Appendix D. Miscellaneous

This appendix contains model skill statistics and formulas, observational data sources and maps showing their locations, a guide on how to understand time-depth plots, methods used to transfer Salish Sea Model predictions to the 303(d) assessment units, and updates to reference conditions.

ADA Accessibility

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[1] https://ecology.wa.gov/about-us/accessibility-equity/accessibility

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Skill Statistics Used for Evaluation of Model Predictions

Willmott Skill Score $(WSS) = 1 - \frac{\sum\ (\ Predicted - Obs\ )^2}{\sum(\ |\ Predicted - \ \overline{Predicted}\ |\ +\ |\ Obs - \ \overline{Obs}\ |)^2}$

Root Mean Square Error $(RMSE) = \sqrt{\frac{1}{N}\sum(Predicted - Obs)^2}$

Relative Error $(RE) = \frac{\sum\ |Obs - Predicted|}{\sum Obs}$

Mean Absolute Error $(MAE) = \frac{\sum\ |\ Predicted - Obs\ |}{N}$

$$R\ = \frac{\sum(Predicted - \ \overline{Predicted})(Obs - \ \overline{Obs}\ )}{\sqrt{\sum(Predicted - \ \overline{Predicted})^2\ \sum(Obs - \ \overline{Obs}\ )^2}}$$

Centered Root Mean Squared Error $(RMSEc) = \sqrt{\frac{1}{N}\sum\left(\left(Predicted - \ \overline{Predicted}\right) - \left(Obs - \ \overline{Obs}\right)\right)^2}$

Centered NRMSE also known as unbiased NRMSE $(NRMSEc\ or\ uRMSE)$

$$= \frac{\sqrt{\frac{1}{N}\sum(\ (Predicted - \ \overline{Predicted}) - (Obs - \overline{Obs})\ )^2}}{sd_{obs}}$$

Normalized Bias $(NBias)\ = \frac{\text{Mean(Predicted)} - \text{Mean(Obs)}}{\text{sd}_{\text{obs}}}$

$$\text{Normalized RMSE } (NRMSE) = \frac{\sqrt{\frac{1}{N}\sum(Predicted - Obs)^2}}{sd_{obs}} = \sqrt{\text{NBias}^2 + \text{NRMSE}c^2}$$

$$\text{Reliability Index } (RI) = e^{\sqrt{\frac{1}{N}\sum log\left(\frac{Obs}{Predicted}\right)^2}}$$

$$\text{Model Efficiency } (MEF) = \frac{\sum(Obs - \overline{Obs})^2 - \sum(Predicted - \overline{Predicted})^2}{\sum(Obs - \overline{Obs})^2}$$

$$\text{Normalized SD } (Nsd) = \frac{\text{sd}_{\text{pred}}}{\text{sd}_{\text{obs}}}$$

Data Sources Used to Test Model Calibration

Sources of marine observational data include Ecology, King County, National Oceanic and Atmospheric Administration (NOAA) and the University of Washington (UW) as listed in Table D-1.

Table D-1. Data sources used to test model calibration.

Data Source	Data URL/Contact	Entities	Data Type
EIM	http://ecyeim/search/Default.aspx	Ecology MMU	CTD/Lab
King County	https://green2.kingcounty.gov/marine/Monitoring/OffshoreCTD	King County	CTD
King County	https://data.kingcounty.gov/Environment-Waste-Management/Water-Quality/vwmt-pvjw/about_data	King County	Lab
NANOOS	https://nvs.nanoos.org/CruiseSalish	NOAA/UW	CTD/Lab
WOAC	Received from Simone Alin (simone.r.alin@noaa.gov) and Jan Newton (janewton@uw.edu)	NOAA/UW	Lab

EIM = Environmental Information Management database
MMU = Marine Monitoring Unit
NANOOS = Northwest Association of Networked Ocean Observing Systems
WOAC = Washington State Ocean Acidification Center

Figures D-1 through D-3 show the location of Ecology's observational stations, and Table D-2 shows the data available for these stations.

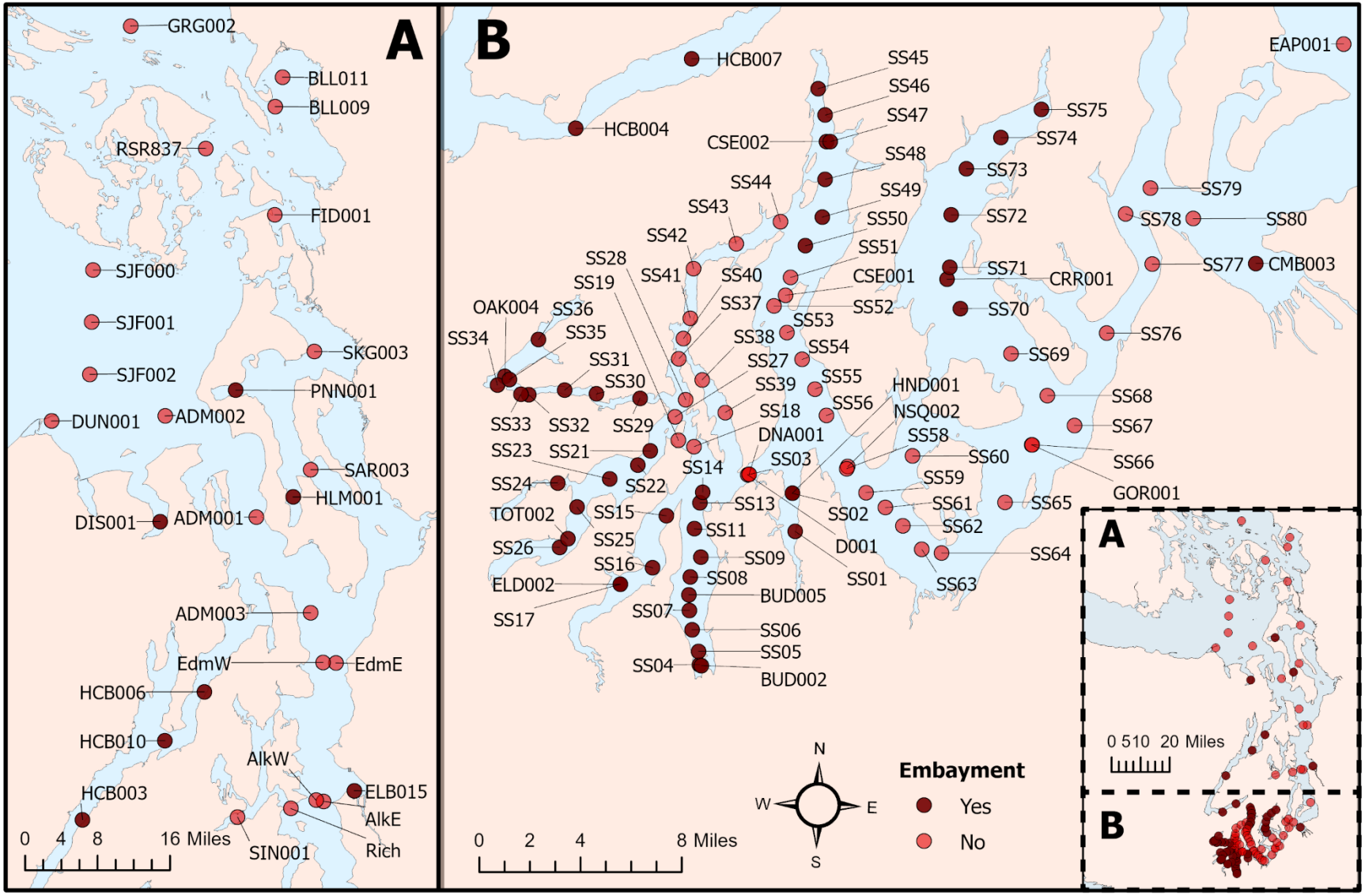

Figure D-1. Marine station locations: Ecology long-term monitoring and South Sound Study stations.

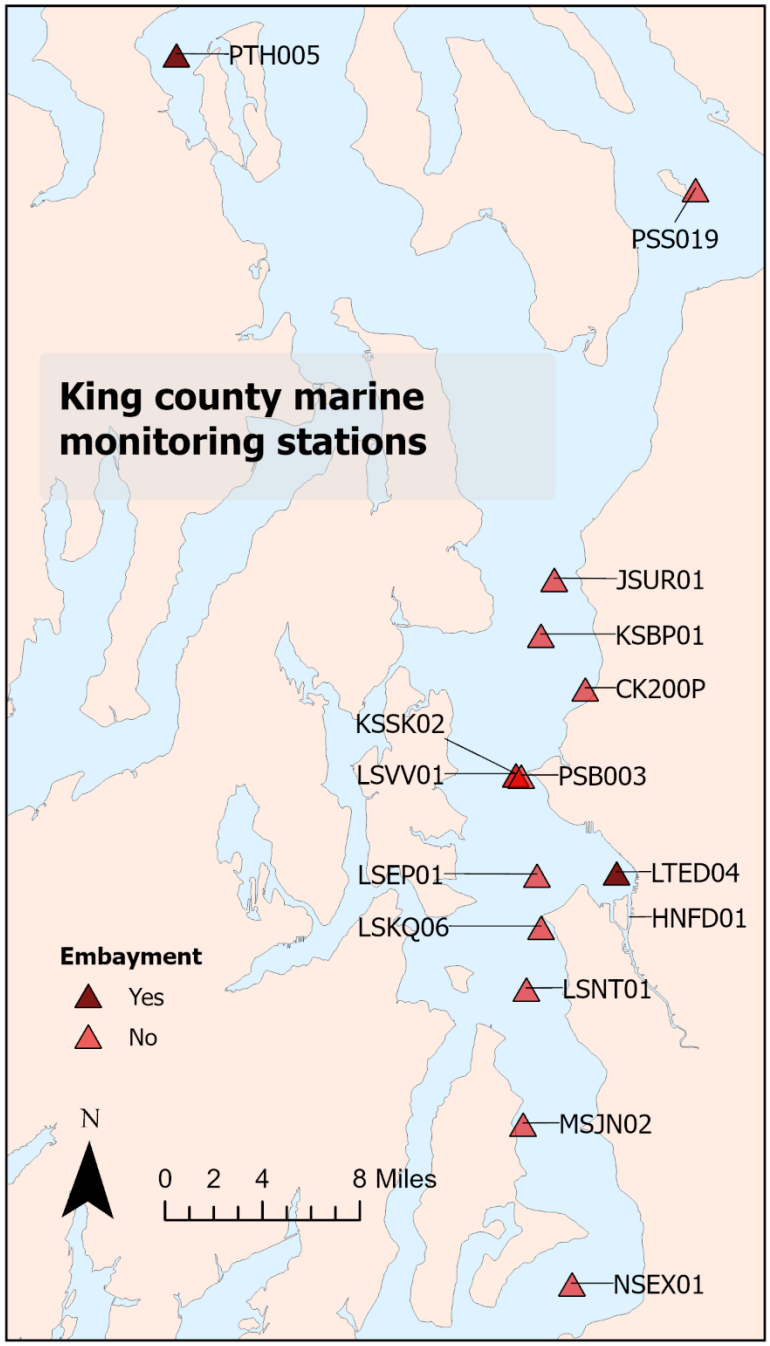

Figure D-2. Marine station locations: King County.

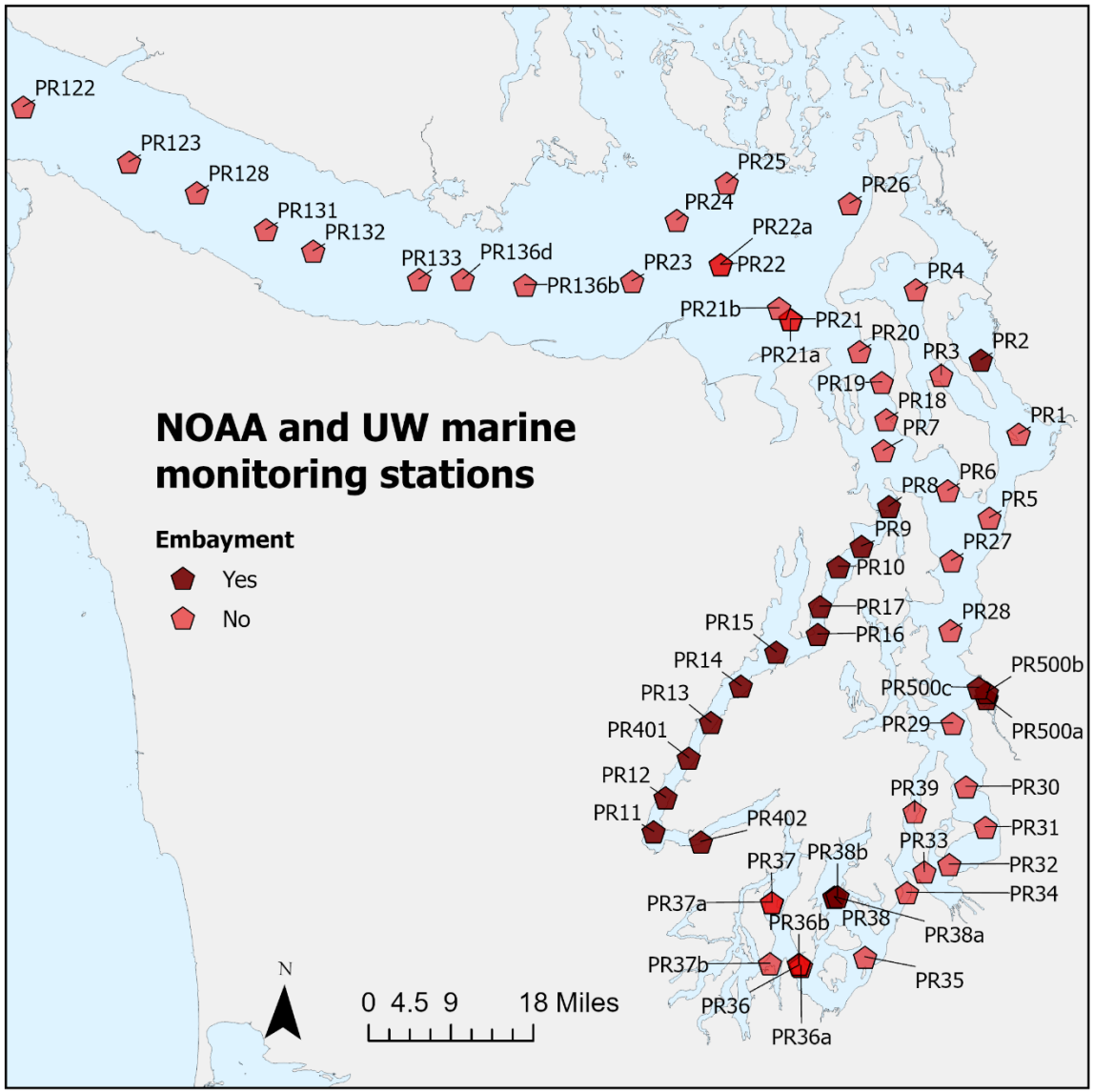

Figure D-3. Marine station locations: NOAA and UW.

Table D-2. Data available for stations shown in Figures D1 – D3.

Station	Source	Available Water Quality Parameters	Year
ADM001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
ADM001	MMU	Alkalinity, Chl_a, DIC, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature, Aragonite_sat, pCO_2	2014
ADM002	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
ADM002	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
ADM003	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
ADM003	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
AlkE	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
AlkW	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
BLL009	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
BLL009	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
BLL011	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000
BUD002	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
BUD005	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
BUD005	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
CK200P	KC	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000, 2006, 2008, 2014
CMB003	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
CMB003	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
CRR001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006
CRR001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
CSE002	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006, 2008
DIS001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000
DNA001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
DNA001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
DUN001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000
EAP001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
EAP001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
EdmE	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
EdmW	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006

Station	Source	Available Water Quality Parameters	Year
ELB015	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
ELB015	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
ELD002	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
FID001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
GOR001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
GOR001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
GRG002	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
GRG002	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
HCB003	MMU	DO, Salinity, Temperature	2000
HCB003	MMU	Chl_a, DO, Salinity, Temperature	2006
HCB003	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
HCB004	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
HCB004	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
HCB006	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000
HCB007	MMU	DO, Salinity, Temperature	2000
HCB007	MMU	Chl_a, DO, Salinity, Temperature	2006
HCB007	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
HCB010	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006, 2008
HCB010	MMU	Alkalinity, Chl_a, DIC, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature, Aragonite_sat, pCO_2	2014
HLM001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2	2008
HND001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
HNFD01	KC	Chl_a, DO, PAR, Salinity, Temperature	2008, 2014
JSUR01	KC	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2006, 2008, 2014
KSBP01	KC	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000, 2006, 2008, 2014
KSSK02	KC	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000, 2006, 2008, 2014
LSEP01	KC	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000, 2008, 2014
LSKQ06	KC	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000, 2006, 2008, 2014

Station	Source	Available Water Quality Parameters	Year
LSNT01	KC	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000, 2006, 2008, 2014
LSVV01	KC	Chl_a, DO, PAR, Salinity, Temperature	2008
LTED04	KC	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000, 2006, 2008, 2014
MSJN02	KC	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2006, 2008, 2014
NSEX01	KC	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2006, 2008, 2014
NSQ002	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
NSQ002	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
OAK004	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
OAK004	MMU	Alkalinity, Chl_a, DIC, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature, Aragonite_sat, pCO_2	2014
PNN001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2	2008
PR1	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR1	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR1	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR10	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR10	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR10	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR11	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR11	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR11	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR12	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR12	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR12	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR122	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR123	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR128	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR13	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR13	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR13	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR131	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008

Station	Source	Available Water Quality Parameters	Year
PR132	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR133	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008
PR136b	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008
PR136b	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature	2014
PR136d	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2014
PR14	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR14	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR14	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR15	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR15	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR15	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR16	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR16	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR16	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR17	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR17	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR17	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR18	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR18	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR18	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR19	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR19	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR19	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR2	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR2	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR2	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008
PR20	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR20	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR20	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR21	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000

Station	Source	Available Water Quality Parameters	Year
PR21	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR21a	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR21b	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2014
PR22	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR22	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR22a	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR23	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR23	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR23	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008
PR24	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR24	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR24	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008
PR25	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR25	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR25	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008
PR26	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR26	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR26	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR27	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR27	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR27	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR27	SS	Chl_a, Salinity, Temperature	2006[1]
PR28	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR28	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR28	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR28	SS	Chl_a, Salinity, Temperature	2006[1]
PR29	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR29	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR29	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR29	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006[1]

Station	Source	Available Water Quality Parameters	Year
PR3	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR3	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR3	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR30	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR30	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR30	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR30	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006[1]
PR31	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR31	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR31	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR31	SS	Chl_a, DO, Salinity, Temperature	2006[1]
PR32	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR32	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR32	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR32	SS	Chl_a, DO, Salinity, Temperature	2006[1]
PR33	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR33	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR33	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR33	SS	Chl_a, Salinity, Temperature	2006[1]
PR34	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR34	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR34	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008
PR34	SS	Chl_a, Salinity, Temperature	2006[1]
PR35	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR35	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR35	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR35	SS	Chl_a, Salinity, Temperature	2006[1]
PR36	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR36	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR36	SS	Chl_a, Salinity, Temperature	2006[1]

Station	Source	Available Water Quality Parameters	Year
PR36a	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008
PR36b	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR37	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR37	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR37	SS	Chl_a, Salinity, Temperature	2006[1]
PR37a	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR37b	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2014
PR38	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR38	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR38	SS	Chl_a, Salinity, Temperature	2006[1]
PR38a	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR38b	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2014
PR39	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR39	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR39	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008
PR39	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006[1]
PR4	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR4	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR4	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR401	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR401	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR402	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR402	NOAA_UW	DO, Salinity, Temperature	2008
PR402	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2014
PR5	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR5	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR5	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR500a	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008
PR500b	NOAA_UW	Alkalinity, DO, Salinity, Temperature	2014
PR500c	NOAA_UW	Alkalinity, DO, Salinity, Temperature	2014

Station	Source	Available Water Quality Parameters	Year
PR6	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR6	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR6	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008
PR7	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR7	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR7	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR8	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR8	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR8	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PR9	NOAA_UW	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2000
PR9	NOAA_UW	Chl_a, DO, NH_4^+, PAR, Salinity, Temperature	2006
PR9	NOAA_UW	Alkalinity, DIC, DO, Salinity, Temperature, Aragonite_sat, pCO_2	2008, 2014
PSB003	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
PSB003	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
PSS019	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
PSS019	MMU	Alkalinity, Chl_a, DIC, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature, Aragonite_sat, pCO2	2014
PTH005	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
PTH005	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
Rich	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
RSR837	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
SAR003	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
SAR003	MMU	Alkalinity, Chl_a, DIC, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature, Aragonite_sat, pCO2	2014
SIN001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2000, 2006, 2008
SIN001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
SJF000	MMU	Chl_a, NH_4^+, NO_3-NO_2	2000
SJF000	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006, 2008
SJF000	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
SJF001	MMU	Chl_a, NH_4^+, NO_3-NO_2	2000
SJF001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006, 2008

Station	Source	Available Water Quality Parameters	Year
SJF001	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
SJF002	MMU	Chl_a, NH_4^+, NO_3-NO_2	2000
SJF002	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006, 2008
SJF002	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
SKG003	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006, 2008
SKG003	MMU	Chl_a, DO, NH_4^+, NO_3-NO_2, PAR, Salinity, Temperature	2014
SS02	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS03	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS04	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS05	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS06	SS	Chl_a, DO, Salinity, Temperature	2006
SS07	SS	Chl_a, DO, Salinity, Temperature	2006
SS08	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS09	SS	Chl_a, DO, Salinity, Temperature	2006
SS11	SS	Chl_a, DO, Salinity, Temperature	2006
SS13	SS	Chl_a, DO, Salinity, Temperature	2006
SS14	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS15	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS16	SS	Chl_a, DO, Salinity, Temperature	2006
SS17	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS18	SS	Chl_a, DO, Salinity, Temperature	2006
SS19	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS21	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS22	SS	Chl_a, DO, Salinity, Temperature	2006
SS23	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS25	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS27	SS	Chl_a, DO, Salinity, Temperature	2006
SS32	SS	Chl_a, DO, Salinity, Temperature	2006
SS35	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS36	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006

Station	Source	Available Water Quality Parameters	Year
SS37	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS38	SS	Chl_a, DO, Salinity, Temperature	2006
SS39	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS40	SS	Chl_a, DO, Salinity, Temperature	2006
SS41	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS42	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS44	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS47	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS48	SS	Chl_a, DO, Salinity, Temperature	2006
SS49	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS50	SS	Chl_a, DO, Salinity, Temperature	2006
SS51	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS52	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS53	SS	Chl_a, DO, Salinity, Temperature	2006
SS54	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS55	SS	Chl_a, DO, Salinity, Temperature	2006
SS56	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS58	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS59	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS60	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS61	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS62	SS	Chl_a, DO, Salinity, Temperature	2006
SS63	SS	Chl_a, DO, Salinity, Temperature	2006
SS64	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS65	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS66	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS67	SS	Chl_a, DO, Salinity, Temperature	2006
SS68	SS	Chl_a, DO, Salinity, Temperature	2006
SS69	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS70	SS	Chl_a, DO, Salinity, Temperature	2006

Station	Source	Available Water Quality Parameters	Year
SS71	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS72	SS	Chl_a, DO, Salinity, Temperature	2006
SS73	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS74	SS	Chl_a, DO, Salinity, Temperature	2006
SS75	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS76	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS77	SS	Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006
SS78	SS	Chl_a, DO, Salinity, Temperature	2006
SS79	SS	Chl_a, DO, Salinity, Temperature	2006
SS80	SS	Alkalinity, Chl_a, DO, NH_4^+, NO_3-NO_2, Salinity, Temperature	2006

[1] Data available at different times from long-term study locations.

KC =King County.

MMU = Marine Monitoring Unit, Environmental Assessment Program, Washington Department of Ecology (Ecology); data are available online in netCDF format at: Water column & sediment data - Washington State Department of Ecology [2] and also available in Ecology's Environmental Information Monitoring database (EIM) at: https://ecology.wa.gov/research-data/data-resources/environmental-information-management-database.

NOAA_UW = National Oceanic and Atmospheric Administration/University of Washington.

SS = South Sound Study; MMU collected the data and provided the QA level that was in place at the time.

[2] https://ecology.wa.gov/research-data/monitoring-assessment/puget-sound-and-marine-monitoring/water-column-data

How to Read Time-Depth Plots

Figure D-5 is an illustration on how to read the time-depth plots presented in this report (for example in Appendices E, F, G and H). The purpose of the time-depth plots is to provide a simple and quick visual assessment of how model simulated values compare to all available observations for a particular parameter and monitoring station across the whole year of simulation. These are then supplemented with more detailed time series plots at individual stations (which do not show all depths) and depth profiles (which do not show values over time).

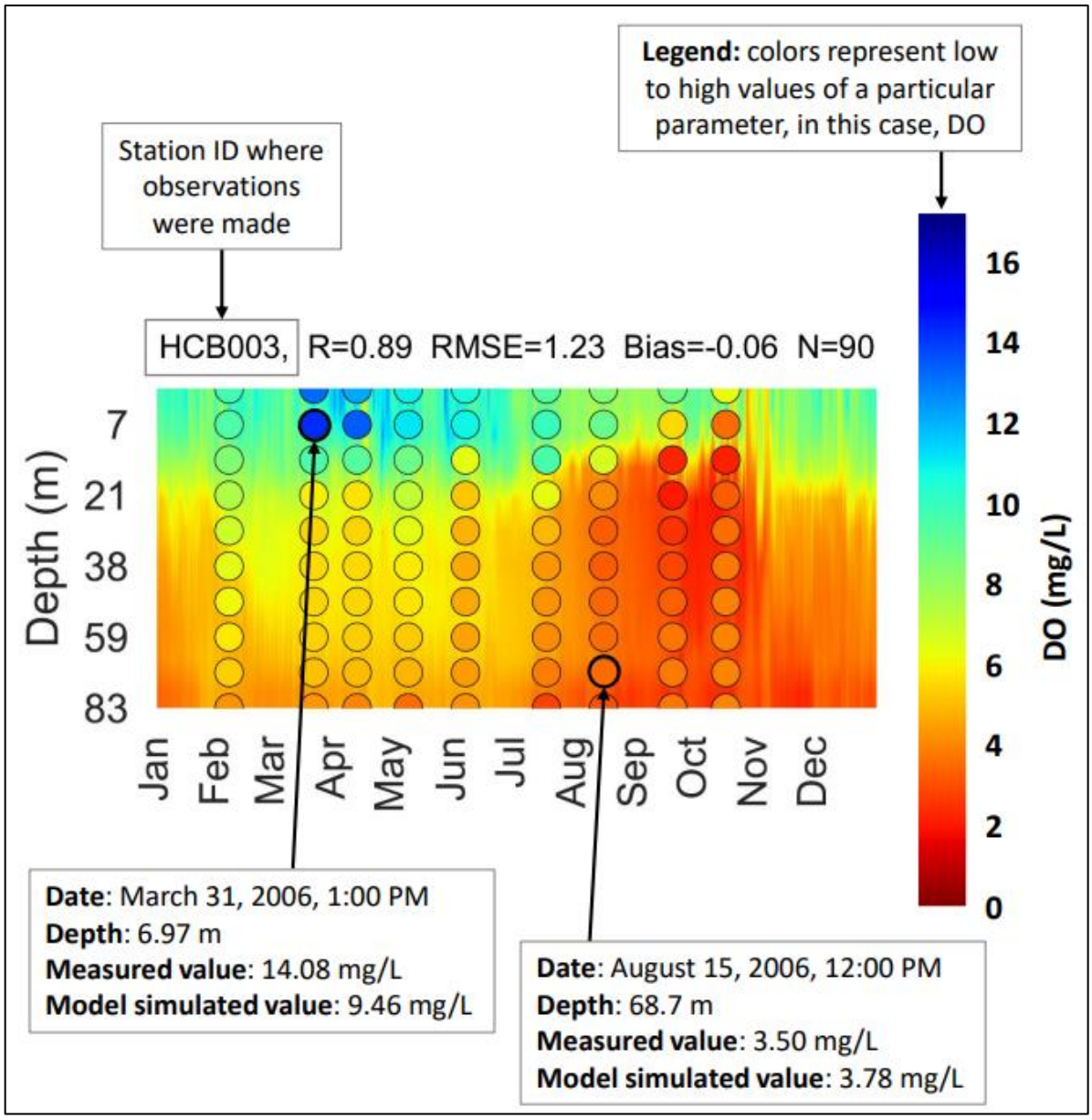

Figure D-2. How to read time-depth plots

Masking and Re-projection of SSM Predictions

The marine 303(d) listings are physically represented by a 4.5-second by 4.5-second latitude/longitude grid cells. These 303(d) assessment units will be called the "303(d) grids" moving forward in this appendix. The Salish Sea Model (SSM) predicts water quality at each of the 16012 nodes that comprise the SSM domain. Water quality is computed at SSM nodes and represents the average over a polygon that is created by the perpendicular intersection of lines connecting the adjacent nodes. These resulting polygons are called tracer control elements or TCEs. In this section, we will describe how we reprojected and merged water quality predictions from SSM available for each TCE onto the 303(d) grid.

Creation of spatially masked 303(d) grid domain

We followed these steps to create a new 303(d) grid layer merged with SSM TCEs:

- **Reviewed SSM grid masking:** As discussed previously (McCarthy, et al. 2018, Ahmed et al. 2019, 2021), due to SSM limitations, model output requires masking. We confirmed appropriate masking of all intertidal and very shallow subtidal areas. In addition, we removed from the model output a small portion of hourly predictions in grid cell surface layers within WA waters due to unrealistically cold temperatures in limited locations during winter as discussed in Appendix A. We also masked nodes with elevations of 4 m or less during ebb tides due to heat flux calculations that produced unreasonably low values for temperature during winter months in low tides.
- **Merged 303(d) grid with TCEs:** in ArcGIS, using the 303(d) and TCE grid shapefiles, we created a 303(d) overlap shapefile using the 'overlay' tool with intersect as an option. This resulted in a new layer, which 1) removed areas in the 303(d) shape file that were outside the TCE shapefile domain and 2) created a spatial merging of the two layers so that each 303(d) polygon was now divided into sections represented by the sections of TCEs within it. We then calculate the area of each TCE section.
- **Removed 303(d) grid cells where majority of the cell is masked:** After merging TCEs with the 303(d) grid, we removed 303(d) grid cells if more than 50% of their area was composed of masked TCEs. Budd Inlet output is masked because it is not included in this Puget Sound analysis since the Budd Inlet TMDL is now complete and approved by EPA (Ecology, 2022). The SSM model was not set up to include the operation of the Capitol Lake Dam, and so was not deemed adequate to represent the hydraulics impacting Budd Inlet.
- **Assign marine DO water quality standards to each 303(d) grid cell:** Ecology's marine water quality standards layer was merged with the final merged and clipped 303(d) grid layer (from the previous two steps) to add the "aquatic life criteria" attribute to every 303(d) grid cell. We added the attribute to specify the numeric "aquatic life criteria" as follows:
    - Extraordinary quality = 7 mg/L
    - Excellent quality = 6 mg/L
    - Good Quality = 5 mg/L
    - Fair Quality = 4 mg/L — there were no grid cells with DO std of 4 mg/L

In a few cases, a 303(d) grid overlapped two different DO numeric criteria. In these cases, the higher more conservative DO criterion was assigned to the whole 303(d) grid (see Figure D-6).

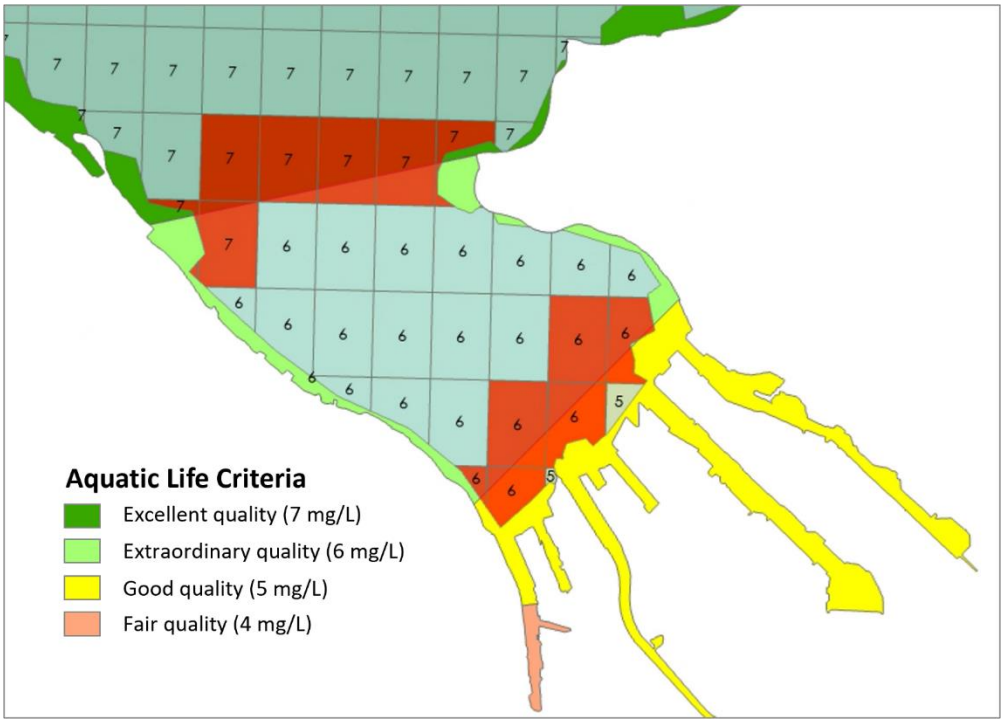

Figure D-3. 303(d) grid overlapped with two different DO criteria.

- **Removed 'orphan' 303(d) grid cells:** a final check was done to discover any "orphan" 303(d) grid cells (i.e., clipped 303(d) grid cells with an area less than 1% of the total area of the original 303(d) grid). These orphan 303(d) grid cells were deleted, and a final shapefile was created (Figure D-7)

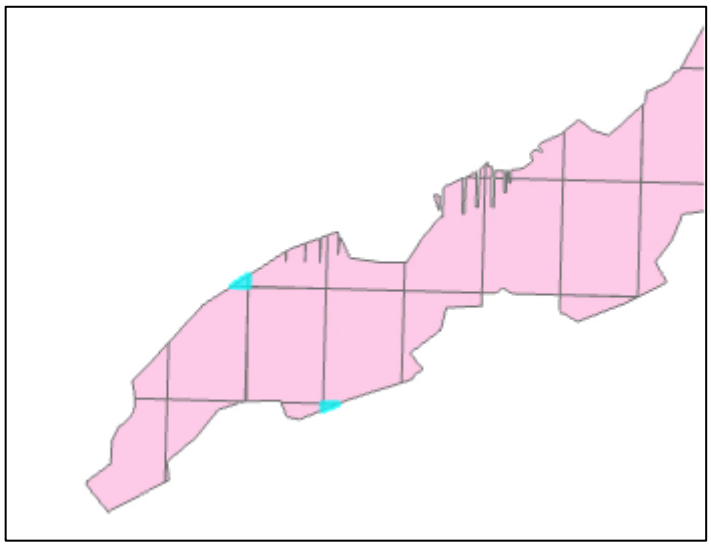

Figure D-4. An example of orphan (blue cells) 303(d) grid cells.

Transferring model predictions in TCE grids to 303(d) grids

Figure D-8 shows a 303(d) grid (red box) along with three SSM model nodes (1,2, and 3) with their associated TCEs (polygon around each node). The colored areas: a (blue), b (orange), and c (yellow) are sections of three different TCEs within a single 303(d) grid cell.

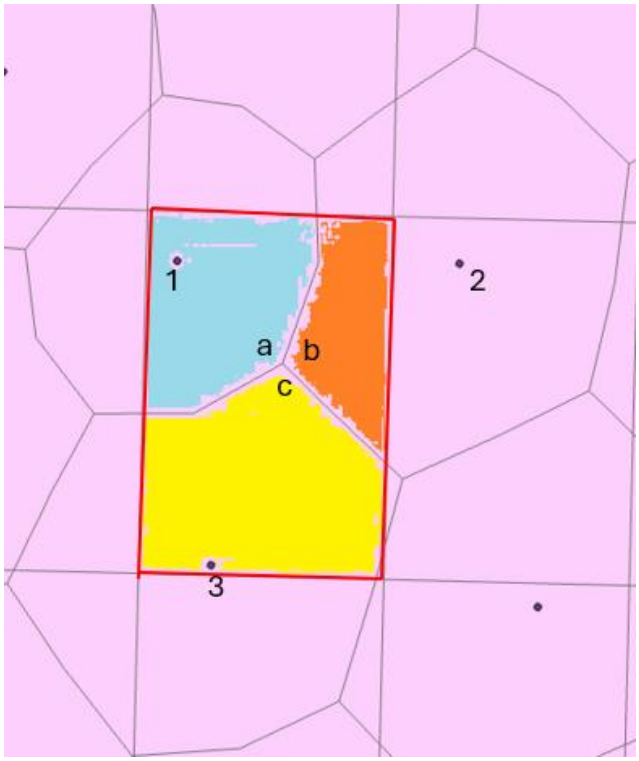

Figure D-5. 303(d) grid superimposed over SSM nodes and TCEs.

The model predicts hourly dissolved oxygen concentration for each of the 10 model layers for each node (1, 2, and 3) and this concentration is applicable within each of the associated TCEs. The model also predicts hourly water surface elevations at each of the nodes. Knowing the bathymetry at each of the nodes, we can calculate the hourly depth of the entire water column as well as the hourly depths of each of the 10 layers within a TCE. Combining the hourly depths of each TCE with the area of the TCE sections, we calculated the hourly volume of each TCE section within each 303(d) grid cell. We then calculated the hourly volume-weighted DO concentration for each of the 10 layers of the 303(d) grid as follows (where a, b, and c are TCE slices in the 303(d) grid and n is the layer number):

$$DO_{303(d)\_n} = [DO_{a\_n} * Vol_{a\_n} + DO_{b\_n} * Vol_{b\_n+} DO_{c\_n} * Vol_{c\_n}] \,/\, (Vol_{a\_n} + Vol_{b\_n} + Vol_{c\_n})$$

Once the DO concentration for each of the ten 303(d) grid layers is estimated, the DO standard noncompliance can be evaluated using the procedure outlined in Appendix F of the Technical Memorandum (Ahmed et al. 2021)

Reference Condition Updates

This section summarizes updates to establishing reference conditions estimates used in the Salish Sea Model (SSM) for reference condition model runs. The following reports, in chronological order, have previously documented the basis for establishing the reference condition:

- Mohamedali et al. (2011a, 2011b) — describes original methods and multiple linear regression approach in detail.
- Pelletier et al. (2017) — Appendix B1 includes updates made since the 2011 effort, which included establishing reference concentrations for marine point sources.
- Ahmed et al. 2019 — includes meta-analysis to corroborate and compare our reference condition estimates with other studies and data.
- Ahmed et al. (2021) — Appendix C includes details on the updates made to reference organic carbon concentrations.

Appendix B1 contains the updates to watershed delineations and associated water quality regressions. Because of these updates to existing concentrations, the watershed-specific reference organic carbon concentrations also changed since these were calculated as percentiles relative to existing concentrations (as documented in Ahmed et al. 2019, 2021) for each watershed inflow. No changes were made to the regional reference conditions for inorganic and organic nitrogen concentrations.

Another update to the reference condition was the establishment of reference concentrations for Lake Washington and Lake Cushman. In previous Salish Sea modeling efforts, these two lakes were left at existing concentrations under the reference condition model run (Ahmed et al. 2019, 2021). For this phase, the nitrogen reference concentrations for these two lakes were set to regional reference concentrations (Mohamedali et al. 2011a, 2011b). The organic carbon reference condition was estimated using the same watershed-specific methods (Ahmed et al. 2019, 2021).

References

Ahmed A., C. Figueroa-Kaminsky, J. Gala, T. Mohamedali, G. Pelletier, and S. McCarthy. 2019. Puget Sound Nutrient Source Reduction Project, Volume 1: Model Updates and Bounding Scenarios. Publication 19-03-001. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/SummaryPages/1903001.html

Ahmed, A., J. Gala, T. Mohamedali, C. Figueroa-Kaminsky, and S. McCarthy. 2021. Appendix C of Technical Memorandum: Puget Sound Nutrient Source Reduction Project Phase II (Optimization Scenarios (Year 1). Washington State Department of Ecology, Olympia. https://www.ezview.wa.gov/Portals/_1962/Documents/PSNSRP/Appendices%20A-G%20for%20Tech%20Memo.pdf

Ecology [Washington State Department of Ecology]., 2022. Budd Inlet Total Maximum Daily Load for Dissolved Oxygen, Publication number 22-10-012, https://apps.ecology.wa.gov/publications/SummaryPages/2210012.html

McCarthy, S., C. Figueroa-Kaminsky, A. Ahmed, T. Mohamedali, and G. Pelletier. 2018. Quality Assurance Project Plan: Salish Sea Model Applications. Publication 18-03-111. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/SummaryPages/1803111.html

Mohamedali, T., M. Roberts, B. Sackmann, and A. Kolosseus. 2011a. Puget Sound dissolved oxygen model nutrient load summary for 1999–2008. Publication 11-03-057. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/SummaryPages/1103057.html

Mohamedali, T., M. Roberts, B. Sackmann, A. Whiley, and A. Kolosseus. 2011b. South Puget Sound dissolved oxygen study: Interim nutrient load summary for 2006–2007. Publication 11- 03-001. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/SummaryPages/1103001.html

Pelletier, G., L. Bianucci, W. Long, T. Khangaonkar, T. Mohamedali, A. Ahmed, and C. Figueroa-Kaminsky. 2017. Salish Sea Model Ocean Acidification Module and the Response to Regional Anthropogenic Nutrient Sources. Publication 17-03-009. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/SummaryPages/1703009.html