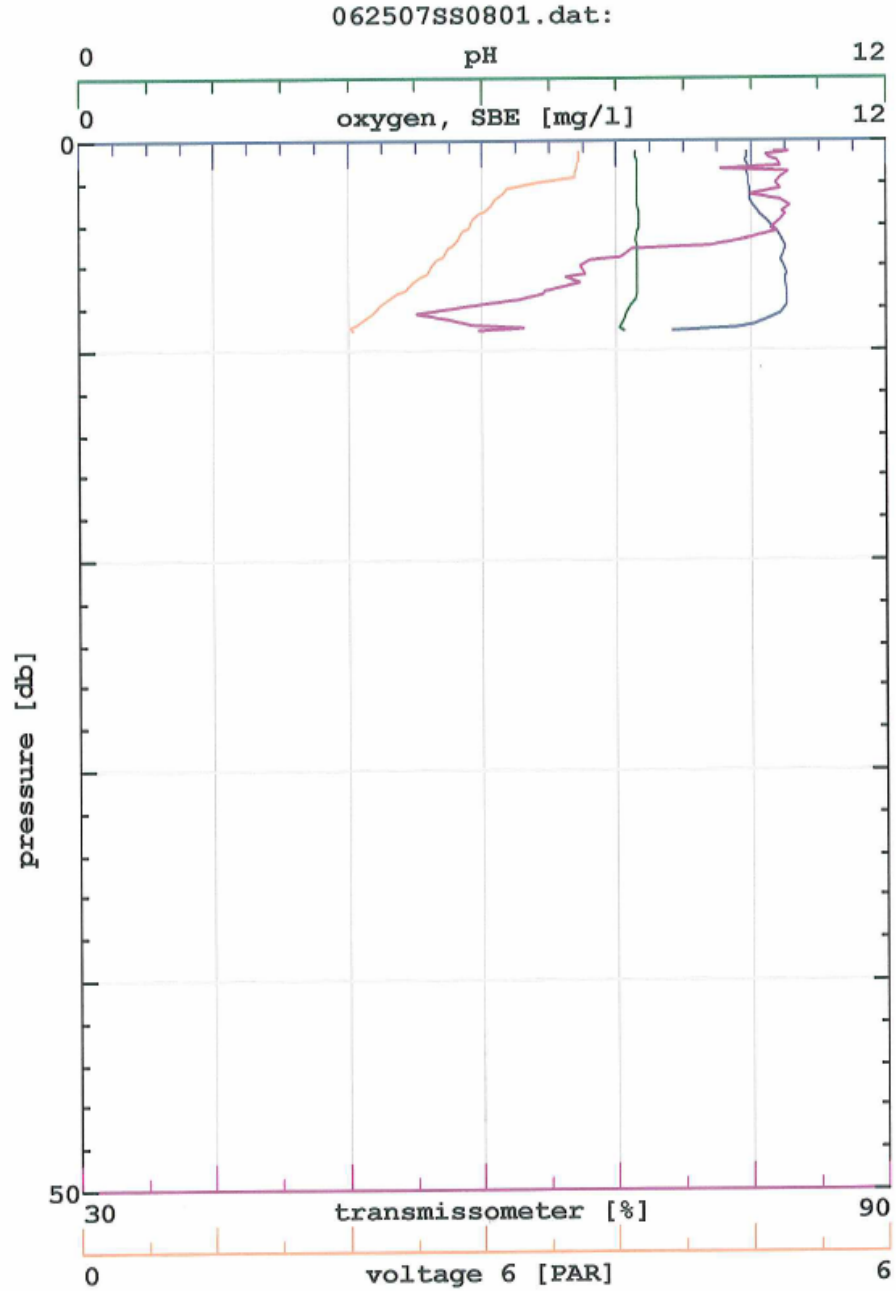

Max. NH4 Conc.
SEPTEMBER 2007
no data
0 - 2 uM
2 - 5 uM
5 - 10 uM
> 10 uM
SEATTLE
Duwamish R.
GIG HARBOR
TACOMA
Nisqually R.
SHELTON
OLYMPIA
Deschutes R.
Puyallup R.
0 2 4 8 12 Miles
N

Location	Max Chla 2006	2007		
Edmonds	=			
Alki	=			
Tacoma Narrows	=			
Nisqually		X		
Carr		X		
North Carr		nd		
Case		X		
North Case		X		
Dana/ Henderson		X		
Budd	*	*		
Eld		X		
Totten		X		
Hammersley/ Oakland		=		
Pickering		X		

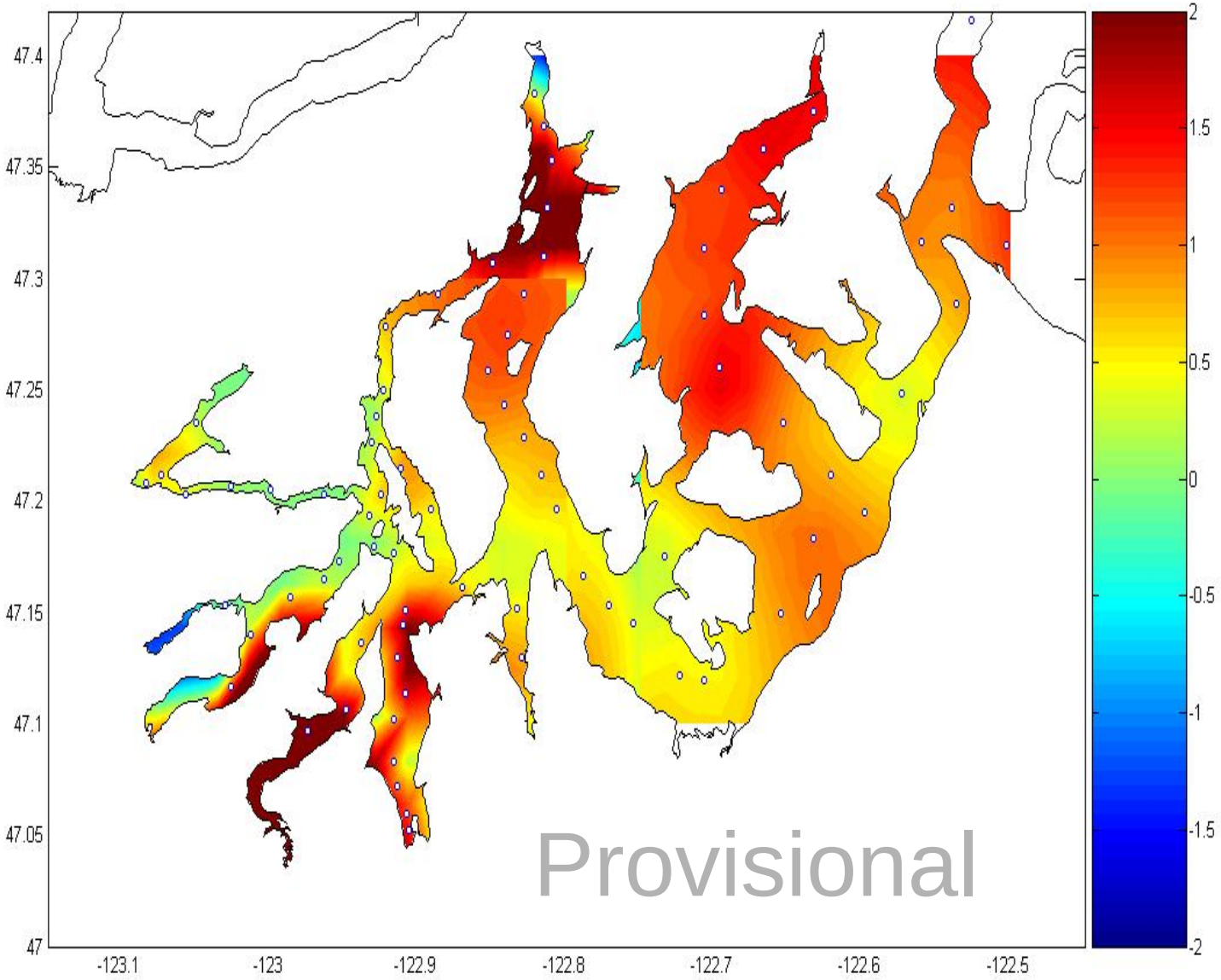
Budd Chla


Chlorophyll-a (ug/L)
100
90
80
70
60
50
40
30
20
10
0
Jul-06
Aug-06
Sep-06
Oct-06
Nov-06
Dec-06
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Depth (m)
0
5
10
15

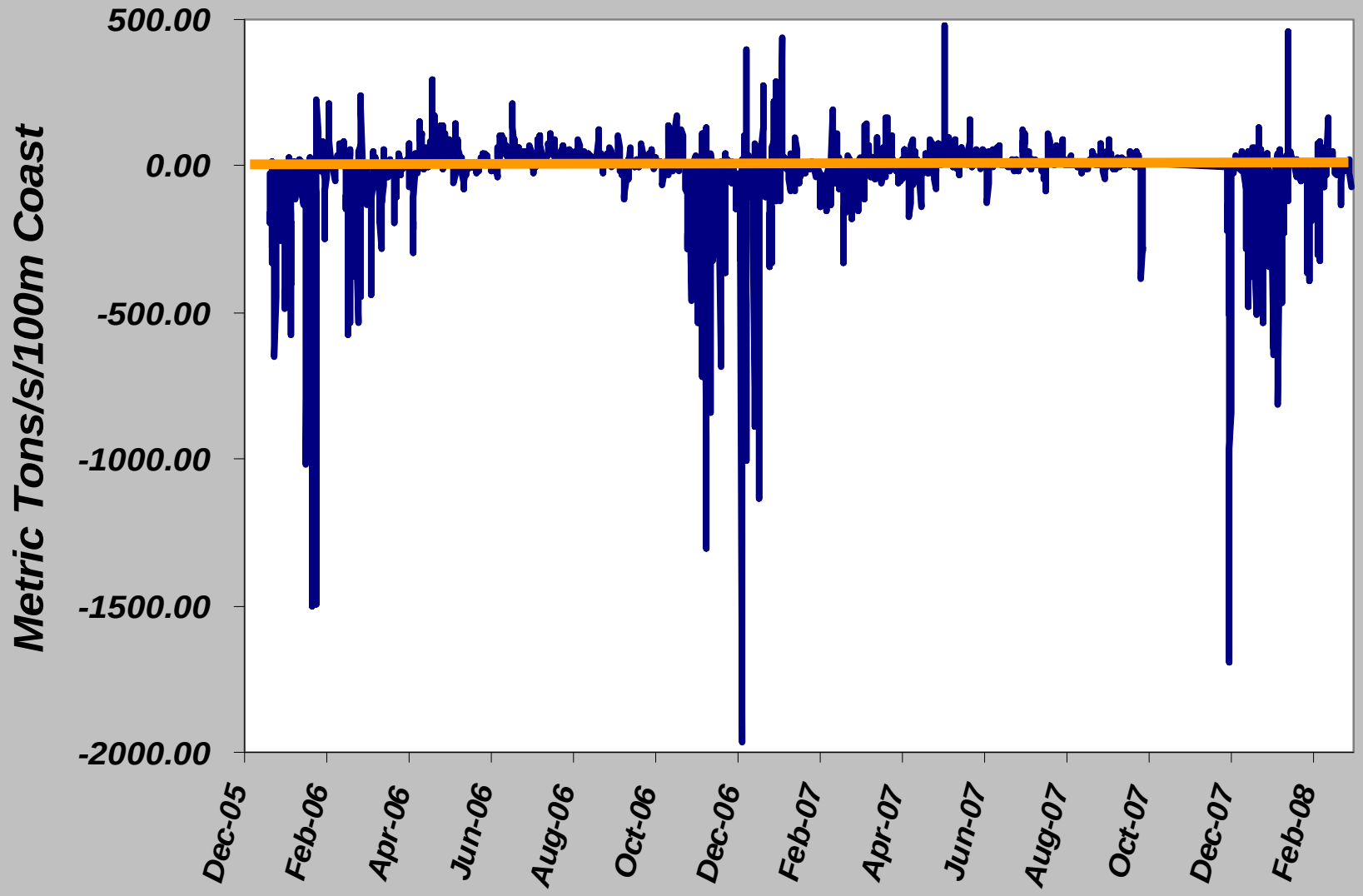

062507SS0801.dat:
18
sigma-t [kg/m^3]
24
5
temperature [deg C]
15
0
pressure [db]
50
20
salinity
32
0
fluorometer, ECO-AFL
30


062507SS0801.dat:
0
pH
12
0
oxygen, SBE [mg/l]
12
0
pressure [db]
50
30
transmissometer [%]
90
0
voltage 6 [PAR]
6

June 2007 Stratification



Upwelling Index - 6 hr - 48N 124W



Data Analysis & Reporting

√ Dissolved Oxygen
√ Chlorophyll
√ Dissolved Nutrients
√ Total Nitrogen & Phosphate
√ Alkalinities

* Contour & Plan View Maps; GIS Layers
* Data Appendix
* Inventory (Hydrodynamic Report)

__ Phytoplankton Biovolume & Counts – Fall 2008
__ Carbon (bimodal analyses – lab unable to validate DIC "absence")
*PCN – ok – utilization?
*DOC – 6-7 month loss, all affected?