South Puget Sound Dissolved Oxygen Study

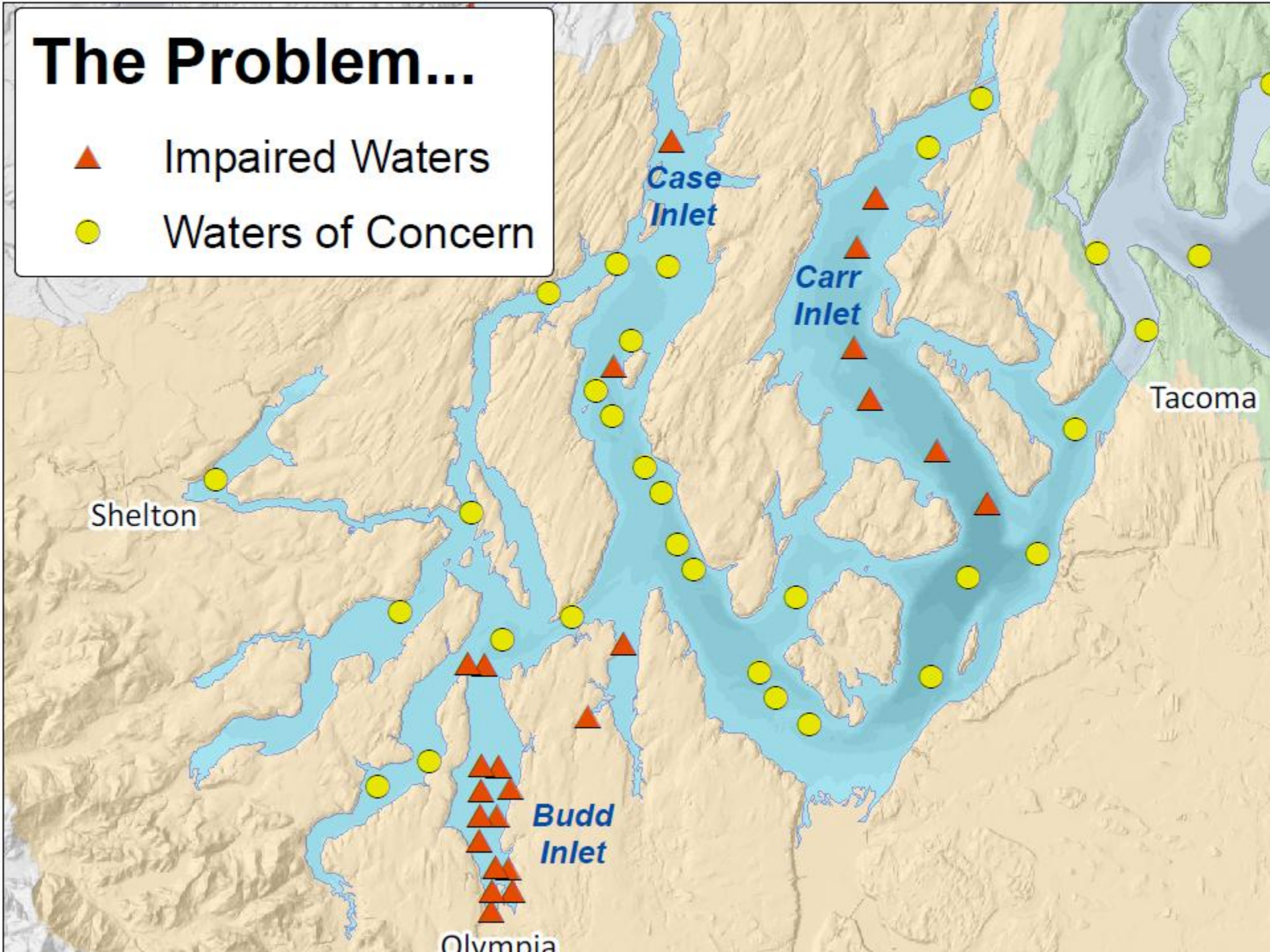
Advisory Committee Meeting
December 8, 2010

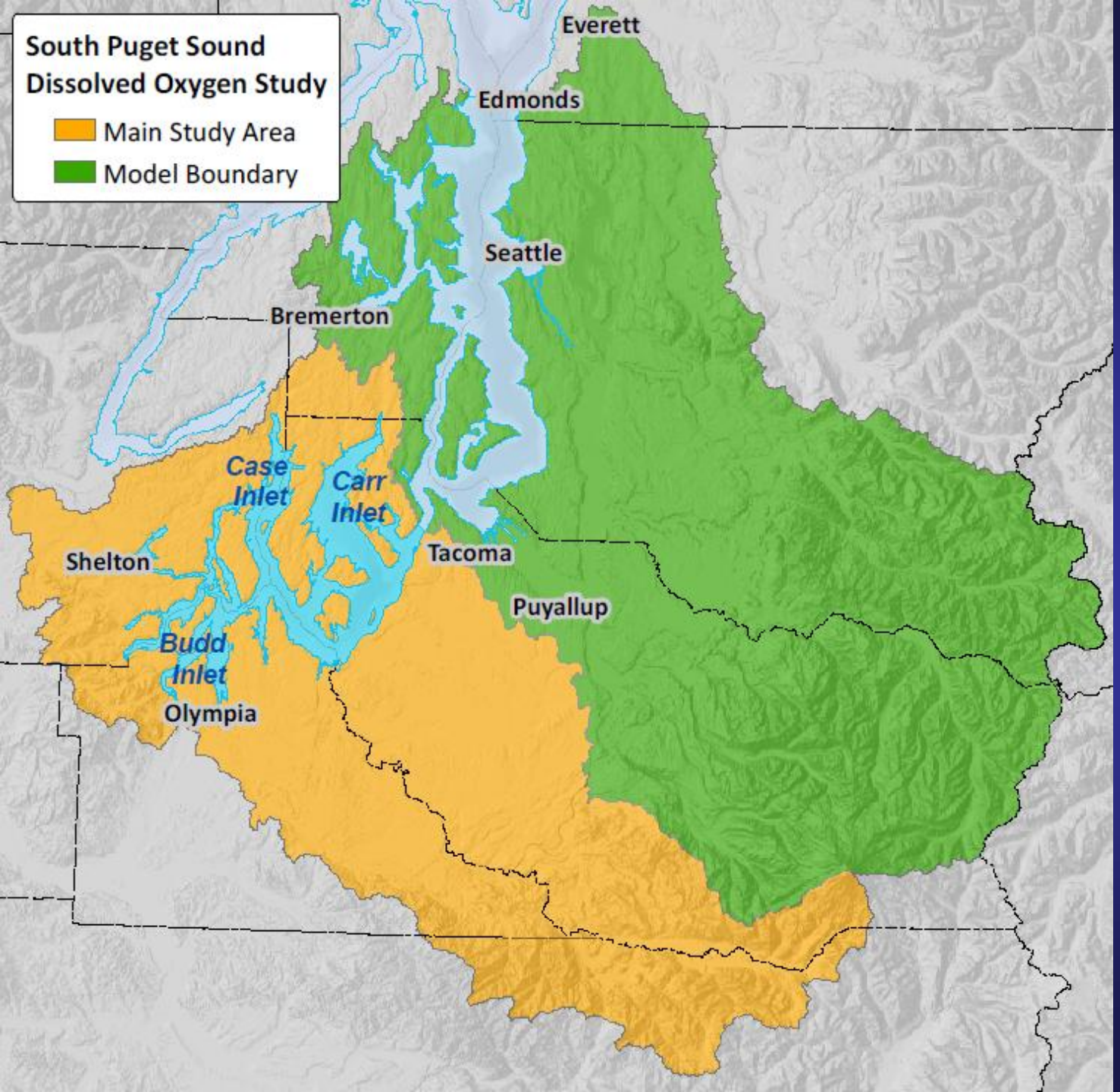
Agenda

- Introductions / Background
- Nutrient Load Summary
  - DIN Loads
  - Calculation of Natural Condition Loads
  - Septics
- Progress on Water Quality Model
- Chambers Creek WWTP Upgrades

Comments Due December 23rd

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

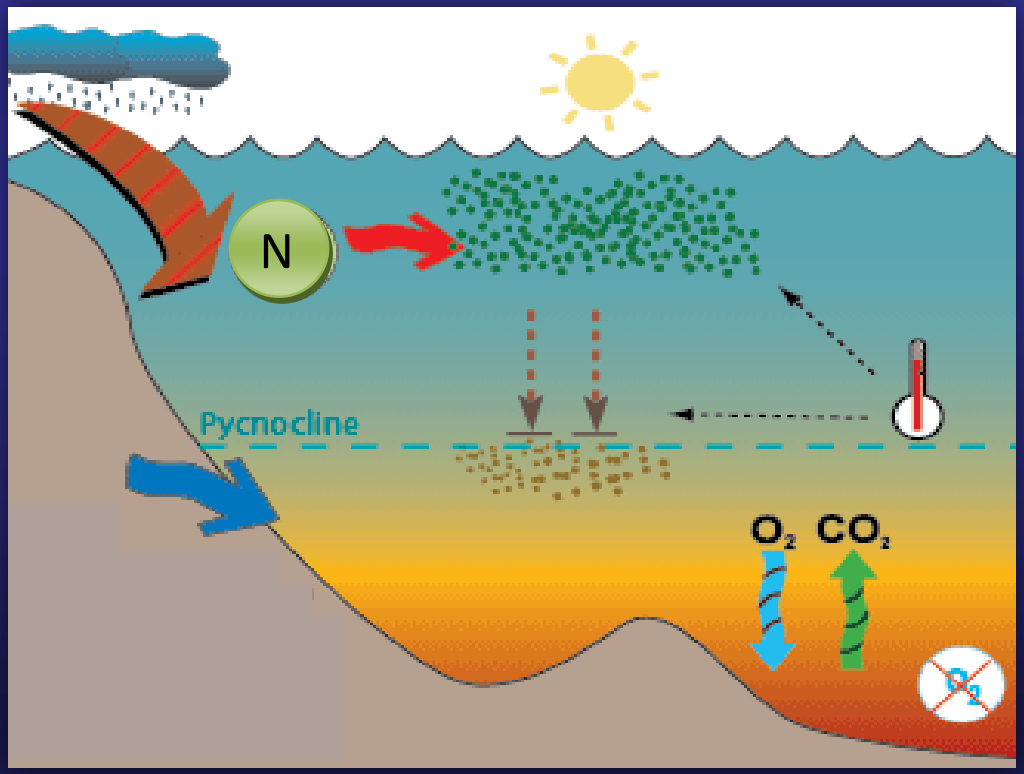

The Problem...
Impaired Waters
Waters of Concern
Case Inlet
Carr Inlet
Budd Inlet
Shelton
Tacoma
Olympia


South Puget Sound
Dissolved Oxygen Study
Main Study Area
Model Boundary
Everett
Edmonds
Seattle
Bremerton
Case Inlet
Carr Inlet
Shelton
Tacoma
Puyallup
Budd Inlet
Olympia

Study Area

Primary Issues

- Many factors involved
- Nitrogen is the main pollutant causing low dissolved oxygen levels
- Fish need oxygen



Goal of the Study

Determine how human activities (along with natural factors) affect low dissolved oxygen levels in South Puget Sound.

Long Term Goal

If the study shows that something needs be done to protect dissolved oxygen levels in South Puget Sound, a plan to improve water quality will be necessary.

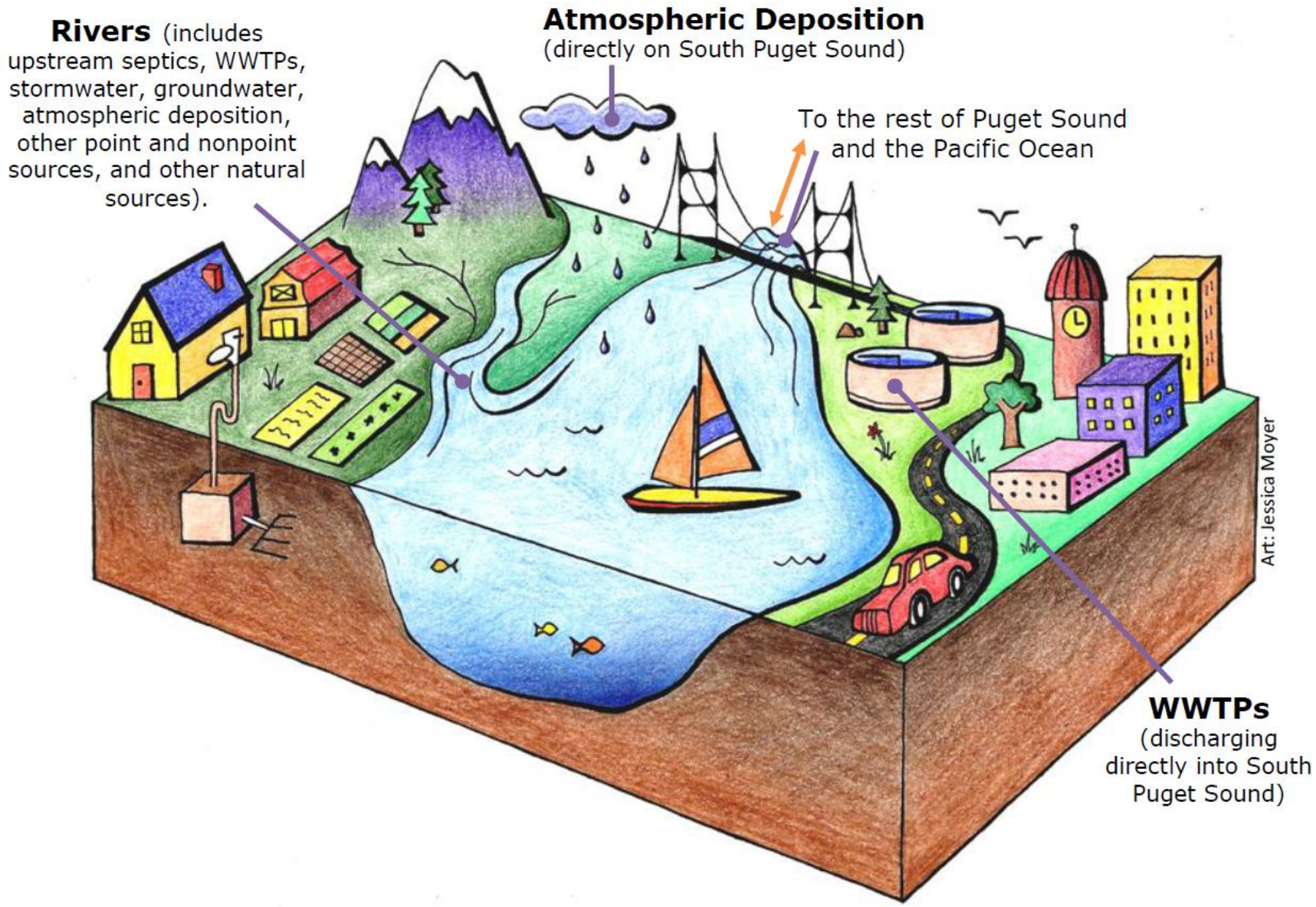
Progress

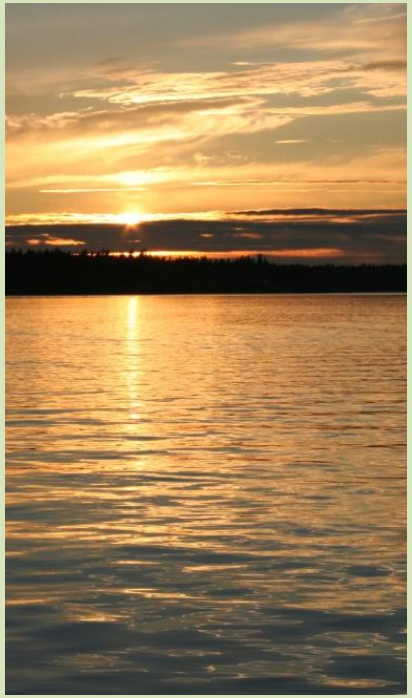
- Data Collection
- 2008 Data Report
- Draft Nutrient Loading Report

- 2009 Draft Circulation Report
- 2011-2012 Water Quality Report
- Additional Management Scenarios

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

Sources of Nitrogen in South Puget Sound





South Puget Sound Dissolved Oxygen Study

NUTRIENT LOADING: 2006-2007

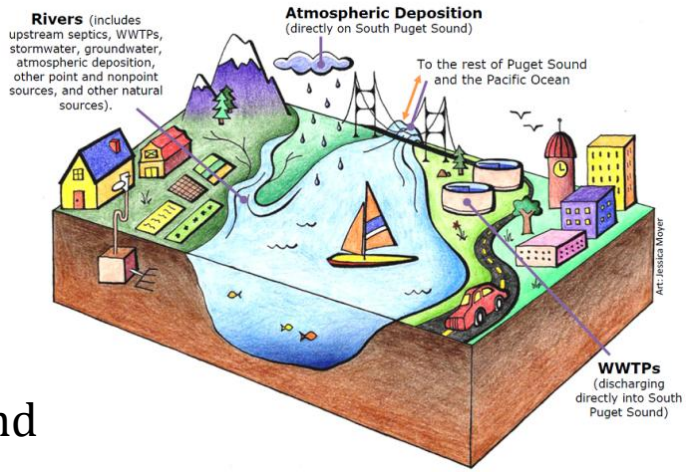
Advisory Meeting: December 8, 2010

Teizeen Mohamedali, Mindy Roberts and Andrew Kolosseus
Washington State Department of Ecology
http://www.ecy.wa.gov/puget_sound/dissolved_oxygen_study.html

OVERVIEW

- **Background** - Andrew
- **Methods** (brief)
  - How loading estimates were developed
- **Results**
  - Nutrient loading for 2006-2007 from rivers and WWTPs
  - Focus on dissolved inorganic nitrogen = DIN
- **Summary**
- **Natural Conditions**
- **Questions**

METHODS



Major terrestrial sources of nutrients:

1. <u>Watershed Loads</u>
   - Includes all sources within the watershed (atmosphere, WWTPs, septic systems, natural sources, stormwater, fertilizer applications and other point and non-point sources

2. <u>Wastewater Treatment Plant Loads (WWTPs)</u>
   - And industrial discharges which discharge directly into marine waters

3. <u>On-site septic systems</u>
   - Near-shore septic systems that enter groundwater and eventually into the marine water → Andrew will discuss this

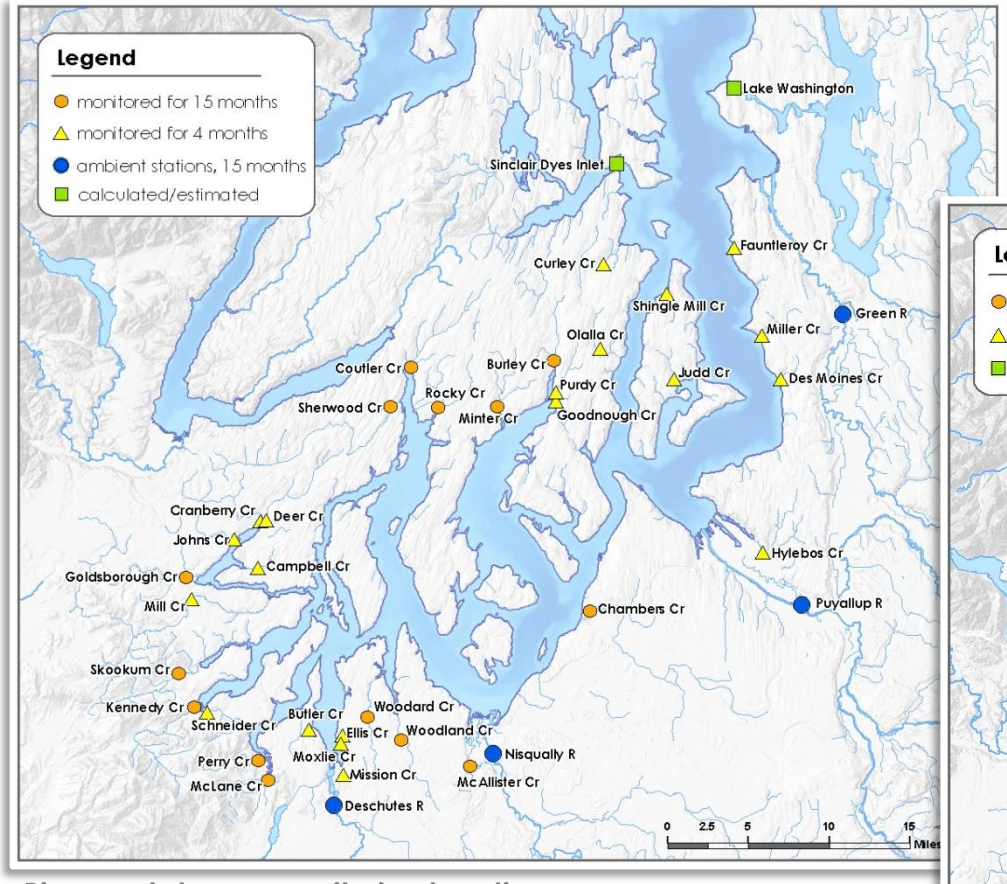
METHODS

Monthly field monitoring:

- July 2006-October 2007
- Streamflow measurements
- 38 rivers and streams
- 29 wastewater treatment plants (WWTPs – includes industrial)
- Various water quality parameters: nitrogen, phosphorus, carbon
- Some monitored for 15 months, some for 3-4 months
- Additional WWTP data sent by the plant or uploaded from DMRs
- Data published in Interim Data Report (December 2008)

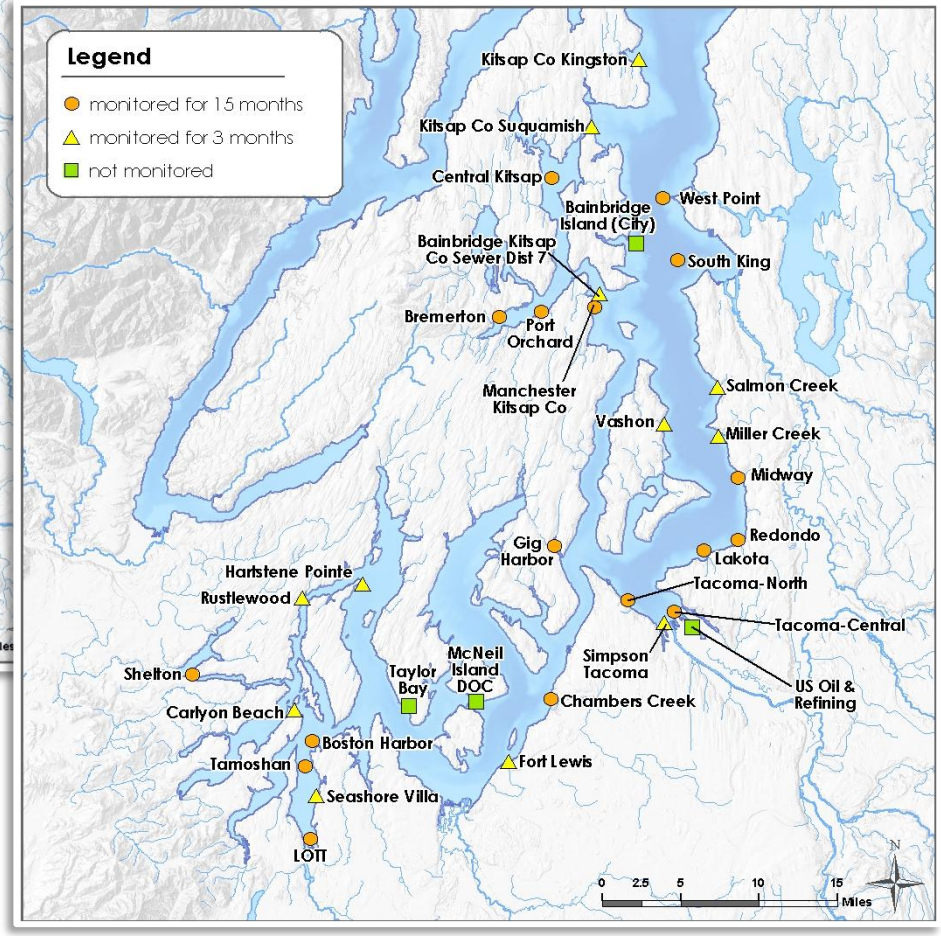
METHODS

WWTPs monitored for 15 months accounted for 89% of the total mean annual discharge of all WWTPs



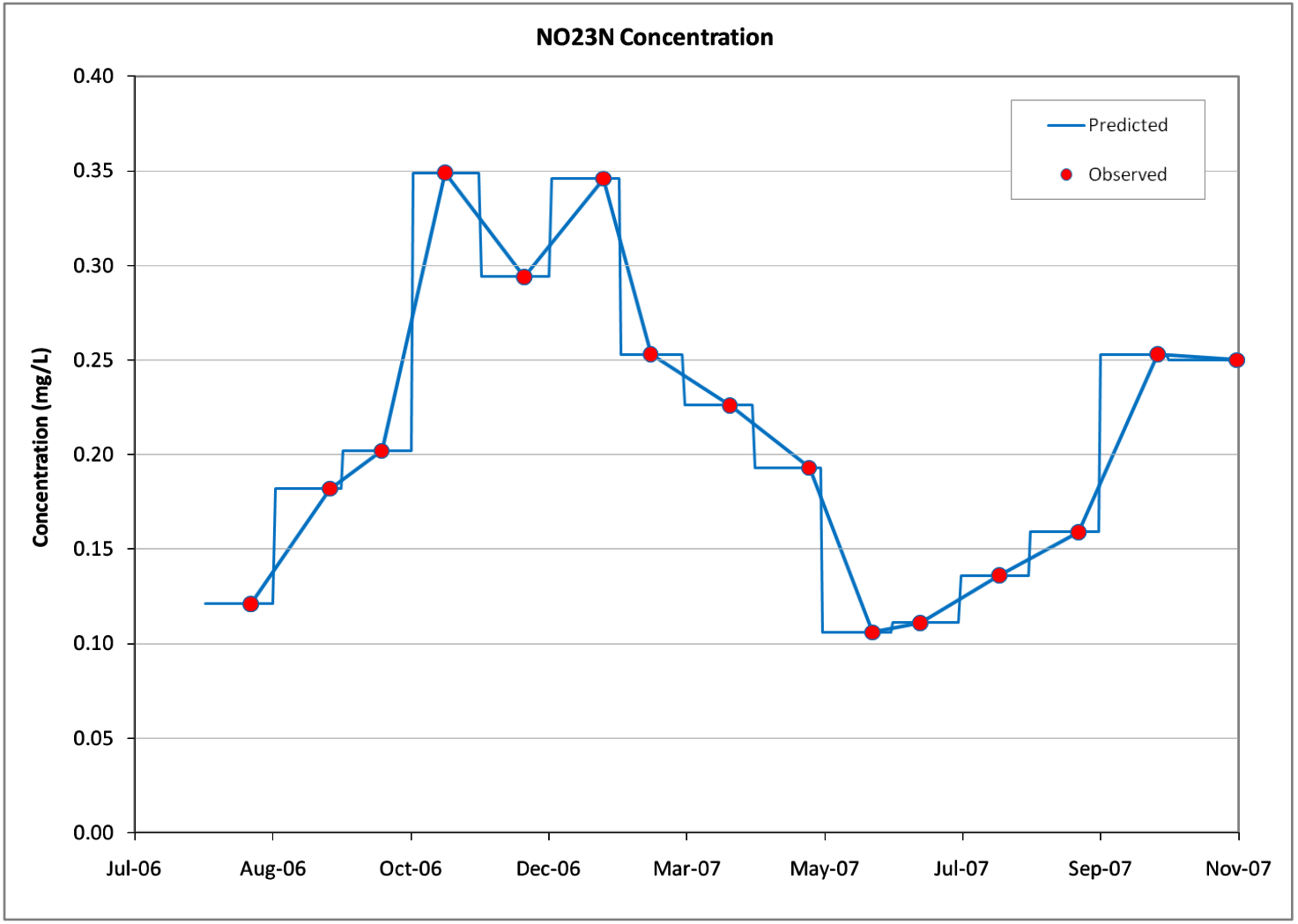
River and stream monitoring locations

Watersheds monitored for 15 months made up 82% of the total study area



WWTP monitoring locations

METHODS



Nitrate + Nitrite Concentration for the Puyallup River

METHODS

Estimating daily concentrations:

- Statistical method called *multiple linear regression*
- Uses observed monitoring data
- Relates observed concentrations to flow and time of year

FLOW TERMS

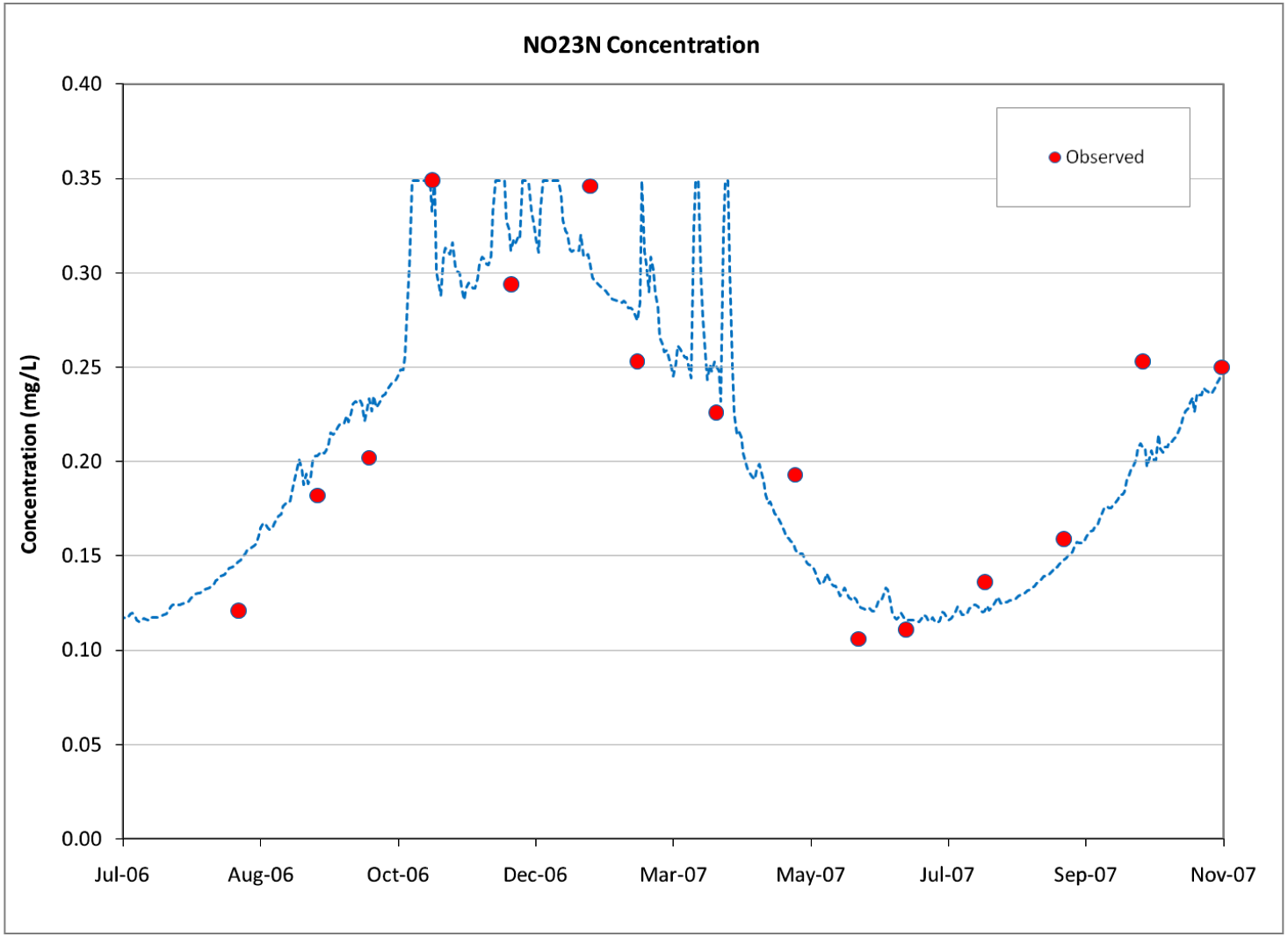
$$\log(C) = b_0 + b_1 \log(Q/A) + b_2 [\log(Q/A)]^2$$

$$+ b_3 \sin(2\pi f_y) + b_4 \cos(2\pi f_y) + b_5 \sin(4\pi f_y) + b_6 \cos(4\pi f_y)$$

TIME OF YEAR TERMS

- No "area" term for WWTPs and not log-transformed

METHODS



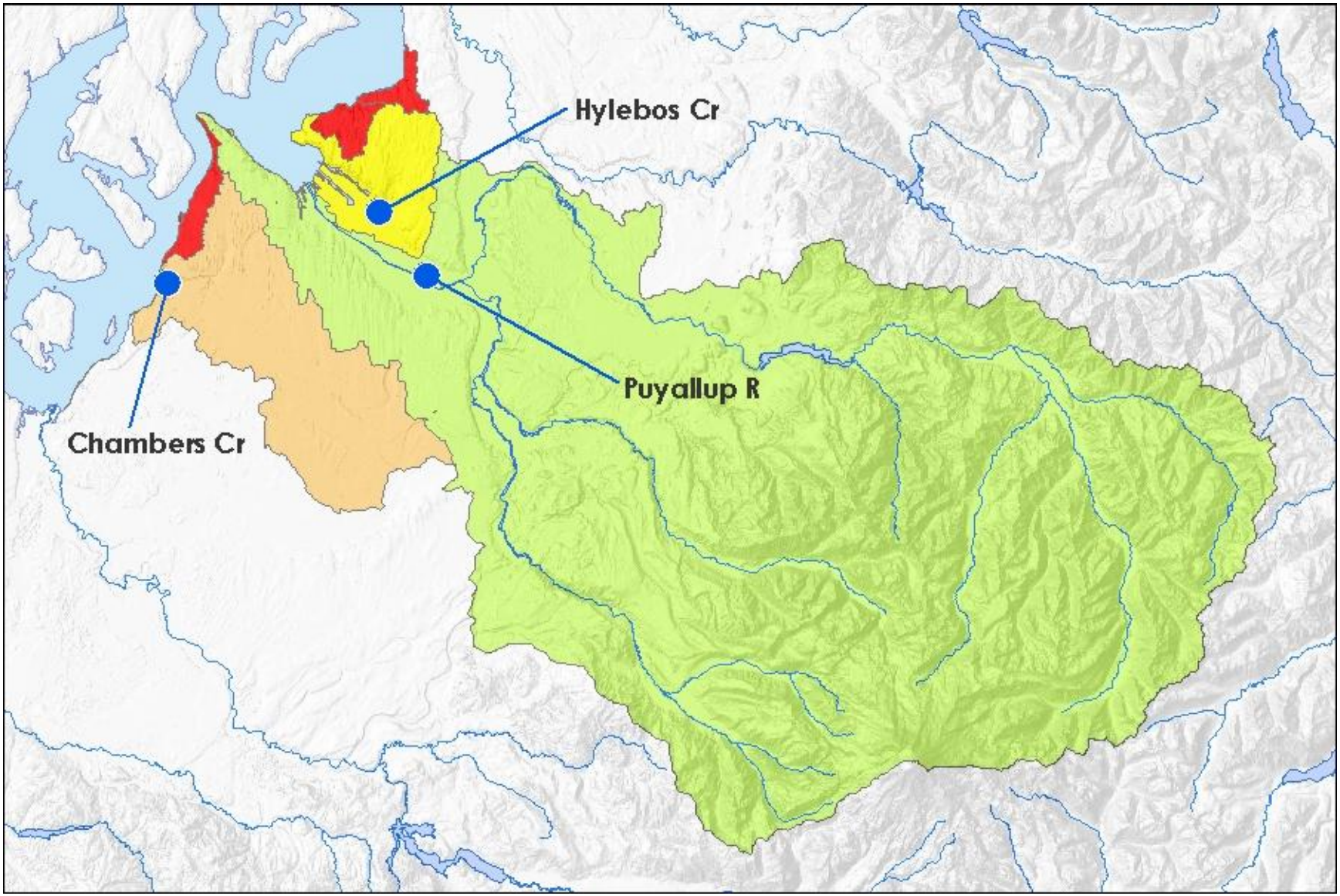
Nitrate + Nitrite Concentration for the Puyallup River

METHODS

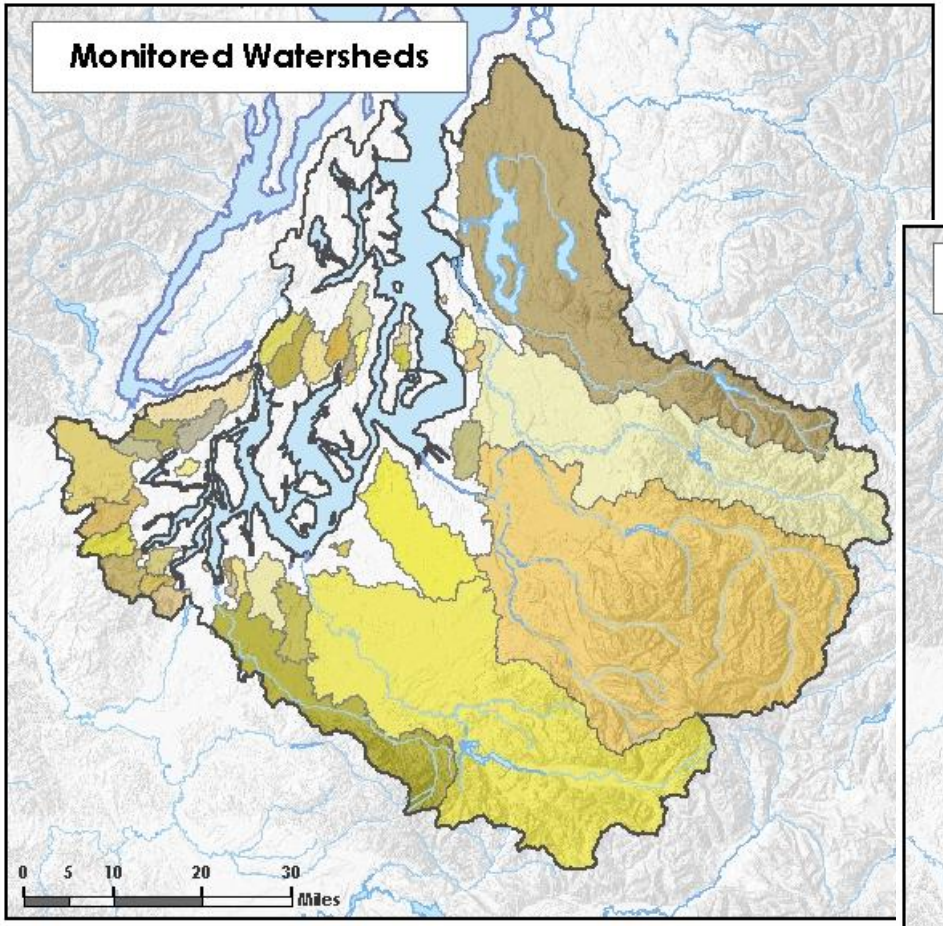
Estimating daily concentrations:

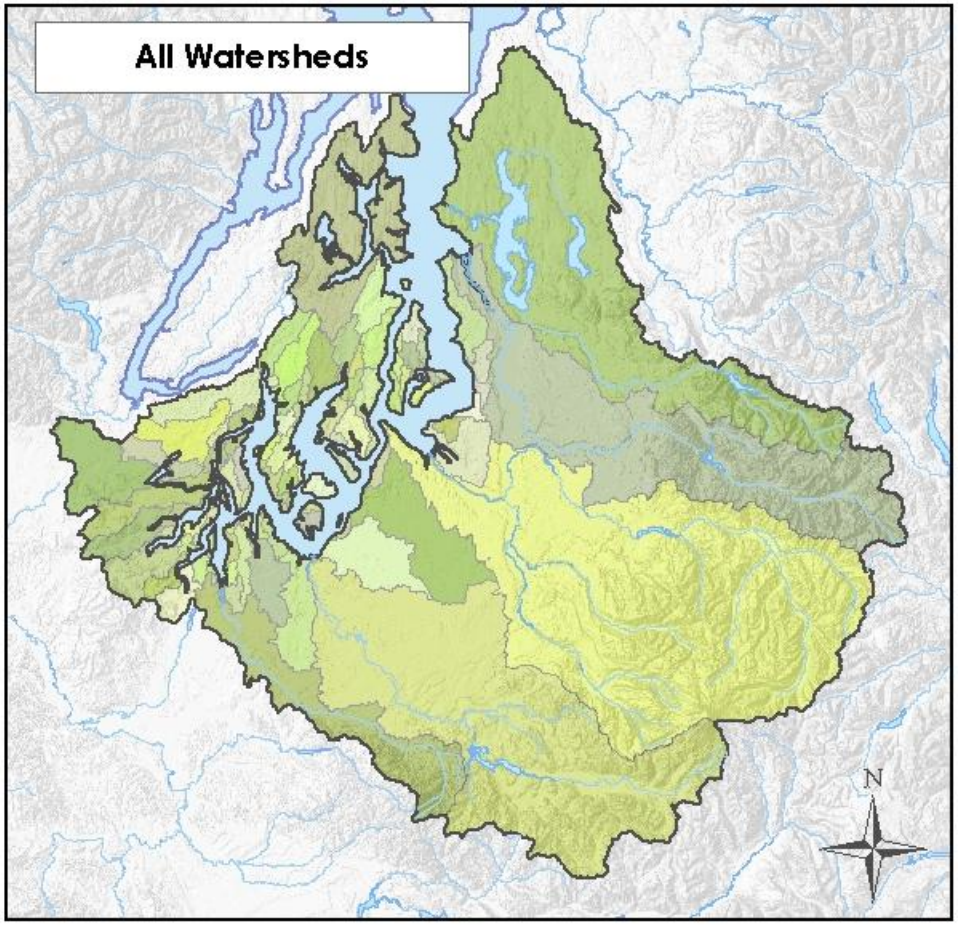
- Statistical method called *multiple linear regression*
- Uses observed monitoring data
- Relates observed concentrations to flow and time of year
- Extrapolated concentrations from monitoring locations to the mouth of watersheds
- Extrapolated to unmonitored regions

METHODS



METHODS



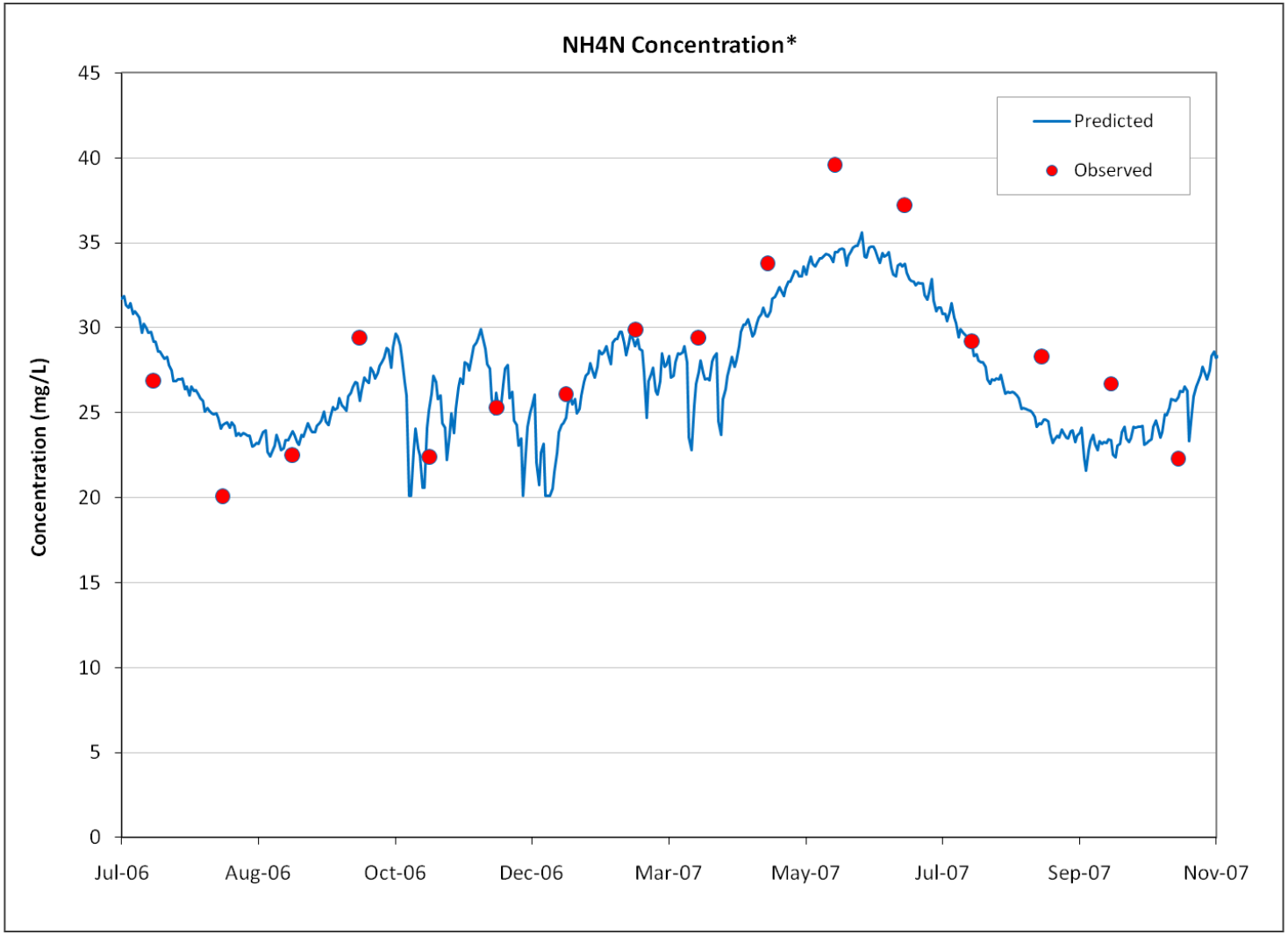


METHODS

Estimating daily concentrations:

- Statistical method called *multiple linear regression*
- Uses observed monitoring data
- Relates observed concentrations to flow and time of year
- Extrapolated concentrations from monitoring locations to the mouth of watersheds
- Extrapolated to unmonitored regions
- Same method for WWTPs
- Applied templates for unmonitored WWTPs

METHODS



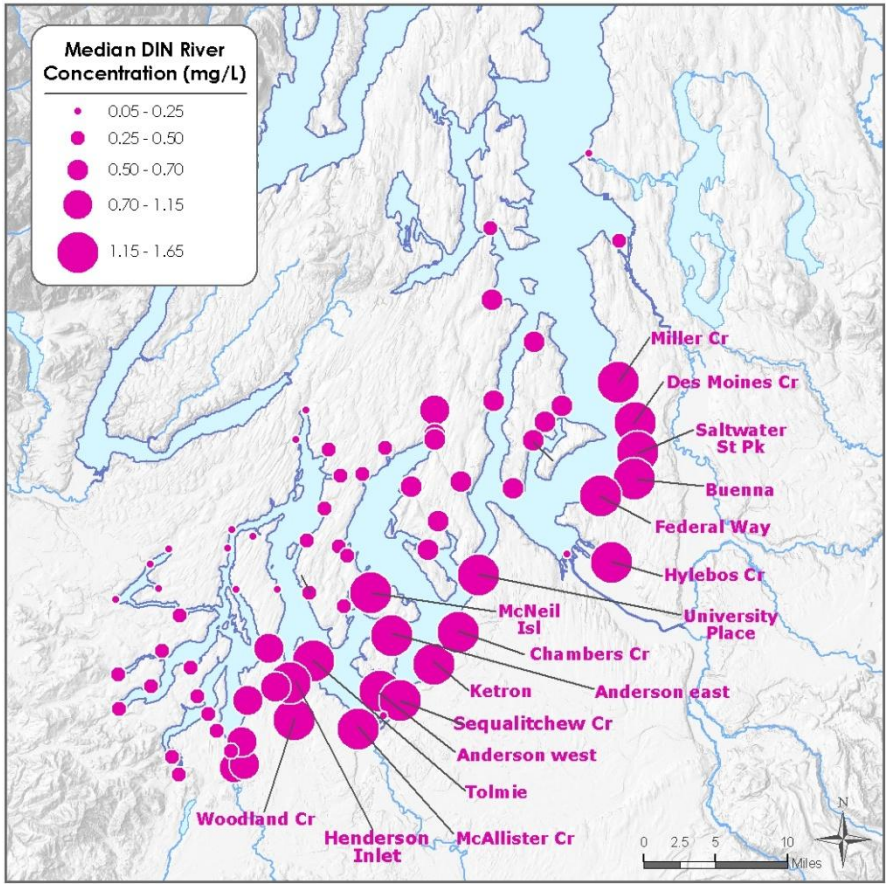
Ammonium concentrations for the Chambers Creek

RESULTS

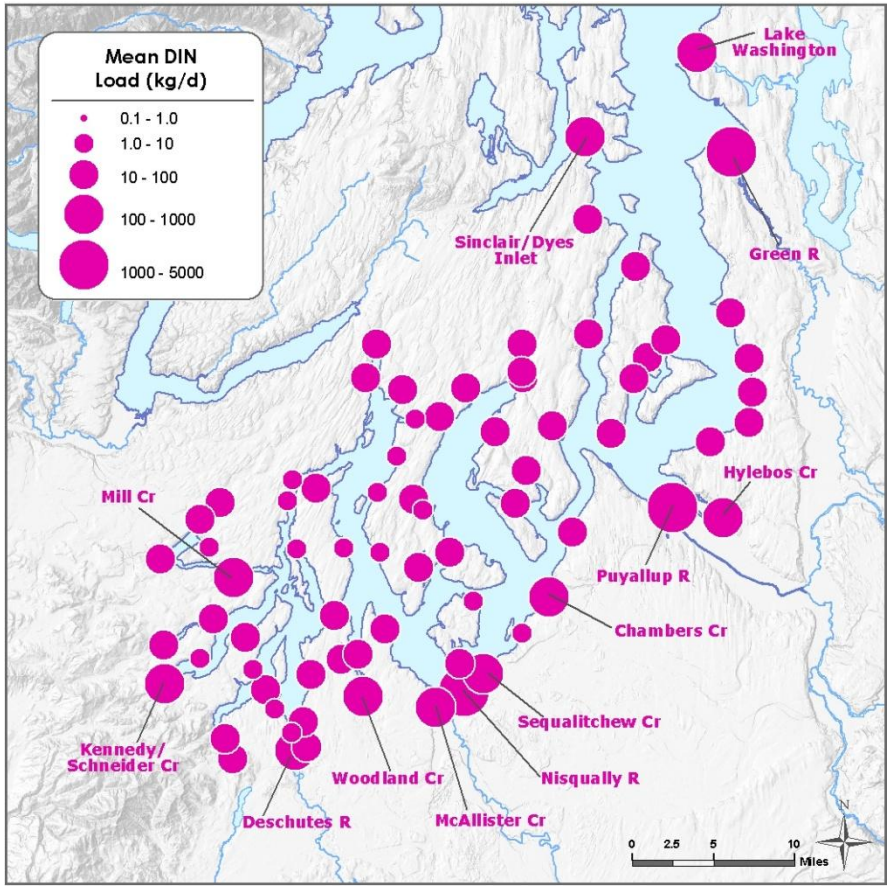
- Will focus on Dissolved Inorganic Nitrogen (DIN)
- DIN Load = DIN Concentration x Flow
- Rivers (**pink**) and WWTPs (**blue**)
- South and Central Puget Sound
- Septic System loads (Andrew)

RESULTS

CONCENTRATIONS

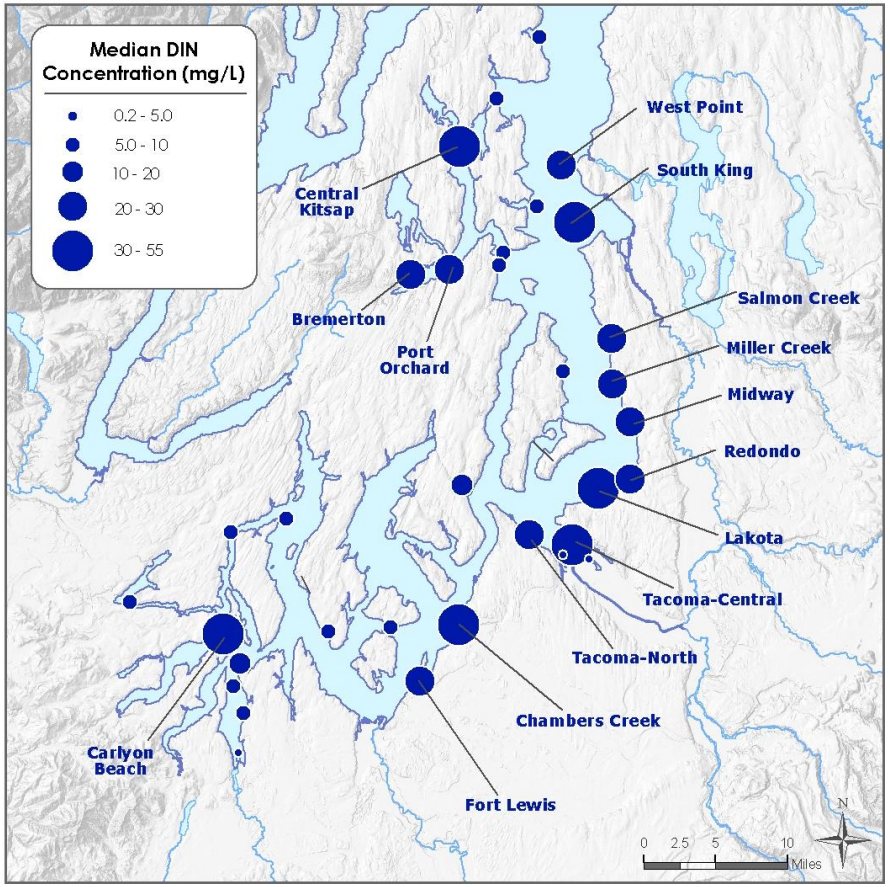


LOADS

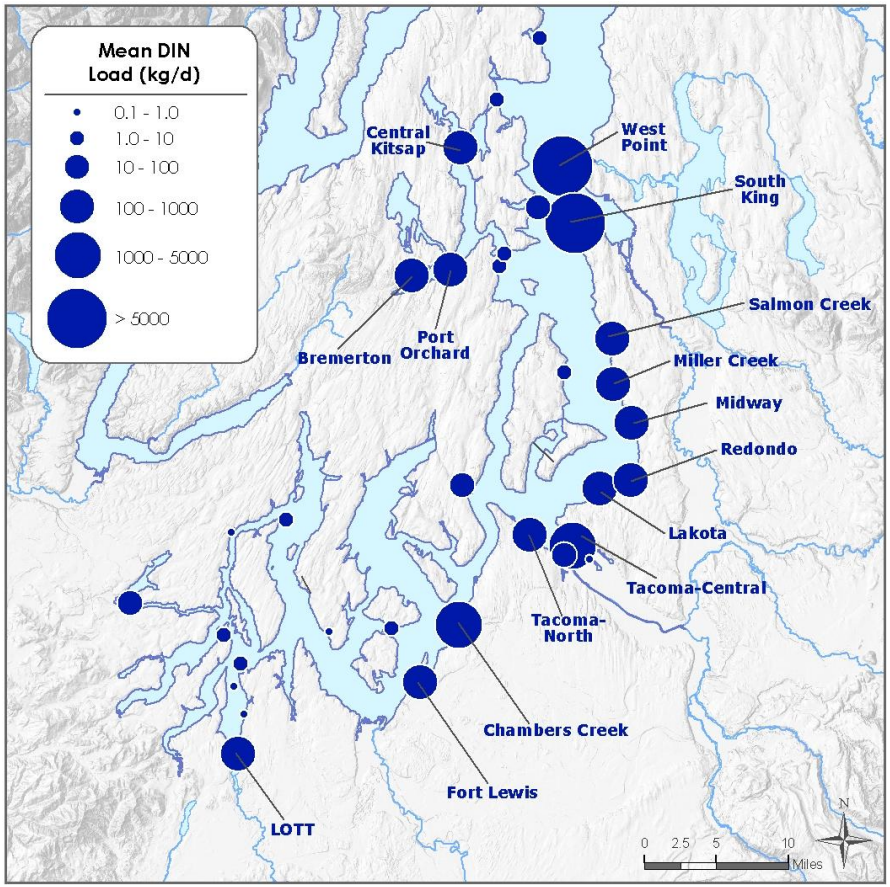


RESULTS

CONCENTRATIONS

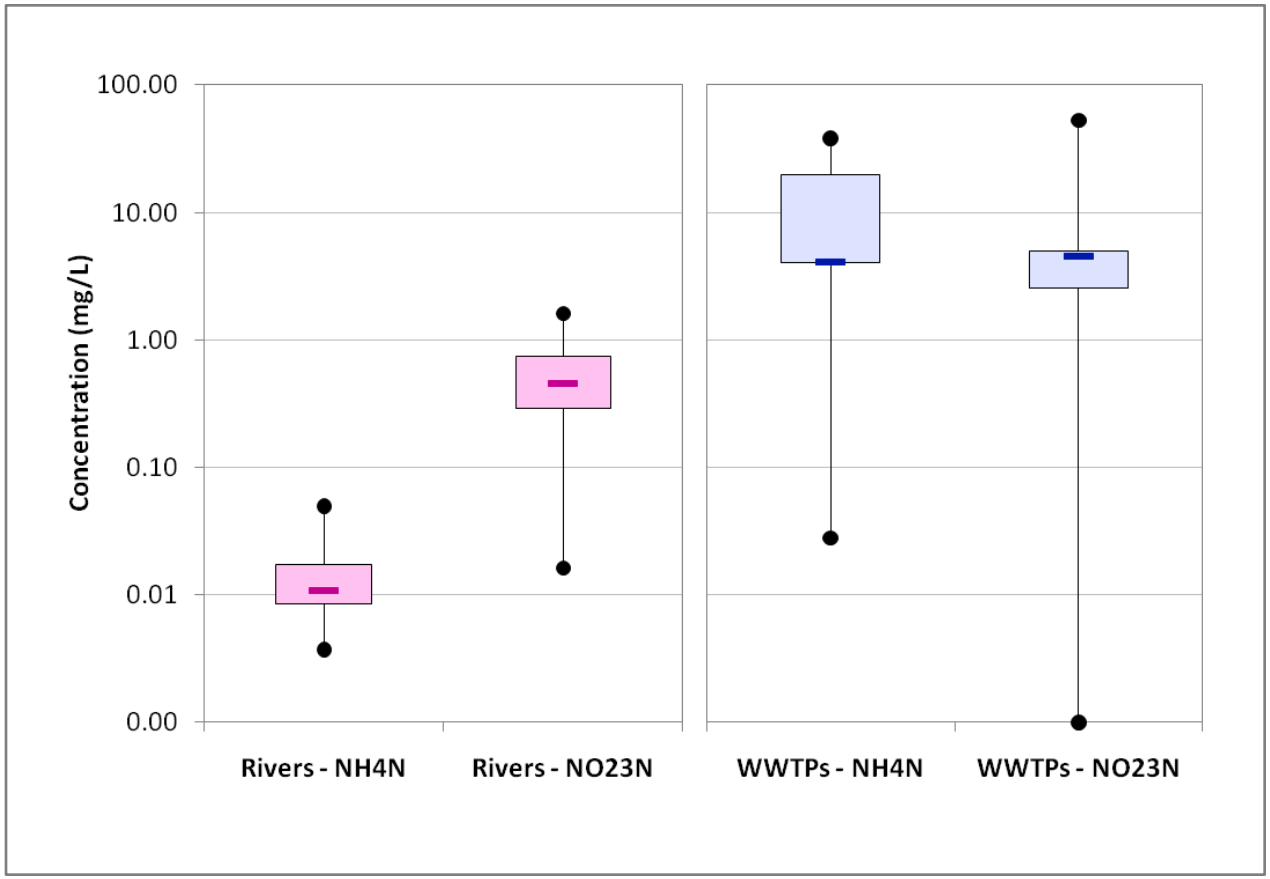


LOADS

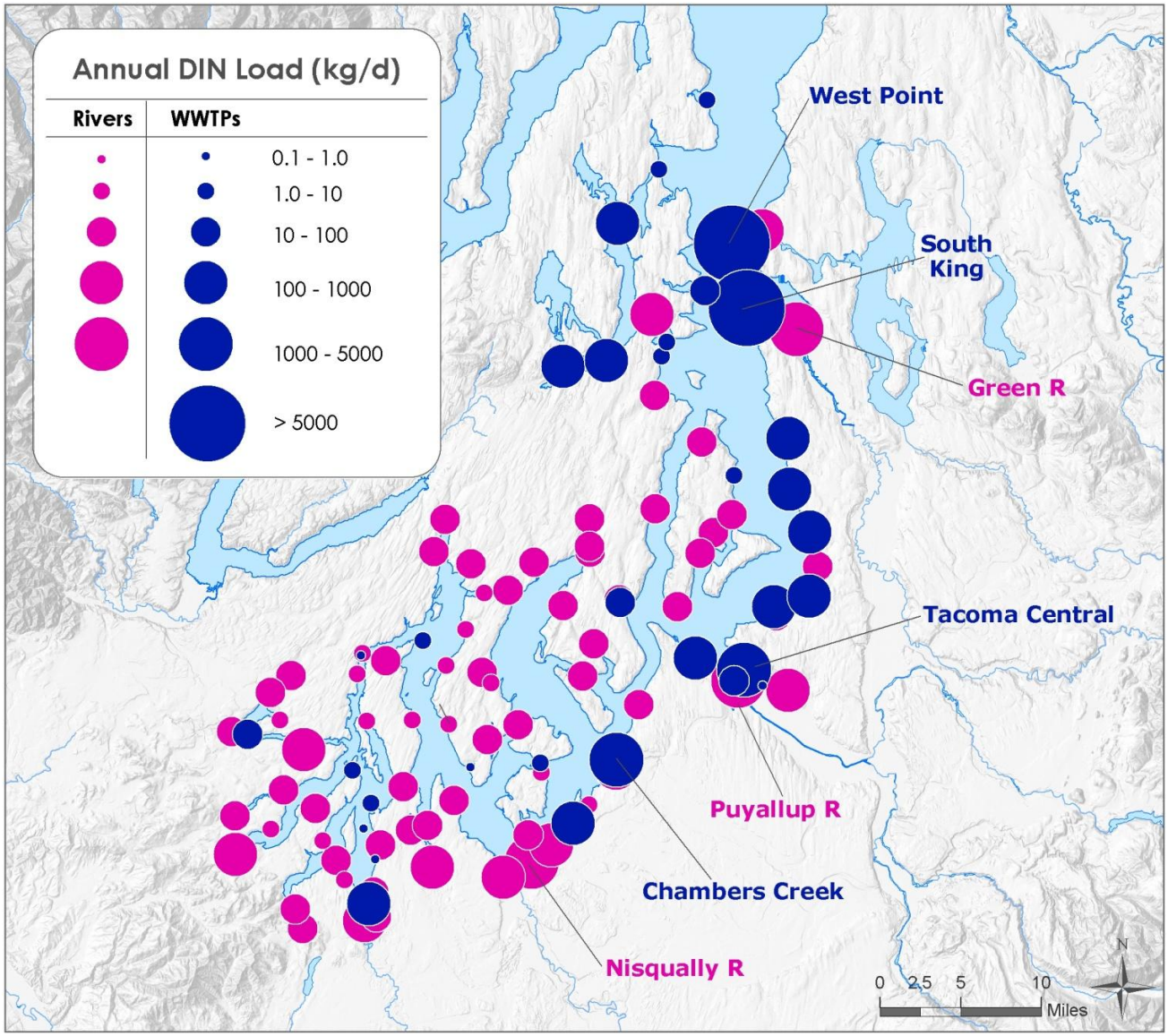


RESULTS

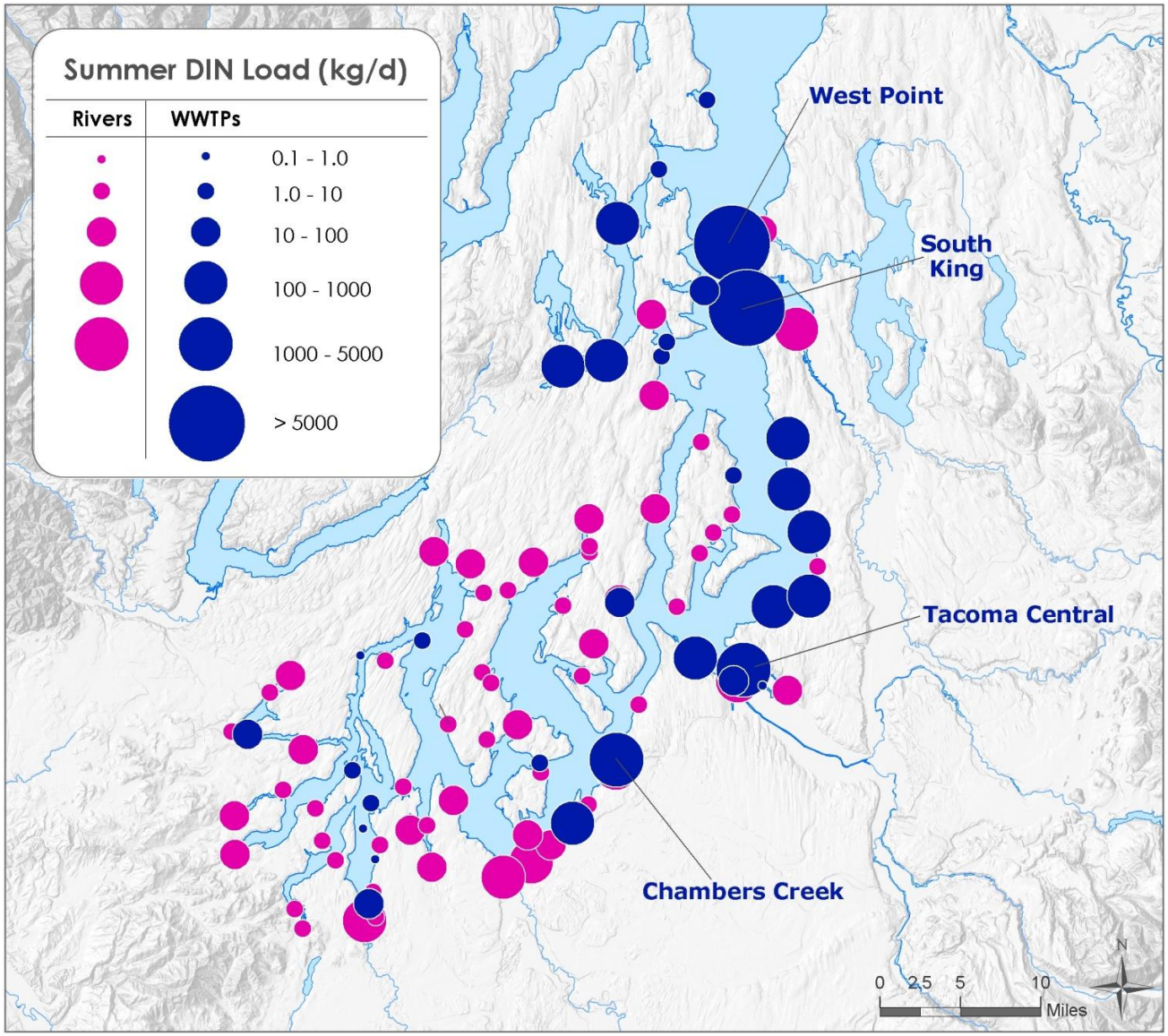
Box Plots showing the range of median ammonium (NH4N) and nitrate + nitrite (NO23N) concentrations in rivers and WWTPs



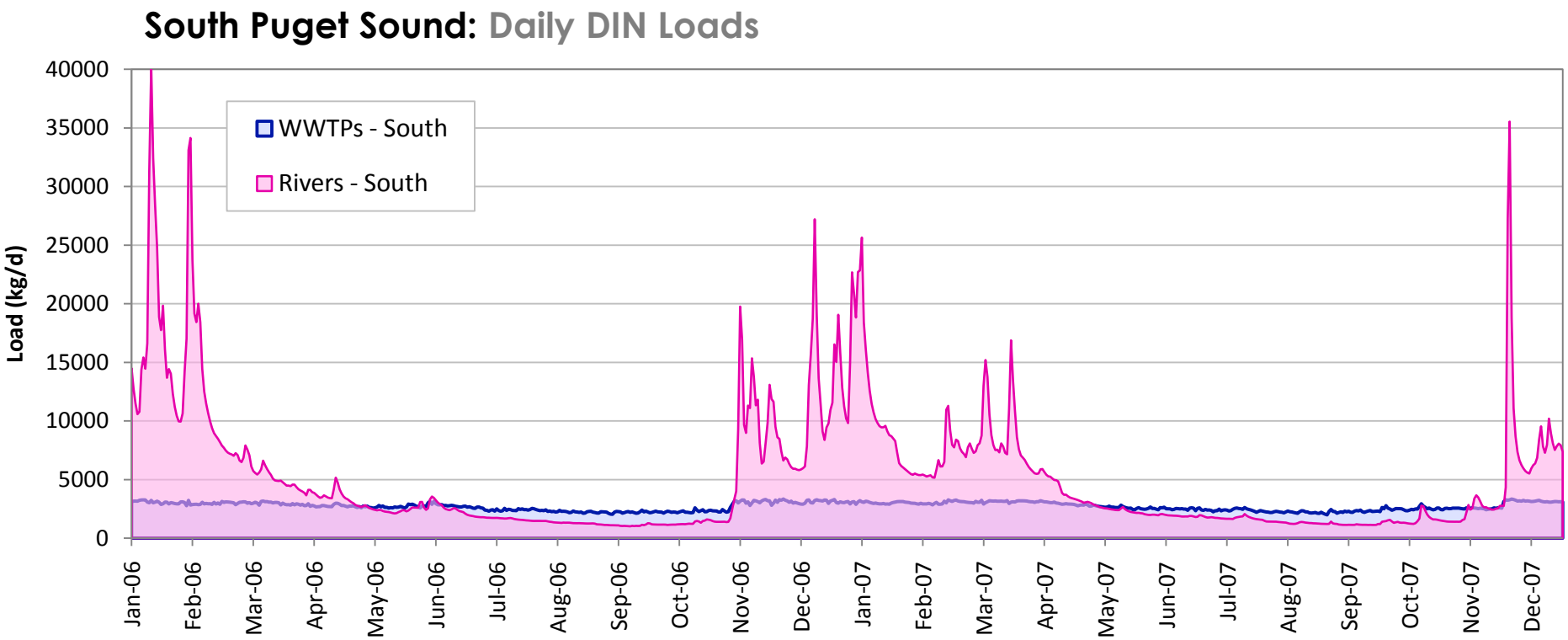
RESULTS


Annual DIN Load (kg/d)
Rivers
WWTPs
0.1 - 1.0
1.0 - 10
10 - 100
100 - 1000
1000 - 5000
> 5000
West Point
South King
Green R
Tacoma Central
Puyallup R
Chambers Creek
Nisqually R
0 2.5 5 10
Miles
N

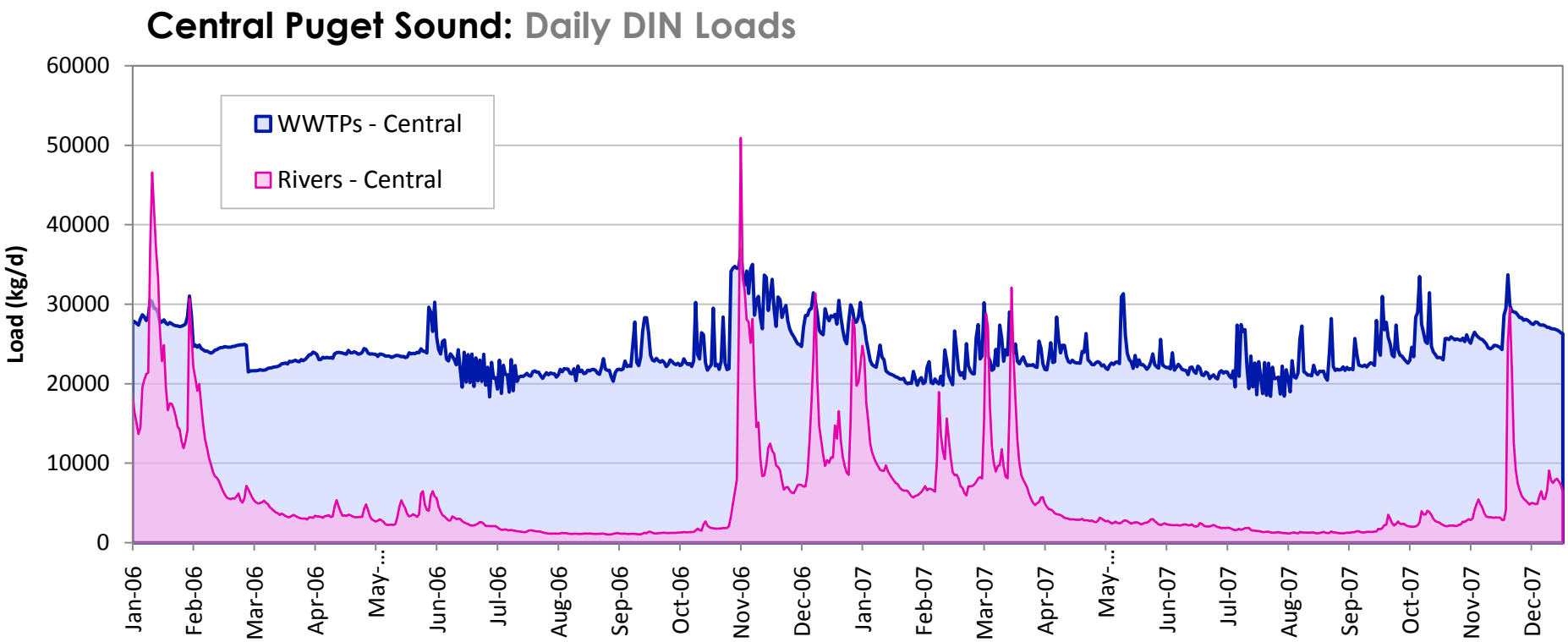
RESULTS


Summer DIN Load (kg/d)
Rivers
WWTPs
0.1 - 1.0
1.0 - 10
10 - 100
100 - 1000
1000 - 5000
> 5000
West Point
South King
Tacoma Central
Chambers Creek
0 2.5 5 10
Miles
N

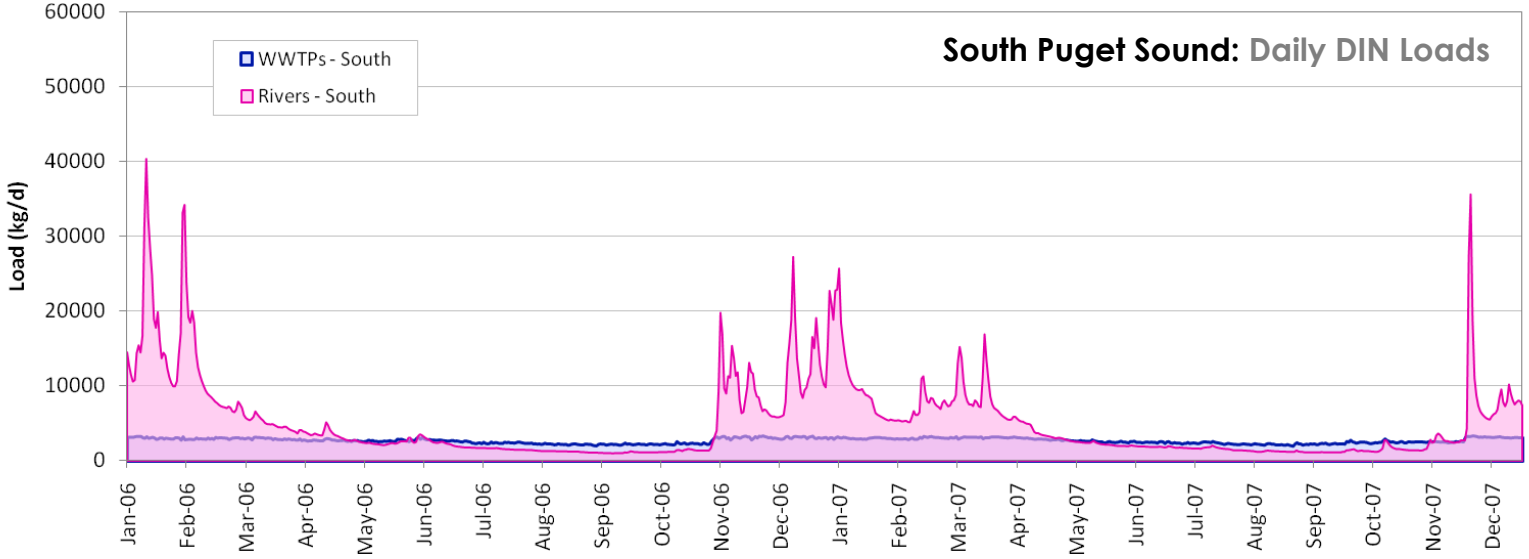
RESULTS

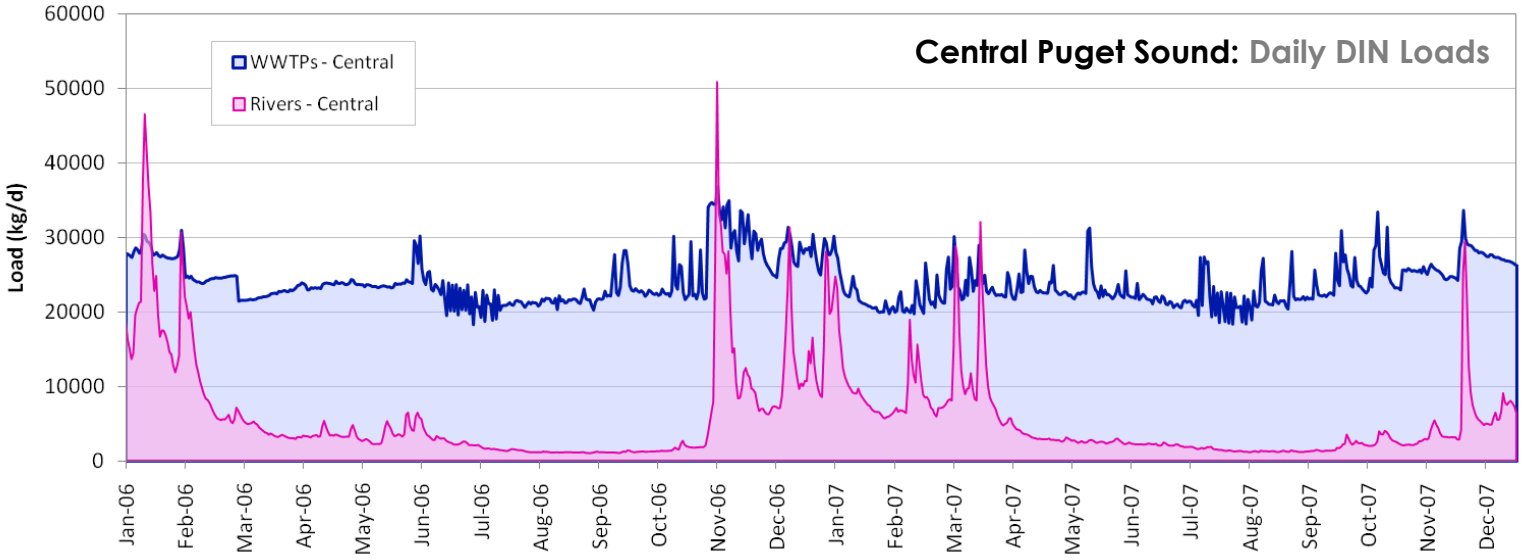

South Puget Sound: Daily DIN Loads
WWTPs - South
Rivers - South
Load (kg/d)
40000
35000
30000
25000
20000
15000
10000
5000
0
Jan-06
Feb-06
Mar-06
Apr-06
May-06
Jun-06
Jul-06
Aug-06
Sep-06
Oct-06
Nov-06
Dec-06
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07

RESULTS


Central Puget Sound: Daily DIN Loads
WWTPs - Central
Rivers - Central
Load (kg/d)
60000
50000
40000
30000
20000
10000
0
Jan-06
Feb-06
Mar-06
Apr-06
May-...
Jun-06
Jul-06
Aug-06
Sep-06
Oct-06
Nov-06
Dec-06
Jan-07
Feb-07
Mar-07
Apr-07
May-...
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07

RESULTS


South Puget Sound: Daily DIN Loads
WWTPs - South
Rivers - South
Load (kg/d)
60000
50000
40000
30000
20000
10000
0
Jan-06
Feb-06
Mar-06
Apr-06
May-06
Jun-06
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
Nov-07
Dec-07


Central Puget Sound: Daily DIN Loads
WWTPs - Central
Rivers - Central
Load (kg/d)
60000
50000
40000
30000
20000
10000
0
Jan-06
Feb-06
Mar-06
Apr-06
May-06
Jun-06
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
Nov-07
Dec-07

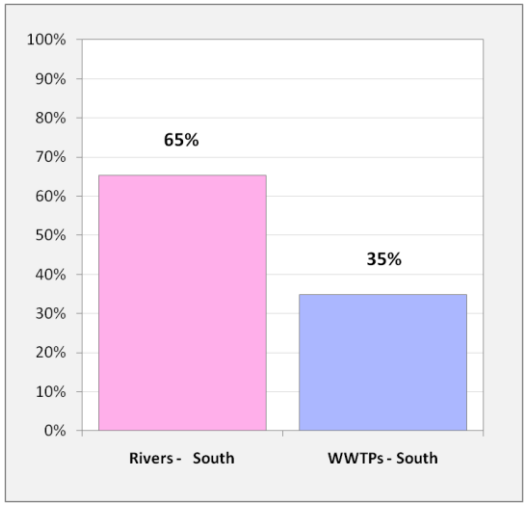
RESULTS

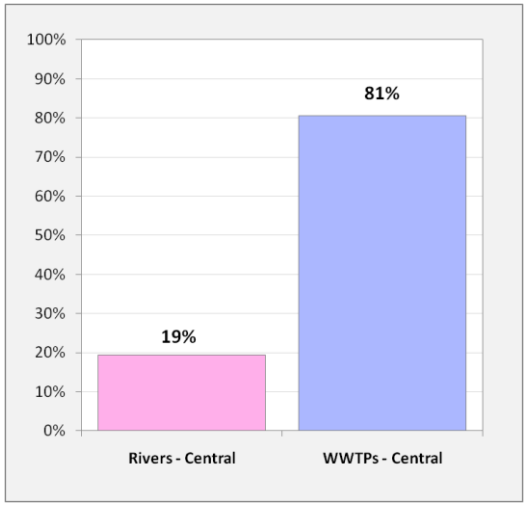
SOUTH PUGET SOUND

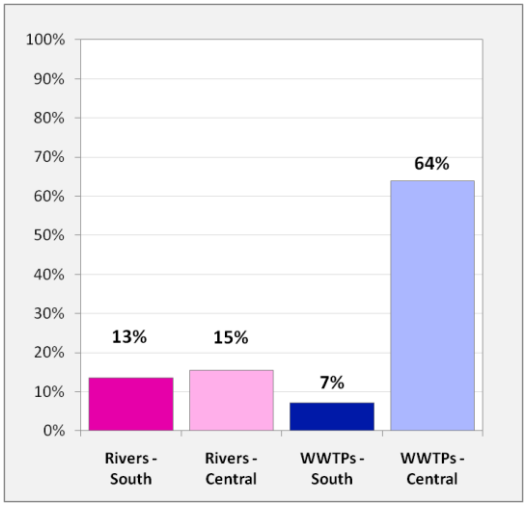
CENTRAL PUGET SOUND

SOUTH+ CENTRAL PUGET SOUND

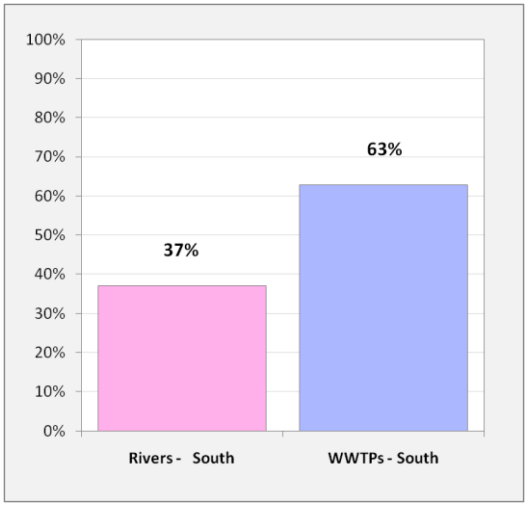
Annual DIN Load

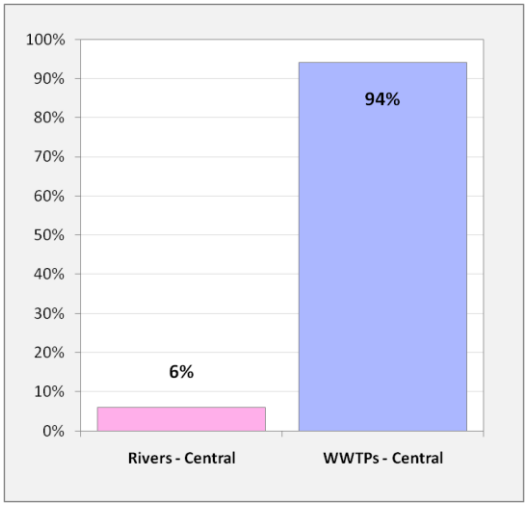


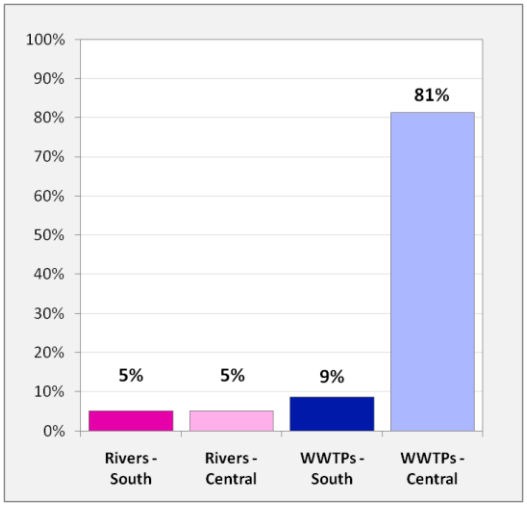




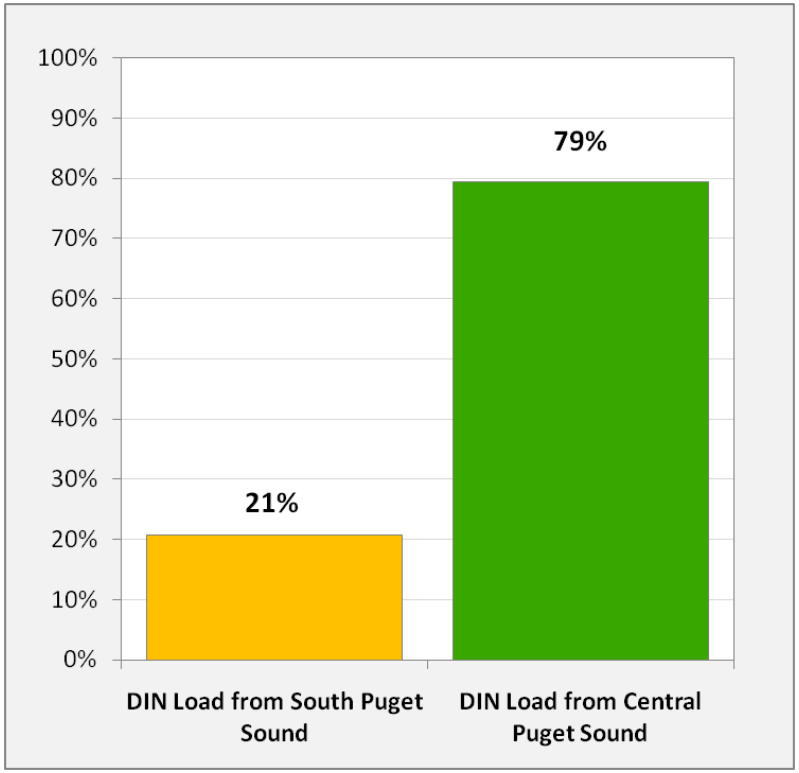
Summer DIN Load

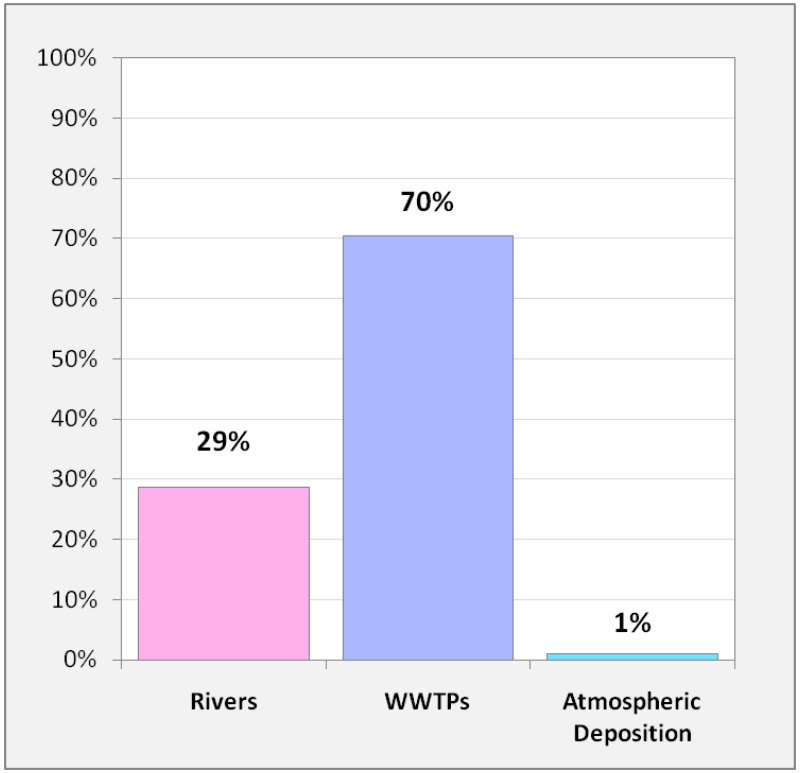






RESULTS


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
21%
79%
DIN Load from South Puget Sound
DIN Load from Central Puget Sound


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
29%
70%
1%
Rivers
WWTPs
Atmospheric Deposition

SUMMARY

- Comprehensive estimates of nutrient loads allows us to compare relative magnitudes and sources
- The location/sources of high loads coincide with higher population
- DIN loads from Central Puget Sound are 3.8 times greater than those from South Puget Sound
- River loads are highly seasonal while WWTPs loads are more constant throughout the year
- WWTPs contribute 71% of the load on an annual basis and 90% during the summer
- 77% of annual DIN loads from rivers occurs from Nov-March
- Modeling will further our understanding of what happens when these loads enter South and Central Puget Sound

NATURAL CONDITIONS

Why look at Natural Conditions?

- Water Quality Standards:

  When a water body's D.O. is lower than 7.0 or 6.0 mg/L "due to natural conditions, then human actions considered cumulatively may not cause the D.O. of that water body to decrease more than 0.2 mg/L."

- Identify how much nitrogen in rivers is from humans

NATURAL CONDITIONS

- **Purpose**: understand what the water quality in Puget Sound was under "natural conditions"
- **Definition**: concentrations of nutrients before significant human influences/sources of nutrients
- No WWTP or septic system loads → focus on rivers/watersheds
- Performed a meta-analysis:
  - Current data
  - Historical data
  - Rainfall data
  - Data from other studies

NATURAL CONDITIONS

METHOD / STATISTIC	TPN (mg/L)	NO23N (mg/L)	NH4N (mg/L)	TP (mg/L)	OP (mg/L)
Recent ambient data within model domain (10%ile)	0.158	0.114	0.010	0.017	0.008
Recent ambient data near model domain (10%ile)	0.025	0.011	0.010	0.006	0.003
Historic data from less developed watersheds (medians)	0.295*	0.200	0.030	0.015	0.010
Recent data from less developed watersheds (medians)	0.141*	0.113	0.010	0.019	0.004
Atmospheric (rainfall) data from Olympics (median)	0.151*	0.108	0.010	--	--
Atmospheric (rainfall) data from Western Washington stations (median)	0.323*	0.230	0.022	--	--
Surface runoff in forested basins (median, from PS Toxics Loading Project)	0.230	0.159	0.005	0.020	0.005
Hood Canal Dissolved Oxygen Program	0.090*	0.070	--	--	--

* Where TPN data were not available, the estimate was based on a relationship developed from the data: DIN = 78% of TPN on average.

NATURAL CONDITIONS

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Hood Canal Dissolved Oxygen Program	0.090*	0.070	--	--	--
OVERALL MEDIAN FOR SELECTED METHODS	**0.158**	**0.114**	**0.010**	**0.017**	**0.008**

* Where TPN data were not available, the estimate was based on a relationship developed from the data: DIN = 78% of TPN on average.

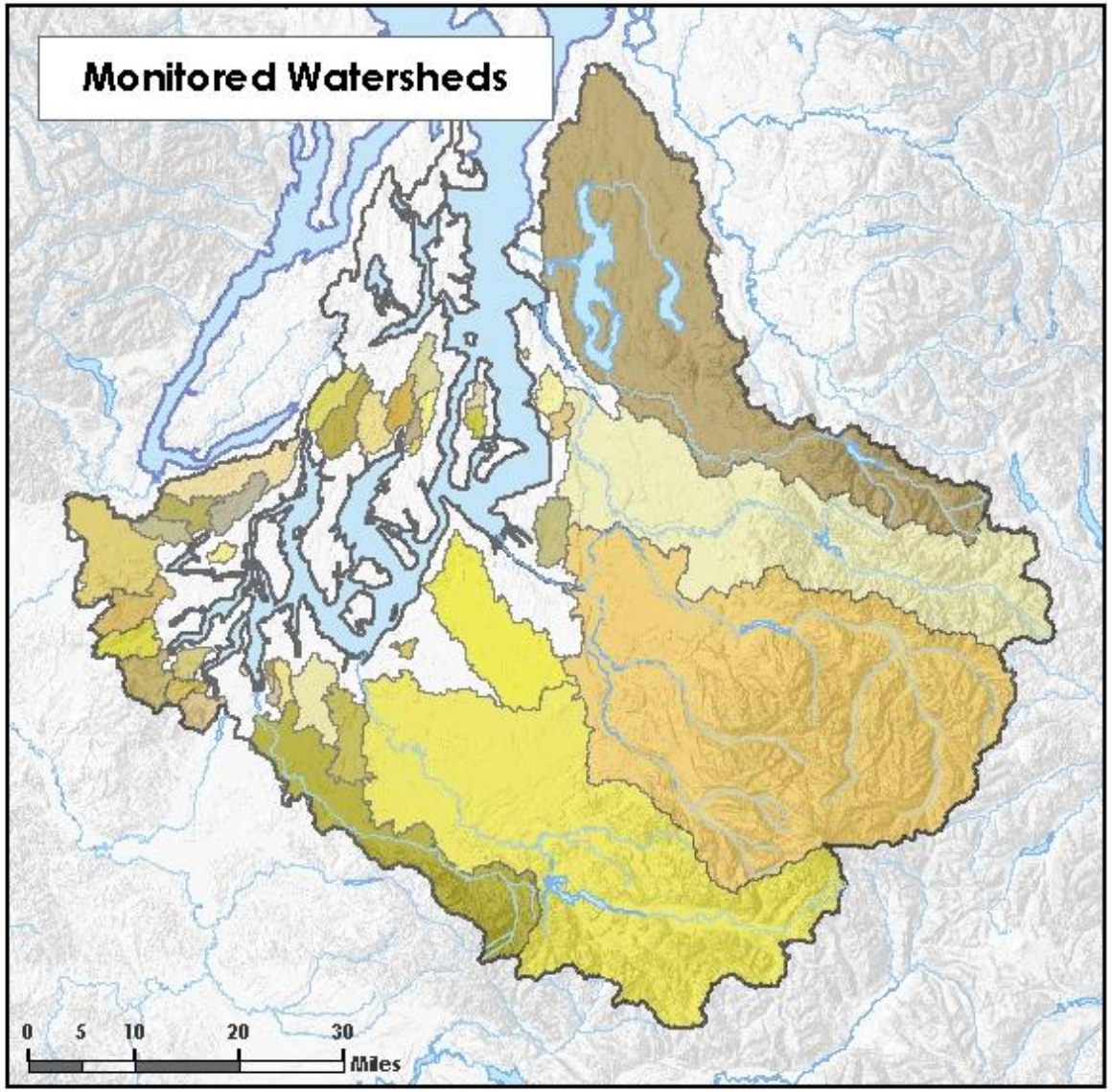
NATURAL CONDITIONS

$$Natural\ DIN\ Concentration = NO23N\ concentration + NH4N\ concentration$$
$$= 0.114\ mg/L + 0.010\ mg/L = \mathbf{0.124\ mg/L}$$

$$DIN\ Load\ \left(\frac{kg}{day}\right) = \frac{\sum(DIN\ Concentration * Daily\ Sound\ wide\ flows\ 2006\ \&\ 2007)}{730\ days}$$

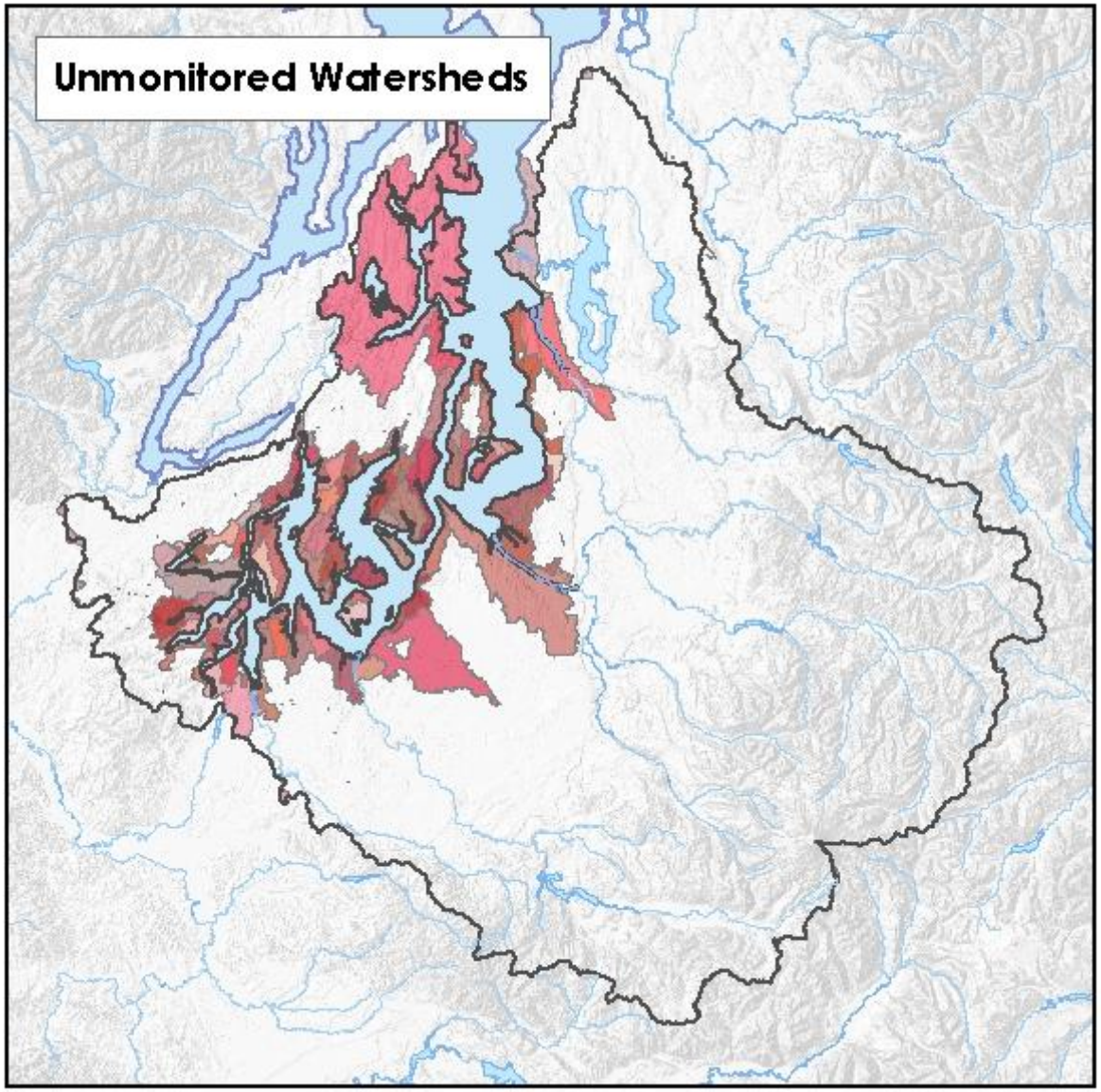
	Average Annual DIN Load (kg/d)		
	Natural Conditions	**2006-2007 Rivers Only**	**2006-2007 Rivers + WWTPs**
South Puget Sound	1410	5080	7785
Central Puget Sound	2415	5810	29860
South + Central Puget Sound	3825	10890	37645

Septics in Unmonitored Areas

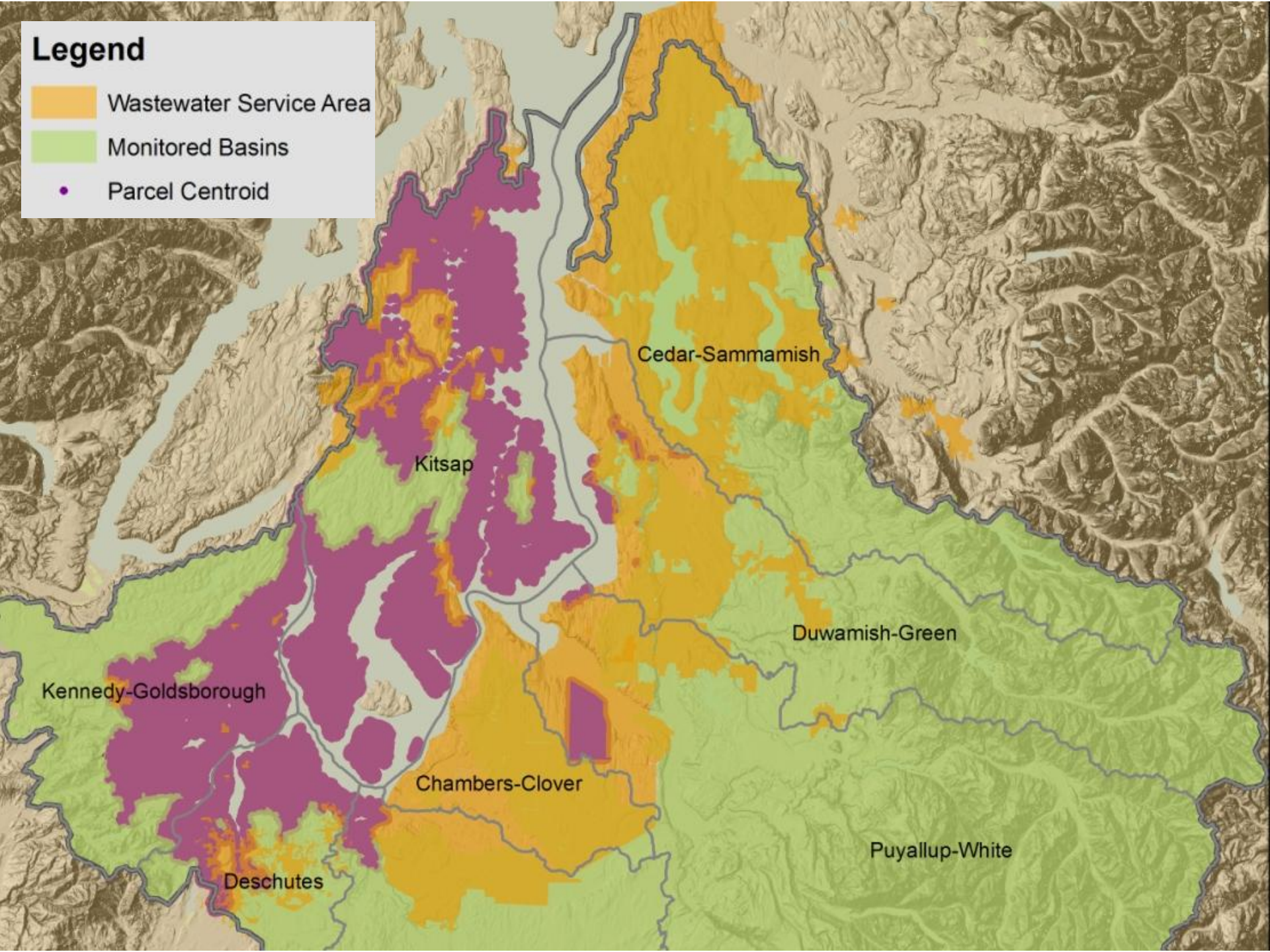


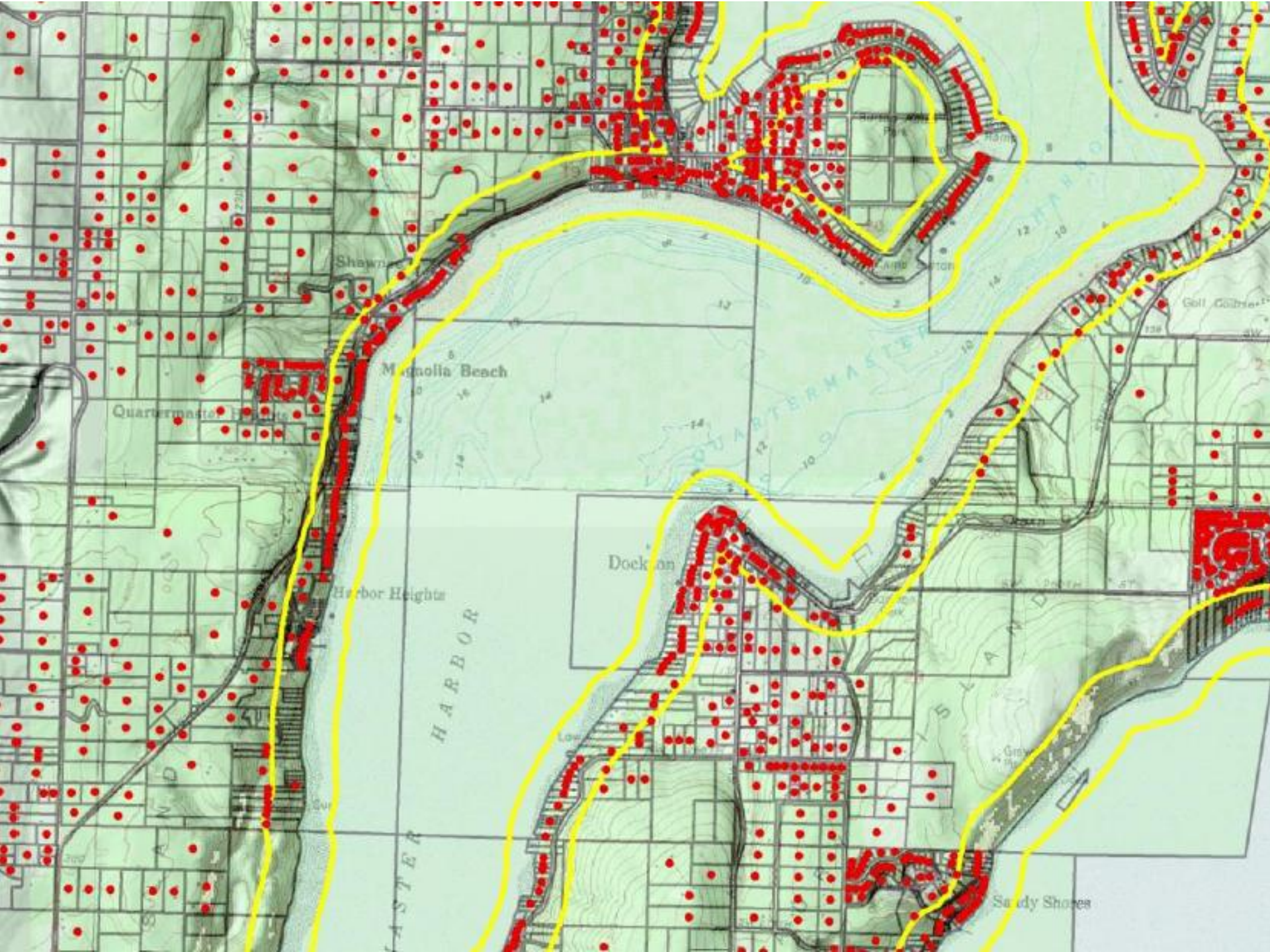
Monitored Watersheds

Septics in Unmonitored Areas



Unmonitored Watersheds


Legend
Wastewater Service Area
Monitored Basins
Parcel Centroid
Cedar-Sammamish
Kitsap
Duwamish-Green
Kennedy-Goldsborough
Chambers-Clover
Puyallup-White
Deschutes


Magnolia Beach
Quartermaster Heights
Harbor Heights
HARBOR
Dockton
Sandy Shores
Golf Course

Septics in Unmonitored Areas

Assumptions	
People	203,000 people
Wastewater generation	69 gallons/capita
DIN effluent concentration (to drain field)	31 mg/L
Attenuation (loss)	10% (less than 150 m from shoreline) 70% (more than 150 m from shoreline)

Septics in Unmonitored Areas

People

- 2008 Tax parcel information
- 2000 Census
- 81,000 residential equivalents
- 203,000 people

Septics in Unmonitored Areas

Wastewater Generation

- 40-80 gal/day: literature analysis:
- 93 gal/day: Ecology calculation based on summer WWTP inflows:
- 69 gal/day: indoor residential water use

Septics in Unmonitored Areas

DIN Effluent Concentration

- 35-80 mg/L TN WWTP influent
- 25-60 mg/L TN onsite effluent
- 65% of TN is inorganic
- 31 mg/L DIN extensive study of onsite effluent

Septics in Unmonitored Areas

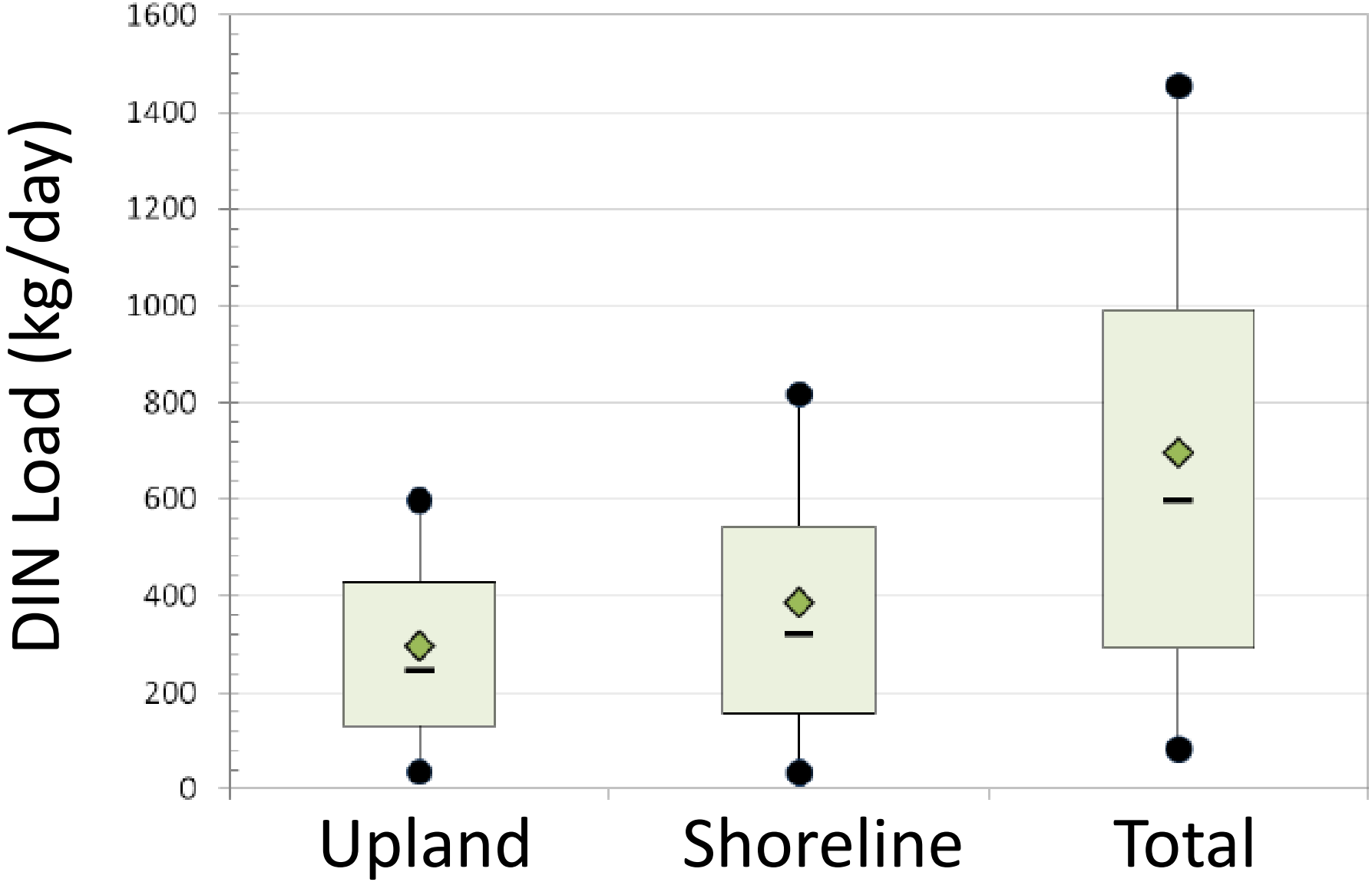
Attenuation

- 10% for shoreline <150 m(Hood Canal)
- 70% (43-88%) Ecology analysis of sub-watersheds in summer for upland (>150 m)

Septics in Unmonitored Areas

	DIN Load
Less than 150 meters from shore	290 kg/day
More than 150 meters from shore	396 kg/day
Total	686 kg/day

Septics in Unmonitored Areas



Septics in Unmonitored Areas

	Load (DIN)
Septics in Unmonitored Areas	686 kg/day
Monitored Rivers (2007)	8,859 kg/day
Unmonitored Areas - Extrapolated	2,722 kg/day
Entire Watershed	11,580 kg/day
WWTPs	27,326 kg/day

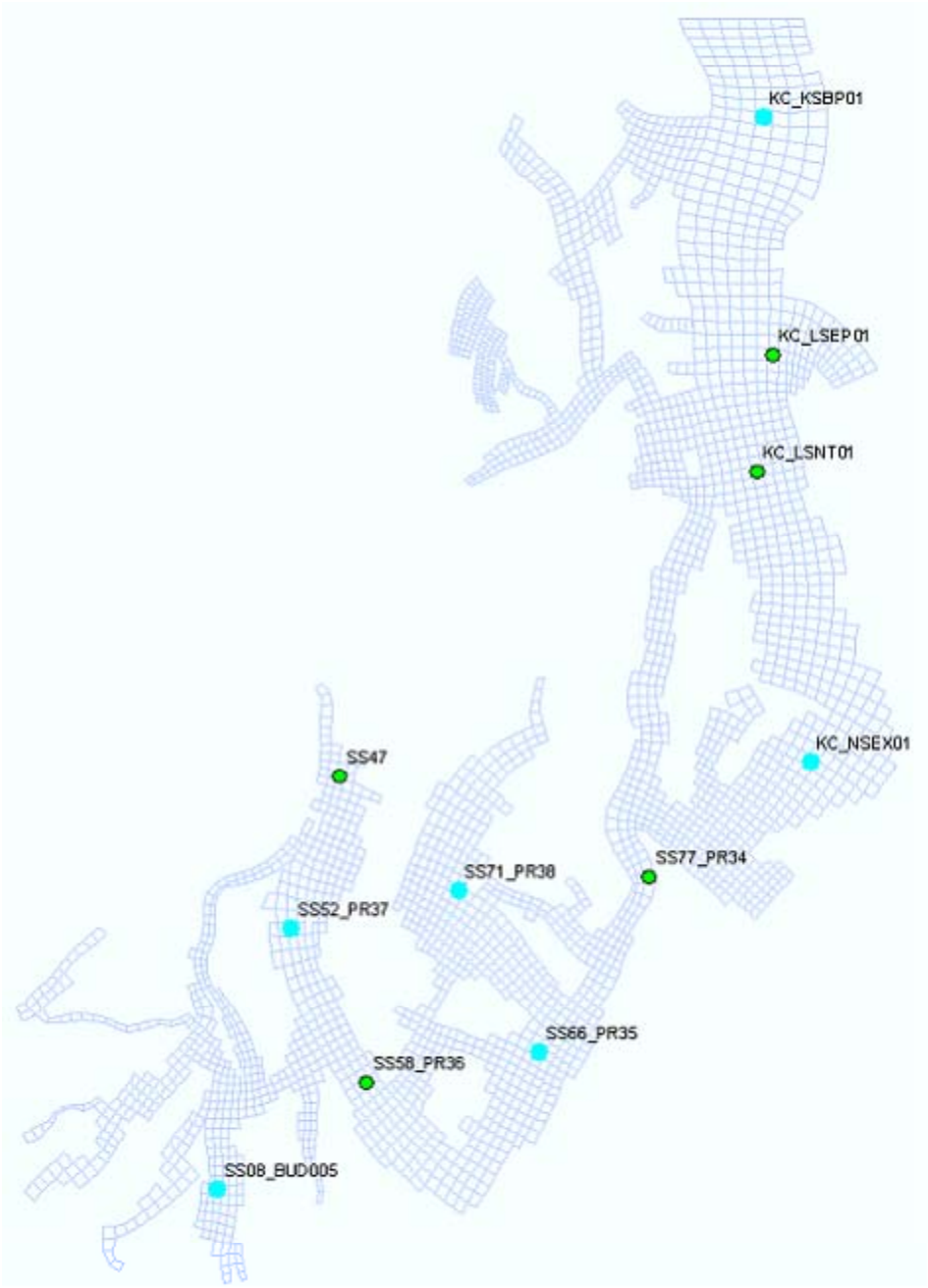
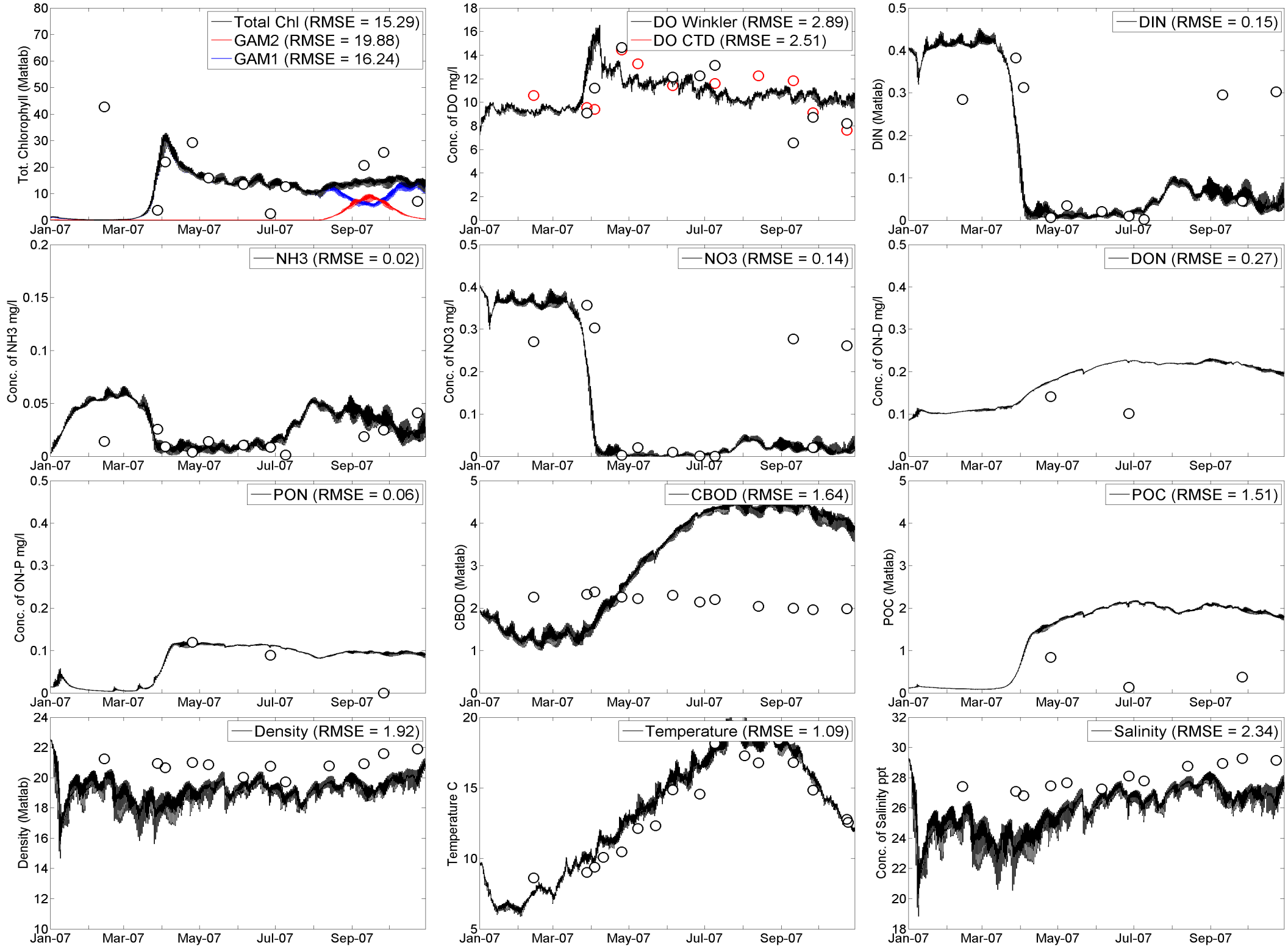
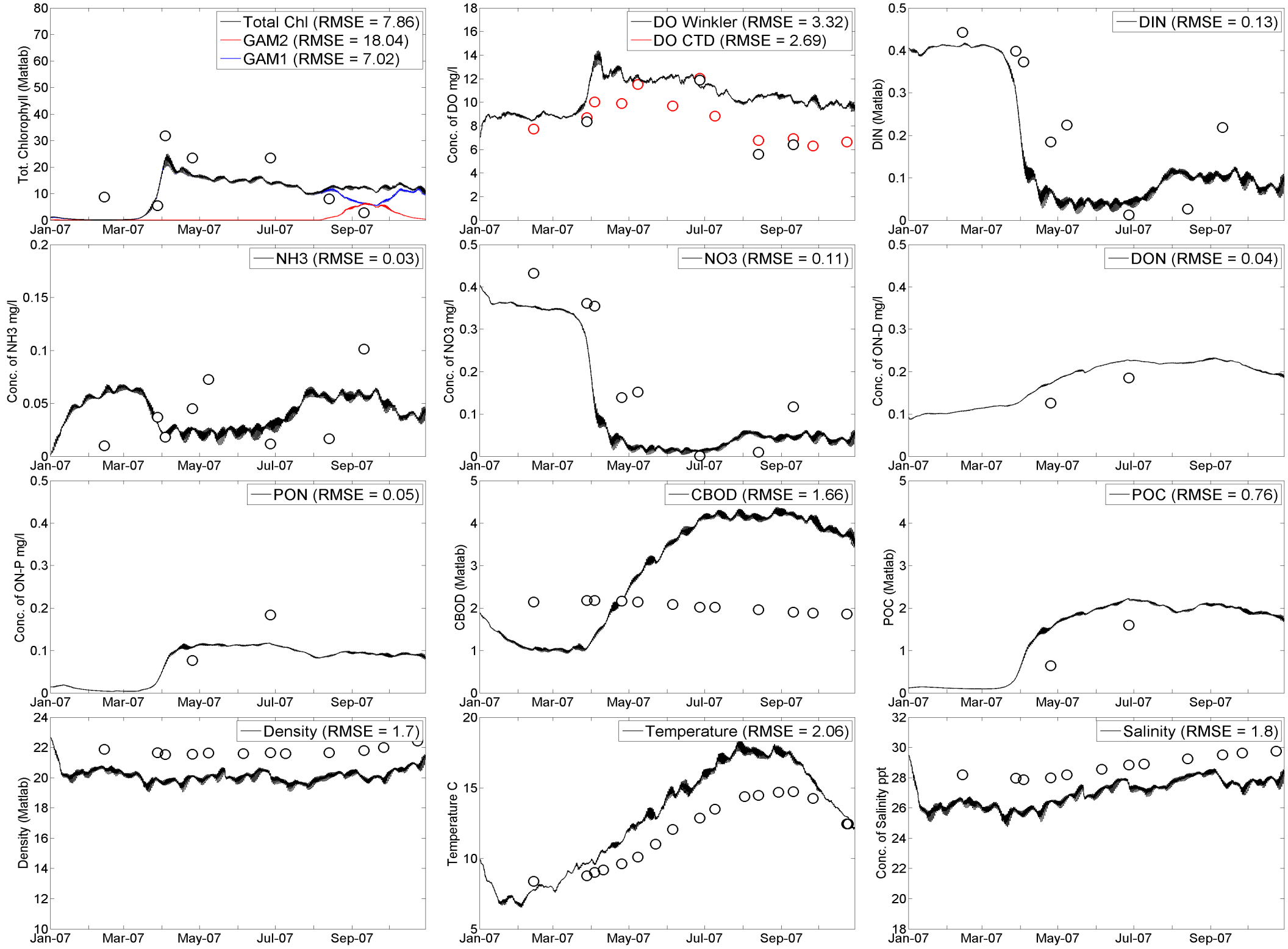
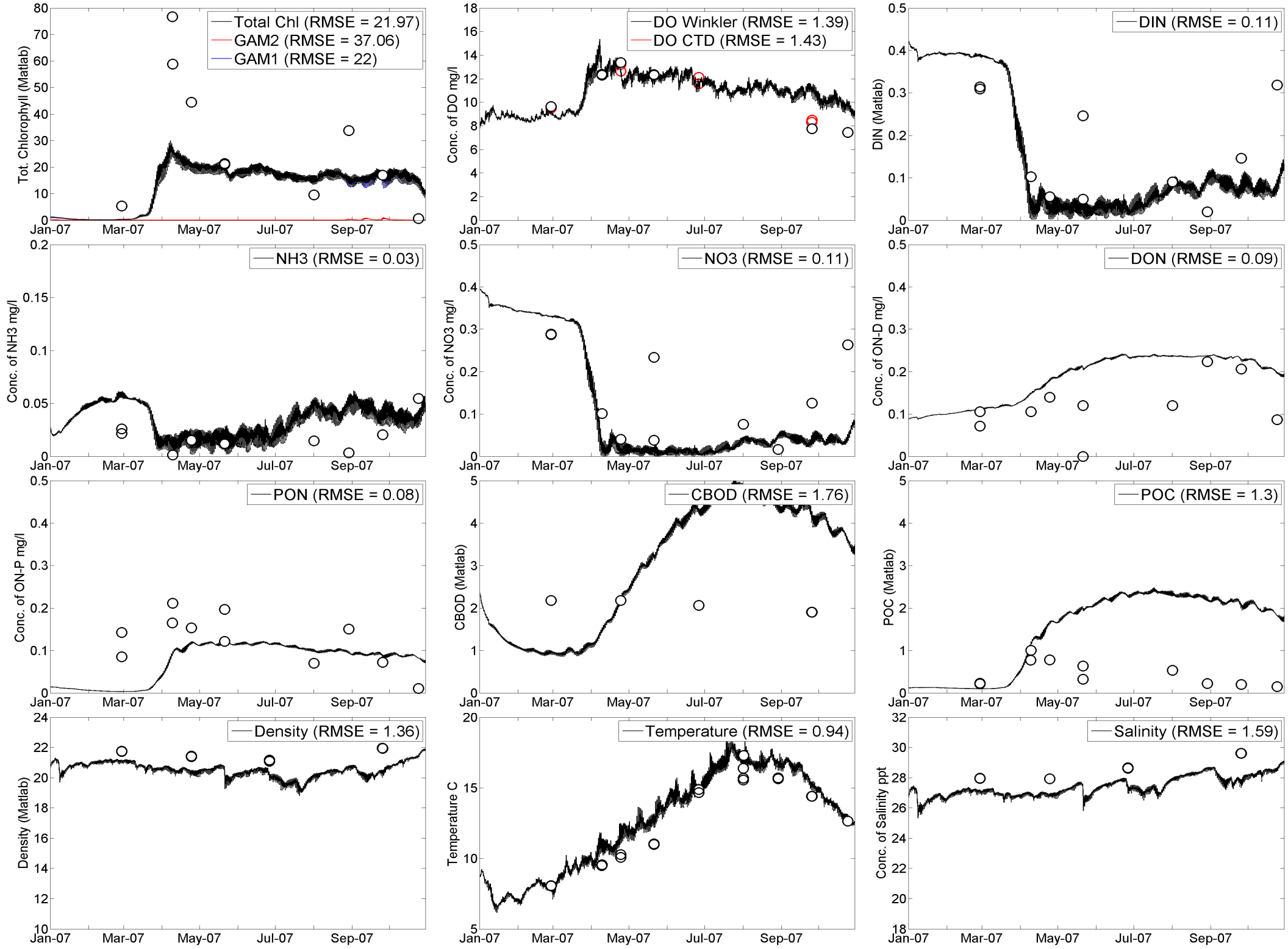
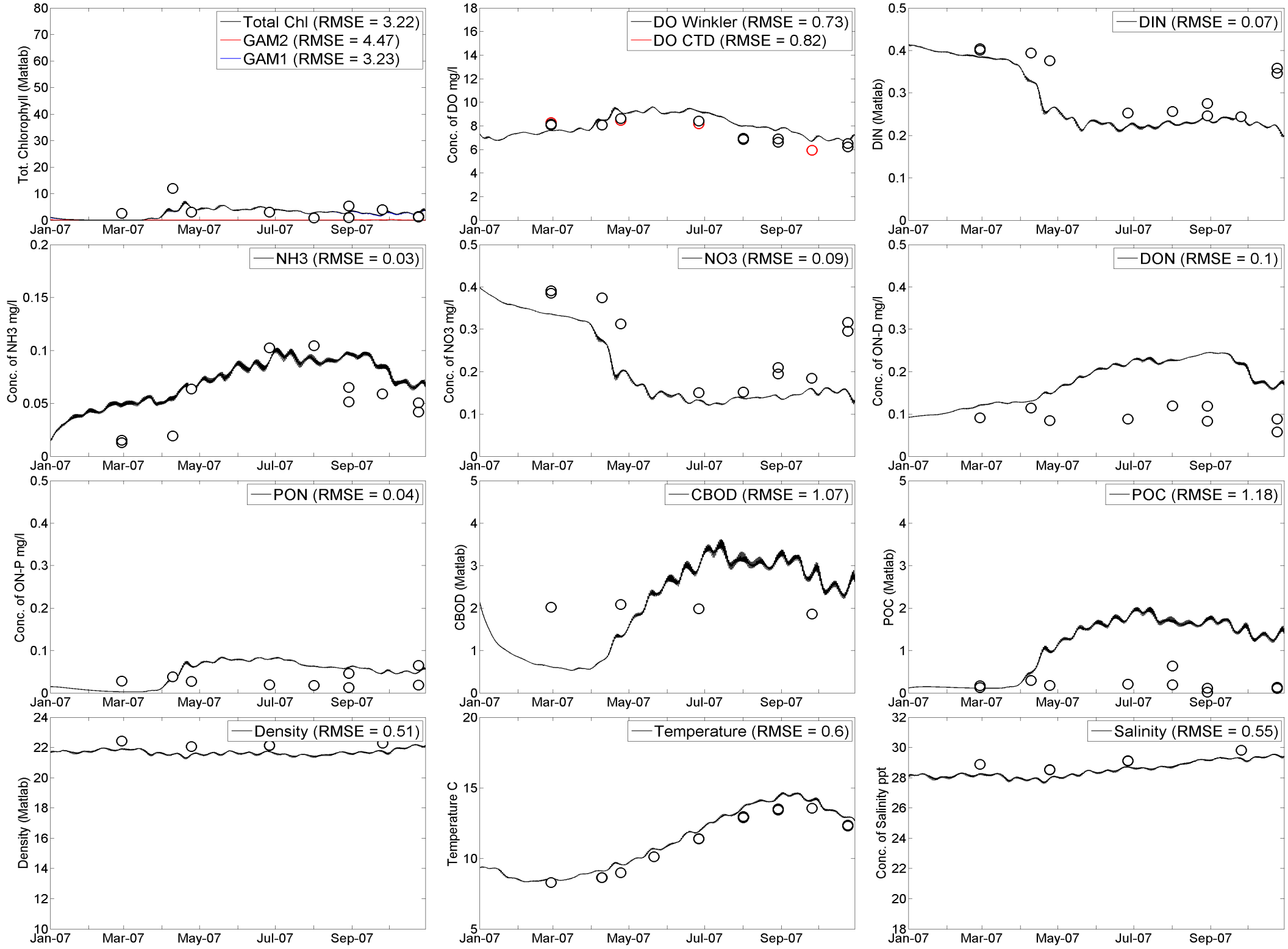


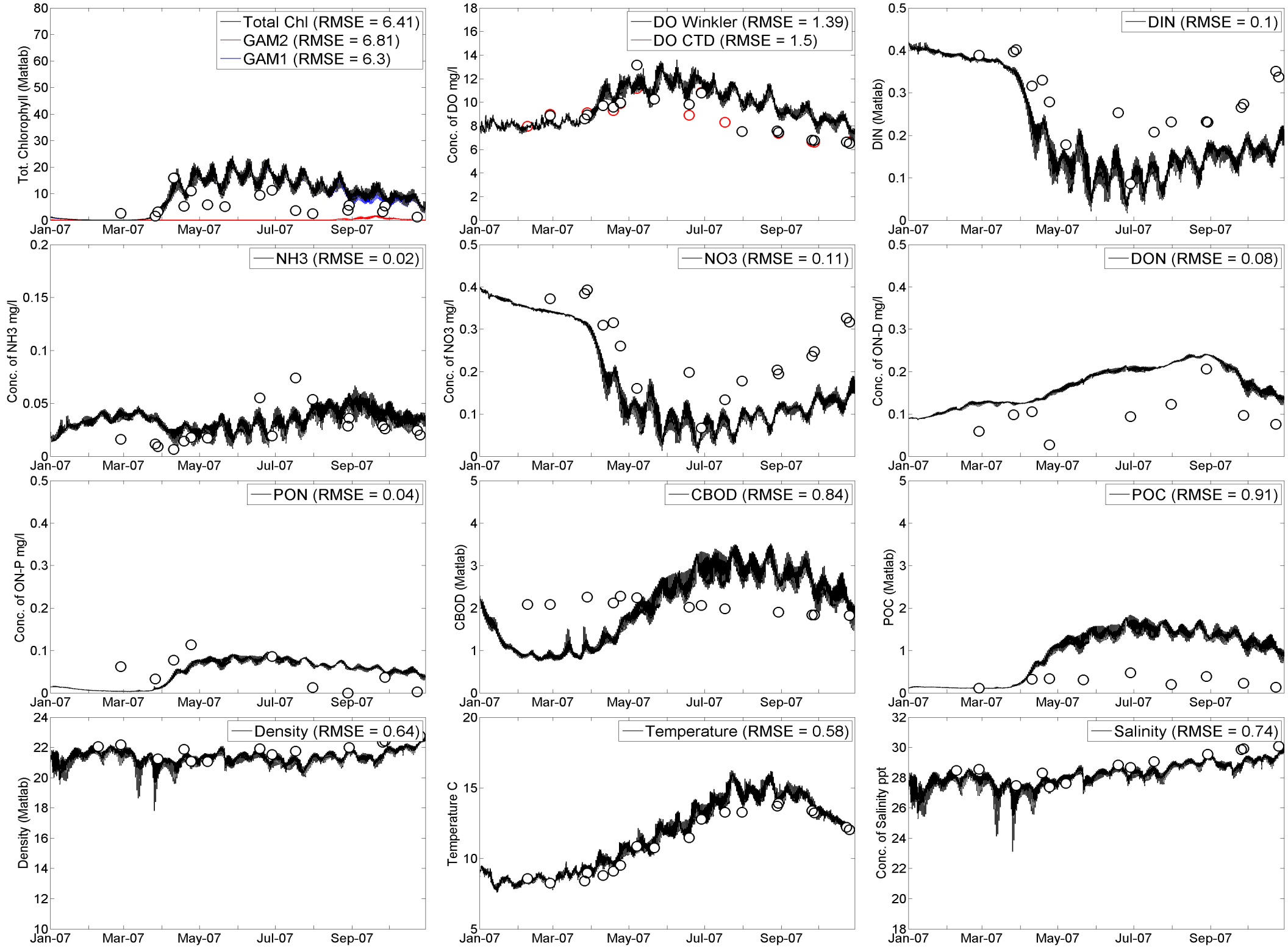
Figure 1. Selected highest priority stations for calibration.

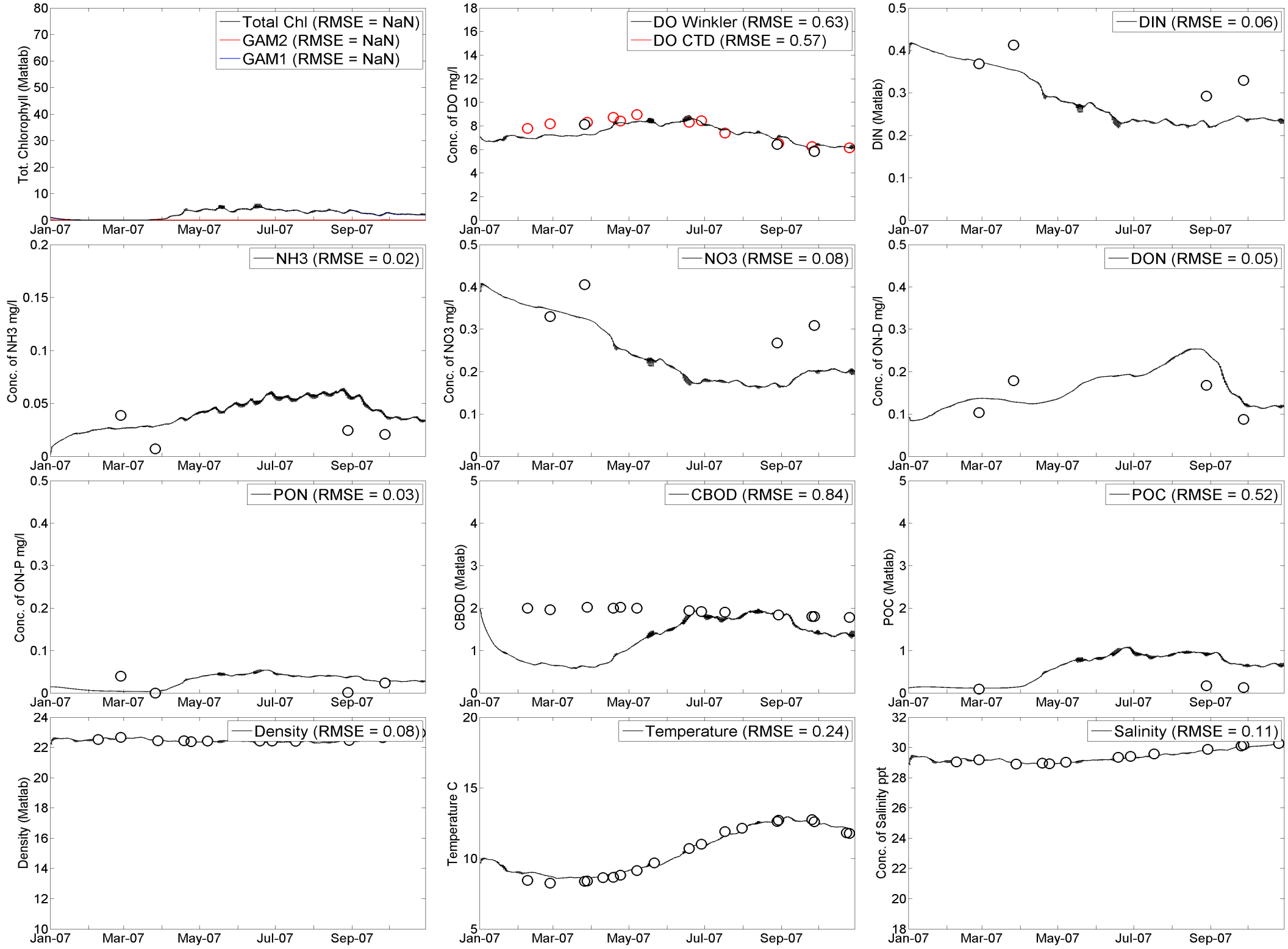

Total Chl (RMSE = 15.29)
GAM2 (RMSE = 19.88)
GAM1 (RMSE = 16.24)
Tot. Chlorophyll (Matlab)
DO Winkler (RMSE = 2.89)
DO CTD (RMSE = 2.51)
Conc. of DO mg/l
DIN (RMSE = 0.15)
DIN (Matlab)
NH3 (RMSE = 0.02)
Conc. of NH3 mg/l
NO3 (RMSE = 0.14)
Conc. of NO3 mg/l
DON (RMSE = 0.27)
Conc. of ON-D mg/l
PON (RMSE = 0.06)
Conc. of ON-P mg/l
CBOD (RMSE = 1.64)
CBOD (Matlab)
POC (RMSE = 1.51)
POC (Matlab)
Density (RMSE = 1.92)
Density (Matlab)
Temperature (RMSE = 1.09)
Temperature C
Salinity (RMSE = 2.34)
Conc. of Salinity ppt
Jan-07
Mar-07
May-07
Jul-07
Sep-07

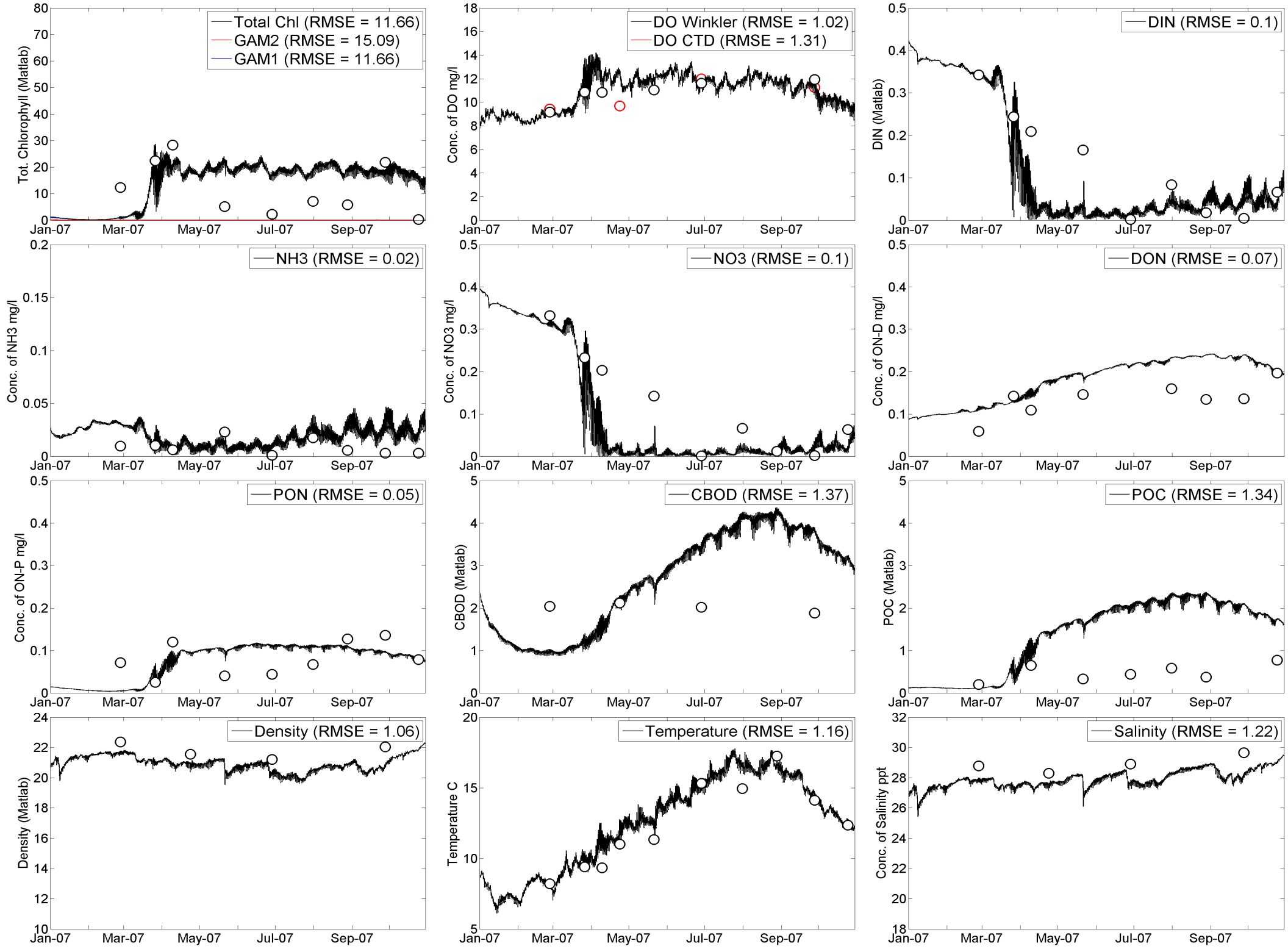

Total Chl (RMSE = 7.86)
GAM2 (RMSE = 18.04)
GAM1 (RMSE = 7.02)
Tot. Chlorophyll (Matlab)
DO Winkler (RMSE = 3.32)
DO CTD (RMSE = 2.69)
Conc. of DO mg/l
DIN (RMSE = 0.13)
DIN (Matlab)
NH3 (RMSE = 0.03)
Conc. of NH3 mg/l
NO3 (RMSE = 0.11)
Conc. of NO3 mg/l
DON (RMSE = 0.04)
Conc. of ON-D mg/l
PON (RMSE = 0.05)
Conc. of ON-P mg/l
CBOD (RMSE = 1.66)
CBOD (Matlab)
POC (RMSE = 0.76)
POC (Matlab)
Density (RMSE = 1.7)
Density (Matlab)
Temperature (RMSE = 2.06)
Temperature C
Salinity (RMSE = 1.8)
Conc. of Salinity ppt
Jan-07
Mar-07
May-07
Jul-07
Sep-07

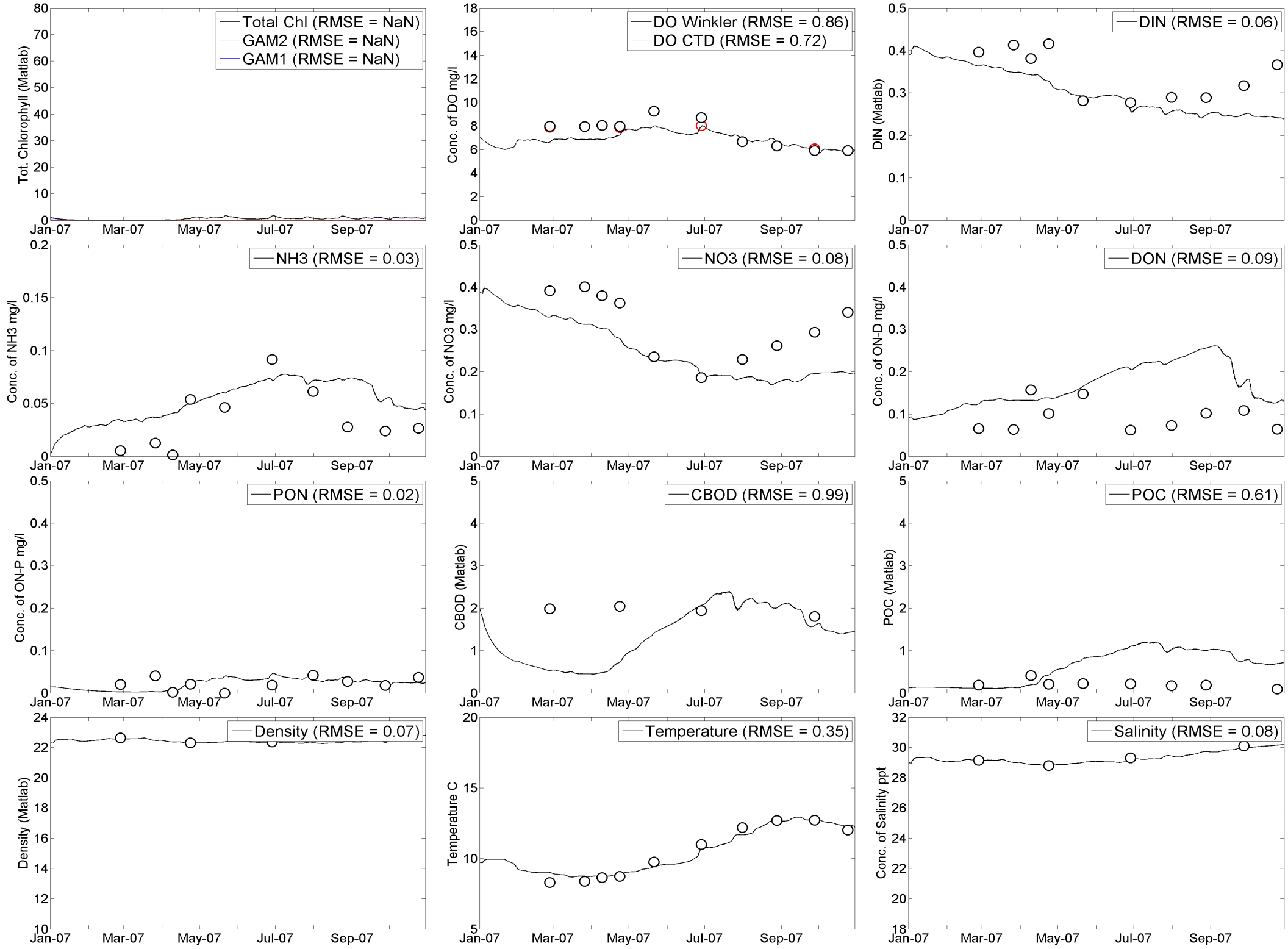

Total Chl (RMSE = 21.97)
GAM2 (RMSE = 37.06)
GAM1 (RMSE = 22)
Tot. Chlorophyll (Matlab)
DO Winkler (RMSE = 1.39)
DO CTD (RMSE = 1.43)
Conc. of DO mg/l
DIN (RMSE = 0.11)
DIN (Matlab)
NH3 (RMSE = 0.03)
Conc. of NH3 mg/l
NO3 (RMSE = 0.11)
Conc. of NO3 mg/l
DON (RMSE = 0.09)
Conc. of ON-D mg/l
PON (RMSE = 0.08)
Conc. of ON-P mg/l
CBOD (RMSE = 1.76)
CBOD (Matlab)
POC (RMSE = 1.3)
POC (Matlab)
Density (RMSE = 1.36)
Density (Matlab)
Temperature (RMSE = 0.94)
Temperature C
Salinity (RMSE = 1.59)
Conc. of Salinity ppt
Jan-07
Mar-07
May-07
Jul-07
Sep-07

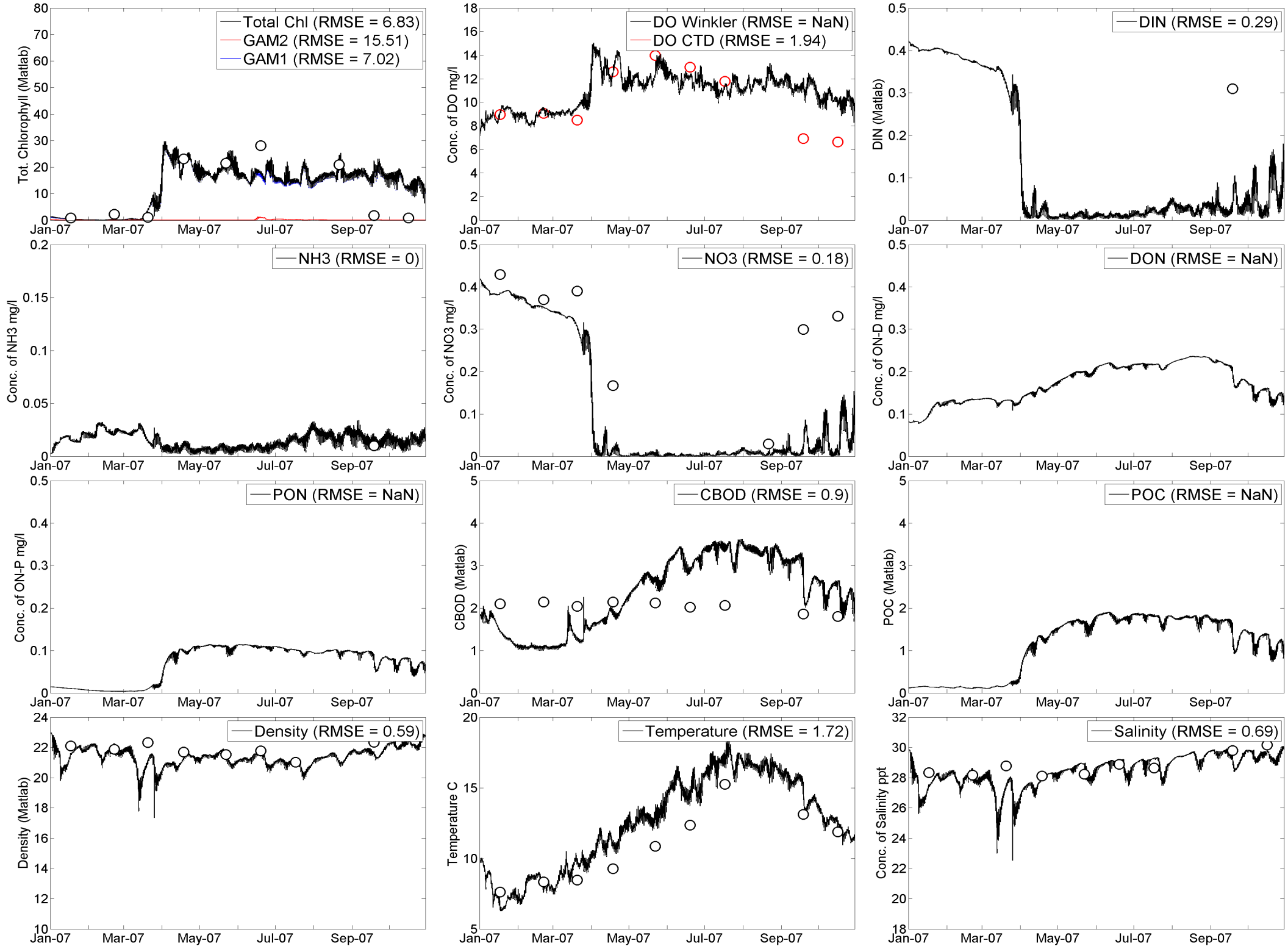

Total Chl (RMSE = 3.22)
GAM2 (RMSE = 4.47)
GAM1 (RMSE = 3.23)
Tot. Chlorophyll (Matlab)
DO Winkler (RMSE = 0.73)
DO CTD (RMSE = 0.82)
Conc. of DO mg/l
DIN (RMSE = 0.07)
DIN (Matlab)
NH3 (RMSE = 0.03)
Conc. of NH3 mg/l
NO3 (RMSE = 0.09)
Conc. of NO3 mg/l
DON (RMSE = 0.1)
Conc. of ON-D mg/l
PON (RMSE = 0.04)
Conc. of ON-P mg/l
CBOD (RMSE = 1.07)
CBOD (Matlab)
POC (RMSE = 1.18)
POC (Matlab)
Density (RMSE = 0.51)
Density (Matlab)
Temperature (RMSE = 0.6)
Temperature C
Salinity (RMSE = 0.55)
Conc. of Salinity ppt
Jan-07
Mar-07
May-07
Jul-07
Sep-07

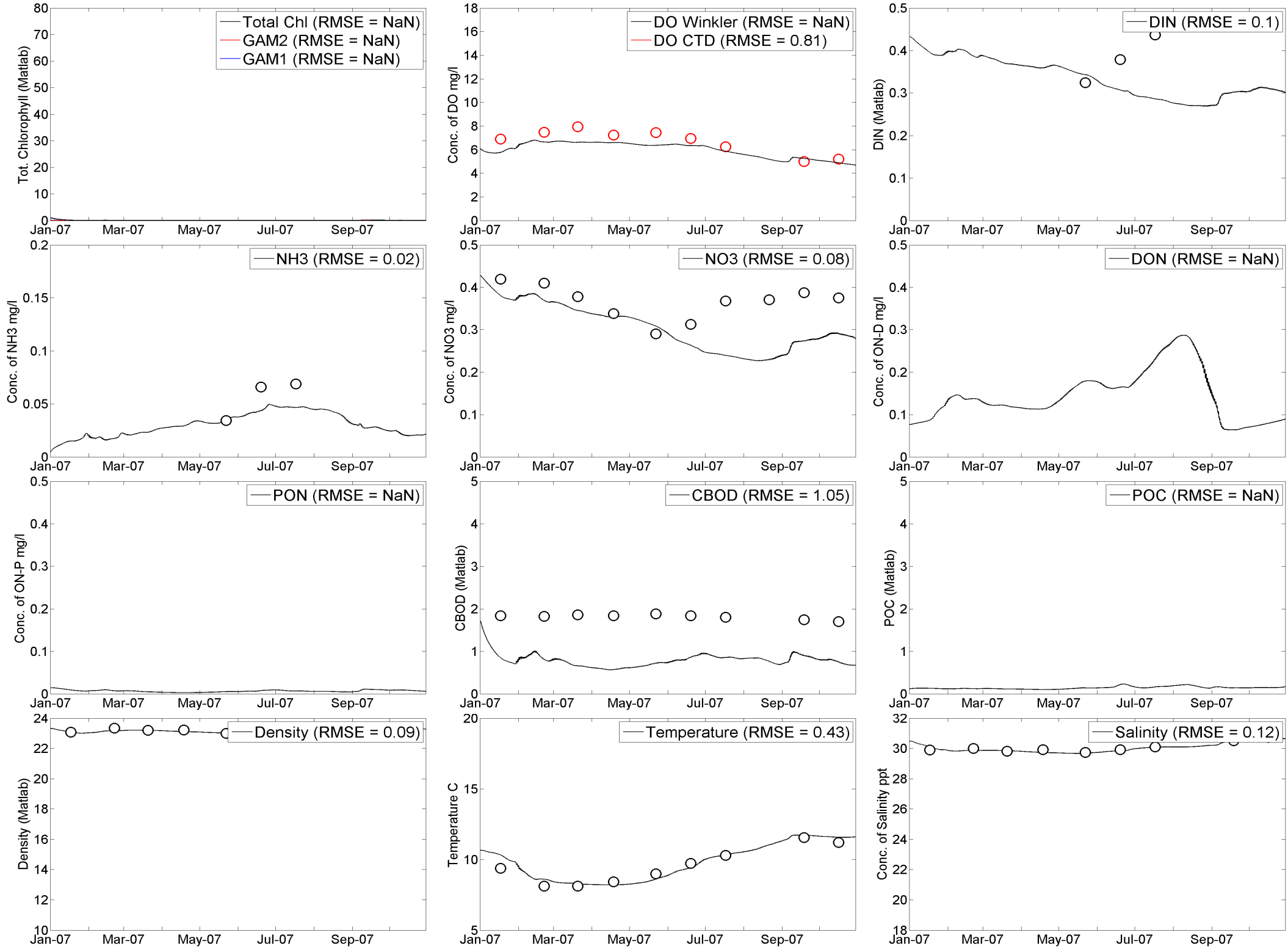

Total Chl (RMSE = 6.41)
GAM2 (RMSE = 6.81)
GAM1 (RMSE = 6.3)
Tot. Chlorophyll (Matlab)
DO Winkler (RMSE = 1.39)
DO CTD (RMSE = 1.5)
Conc. of DO mg/l
DIN (RMSE = 0.1)
DIN (Matlab)
NH3 (RMSE = 0.02)
Conc. of NH3 mg/l
NO3 (RMSE = 0.11)
Conc. of NO3 mg/l
DON (RMSE = 0.08)
Conc. of ON-D mg/l
PON (RMSE = 0.04)
Conc. of ON-P mg/l
CBOD (RMSE = 0.84)
CBOD (Matlab)
POC (RMSE = 0.91)
POC (Matlab)
Density (RMSE = 0.64)
Density (Matlab)
Temperature (RMSE = 0.58)
Temperature C
Salinity (RMSE = 0.74)
Conc. of Salinity ppt
Jan-07
Mar-07
May-07
Jul-07
Sep-07

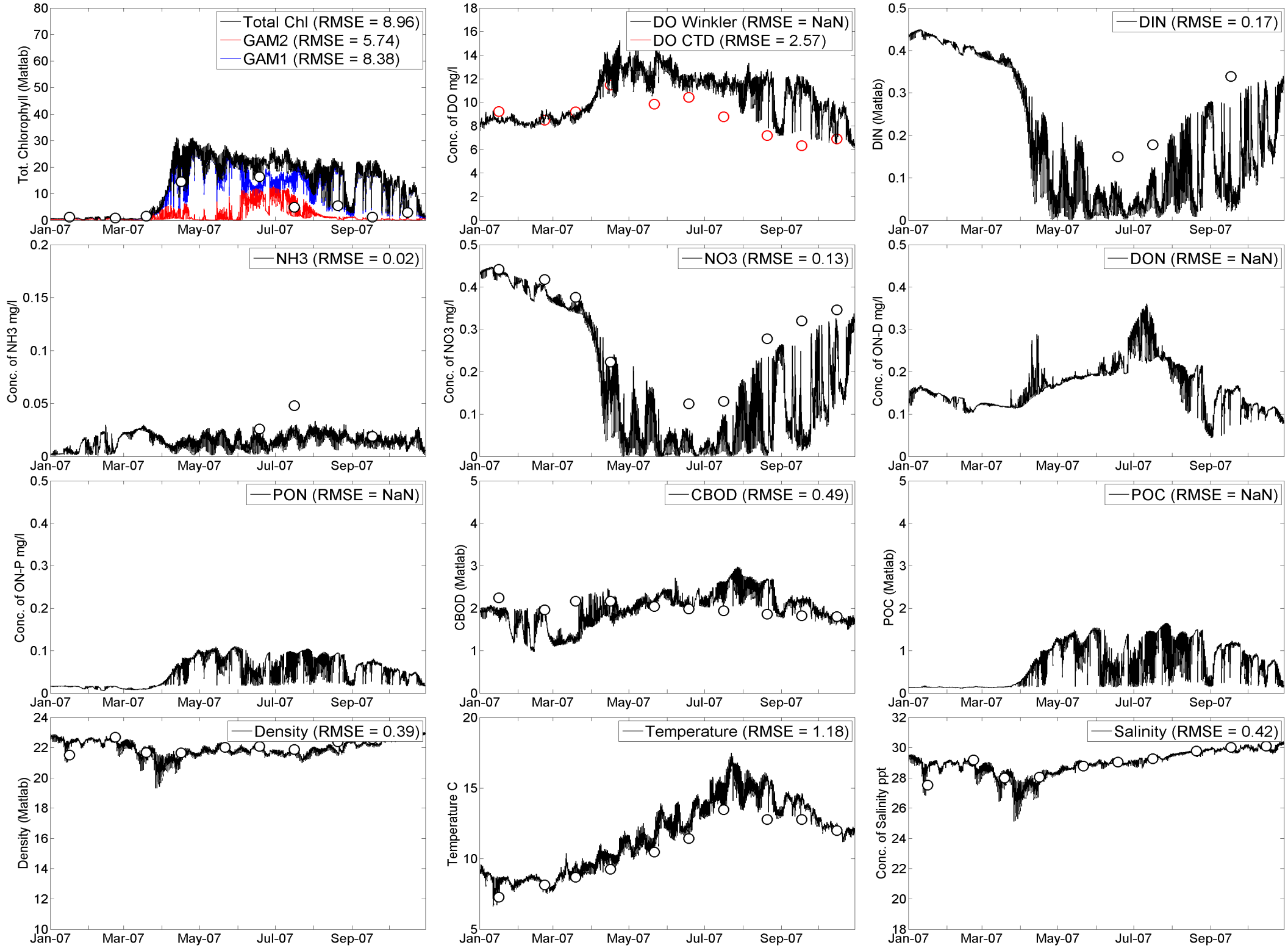

Total Chl (RMSE = NaN)
GAM2 (RMSE = NaN)
GAM1 (RMSE = NaN)
Tot. Chlorophyll (Matlab)
DO Winkler (RMSE = 0.63)
DO CTD (RMSE = 0.57)
Conc. of DO mg/l
DIN (RMSE = 0.06)
DIN (Matlab)
NH3 (RMSE = 0.02)
Conc. of NH3 mg/l
NO3 (RMSE = 0.08)
Conc. of NO3 mg/l
DON (RMSE = 0.05)
Conc. of ON-D mg/l
PON (RMSE = 0.03)
Conc. of ON-P mg/l
CBOD (RMSE = 0.84)
CBOD (Matlab)
POC (RMSE = 0.52)
POC (Matlab)
Density (RMSE = 0.08)
Density (Matlab)
Temperature (RMSE = 0.24)
Temperature C
Salinity (RMSE = 0.11)
Conc. of Salinity ppt
Jan-07
Mar-07
May-07
Jul-07
Sep-07

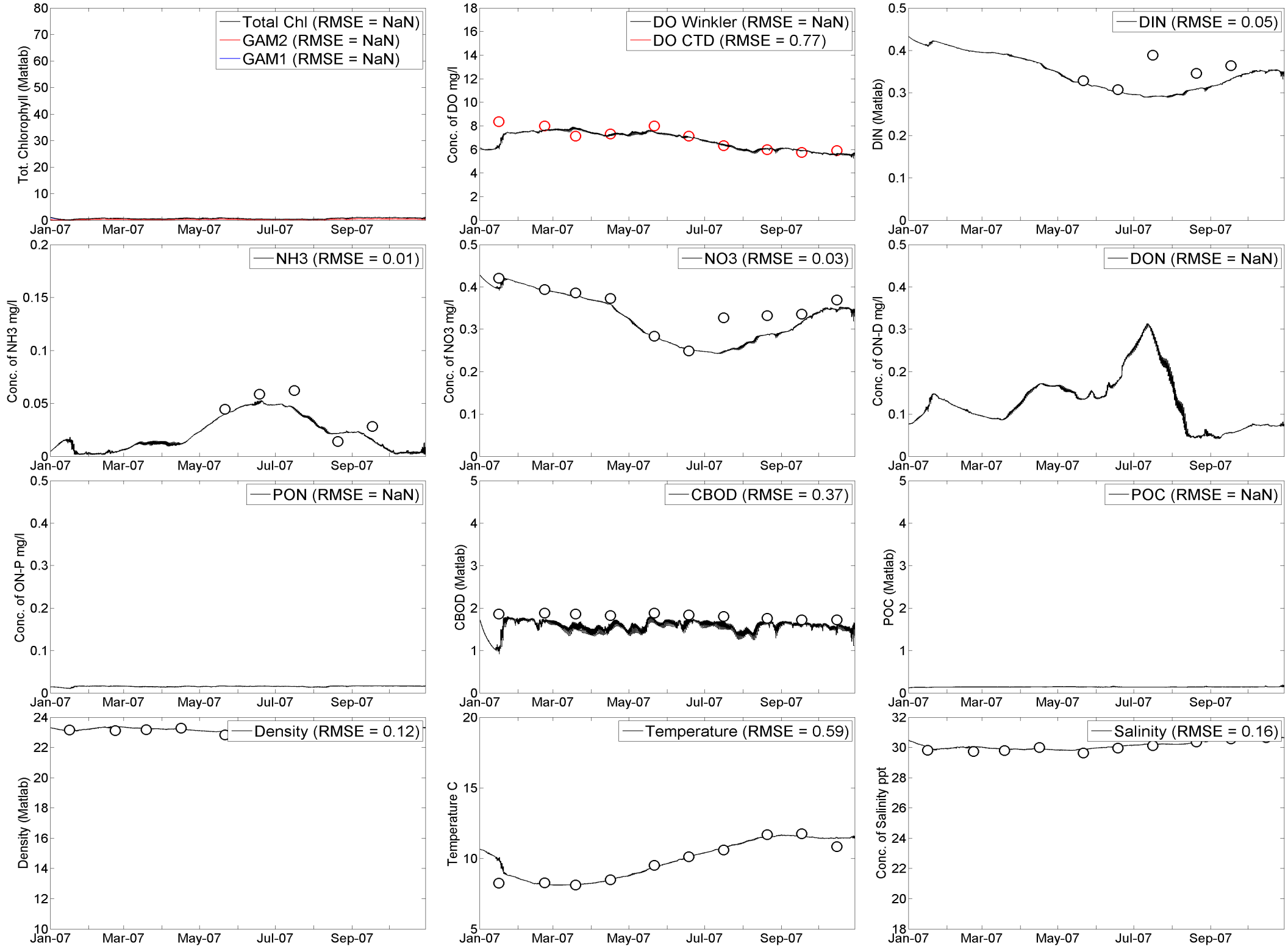

Total Chl (RMSE = 11.66)
GAM2 (RMSE = 15.09)
GAM1 (RMSE = 11.66)
Tot. Chlorophyll (Matlab)
DO Winkler (RMSE = 1.02)
DO CTD (RMSE = 1.31)
Conc. of DO mg/l
DIN (RMSE = 0.1)
DIN (Matlab)
NH3 (RMSE = 0.02)
Conc. of NH3 mg/l
NO3 (RMSE = 0.1)
Conc. of NO3 mg/l
DON (RMSE = 0.07)
Conc. of ON-D mg/l
PON (RMSE = 0.05)
Conc. of ON-P mg/l
CBOD (RMSE = 1.37)
CBOD (Matlab)
POC (RMSE = 1.34)
POC (Matlab)
Density (RMSE = 1.06)
Density (Matlab)
Temperature (RMSE = 1.16)
Temperature C
Salinity (RMSE = 1.22)
Conc. of Salinity ppt
Jan-07
Mar-07
May-07
Jul-07
Sep-07


Total Chl (RMSE = NaN)
GAM2 (RMSE = NaN)
GAM1 (RMSE = NaN)
Tot. Chlorophyll (Matlab)
DO Winkler (RMSE = 0.86)
DO CTD (RMSE = 0.72)
Conc. of DO mg/l
DIN (RMSE = 0.06)
DIN (Matlab)
NH3 (RMSE = 0.03)
Conc. of NH3 mg/l
NO3 (RMSE = 0.08)
Conc. of NO3 mg/l
DON (RMSE = 0.09)
Conc. of ON-D mg/l
PON (RMSE = 0.02)
Conc. of ON-P mg/l
CBOD (RMSE = 0.99)
CBOD (Matlab)
POC (RMSE = 0.61)
POC (Matlab)
Density (RMSE = 0.07)
Density (Matlab)
Temperature (RMSE = 0.35)
Temperature C
Salinity (RMSE = 0.08)
Conc. of Salinity ppt
Jan-07
Mar-07
May-07
Jul-07
Sep-07


Total Chl (RMSE = 6.83)
GAM2 (RMSE = 15.51)
GAM1 (RMSE = 7.02)
Tot. Chlorophyll (Matlab)
DO Winkler (RMSE = NaN)
DO CTD (RMSE = 1.94)
Conc. of DO mg/l
DIN (RMSE = 0.29)
DIN (Matlab)
NH3 (RMSE = 0)
Conc. of NH3 mg/l
NO3 (RMSE = 0.18)
Conc. of NO3 mg/l
DON (RMSE = NaN)
Conc. of ON-D mg/l
PON (RMSE = NaN)
Conc. of ON-P mg/l
CBOD (RMSE = 0.9)
CBOD (Matlab)
POC (RMSE = NaN)
POC (Matlab)
Density (RMSE = 0.59)
Density (Matlab)
Temperature (RMSE = 1.72)
Temperature C
Salinity (RMSE = 0.69)
Conc. of Salinity ppt
Jan-07
Mar-07
May-07
Jul-07
Sep-07


Total Chl (RMSE = NaN)
GAM2 (RMSE = NaN)
GAM1 (RMSE = NaN)
Tot. Chlorophyll (Matlab)
DO Winkler (RMSE = NaN)
DO CTD (RMSE = 0.81)
Conc. of DO mg/l
DIN (RMSE = 0.1)
DIN (Matlab)
NH3 (RMSE = 0.02)
Conc. of NH3 mg/l
NO3 (RMSE = 0.08)
Conc. of NO3 mg/l
DON (RMSE = NaN)
Conc. of ON-D mg/l
PON (RMSE = NaN)
Conc. of ON-P mg/l
CBOD (RMSE = 1.05)
CBOD (Matlab)
POC (RMSE = NaN)
POC (Matlab)
Density (RMSE = 0.09)
Density (Matlab)
Temperature (RMSE = 0.43)
Temperature C
Salinity (RMSE = 0.12)
Conc. of Salinity ppt
Jan-07
Mar-07
May-07
Jul-07
Sep-07


Total Chl (RMSE = 8.96)
GAM2 (RMSE = 5.74)
GAM1 (RMSE = 8.38)
Tot. Chlorophyll (Matlab)
DO Winkler (RMSE = NaN)
DO CTD (RMSE = 2.57)
Conc. of DO mg/l
DIN (RMSE = 0.17)
DIN (Matlab)
NH3 (RMSE = 0.02)
Conc. of NH3 mg/l
NO3 (RMSE = 0.13)
Conc. of NO3 mg/l
DON (RMSE = NaN)
Conc. of ON-D mg/l
PON (RMSE = NaN)
Conc. of ON-P mg/l
CBOD (RMSE = 0.49)
CBOD (Matlab)
POC (RMSE = NaN)
POC (Matlab)
Density (RMSE = 0.39)
Density (Matlab)
Temperature (RMSE = 1.18)
Temperature C
Salinity (RMSE = 0.42)
Conc. of Salinity ppt
Jan-07
Mar-07
May-07
Jul-07
Sep-07


Total Chl (RMSE = NaN)
GAM2 (RMSE = NaN)
GAM1 (RMSE = NaN)
Tot. Chlorophyll (Matlab)
DO Winkler (RMSE = NaN)
DO CTD (RMSE = 0.77)
Conc. of DO mg/l
DIN (RMSE = 0.05)
DIN (Matlab)
NH3 (RMSE = 0.01)
Conc. of NH3 mg/l
NO3 (RMSE = 0.03)
Conc. of NO3 mg/l
DON (RMSE = NaN)
Conc. of ON-D mg/l
PON (RMSE = NaN)
Conc. of ON-P mg/l
CBOD (RMSE = 0.37)
CBOD (Matlab)
POC (RMSE = NaN)
POC (Matlab)
Density (RMSE = 0.12)
Density (Matlab)
Temperature (RMSE = 0.59)
Temperature C
Salinity (RMSE = 0.16)
Conc. of Salinity ppt
Jan-07
Mar-07
May-07
Jul-07
Sep-07