

TECHNICAL MEMORANDUM

Methods and Data for PacifiCorp Phytoplankton Sampling in the Klamath River System, 2001-2005

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DATE: October 26, 2005

Introduction

This memorandum describes the methods used to collect and analyze phytoplankton samples collected during 2001-2005. The available data generated from laboratory analysis of the phytoplankton samples also are attached. This includes results from all samples collected during 2001-2004 and available data from 2005. Additional 2005 data will be made available as soon as sample analysis, validation, and data analysis are completed.

Water Quality Sampling Program

As part of PacifiCorp's relicensing efforts for the Klamath Hydroelectric Project (Project), a monthly water quality sampling program began in 2001 and continues into 2005. The purpose of this sampling is to obtain data to support water quality modeling, to assess Project effects on water quality in the Klamath River, and to understand and characterize current water quality conditions within and downstream of Project area. Results for water quality constituents, except phytoplankton, are available on the Project relicensing website for 2001 through 2004 (<http://www.pacificorp.com/Article/Article579.html>). Data from 2005 water quality samples will be made available as soon as testing and data analysis are completed.

Phytoplankton samples were collected as part of the overall water quality program to characterize the phytoplankton community and to identify their typical seasonal succession. During 2001-2004, phytoplankton samples were analyzed on a different schedule than the water quality constituents used to support the water quality modeling and to assess Project effects. PacifiCorp prioritized use of chlorophyll *a* results as the more commonly-used measure of algal productivity within the aquatic system.

Geographic Scope

PacifiCorp began sampling phytoplankton in the vicinity of the Project in 2001, primarily in the Project's reservoirs. The program was expanded in 2002 to include a number of river stations within and below the Project. Samples have been collected from 17 sites in the Klamath River (and associated reservoirs) and from four tributaries in the vicinity of the Project. The sites are listed in Table 1. Site locations are depicted in Figure 1.

Sampling Methods

Phytoplankton samples were collected approximately monthly between March and November from 2001 through 2004. This period includes the relatively warmer weather months in late spring, summer, and early fall when phytoplankton is most prevalent in the Klamath River system. The dates and locations of phytoplankton samples collected along the mainstem of the Klamath River are depicted in Figure 2. In addition to the mainstem locations pictured, samples were collected in 2002 from near the mouth of Spencer Creek, Shovel Creek, Fall Creek, and the Shasta River.

Samples were collected from approximately 0.5 m depth at the river and stream sites, and from 0.5 to 1.0 m depth in the reservoirs at sites near the dams. In addition, an integrated sample of the top 10 m of water in Copco and Iron Gate reservoirs was collected by lowering a weighted tube to 10 m, clamping off the top, retrieving the tube and draining it into a container. The contents of the container were mixed and dispensed into sample bottles. Approximately every 10th sample, but at least one sample in every sample set, was duplicated for quality control purposes.

Additional samples have been taken on occasion in Copco and Iron Gate reservoirs from the most concentrated area of a localized algal bloom at the surface of the water. These additional samples were taken based on observed conditions present at the time of sampling.

Immediately after collection, samples were dispensed into bottles supplied by the laboratory. Phytoplankton samples were preserved with Lugol's solution; chlorophyll *a* samples were preserved with magnesium carbonate. Chlorophyll *a* samples were kept in opaque bottles, on ice in the dark until analyzed. Samples were collected by E&S Environmental of Corvallis, Oregon and analyzed in the laboratory by Aquatic Analysts of White Salmon, Washington for chlorophyll *a* and phytoplankton species abundance and biovolume.

Table 1. Phytoplankton sample sites in the vicinity of the Klamath Hydroelectric Project, 2001-2004.

Site ID ¹	River Mile	Latitude	Longitude	Site Name
KR17300	173.00	41.8362	-122.5825	Klamath River above Shasta River
KR17600	176.00	41.8301	-122.5937	Klamath River at I-5 Rest Area
KR18973	189.73	41.9310	-122.4423	Iron Gate dam Outflow
KR19019	190.19	41.9342	-122.4350	Iron Gate reservoir near dam
KR19645	196.45	41.9731	-122.3652	Copco 2 dam Outflow
KR19874	198.74	41.9794	-122.3333	Copco reservoir
KR20642	206.42	41.9721	-122.2016	Klamath River upstream of Shovel Creek
KR22040	220.40	42.0932	-122.0713	Klamath River upstream, of J.C. Boyle Powerhouse
KR22460	224.60	42.1217	-122.0494	Klamath River below J.C. Boyle dam
KR22478	224.78	42.1228	-122.0470	J.C. Boyle reservoir at Log Boom
KR22600	226.00	42.1351	-122.0313	J.C. Boyle reservoir at Hwy 66 Bridge
KR22822	228.22	42.1499	-122.0154	Klamath River above J.C. Boyle reservoir
KR23334	233.34	42.1353	-121.9489	Keno dam Outflow
KR23360	233.60	42.1345	-121.9482	Keno reservoir at Log Boom
KR23490	234.90	42.1222	-121.9194	Klamath River at Keno Bridge (Hwy 66)
KR25312	253.12	42.2188	-121.7884	Link River at Mouth
KR25479	254.79	42.2383	-121.8053	Upper Klamath Lake at Fremont St Bridge
SP00	0	42.1528	-122.0325	Spencer Creek near Mouth
SR00	0	41.9724	-122.2027	Shovel Creek near Mouth
FA00	0	41.9681	-122.3653	Fall Creek near Mouth
SH01	1	41.8231	-122.5944	Shasta River near Mouth

¹ Please note that the site ID numbers equate to River Miles ascending upstream from the mouth of the Klamath River (e.g., site KR17300 is at Klamath River Mile (RM) 173.0 just above the Shasta River). The exception of the last four ID numbers which relate to tributaries (Spencer Creek, Shovel Creek, Fall Creek, and the Shasta River).

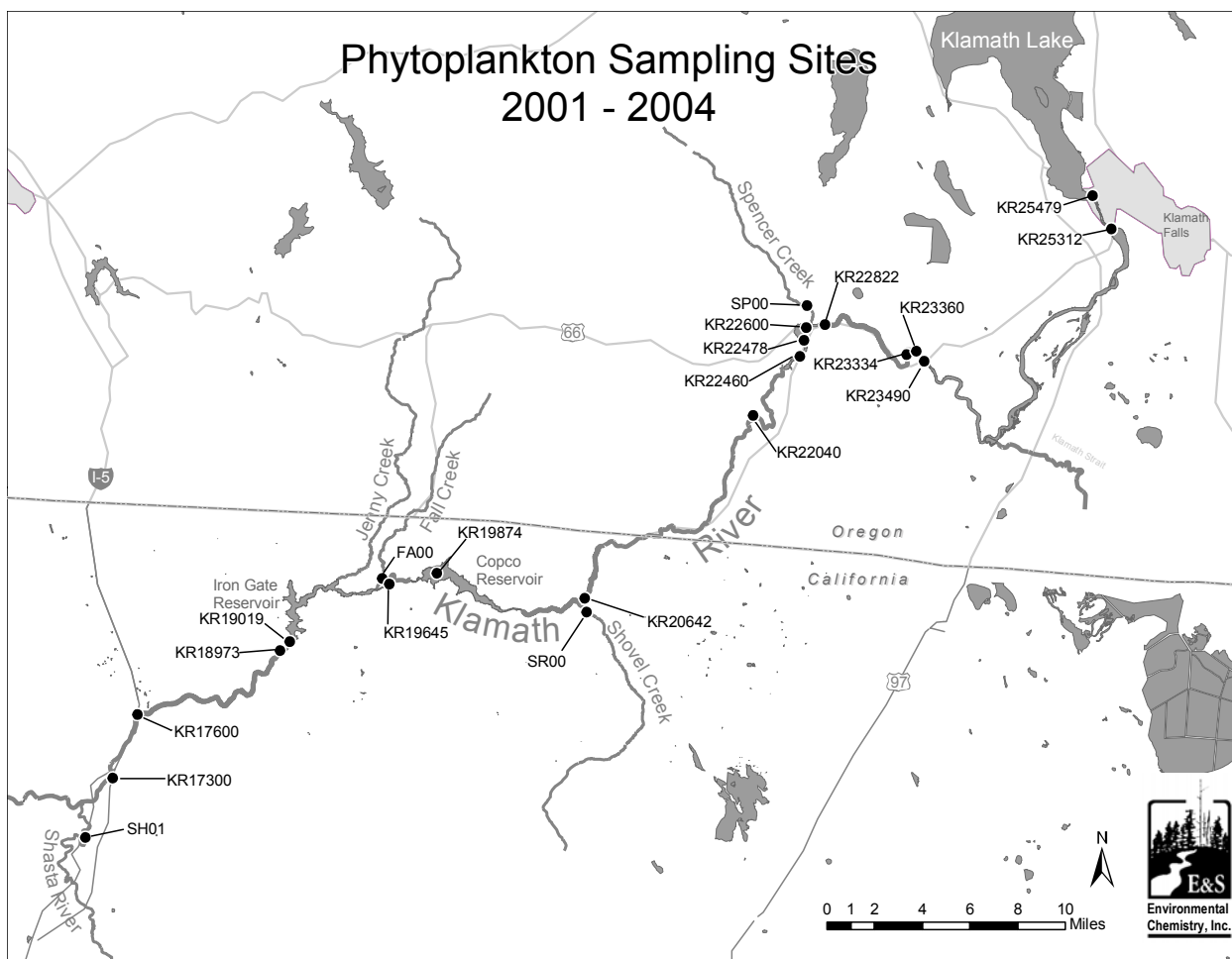


Figure 1. Location of phytoplankton collection sites in the vicinity of the Klamath Hydroelectric Project, 2001-2004.

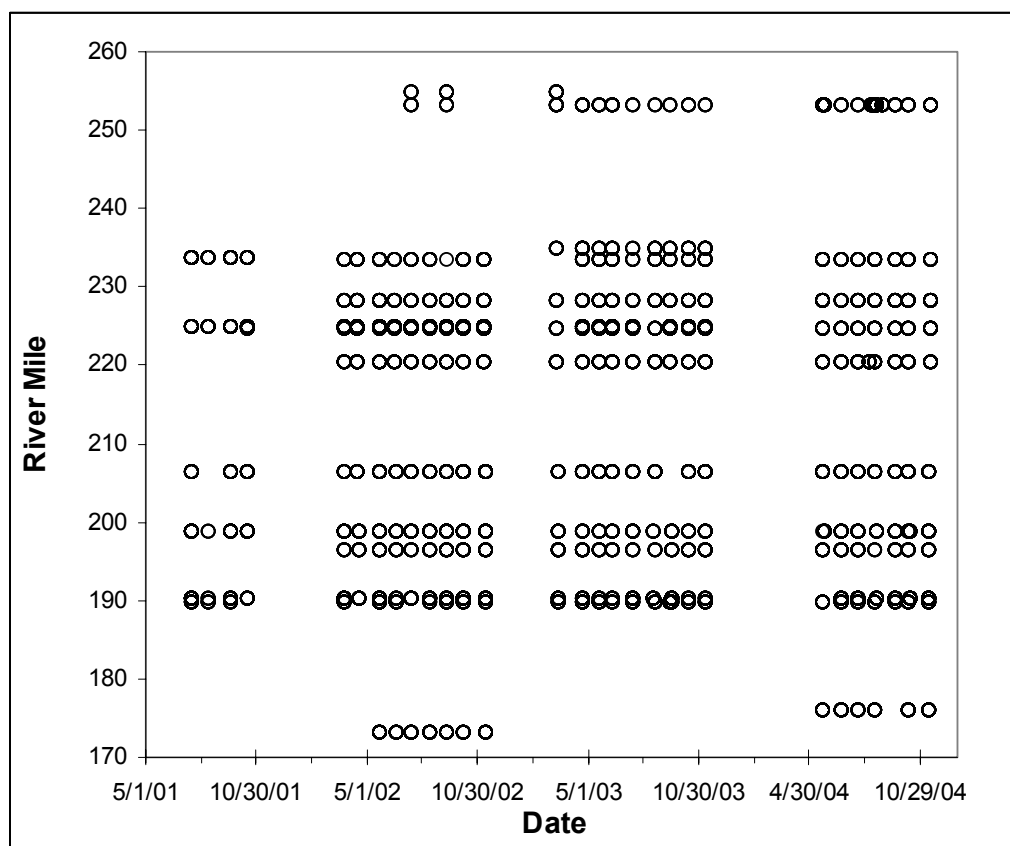


Figure 2. Date and location of phytoplankton samples in the vicinity of the Klamath Hydroelectric Project, 2001-2004.

2001-2004 Data and Summary Statistics

Phytoplankton samples were collected in 29 total months between March and November from 2001 through 2004. A total of 205 phytoplankton species were observed in the 462 samples collected during 2001-2004. A complete list of species is included as Appendix 1.

Phytoplankton samples were analyzed for species identification, algal abundance, algal biovolume, and chlorophyll *a* concentration. Summary statistics (i.e., mean, median, minimum, and quartile values) for the three variables for each station are provided in Appendix 2.

The phytoplankton data is contained in the attached Excel spreadsheet file titled "2001-2004 Phytoplankton.xls". The spreadsheet file contains five tabs. The *Dictionary* tab provides definitions for the various field (column) headings used in the file. The tab *CHLA* contains a worksheet with the chlorophyll *a* data for the collected samples. The tab *PPLK* contains a worksheet with the phytoplankton density and biovolume data for the collected samples. The tab *17JUL02CHLA* contains a worksheet with the chlorophyll *a* data for the samples collected on July 17, 2002 to assess spatial variation in phytoplankton abundance in Copco and Iron Gate reservoirs. The tab *MCYS* includes a summary of *Microcystis aeruginosa* concentrations identified in the samples.

2005 Data

Phytoplankton samples that have been collected to-date in 2005 are still pending completion of sample analysis, validation, and analysis of results. The exception is results from samples taken on August 23, 2005. The analysis of these samples was expedited because a bloom of *Microcystis aeruginosa* was suspected at the time.

The August 23 samples were collected at 1 m depth (grab sample) in Iron Gate reservoir (KR19019), Copco reservoir (KR19874), and in the Klamath River below Iron Gate dam (KR19873, hatchery bridge). Integrated samples of the top 10 m were collected in each reservoir per methods as previously described. In addition, based on observed conditions present at the time of sampling, a sample was collected from the surface of Iron Gate Reservoir (0.1 m) from the densest part of the algal bloom.

The samples collected on August 23, 2005 contained two common species of cyanophytes that are capable of producing toxins: *Microcystis aeruginosa* and *Aphanizomenon flos-aquae*. The abundance data for these two species are contained in a separate excel spreadsheet file on the enclosed disk titled "Microcystis Data August 23 2005.xls". The remainder of the 2005 phytoplankton data will be made available as soon as testing and data analysis are completed.

Appendix 1

List of Species

SPECIES	Frequency	SPECIES	Frequency
<i>Rhodomonas minuta</i>	337	<i>Gomphonema olivaceum</i>	45
<i>Cryptomonas erosa</i>	304	<i>Navicula minima</i>	45
<i>Ankistrodesmus falcatus</i>	292	<i>Scenedesmus acuminatus</i>	45
<i>Cocconeis placentula</i>	258	<i>Cyclotella pseudostelligera</i>	43
<i>Aphanizomenon flos-aquae</i>	251	<i>Navicula cryptocephala</i>	41
<i>Stephanodiscus hantzschii</i>	237	<i>Nitzschia microcephala</i>	41
<i>Nitzschia frustulum</i>	236	<i>Navicula</i> sp.	40
<i>Navicula cryptocephala veneta</i>	232	<i>Nitzschia capitellata</i>	39
<i>Rhoicosphenia curvata</i>	231	<i>Synedra radians</i>	39
<i>Nitzschia amphibia</i>	222	<i>Chrysococcus rufescens</i>	35
<i>Nitzschia palea</i>	203	<i>Cocconeis klamathensis</i>	35
<i>Cyclotella meneghiniana</i>	194	<i>Nitzschia volcanica</i>	35
<i>Stephanodiscus astraea minutula</i>	190	<i>Cyclotella stelligera</i>	33
<i>Nitzschia paleacea</i>	174	<i>Stephanodiscus binderanus</i>	30
<i>Nitzschia dissipata</i>	173	<i>Nitzschia communis</i>	29
<i>Gomphonema angustatum</i>	162	<i>Fragilaria capucina mesolepta</i>	28
<i>Fragilaria construens venter</i>	139	<i>Oocystis pusilla</i>	28
<i>Scenedesmus quadricauda</i>	139	<i>Anabaena flos-aquae</i>	27
<i>Achnanthes lanceolata</i>	131	<i>Glenodinium</i> sp.	27
<i>Fragilaria construens</i>	126	<i>Navicula minuscula</i>	27
<i>Aulacosira granulata</i>	125	<i>Amphora ovalis</i>	25
<i>Chlamydomonas</i> sp.	121	<i>Gomphonema clevei</i>	25
<i>Fragilaria vaucheria</i>	121	<i>Mougeotia</i> sp.	24
<i>Gomphonema subclavatum</i>	120	<i>Cymbella sinuata</i>	23
<i>Achnanthes minutissima</i>	113	<i>Synedra cyclopus</i>	23
<i>Asterionella formosa</i>	106	<i>Scenedesmus abundans</i>	22
<i>Selenastrum minutum</i>	98	<i>Actinastrum hantzschii</i>	21
<i>Aulacosira ambigua</i>	92	<i>Fragilaria pinnata</i>	21
<i>Nitzschia acicularis</i>	80	<i>Nitzschia fonticola</i>	20
<i>Diatoma vulgare</i>	73	<i>Synedra rumpens</i>	20
<i>Aulacosira granulata angustissima</i>	72	<i>Cocconeis disculus</i>	19
<i>Fragilaria crotonensis</i>	68	<i>Cryptomonas ovata</i>	19
<i>Sphaerocystis Schroeteri</i>	67	<i>Nitzschia innominata</i>	18
<i>Cymbella minuta</i>	65	<i>Nitzschia linearis</i>	18
<i>Gomphonema ventricosum</i>	63	<i>Unidentified flagellate</i>	17
<i>Synedra ulna</i>	63	<i>Hannaea arcus</i>	16
<i>Chromulina</i> sp.	62	<i>Navicula cascadiensis</i>	16
<i>Amphora perpusilla</i>	59	<i>Oscillatoria</i> sp.	14
<i>Cocconeis pediculus</i>	57	<i>Gomphonema parvulum</i>	12
<i>Aulacosira varians</i>	55	<i>Synedra socia</i>	12
<i>Nitzschia</i> sp.	55	<i>Cyclotella atomus</i>	11
<i>Microcystis aeruginosa</i>	54	<i>Pinnularia</i> sp.	11
<i>Achnanthes linearis</i>	53	<i>Achnanthes exigua</i>	9
<i>Kephyrion</i> sp.	53	<i>Coelastrum microporum</i>	9
<i>Navicula pupula</i>	48	<i>Epithemia sorex</i>	9
<i>Navicula tripunctata</i>	48	<i>Gomphonema</i> sp.	9

SPECIES	Frequency	SPECIES	Frequency
<i>Gomphonema tenellum</i>	9	<i>Navicula biconica</i>	3
<i>Achnanthes hauckiana</i>	8	<i>Navicula rhynchocephala</i>	3
<i>Gomphonema acuminatum</i>	8	<i>Peridinium cinctum</i>	3
<i>Oocystis lacustris</i>	8	<i>Trachelomonas hispida</i>	3
<i>Trachelomonas volvocina</i>	8	<i>Achnanthes clevei</i>	2
<i>Amphora coffeiformes</i>	7	<i>Achnanthes</i> sp.	2
<i>Cymbella affinis</i>	7	<i>Anomoeoneis vitrea</i>	2
<i>Gloeocystis ampla</i>	7	<i>Chodatella wratislawiensis</i>	2
<i>Navicula anglica</i>	7	<i>Cyclotella ocellata</i>	2
<i>Navicula capitata</i>	7	<i>Cymbellonitzschia diluviana</i>	2
<i>Navicula mutica</i>	7	<i>Diatoma tenue elongatum</i>	2
<i>Pediastrum boryanum</i>	7	<i>Diploneis elliptica</i>	2
<i>Pediastrum duplex</i>	7	<i>Euglena</i> sp.	2
<i>Synedra parasitica</i>	7	<i>Gloeotrichia echinulata</i>	2
<i>Tetraedron minimum</i>	7	<i>Navicula mournei</i>	2
<i>Closteriopsis longissima</i>	6	<i>Navicula radiosa</i>	2
<i>Eudorina elegans</i>	6	<i>Ochromonas</i> sp.	2
<i>Fragilaria brevistriata</i>	6	<i>Staurostrum</i> sp.	2
<i>Gomphoneis herculeana</i>	6	<i>Stephanodiscus astraea</i>	2
<i>Navicula graciloides</i>	6	<i>Achnanthes lewisiana</i>	1
<i>Navicula menisculus upsaliensis</i>	6	<i>Achnanthes pinnata</i>	1
<i>Synedra mazamaensis</i>	6	<i>Achnanthes prava</i>	1
<i>Caloneis ventricosa minuta</i>	5	<i>Anabaena planctonica</i>	1
<i>Cosmarium</i> sp.	5	<i>Chroococcus limnetica</i>	1
<i>Diatoma hiemale mesodon</i>	5	<i>Chroococcus minimus</i>	1
<i>Kephyrion littorale</i>	5	<i>Closterium</i> sp.	1
<i>Mallomonas</i> sp.	5	<i>Crucigenia crucifera</i>	1
<i>Navicula decussis</i>	5	<i>Cymbella angustata</i>	1
<i>Scenedesmus bijuga</i>	5	<i>Cymbella mexicana</i>	1
<i>Stauroneis</i> sp.	5	<i>Cymbella microcephala</i>	1
<i>Stephanodiscus niagarae</i>	5	<i>Cymbella muelleri</i>	1
<i>Surirella ovata</i>	5	<i>Cymbella naviculiformis</i>	1
<i>Tetrastrum staurogeniaforme</i>	5	<i>Dictyosphaerium ehrenbergianum</i>	1
<i>Ulothrix</i> sp.	5	<i>Dinobryon bavaricum</i>	1
<i>Characium limneticum</i>	4	<i>Dinobryon</i> sp.	1
<i>Chlorella</i> sp.	4	<i>Elakatothrix gelatinosa</i>	1
<i>Crucigenia quadrata</i>	4	<i>Epithemia turgida</i>	1
<i>Fragilaria leptostauron</i>	4	<i>Eunotia</i> sp.	1
<i>Navicula gregaria</i>	4	<i>Fragilaria capucina</i>	1
<i>Nitzschia recta</i>	4	<i>Fragilaria</i> sp.	1
<i>Scenedesmus denticulatus</i>	4	<i>Frustulia rhomboides</i>	1
<i>Synedra ulna contracta</i>	4	<i>Gomphonema gracile</i>	1
<i>Anabaena</i> sp.	3	<i>Gyrosigma spencerii</i>	1
<i>Ceratium hirundinella</i>	3	<i>Hemidinium</i> sp.	1
<i>Cyclotella</i> sp.	3	<i>Lagynion</i> sp.	1
<i>Dinobryon sertularia</i>	3	<i>Lyngbya</i> sp.	1
<i>Eunotia pectinalis</i>	3	<i>Aulacosira distans alpigena</i>	1
<i>Gloeocystis</i> sp.	3	<i>Aulacosira excurrens</i>	1
<i>Hantzschia amphioxys</i>	3	<i>Aulacosira italica</i>	1

SPECIES	Frequency	SPECIES	Frequency
<i>Meridion circulare</i>	3	<i>Mougeotia</i> sp?	1
<i>Navicula contenta biceps</i>	1	<i>Pseudopedinella</i> sp.	1
<i>Navicula pseudoscutiformis</i>	1	<i>Scenedesmus</i> sp.	1
<i>Navicula seminulum</i>	1	<i>Tetraedron regulare</i>	1
<i>Nitzschia constricta</i>	1	<i>Trachelomonas granulosa</i>	1
<i>Nitzschia tryblionella</i>	1	<i>Trachelomonas scabra</i>	1
<i>Nostoc</i> sp.	1	<i>Volvox</i> sp.	1
<i>Phacus</i> sp.	1		

Appendix 2 Summary Statistics

Algal abundance (units/mL)

Station	N	Mean	Minimum	1st Quartile	Median	3rd Quartile	Maximum
KR17300	7	983	354	492	752	1560	1824
KR17600	7	1015	311	569	729	830	3128
KR18973	27	1531	160	345	920	1797	6965
KR19019	62	1815	11	129	498	1977	22333
KR19645	25	1158	103	213	462	1785	6707
KR19874	65	4179	18	111	574	1998	102441
KR20642	32	1332	328	665	1003	1410	4591
KR22040	27	592	126	267	386	726	2595
KR22460	26	2506	358	506	1136	2393	10286
KR22478	34	3702	262	699	1439	6227	17852
KR22822	25	3637	503	1001	1650	3973	20145
KR23334	23	6240	630	1470	3861	11555	25264
KR23360	7	4537	697	1441	4808	8194	8719
KR23490	9	8413	848	1246	2775	11841	36563
KR25312	28	8200	303	1002	2315	9830	36510
KR25479	3	7692	1324	1324	9922	11831	11831
SH01	9	748	289	513	691	903	1518
FA00	9	158	63	84	104	215	455
SP00	10	197	99	113	147	282	484
SR00	9	263	131	147	222	386	507

Appendix 2

Summary Statistics

Chlorophyll <i>a</i> (ug/L)							
Station	N	Mean	Minimum	1st Quartile	Median	3rd Quartile	Maximum
KR17300	6	8.2	2.0	2.3	3.7	14.4	27.0
KR17600	7	7.6	2.0	3.7	8.8	10.2	14.7
KR18973	26	9.7	2.0	4.4	9.5	13.5	29.0
KR19019	62	9.7	0.5	2.4	4.8	11.0	58.0
KR19645	25	10.2	1.0	2.2	4.9	11.3	81.7
KR19874	64	10.1	0.3	3.0	6.1	12.9	58.4
KR20642	32	9.4	1.5	5.2	7.4	13.2	38.0
KR22040	27	4.8	1.2	2.4	3.9	5.8	16.0
KR22460	26	12.5	1.0	4.3	8.0	16.5	39.4
KR22478	34	17.7	0.5	4.8	7.9	22.4	93.0
KR22822	25	17.6	2.0	7.3	13.2	20.8	64.2
KR23334	23	26.9	2.0	7.3	12.4	43.8	88.0
KR23360	7	27.4	6.8	8.3	28.7	45.3	61.5
KR23490	9	27.3	3.7	5.6	9.5	38.8	123.0
KR25312	28	52.5	1.0	10.1	24.5	49.7	257.0
KR25479	3	54.9	3.7	3.7	43.9	117.0	117.0
SH01	8	4.0	1.5	2.1	3.7	6.6	7.3
FA00	9	1.8	0.4	0.5	1.0	3.0	5.4
SP00	10	2.4	0.9	1.0	1.8	2.7	8.8
SR00	9	1.9	0.5	0.8	2.0	2.9	3.4

Appendix 2

Summary Statistics

Biovolume (um³/mL)							
Station	N	Mean	Minimum	1st Quartile	Median	3rd Quartile	Maximum
KR17300	7	766,109	201,526	205,834	291,995	1,312,000	2,676,000
KR17600	7	363,352	121,828	265,150	356,716	402,963	691,121
KR18973	27	1,104,000	51,069	246,243	718,314	1,426,000	5,370,000
KR19019	62	1,304,000	3,255	118,512	506,383	1,307,000	19,640,000
KR19645	25	529,291	54,058	125,765	286,198	601,599	2,356,000
KR19874	65	2,584,000	4,152	65,382	360,381	1,356,000	57,990,000
KR20642	32	389,497	70,625	188,718	284,668	486,025	1,529,000
KR22040	27	186,351	33,002	65,265	120,974	254,300	895,580
KR22460	26	728,954	112,798	192,730	408,627	1,113,000	2,813,000
KR22478	34	1,236,000	94,789	225,980	420,949	1,747,000	6,818,000
KR22822	25	1,267,000	140,471	303,698	544,821	1,479,000	6,303,000
KR23334	23	2,947,000	328,011	531,378	1,570,000	4,664,000	14,450,000
KR23360	7	1,796,000	273,983	289,049	1,630,000	2,935,000	4,202,000
KR23490	9	4,512,000	259,686	398,566	1,187,000	9,797,000	13,780,000
KR25312	28	7,136,000	121,113	570,610	1,492,000	8,397,000	34,490,000
KR25479	3	6,490,000	161,023	161,023	7,931,000	11,370,000	11,370,000
SH01	9	310,269	113,522	168,191	267,287	437,559	655,656
FA00	9	47,248	15,464	24,078	30,795	56,501	153,640
SP00	10	90,856	23,741	34,062	45,355	151,581	289,178
SR00	9	107,448	34,691	48,309	65,088	170,278	216,510