Nutrient Criteria in Lakes
2007 Sampling Survey
UAF Institute of Marine Science

Introduction

This report summarizes the results of water a quality sampling program for the Cook Inlet Ecoregion in South-Central Alaska. The area of the state to be investigated for assessing and establishing nutrient criteria is within the USGS level III ecoregion number 115. This region contains Anchorage, the western half of the Kenai Peninsula, and the Matanuska-Susitna Valley (Mat-Su). Within this region, USGS has found over 200 lakes which are larger than 20 acres. After logistical and resource considerations, the Mat-Su Valley was chosen as the focus of the project and 24 lakes were proposed for sampling during this initial phase.

The Mat-Su valley was selected for sampling, because this area has the fastest growing population in the state and there is a high potential for human nutrient sources impacting this region's numerous water bodies. In addition, more lake monitoring data exists for this valley than any other region in Alaska. It is generally accepted that most lakes within ecoregion 115 have nutrient concentrations below the levels considered eutrophic.

Much of the area is inaccessible by road and many area lakes, therefore, are essentially unaltered. This region also has the most lakes that are accessible by road in Alaska, thus minimizing expense of travel. The fact that there are large areas of the region having minimal contact and that there are large areas having road access may seem contradictory. However, this large region (~24,600 square miles) is the size of West Virginia, so these concepts are realistic.

The State of Alaska currently has no numerical criteria for nutrients. This report serves as a first step in moving Alaska closer to fulfilling EPA's sub-objective (2.2.1). Alaska State general funds are not presently available for adequate data collection, analysis and interpretation. One major caveat in interpreting this data set is that seasonality cannot be addressed and all lakes have basically been sampled at one site, without adequate vertical sampling and without areal coverage.

Methods

All sampling was performed within a week time, during September of 2007. Of the 24 lakes initially chosen, 3 remained inaccessible and therefore, only data for 21 lakes were collected at this time (Table 1). An inflatable boat or float plane was used to access each lake, seeking the deepest part of each lake. Due to the considerable distances between lakes (Figure 1), the sampling period covered a week's duration. A Secchi disc reading, ctd profile (SeaBird model SBE19), and water collection for nutrients and chlorophyll were carried out at one site in each lake. Observations on local land use were also noted. All lake information: including the lake's name, location and approximate depth are

presented in Table 1. Initially, the lakes were deemed deep if greater than 6 meters depth or shallow if less than 6 meters.

Table 1. Nutrient Criteria Lake information during September 2007 sampling period.

Lake Name	#	*Location*	*Depth max*	*Depth sampled*	*Comments*
Big Lake	1	61° 31'; 149° 59'	27	20.8	303 (d) impaired
Byers Lake	2	62° 44'; 150° 06'	54		public use cabin
Homestead Lake	3	61° 31' 58"; 149° 51' 19"	5	4.8	
Horseshoe Lake	4	61° 34' 33"; 149° 55' 47"	7.5	4.9	pike present
James Lake	5	61° 38' 06"; 150° 05' 42"	?	5.3	public use cabin
Jim Lake	6	61° 33' 13"; 148° 55' 50"	1.8	1	
Johnson Lake	7	61° 33' 59"; 149° 13' 59"	?	1.7	remote, pristine?
Lake Louise	8	62° 16' 48"; 146° 31' 31"	38.0	14.3	
Lake Lucille	9	61° 34' 44"; 149° 27' 38"	4.8	5.5	303 (d) impaired
Lalen Lake	10	61° 36' 24"; 149°41' 17"	3.6	3.7	
Loonsong Lake	11	61° 26' 48"; 149° 56' 05"	?	4.5	remote, pristine?
Mud Lake	12	61° 35'; 149° 20'	5.2	0.6	
Nancy Lake	13	61° 41' 13"; 150° 00' 14"	19.8	19.1	public use cabin
Redshirt Lake	14	61° 37' 25"; 150° 10' 25"	15.2	11.3	public use cabin
Shell Lake	15	61° 58'; 151° 33'	58.7	17.7	
Threemile Lake	16	61° 30'; 149° 46'	4.6	3.7	
Vera Lake	17	61° 42' 42"; 150° 08 '26"	7	5.3	
Wasilla Lake	18	61° 35'; 149° 24'	14.6	12.1	pike present
West Papoose Lake	19	61° 32' 09"; 150° 05' 42"	?	10.1	
Wolverine Lake	20	61° 34' 47"; 149° 14' 27"	2.8	1.5	floatplane base
Zero Lake	21	61° 38' 52"; 149° 48' 25"	?	9.3	remote, pristine?
Falk Lake	22	61° 33' 24"; 149° 03' 07"	?	not sampled	
Unknown #1	23	62° 02' 03"; 149° 58' 21"	?	not sampled	
Unknown #2	24	61° 02' 04"; 148° 46' 11"	?	not sampled	

Nutrient sampling:
Nutrient samples were collected at all lakes. At each location, samples for nutrient analyses were collected from near surface, the mixed layer and below the thermocline. Exceptions at Mud Lake (at 0.6m depth), Johnson Lake (at 1.7m depth), Jim Lake (at 0.9m depth) and Wolverine Lake (at 1.5m depth), were due to the shallow depth only 1 or 2 samples could be taken with respect to depth.

Samples were collected from the near surface to determine the nutrients available to algal blooms resulting from nutrient loadings. Deeper samples were collected to examine the effects of wind generated nutrient mixing and nutrient pool availability in deeper

stratified waters. After collection all samples were placed in ice chests and transported back to the lab for analysis. Nutrient samples were processed for nitrate, ammonium, silicate, and phosphate concentrations using an automated nutrient analyzer (ALPKEM model RFA 300). Detection limits are approximately 0.05 μM for nitrate, nitrite and silicate and approximately 0.1 μM for orthophosphate and ammonium.

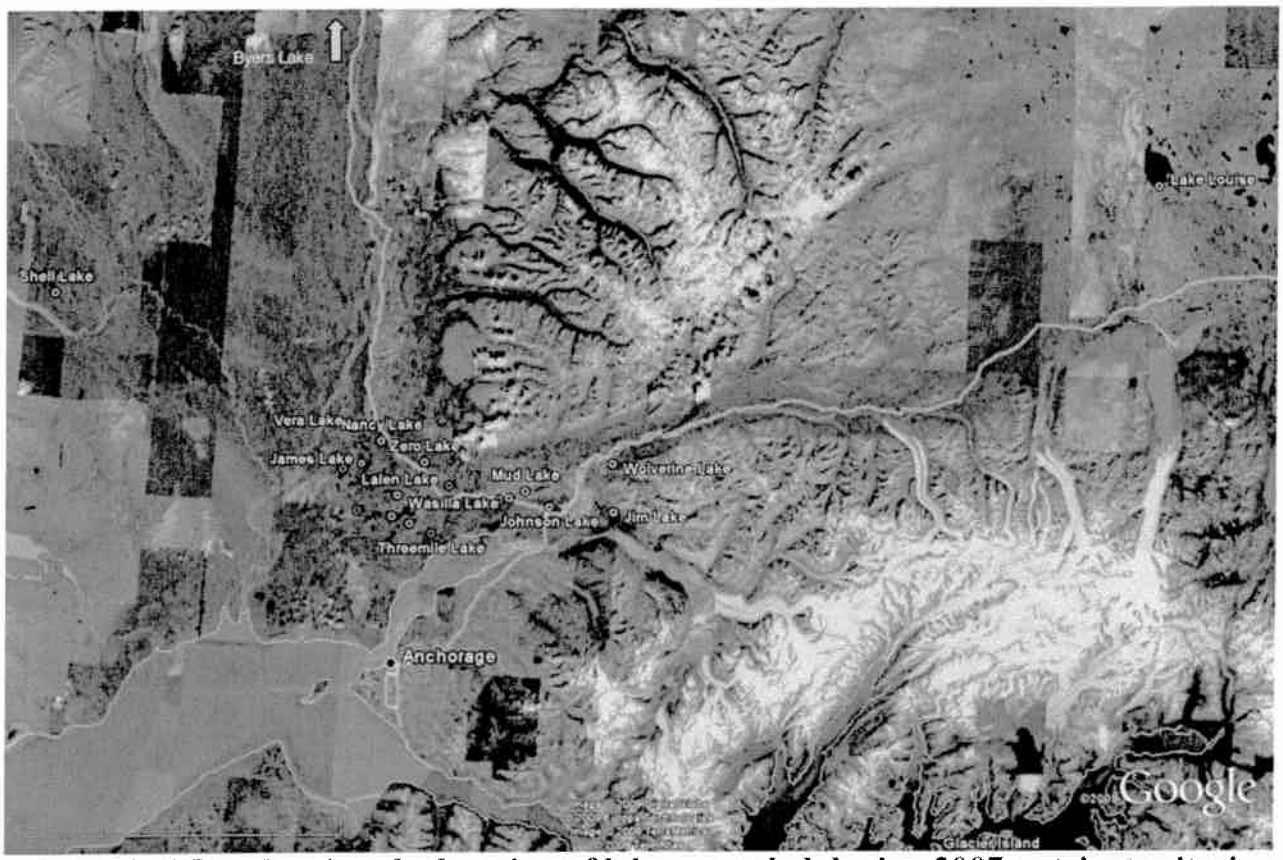

Figure 2. Map showing the location of lakes sampled during 2007 nutrient criteria program. Note that Byers lake lies to the north of the maps northern boundary.

Chlorophyll sampling:
Chlorophyll samples were collected by using a Niskin water sampling bottle to obtain one liter of sample water from depths similar to that of the nutrient sampling schema. The liter of water was then passed through a sample filter (GF/F glass fiber filter, with nominal pore size of 0.7 μm) using a hand pump. The liter of water and filtering process was shielded as much as possible to prevent photodegradation of chlorophyll. Sample filters were wrapped in aluminium foil and placed on ice within ice chests for transport to the laboratory for analysis. All filters were extracted in 90% acetone and read fluorometrically as per methods outlined in Holm-Hansen et al., (1965).

Results

General information collected for each lake is summarized in Table 2. Secchi disc depths ranged from 2.3 to 8.5 m. By the classification scheme adopted by the Michigan DEQ for Secchi disc measurements, 6 Mat-Su Valley lakes appeared to be oligotrophic and 11

lakes appeared as mesotrophic. Typically the deeper lakes tended to yield deeper Secchi values. Surface water temperatures during this fall sampling period ranged between 14 and 17.7 °C. Mixed layers were highly variable with, two of the shallow lakes (Threemile Lake and Vera Lake) having a distinct thermocline from surface to the bottom. Most lakes had mixed layers in excess of 10 m.

Table 2. Nutrient Criteria Lake Survey data collected during September 2007 sampling period, in conjunction with nutrient and chlorophyll sampling.

DEC Lake Sampling 2007

Lake Surface Values		Date Sampled	Secchi (m)	Depth (m)	Depth Type >6m or <6m	Urbanization	Temp (°C)	Mixed Layer Depth (m)
Big Lake	1	9/7/2007	8.50*	20.8	Deep	High	16.9	23
Byers Lake	2	9/8/2007	6.50*	137.2	Deep	L		none
Homestead Lake	3	9/4/2007	3.50**	4.8	Shallow	L	17.7	7.5
Horseshoe Lake	4	9/10/2007	3.80**	4.9	Shallow	Med		none
James Lake	5	9/5/2007	4.00**	5.3	Shallow	L	17.0	10
Jim Lake	6	9/6/2007		0.9	Shallow	L		none
Johnson Lake	7	9/6/2007		1.7	Shallow	L		none
Lake Louise	8	9/7/2007	6.00*	14.3	Deep	Med	14.0	28.3
Lake Lucille	9	9/7/2007	3.00**	5.5	Shallow	M-H	15.5	10
Lalen Lake	10	9/3/2007	2.30**	3.7	Shallow	M-H	17.2	9
Loonsong Lake	11	9/5/2007	2.90**	4.5	Shallow	L	16.7	14.8
Mud Lake	12	9/6/2007		0.6	Shallow	High		0
Nancy Lake	13	9/10/2007	3.00**	19.1	Deep	Med		none
Redshirt Lake	14	9/5/2007	5.00*	11.3	Deep	L	17.0	18
Shell Lake	15	9/5/2007	4.50**	17.7	Deep	L	15.9	20
Threemile Lake	16	9/7/2007	3.20**	3.7	Shallow	L	16.0	thermo to bottom
Vera Lake	17	9/4/2007	4.00**	5.3	Shallow	L	17.3	thermo to bottom
Wasilla Lake	18	9/6/2007	2.50**	12.1	Deep	High	15.9	17.5
West Papoose	19	9/5/2007	5.00*	10.1	Deep	L	16.9	20
Wolverine Lake	20	9/5/2007		1.5	Shallow	Med	14.8	5
Zero Lake	21	9/3/2007	5.00*	9.3	Deep	L	17.3	19

*oligotrophic, **mesotrophic

Nutrient sampling:

Table 3 displays the sample summary for all nutrient samples. Data are presented for phosphate (PO_4), silicate (SiO_4), nitrite (NO_2), ammonium (NH_4), nitrate (NO_3) and dissolved inorganic nitrogen (DIN). Surface phosphate concentrations ranged from below detection (Horseshoe Lake) to 2.411 µM (Zero Lake), but were typically below 1 µM. Surface nitrate concentrations were typically below 1 µM, ranging from 0.035 µM

(Zero Lake) to 29.002 µM (Shell Lake). The ratio of nitrogen to phosphate was typically below 16 suggesting phosphate limitation to primary productivity. Exceptions, with N:P values in excess of 16 were Byers Lake, Horseshoe Lake, and Shell Lake. Both Byers Lake and Shell Lake had the highest concentrations of nitrate at depth, with values in excess of 30 µM

Table 3. Nutrient Criteria Lake Survey nutrient summary. All values in µmoles of nutrient per liter. Data collected during September 2007.

Lake Name		DEPTH m	PO4 µM	SIO4 µM	N+N µM	NO2 µM	NH4 µM	NO3 µM	DIN µM
Big Lake	1	0	0.970	107.856	0.060	0.025	0.368	0.035	0.428
Big Lake	1	10	1.058	141.163	0.060	0.025	0.276	0.035	0.336
Big Lake	1	20	0.670	192.495	9.576	0.025	1.908	9.551	11.484
Byers Lake	2	0	0.423	85.034	6.823	0.025	0.536	6.798	7.358
Byers Lake	2	14	0.723	29.448	21.845	0.025	0.160	21.820	22.005
Byers Lake	2	28	0.388	29.780	30.703	0.025	1.038	30.678	31.741
Homestead Lake	3	0	0.753	3.748	0.479	0.025	0.269	0.454	0.748
Homestead Lake	3	2	0.394	3.871	0.239	0.025	0.310	0.214	0.549
Homestead Lake	3	4	0.441	3.994	0.060	0.025	0.377	0.035	0.437
Horseshoe Lake	4	0	0.000	34.656	1.496	0.025	0.425	1.471	1.922
Horseshoe Lake	4	2	1.570	78.331	0.120	0.025	0.306	0.094	0.426
Horseshoe Lake	4	5	0.741	99.669	0.180	0.025	0.281	0.154	0.461
James Lake	5	0	1.299	18.762	0.060	0.025	0.202	0.035	0.262
James Lake	5	2	0.976	19.034	0.060	0.025	0.216	0.035	0.275
James Lake	5	3.5	1.111	18.713	0.060	0.025	0.202	0.035	0.262
Jim Lake	6	0	1.058	63.646	1.017	0.025	2.561	0.992	3.579
Jim Lake	6	1	1.041	64.125	1.137	0.025	2.334	1.112	3.471
Johnson Lake	7	0	0.953	8.830	0.060	0.025	0.188	0.035	0.248
Lake Louise	8	0	0.882	18.333	0.060	0.025	0.311	0.035	0.371
Lake Louise	8	7	0.706	14.375	0.239	0.025	0.286	0.214	0.526
Lake Louise	8	14	0.582	32.162	0.120	0.025	0.423	0.094	0.542
Lake Lucille	9	0	1.076	174.258	0.120	0.025	0.519	0.094	0.639
Lake Lucille	9	2	0.847	173.133	0.060	0.025	0.507	0.035	0.567
Lake Lucille	9	5	0.370	177.635	0.120	0.025	0.536	0.094	0.656
Lalen Lake	10	0	0.929	21.573	2.035	0.025	2.034	2.010	4.069
Lalen Lake	10	2	0.976	22.288	0.120	0.025	2.317	0.094	2.437
Lalen Lake	10	4	1.147	19.601	0.120	0.025	2.155	0.094	2.275
Loonsong Lake	11	0	0.523	35.183	3.890	0.025	1.320	3.865	5.210
Loonsong Lake	11	2	0.429	40.779	0.898	0.025	1.374	0.872	2.272
Loonsong Lake	11	3	1.147	41.642	2.274	0.025	1.536	2.249	3.810
Mud Lake	12	0	0.917	147.467	0.299	0.025	0.213	0.274	0.512
Nancy Lake	13	0	0.723	82.035	2.873	0.025	0.514	2.848	3.387
Nancy Lake	13	10	0.794	124.277	0.239	0.025	0.314	0.214	0.553
Nancy Lake	13	20	0.847	30.035	0.299	0.025	0.316	0.274	0.615
Redshirt Lake	14	0	0.806	124.976	2.993	0.025	0.404	2.967	3.397
Redshirt Lake	14	5	0.782	120.366	0.060	0.025	3.650	0.035	3.710
Redshirt Lake	14	10	0.759	116.347	5.027	0.025	0.269	5.002	5.297
Shell Lake	15	0	1.000	104.636	29.027	0.025	0.202	29.002	29.229
Shell Lake	15	10	2.458	9.344	14.005	0.025	0.269	13.980	14.274
Shell Lake	15	20	1.429	62.426	34.234	0.025	0.135	34.209	34.369
Threemile Lake	16	0	0.441	129.005	0.419	0.025	1.252	0.394	1.671

Threemile Lake	16	1	0.759	124.953	0.060	0.025	0.944	0.035	1.004
Threemile Lake	16	3.5	0.864	120.450	0.778	0.025	1.107	0.753	1.885
Vera Lake	17	0	0.788	46.130	0.239	0.025	0.189	0.214	0.428
Vera Lake	17	3	0.800	43.590	0.599	0.025	0.269	0.573	0.868
Vera Lake	17	4	1.005	31.731	0.419	0.025	0.808	0.394	1.227
Wasilla Lake	18	0	1.411	89.457	0.958	0.025	0.235	0.932	1.192
Wasilla Lake	18	5	1.147	92.747	0.060	0.025	0.223	0.035	0.283
Wasilla Lake	18	10	1.235	97.073	0.060	0.025	0.238	0.035	0.298
West Papoose	19	0	1.017	35.848	3.950	0.025	0.674	3.925	4.624
West Papoose	19	5	1.082	41.297	0.120	0.025	0.458	0.094	0.578
West Papoose	19	9	0.723	28.255	1.377	0.025	0.471	1.351	1.848
Wolverine Lake	20	0	1.000	33.038	0.898	0.025	1.468	0.872	2.366
Wolverine Lake	20	1.5	1.382	30.498	0.898	0.025	1.212	0.872	2.110
Zero Lake	21	0	2.411	11.884	0.060	0.025	0.148	0.035	0.208
Zero Lake	21	5	0.853	9.196	0.060	0.025	0.148	0.035	0.208
Zero Lake	21	6	1.200	3.698	0.060	0.025	0.418	0.035	0.477

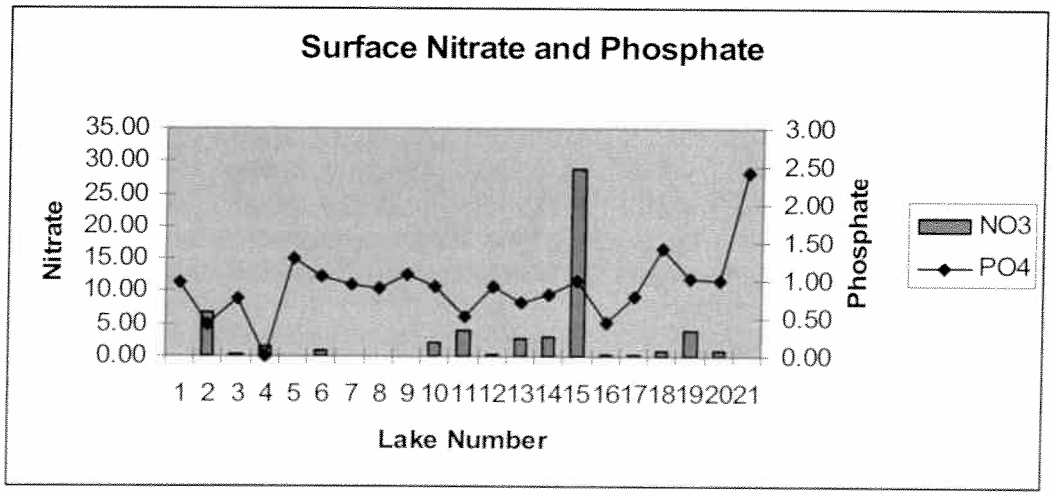

Figure 2. Surface nitrate and phosphate concentration for 21 lakes sampled in 2007. Concentrations of nitrate and phosphate measured in µmoles per liter. Note Lake 15, with exceptionally high nitrate, is Shell Lake. Lake 21 with exceptionally high phosphate is Zero Lake.

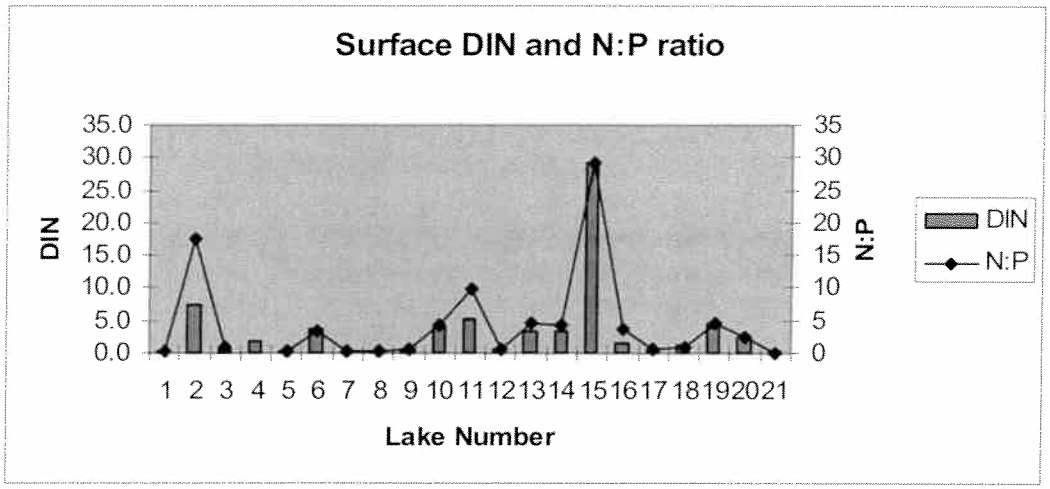

Figure 3. Surface dissolved inorganic nitrogen (DIN) concentrations and N:P ratio for 21 lakes sampled in 2007. The concentration of DIN is expressed µmoles nitrogen per liter. Highest DIN concentrations are found in Lake 15 (Shell Lake) and Lake 2 (Byers Lake). Also note with undetectable phosphate in Lake 4 (Horseshoe Lake) the N:P ration could not be calculated.

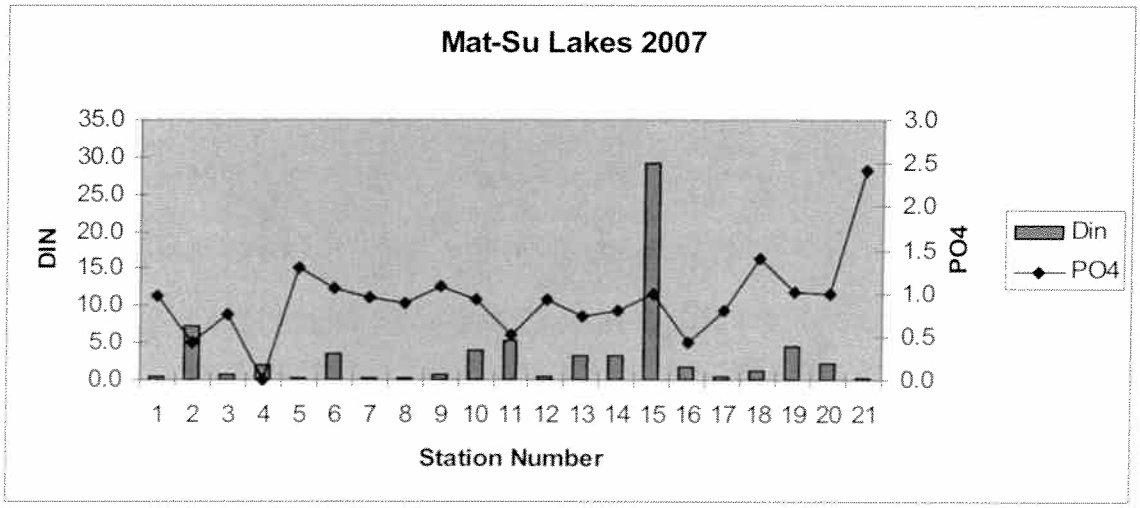

Figure 4. Surface dissolved inorganic nitrogen and phosphate concentrations in Mat-Su Lakes during September 2007.

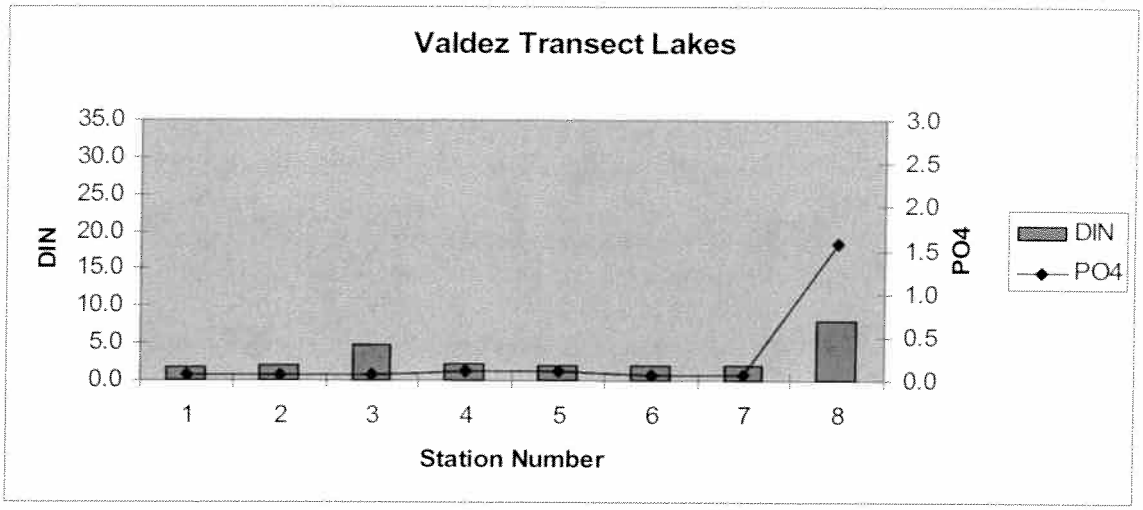

Figure 5. Surface dissolved inorganic nitrogen and phosphate concentrations in lakes accessible from the highway between Valdez and Fairbanks in July 2005.

Chlorophyll sampling.

Table 4 displays the sample summary for surface chlorophyll concentration by lake. Surface values range from 1.18 to 57.69 µg Chl L^{-1}, with only 7 lakes having values less than 5 µg Chl L^{-1}. All chlorophyll data are presented in Table 5. Certainly the lakes in excess of 10 µg Chl L^{-1} indicate signs of eutrophication. Chlorophyll values of >20 are not uncommon within the Mat-Su lakes sampled, yet Lake Lucille, Wasilla Lake, and Zero Lake all had chlorophyll concentrations comparable to eutrophic lakes. Chlorophyll concentrations in Jim Lake, Johnson Lake, Lake Lucille, and Redshirt Lake were all low and characteristic of oligotrophic systems.

Table 4. DEC Lake Sampling 2007, surface chlorophyll and phaeopigment data. Concentrations in µg Chl L^{-1} and in µg phaeo L^{-1}.

Lake Surface Values		Date Sampled	Depth m	Chl (µg L^{-1})	Phaeo (µg L^{-1})	Chl:Phaeo
Big Lake	1	9/7/2007	0	6.91	0.97	7.15
Byers Lake	2	9/8/2007	0	11.97	0.89	13.47
Homestead Lake	3	9/4/2007	0	13.11	1.46	9.01
Horseshoe Lake	4	9/10/2007	0	2.23	0.42	5.33
James Lake	5	9/5/2007	0	18.53	2.94	6.31
Jim Lake	6	9/6/2007	0	1.44	0.69	2.09
Johnson Lake	7	9/6/2007	0	1.37	0.04	35.89
Lake Louise	8	9/7/2007	0	1.18	0.11	11.06
Lake Lucille	9	9/7/2007	0	57.69	12.68	4.55
Lalen Lake	10	9/3/2007	0	28.49	1.93	14.75
Loonsong Lake	11	9/5/2007	0	23.08	3.39	6.82

Mud Lake	12	9/6/2007	0	22.03	5.46	4.03
Nancy Lake	13	9/10/2007	0	5.86	0.65	9.08
Redshirt Lake	14	9/5/2007	0	1.73	0.35	4.91
Shell Lake	15	9/5/2007	0	1.79	0.21	8.43
Threemile Lake	16	9/7/2007	0	2.01	0.18	11.32
Vera Lake	17	9/4/2007	0	10.63	2.06	5.16
Wasilla Lake	18	9/6/2007	0	33.04	0.47	70.31
West Papoose	19	9/5/2007	0	13.29	1.57	8.44
Wolverine Lake	20	9/5/2007	0	16.78	5.42	3.10
Zero Lake	21	9/3/2007	0	14.42	1.01	14.26

Table 5. DEC Lake Sampling 2007, all chlorophyll and phaeopigment data. Concentrations in µg Chl L^{-1} and in µg phaeo L^{-1}.

Lake Name		Date Sampled	Depth (m)	Chl (µg Chl L^{-})	Phaeo (µg phaeo L^{-1})
Big Lake	1	9/7/2007	0	6.91	0.97
Big Lake	1	9/7/2007	10	34.00	0.60
Big Lake	1	9/7/2007	20	0.41	0.32
Byers Lake	2	9/8/2007	0	11.97	0.89
Byers Lake	2	9/8/2007	14	12.52	1.24
Byers Lake	2	9/8/2007	28	0.56	0.25
Homestead Lake	3	9/4/2007	0	13.11	1.46
Homestead Lake	3	9/4/2007	2	13.29	2.46
Homestead Lake	3	9/4/2007	4	23.77	5.33
Horseshoe Lake	4	9/10/2007	0	2.23	0.42
Horseshoe Lake	4	9/10/2007	2	2.95	0.39
Horseshoe Lake	4	9/10/2007	5	2.69	0.44
James Lake	5	9/5/2007	0	18.53	2.94
James Lake	5	9/5/2007	2	20.98	3.72
James Lake	5	9/5/2007	3.5	19.58	3.80
Jim Lake	6	9/6/2007	0	1.44	0.69
Jim Lake	6	9/6/2007	1	10.84	4.76

Johnson Lake	7	9/6/2007	0	1.37	0.04
Lake Louise	8	9/7/2007	1	1.18	0.11
Lake Louise	8	9/7/2007	7	1.23	0.08
Lake Louise	8	9/7/2007	14	0.56	0.20
Lake Lucille	9	9/7/2007	0	57.69	12.68
Lake Lucille	9	9/7/2007	2	60.83	13.79
Lake Lucille	9	9/7/2007	5	6.53	1.42
Lalen Lake	10	9/3/2007	0	28.49	1.93
Lalen Lake	10	9/3/2007	2	27.27	3.60
Lalen Lake	10	9/3/2007	4	38.81	9.39
Loonsong Lake	11	9/5/2007	0	23.08	3.39
Loonsong Lake	11	9/5/2007	2	22.20	3.09
Loonsong Lake	11	9/5/2007	4	22.38	3.79
Mud Lake	12	9/6/2007	0	22.03	5.46
Nancy Lake	13	9/10/2007	0	5.86	0.65
Nancy Lake	13	9/10/2007	10	0.93	0.44
Nancy Lake	13	9/10/2007	20	0.68	0.72
Redshirt Lake	14	9/5/2007	0	1.73	0.35
Redshirt Lake	14	9/5/2007	5	1.94	0.33
Redshirt Lake	14	9/5/2007	10	0.48	0.96
Shell Lake	15	9/5/2007	0	1.79	0.21
Shell Lake	15	9/5/2007	10	0.76	0.18
Shell Lake	15	9/5/2007	20	8.48	3.65
Threemile Lake	16	9/7/2007	0	2.01	0.18
Threemile Lake	16	9/7/2007	1	18.88	2.44
Threemile Lake	16	9/7/2007	3.5	2.69	0.38
Vera Lake	17	9/4/2007	0	10.63	2.06
Vera Lake	17	9/4/2007	3	10.66	1.85
Vera Lake	17	9/4/2007	4	13.99	12.04
Wasilla Lake	18	9/6/2007	0	33.04	0.47

Wasilla Lake	18	9/6/2007	5	40.38	0.47
Wasilla Lake	18	9/6/2007	10	15.03	72.22
West Papoose	19	9/5/2007	0	13.29	1.57
West Papoose	19	9/5/2007	5	14.33	2.14
West Papoose	19	9/5/2007	9	81.81	29.96
Wolverine Lake	20	9/5/2007	0	16.78	5.42
Wolverine Lake	20	9/5/2007	1.5	1.92	0.85
Zero Lake	21	9/3/2007	0	14.42	1.01
Zero Lake	21	9/3/2007	4	16.96	1.78
Zero Lake	21	9/3/2007	8	35.31	25.51

Figures 6 and 7 demonstrate the variability between lakes when surface chlorophyll concentrations are compared to either DIN or N:P ratios. Byers Lake (Lake 2) and Shell Lake (Lake 15) both show elevated DIN and N:P ratios, primary due in increase nitrate concentrations. Lakes 9 (Lake Lucille), 10 (Lalen Lake), 11 (Loonsong Lake) and 12 (Mud Lake) are all shallow lakes (<5m depth) showing elevated chlorophyll concentrations. Lake 18 (Wasilla Lake) is the only deep lake showing high surface chlorophyll concentrations.

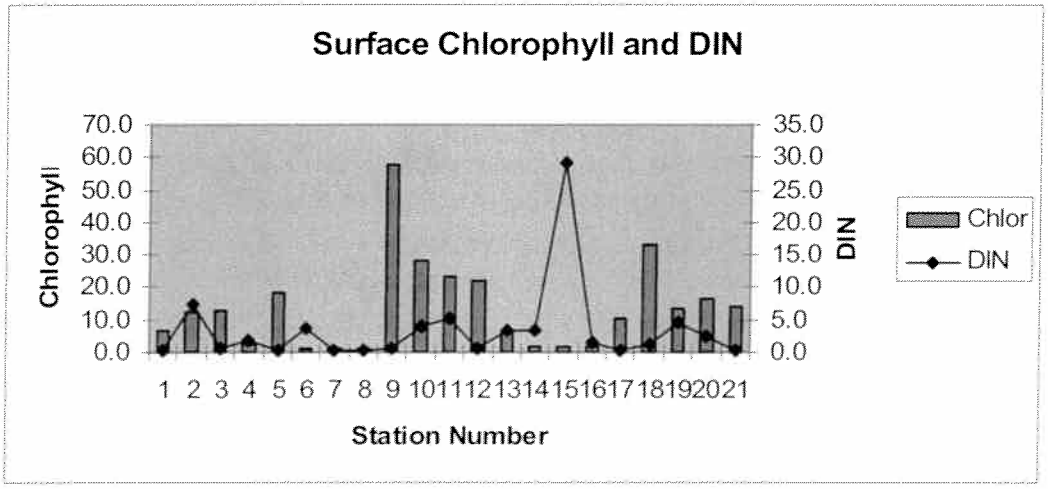

Figure 6. Surface chlorophyll distribution by lake, concentrations in µg Chl L^{-1}. Surface dissolved inorganic nitrogen (DIN) concentrations are given in µmole nitrogen per liter.

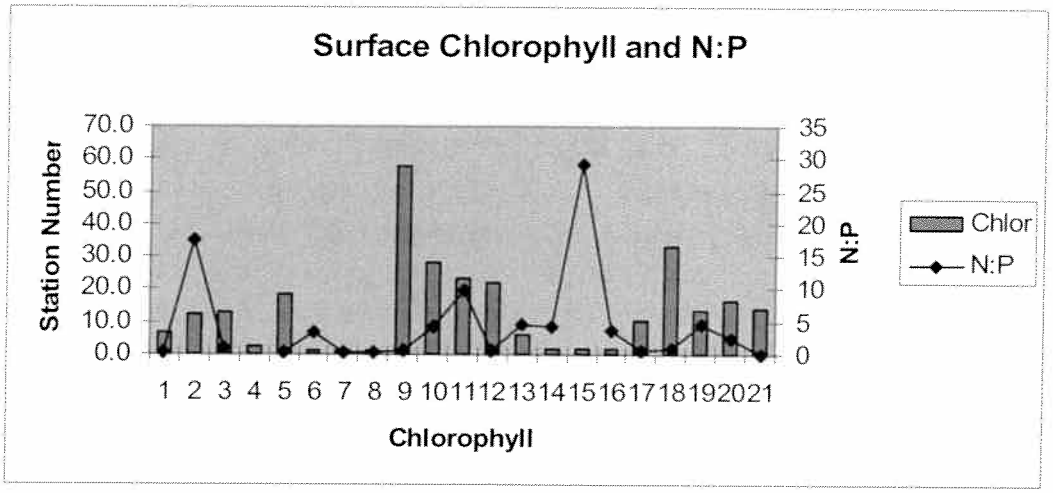

Figure 7. Surface chlorophyll distribution by lake, concentrations in µg Chl L^{-1}. Ratio of nitrogen to phosphate for surface nutrient concentrations.

Discussion

Nutrient samples were collected in 21 lakes on the Mat-Su valley for the purpose of obtaining an indication whether anthropogenic eutrophication is a management issue that might need to be considered in the future. With this possible objective in mind, it is helpful to consider the context of ambient nutrient and chlorophyll data to some general physical, chemical and biological processes that occur in lake waters.

The ambient concentrations of major biogenic nutrients especially orthophosphate, nitrate, nitrite, ammonium and dissolved silicon (silicate) can be used to assess the nutrient availability in marine and freshwaters but care must be taken to avoid the mistake of assuming that an instantaneous concentration measurement of a nutrient accurately represents a longer term value. A single measurement of nutrient concentrations can provide a quick glimpse of the possible nutrient status but a series of measurements over time can provide much more information about the long term nutrient status. The temporal scale of variability of nutrients in the Mat-Su lakes certainly exhibit a seasonal signal but it is probable that short term variations over days to weeks are also important as well as possible long term variation over years.

The Mat-Su nutrient/chlorophyll samples were collected in late summer/early autumn so the typical seasonal cycle of nutrient utilization by the phytoplankton would typically be at a low level with an annual minimum in the nutrient concentrations. That would be especially true for orthophosphate, nitrate, nitrite and silicate but ammonium may display a different pattern since it is derived from microbial decomposition of dissolved and particulate organic matter. The chemical forms of nitrogen may also show variations due to transformation between chemical species (e.g. oxidation of ammonium to nitrate) depending on oxidation-reduction reactions in the water column and within the sediments. The presence of organic forms of the nutrients can also be significant factor depending on the environmental conditions. So, a quick survey may provide indications

of excess nutrient concentrations or plant growth (phytoplankton and attached algae) but a longer time series of measurements over the annual cycle that includes all nutrients in their various oxidation states and inorganic/organic forms must be attained before a valid nutrient criteria characterization can be made. When nutrient concentrations are observed to be low in samples, the chlorophyll concentrations are often useful indicators of phytoplankton growth that occurred previous to the sampling. It is not unusual to measure low nutrient and high chlorophyll concentrations in a very productive lake. Table 6 contains the estimated amounts of nitrate in each of the Mat-Su lakes that would account for the ambient nitrate concentrations plus the amount of nitrate required to produce the observed chlorophyll. The total nitrogen in the dissolved and particulate forms of nitrogen was <10 :M in ten of the Mat-Su lakes, 10-20 :M in five lakes, 20-30 :M in 3 lakes and >30 :M in two lakes. It is noteworthy that the highest value was registered in Lake Lucille adjacent to the urban area of Wasilla.

The kinetics of phytoplankton nutrient utilization is often a useful tool to assist in determining whether a specific nutrient value observed in a lake is considered either high or low. In general, the two variables of maximum uptake rate, VMAX, and the half saturation constant, Ks, are used to describe the growth potential of phytoplankton in relation to nutrient substrate concentrations. The value of Ks is normally considered to be a useful concentration of nutrient substrate that below which indicates a possible nutrient limitation. For instance, the Ks for nitrate is approximately 1 uM so nitrate concentrations less than 0.5uM may be considered near the threshold of a limiting concentration. All nitrate values above Ks would support good growth and values that are twice the Ks, i.e. 2uM, would support a maximal growth rate. All of the nutrients conform to uptake kinetics as long as some other substrate (nutrient or light) does not become limiting.

Observations of nutrient concentrations in lakes can be greatly influenced by the physical characteristics of the lake, especially water depth and thermal stratification. Shallow lakes are most likely to have higher summer temperatures which can increase growth rates and microbial decomposition. In addition, shallow lakes may have larger amounts of sunlight penetration of the waters and support benthic primary production. Shallow lakes therefore have more extreme conditions and may show higher effects of nutrient enrichment and plant growth. In contrast, deeper lakes (>6meters) can be thermally stratified which limits the vertical circulation in the lake except during a short time in the spring and fall seasons. For these reasons surface sampling may be adequate in shallow lakes while samples from the surface and near the bottom may be most informative in deeper lakes.

Comparisons with other lakes:
A two year sampling program conducted by ADF&G in two lakes on Kodiak Island, demonstrated marked seasonality in nutrient loadings (Figs. 7 and 8). Phosphate values in these two lakes were low and remained below 0.2 μ mole/liter but seasonal variability is also quite evident. These values were comparable to phosphate values found along the Valdez Highway transect samples (Fig.4). This suggests that phosphate loadings within all 21 Mat-Su valley lakes are somewhat elevated above expected concentrations and

could be classified as mesotrophic. Nitrate concentrations in the two lakes showed a prominent seasonal cycle with spring drawdown as bloom conditions developed, with a summer depletion for 2 months and then with a fall enrichment that resulted from convective overturn and reduced rates of plankton productivity. The total nitrogen values could also qualify about half of the Mat-Su lakes as potentially mesotrophic. No obvious trends related to relative depth of the lakes were noted.

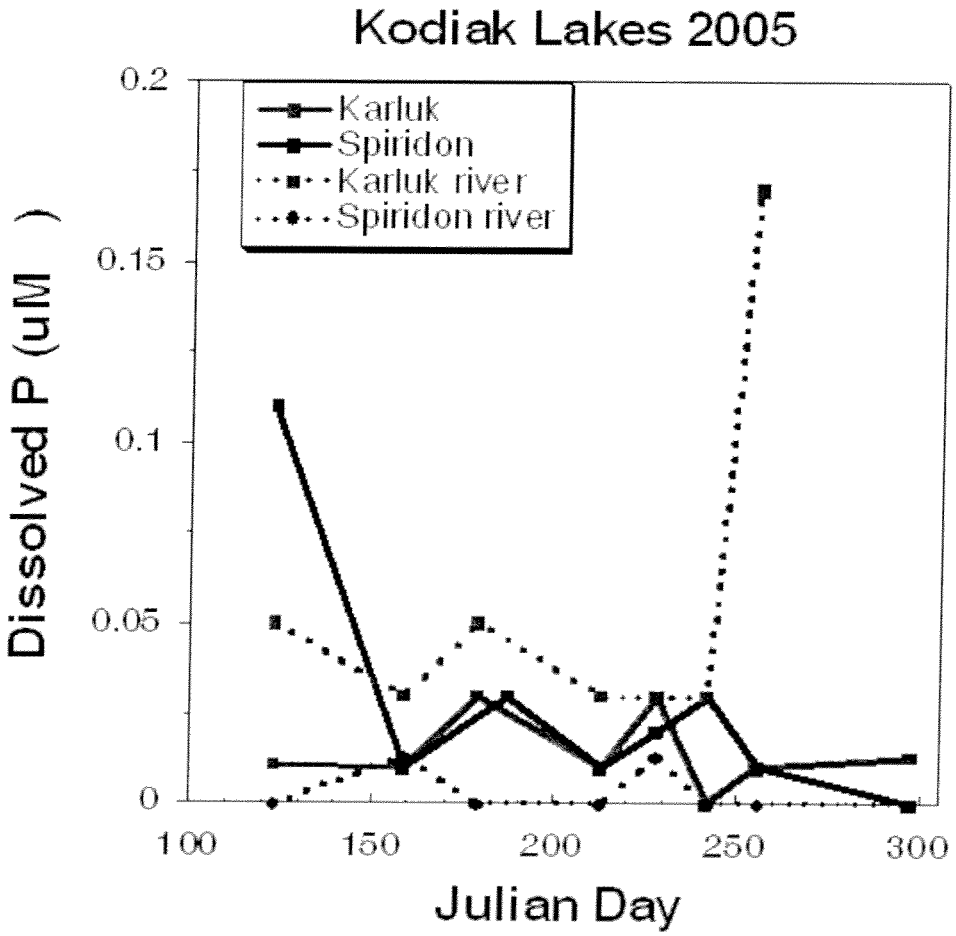

Figure 8. Seasonal surface phosphate concentrations found in Karluk Lake and Spiridon Lake, Kodiak Island, during 2005.

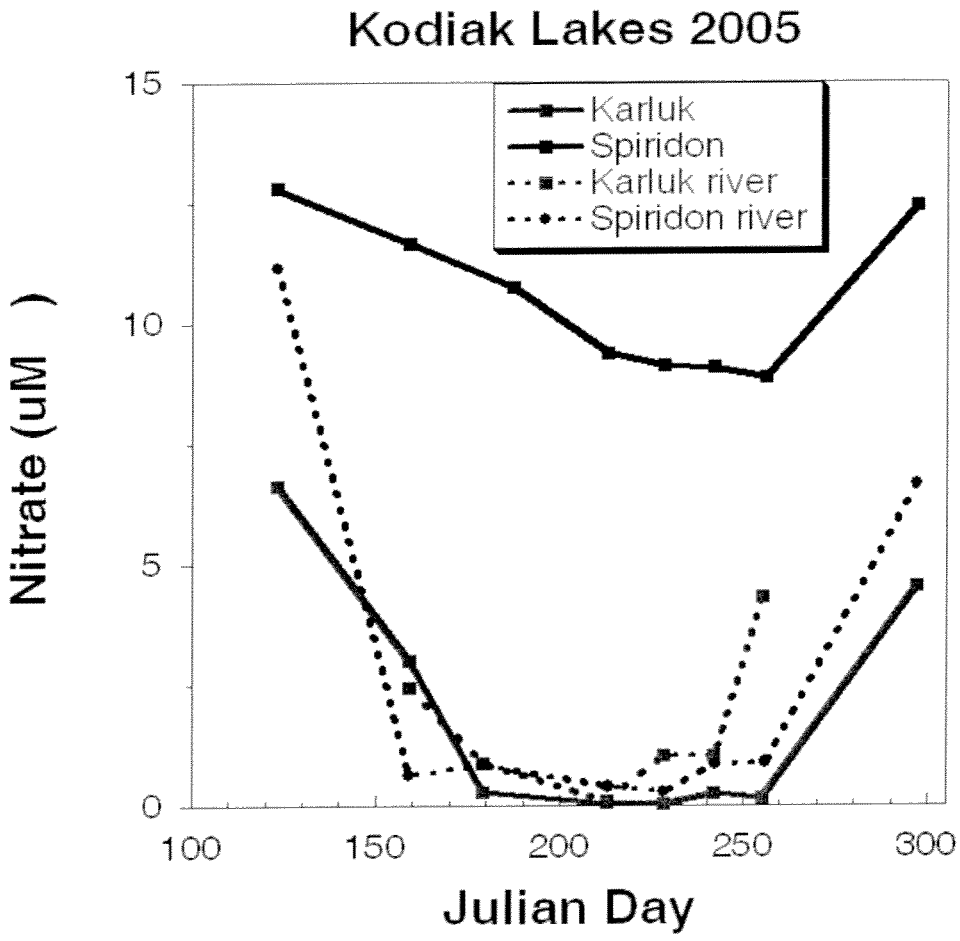

Figure 9. Seasonal surface nitrate concentrations found in Karluk Lake and Spiridon Lake, Kodiak Island, during 2005.

Potential: Based on the chlorophyll values present in each lake and DIN concentrations (shown in Table 5) estimates of initial total nitrogen potentially available for each lake were calculated.

Table 6. Using chlorophyll to estimate nitrate (at 0.7 µmole nitrate per 1 µg Chl/L), total nitrogen concentration for each lake was estimated. DEC Lake Sampling 2007, surface values only.

Lake Name		Chl ($\mu g\ L^{-}$)	DIN µM	Conversion Chl to NO_3	Total N
Big Lake	1	6.91	0.43	4.83	5.26
Byers Lake	2	11.97	7.36	8.38	15.74
Homestead Lake	3	13.11	0.75	9.18	9.93
Horseshoe Lake	4	2.23	1.92	1.56	3.48
James Lake	5	18.53	0.26	12.97	13.23
Jim Lake	6	1.44	3.58	1.01	4.59
Johnson Lake	7	1.37	0.25	0.96	1.21
Lake Louise	8	1.18	0.37	0.83	1.20
Lake Lucille	9	57.69	0.64	40.38	41.02
Lalen Lake	10	28.49	4.07	19.95	24.01
Loonsong Lake	11	23.08	5.21	16.15	21.36
Mud Lake	12	22.03	0.51	15.42	15.93
Nancy Lake	13	5.86	3.39	4.10	7.49
Redshirt Lake	14	1.73	3.40	1.21	4.60
Shell Lake	15	1.79	29.23	1.25	30.48
Threemile Lake	16	2.01	1.67	1.41	3.08
Vera Lake	17	10.63	0.43	7.44	7.87
Wasilla Lake	18	33.04	1.19	23.13	24.32
West Papoose	19	13.29	4.62	9.30	13.92
Wolverine Lake	20	16.78	2.37	11.75	14.11

Recommendations

Due to the extreme seasonality throughout the drainage basin in both timing and volume of drainage is quite variable. Additionally, recreational usage peaks during the summer and diminishes during the winter. Therefore, before natural or background levels can be determined for lakes in the Mat-Su Valley, a multi-year and seasonally variable study must be completed if this relates to Alaska's attempts to develop nutrient criteria.

References

Holm-Hansen, O., C. J. Lorenzen, R. W. Holmes and J. D. H. Strickland. 1965. Fluorometric Determination of Chlorophyll. Journal du Conseil 30(1):3-15.

Michigan Department of Natural Resources, 1982, Michigan Inland Lake Project: Identification, Survey and Classification: U.S. Environmental Protection Agency Clean Lakes Agreement No. S 005511-01 Final Project Report, September 1982.

DEC Lake Sampling 2007

Lake	Date Sampled	Depth m	Chl ($\mu g\ L^{-1}$)	Phaeo ($\mu g\ L^{-1}$)
Lalen Lake	9/3/2007	0	28.49	1.93
Lalen Lake	9/3/2007	2	27.27	3.60
Lalen Lake	9/3/2007	4	38.81	9.39
Zero Lake	9/3/2007	0	14.42	1.01
Zero Lake	9/3/2007	4	16.96	1.78
Zero Lake	9/3/2007	8	35.31	25.51
Vera Lake	9/4/2007	0	10.63	2.06
Vera Lake	9/4/2007	3	10.66	1.85
Vera Lake	9/4/2007	4	13.99	12.04
Homestead Lake	9/4/2007	0	13.11	1.46
Homestead Lake	9/4/2007	2	13.29	2.46
Homestead Lake	9/4/2007	4	23.77	5.33
Loongsong Lake	9/5/2007	0	23.08	3.39
Loongsong Lake	9/5/2007	2	22.20	3.09
Loongsong Lake	9/5/2007	4	22.38	3.79
West Papoose	9/5/2007	0	13.29	1.57
West Papoose	9/5/2007	5	14.33	2.14
West Papoose	9/5/2007	9	81.81	29.96
Redshirt Lake	9/5/2007	0	1.73	0.35
Redshirt Lake	9/5/2007	5	1.94	0.33
Redshirt Lake	9/5/2007	10	0.48	0.96
Shell Lake	9/5/2007	0	1.79	0.21
Shell Lake	9/5/2007	10	0.76	0.18
Shell Lake	9/5/2007	20	8.48	3.65
James Lake	9/5/2007	0	18.53	2.94
James Lake	9/5/2007	2	20.98	3.72
James Lake	9/5/2007	3.5	19.58	3.80
Woverine Lake	9/5/2007	0	16.78	5.42
Woverine Lake	9/5/2007	1.5	1.92	0.85
Jim Lake	9/6/2007	0	1.44	0.69
Jim Lake	9/6/2007	1	10.84	4.76
Wasilla Lake	9/6/2007	0	33.04	0.47
Wasilla Lake	9/6/2007	5	40.38	0.47
Wasilla Lake	9/6/2007	10	15.03	72.22
Mud Lake	9/6/2007	0	22.03	5.46

Johnson Lake	9/6/2007	0	1.37	0.04
Lake Louise	9/7/2007	1	1.18	0.11
Lake Louise	9/7/2007	7	1.23	0.08
Lake Louise	9/7/2007	14	0.56	0.20
Lake Lucille	9/7/2007	0	57.69	12.68
Lake Lucille	9/7/2007	2	60.83	13.79
Lake Lucille	9/7/2007	5	6.53	1.42
Threemile Lake	9/7/2007	0	2.01	0.18
Threemile Lake	9/7/2007	1	18.88	2.44
Threemile Lake	9/7/2007	3.5	2.69	0.38
Big Lake	9/7/2007	0	6.91	0.97
Big Lake	9/7/2007	10	34.00	0.60
Big Lake	9/7/2007	20	0.41	0.32
Byers Lake	9/8/2007	0	11.97	0.89
Byers Lake	9/8/2007	14	12.52	1.24
Byers Lake	9/8/2007	28	0.56	0.25
Nancy Lake	9/10/2007	0	5.86	0.65
Nancy Lake	9/10/2007	10	0.93	0.44
Nancy Lake	9/10/2007	20	0.68	0.72
Horseshoe Lake	9/10/2007	0	2.23	0.42
Horseshoe Lake	9/10/2007	2	2.95	0.39
Horseshoe Lake	9/10/2007	5	2.69	0.44

Lake Name	Lat	Lon	Depth (ft)	Clear to Bottom?
Lalen Lake	61.60104	149.69048	12.2	No
Zero Lake	61.64794	149.80600	30.6	No
Vera Lake	61.71444	150.13974	17.3	No
Homestead Lake	61.51595	149.85535	15.7	No
Loonsong Lake	61.46799	149.94843	14.8	No
West Papoose Lake	61.53682	150.09546	33	No
Redshirt Lake	61.62325	150.17119	37.1	No
Shell Lake	61.95455	151.54263	58	No
James Lake	61.63729	150.08946	17.5	No
Wolverine Lake	61.66526	148.96277	5	Yes
Jim Lake	61.56297	148.94710	3.1	Yes
Wasilla Lake	61.58176	149.41806	39.7	No
Mud Lake	61.59772	149.34750	2	Yes
Johnson Lake	61.56759	149.23633	5.6	
Lake Louise	62.28861	146.52020	47	No
Lake Lucille	61.57750	149.46178	17.9	No
Threemile Lake	61.49754	149.75626	12.1	No
Big Lake	61.52923	149.93700	68.1	No
Byers Lake	62.73953	150.11482	450	No
Nancy Lake	61.68750	150.00726	62.6	No
Horseshoe Lake	61.57470	149.91785	16	No

Nutrient Criteria Development Plan
Lakes sampled in 2007 by DEC and UAF

Lake Name	Date Sampled	Lake sampled?	Arrival Time	Precip	Surface Conditions	Lat	Lon	Depth (ft)	Depth Samples Collected (m) Top-Mid-Bot			Nutrient Samples Collected Top-Mid-Bot			Chlorophyl-a Samples Collected Top-Mid-Bot			CTD Cast?
Lalen Lake	9/3/2007	Yes	12:04	None	Flat	61.60104	149.69048	12.2	>1	2	4	Nut 1	Nut 2	Nut 3	Chla 1	Chla 2	Chla 3	Yes
Zero Lake	9/3/2007	Yes	14:16	None	Flat	61.64794	149.80600	30.6	>1	5	10	Nut 4	Nut 5	Nut 6	Chla 4	Chla 5	Chla 6	Yes
Vera Lake	9/4/2007	Yes	13:05	None	Flat	61.71444	150.13974	17.3	>1	12	15	Nut 7	Nut 8	Nut 8	Chla 7	Chla 8	Chla 9	Yes
Homestead Lake	9/4/2007	Yes	15:53	None	Flat	61.51595	149.85535	15.7	>1	6	12	Nut 10	Nut 11	Nut 12	Chla 10	Chla 11	Chla 12	Yes
Loonsong Lake	9/5/2007	Yes	9:25	None	Flat	61.46799	149.94843	14.8	>1	6	12	Nut 13	Nut 14	Nut 15	Chla 13	Chla 14	Chla 15	Yes
West Papoose Lake	9/5/2007	Yes	11:00	None	Flat	61.53682	150.09546	33	>1	5	10	Nut 16	Nut 17	Nut 18	Chla 16	Chla 17	Chla 18	Yes
Redshirt Lake	9/5/2007	Yes	11:45	None	Flat	61.62325	150.17119	37.1	>1	5	11	Nut 19	Nut 20	Nut 21	Chla 19	Chla 20	Chla 21	Yes
Shell Lake	9/5/2007	Yes	12:47	None	Flat	61.95455	151.54263	58	>1	10	20	Nut 22	Nut 23	Nut 24	Chla 22	Chla 23	Chla 24	Yes
James Lake	9/5/2007	Yes	13:45	None	Flat	61.63729	150.08946	17.5	>1	2	3.5	Nut 25	Nut 26	Nut 27	Chla 25	Chla 26	Chla 27	Yes
Wolverine Lake	9/5/2007	Yes	14:31	None	Flat	61.66526	148.96277	5	>1	1		Nut 28	Nut 29		Chla 28	Chla 29		No
Jim Lake	9/6/2007	Yes	11:04	Light	Flat	61.56297	148.94710	3.1	>1	1		Nut 30	Nut 31		Chla 30	Chla 31		Yes
Wasilla Lake	9/6/2007	Yes	13:01	Light	Flat	61.58176	149.41806	39.7	>1	5	10	Nut 32	Nut 33	Nut 34	Chla 30	Chla 31	Chla 32	Yes
Mud Lake	9/6/2007	Yes	15:20	None	Flat	61.59772	149.34750	2	>1			Nut 35			Chla 35			No
Johnson Lake	9/6/2007	Yes	16:10	None	Flat	61.56759	149.23633	5.6	>1			Nut 36			Chla 36			No
Lake Louise	9/7/2007	Yes	11:00	None	Ripples	62.28861	146.52020	47	>1	7	14	Nut 37	Nut 38	Nut 39	Chla 37	Chla 38	Chla 39	Yes
Lake Lucille	9/7/2007	Yes	12:40	None	Flat	61.57750	149.46178	17.9	>1	2	5	Nut 40	Nut 41	Nut 42	Chla 40	Chla 41	Chla 42	Yes
Threemile Lake	9/7/2007	Yes	13:45	None	Flat	61.49754	149.75626	12.1	>1	1	3.5	Nut 43	Nut 44	Nut 45	Chla 43	Chla 44	Chla 45	yes
Big Lake	9/7/2007	Yes	14:04	None	Flat	61.52923	149.93700	68.1	>1	10	20	Nut 46	Nut 47	Nut 48	Chla 46	Chla 47	Chla 48	Yes
Byers Lake	9/8/2007	Yes	12:15	Light	Ripples	62.73953	150.11482	450	>1	14	28	Nut 49	Nut 50	Nut 51	Chla 49	Chla 50	Chla 51	No
Nancy Lake	9/10/2007	Yes	9:15	Light	Flat	61.68750	150.00726	62.6	>1	10	20	Nut 52	Nut 53	Nut 54	Chla 52	Chla 53	Chla 54	No
Horseshoe Lake	9/10/2007	Yes	10:09	Light	Flat	61.57470	149.91785	16	>1	2	5	Nut 55	Nut 56	Nut 57	Chla 55	Chla 56	Chla 57	No

Lakes unable to Sample

Unknown #1 Lake	9/4/2007	No	No obvious signs of a lakes, unable to locate
Falk Lake	9/6/2007	No	Could not obtain homeowner premission to access
Unknown #2 Lake	9/7/2007	No	Lake too small to land floatplane and no road access

Secchi Disappears(m) Rep 1	Secchi Disappears(m) Rep 2	Secchi Reappears(m) Rep 1	Secchi Reappears(m) Rep 2	Clear to Bottom?	Comments
2.3	2.5	2.5	2.3	No	
5.0	5.0	5.0	5.0	No	
4.0	4.1	3.8	4.0	No	
3.5	3.5	3.0	3.0	No	
2.9	3.0	2.8	2.8	No	
5.0	5.0	4.5	4.5	No	
5.0	5.0	4.5	4.5	No	
4.5	4.5	4.0	4.3	No	CTD may have been laying on bottom
4.0	4.0	3.8	3.8	No	
				Yes	
				Yes	
2.5	2.8	2.0	2.5	No	
				Yes	Site too shallow, took sample form shore
					access extremely limited, fenced along shoreline and only access point, took sample from shoreline
6.0	6.0	5.5	5.5	No	
3.0	3.0	2.5	2.5	No	
3.2	3.3	2.5	3.0	No	
8.5	8.5	8.0	8.0	No	
6.5	6.5	6.3	6.3	No	very deep site, unable to use sonar for depth, used weighted line;
3.0	3.0	2.8	2.8	No	
3.8	4.0	3.5	3.8	No	

Mat-Su Lake Classification Matrix- Draft

	Lake Name	Lat	Lon	lake typology based upon previous studies	lake depth (m) max	AKMAP Lake	Open Basin?	anadromous?	Stocked?
Shallow <6m	Jim	61.56297	148.94710		1.8		Y	Y	
	Threemile	61.49754	149.75626		4.6		Y	Y	Y
	Homestead Lake	61.51595	149.85535		5				Y
	Wolverine	61.66526	148.96277		2.8		Y	Y	
	Lalen	61.60104	149.69048		3.6		Y		Y
	Mud	61.59772	149.34750	stained	5.2		Y	Y	
	Lake Lucille	61.57750	149.46178	stained	5.4?		Y		Y
Deep >6m	Vera Lake	61.71444	150.13974		7	Y			Y
	Red Shirt	61.62325	150.17119	stained	15.2		Y	Y	
	Byers	62.73953	150.11482	clear	54		Y	Y	
	Shell	61.95455	151.54263	stained	58.7		Y		
	Horseshoe	61.57470	149.91785	stained	7.5		Y		
	Nancy	61.68750	150.00726	stained	19.8		Y	Y	
	Lake Louise	62.28861	146.52020		38.0		Y		
	Wasilla	61.58176	149.41806	stained	14.6		Y	Y	
	Big Lake	61.52923	149.93700	clear	27		Y	Y	
Unknown	James	61.63729	150.08946						
	West Papose	61.53682	150.09546			Y			
	Johnson Lake	61.56759	149.23633						
	Loonsong Lake	61.46799	149.94843						
	Zero Lake	61.64794	149.80600						

Mat-Su Lake Classification Matrix- Draft

Bathymetric map?	*approx. comparative watershed urbanization (H, M, L)*	*USGS Data*	*ADF&G Data*	*Volunteer Data*	*303 (d) Impaired Waterbody*	Comment
Y	L			Jim Lake Master Data.xls		
Y	L					
Y	L					
Y	M			Wolverine Master Data.xls		floatplane base
Y	Med-High			Lalen Lake Master.xls		
	H		ADF&G 25 lakes			
Y	M-H		ADF&G 25 lakes	Lake Lucille Master Data.xls	yes	
Y	L					
Y	L	USGS 5 lakes	ADF&G 25 lakes			public use cabin
Y	L		ADF&G 25 lakes			public use cabin
	L		ADF&G 25 lakes			
Y	M	USGS 5 lakes	ADF&G 25 lakes			Pike present
Y	M	USGS 5 lakes	ADF&G 25 lakes			public use cabin
	Med			Lake Louise Master.xls		
	H		ADF&G 25 lakes			Pike present
Y	H	USGS 5 Lakes	ADF&G 25 lakes		yes	
	L					public use cabin
	L					
	L					small, remote
	L					small, remote
	L					small, remote

2007 Nutrient Lakes

Seabird 19 Data

Site ID	Date	Depth [fresh water, m]	Conductivity [uS/cm]	Temperature [ITS-90, deg C]	# scans averged in bin	Comments
Lalen Lake	9/3/2007	0.0	670.6505	17.2603	10	
		0.5	-179.387	17.1731	42	
		1.0	132.1169	17.118	11	
		1.5	128.6841	17.0551	10	
		2.0	118.5437	16.977	10	
		2.5	105.2549	16.8981	11	
		3.0	95.16906	16.9253	24	
		3.5	76.67375	17.2018	4	
Zero Lake	9/3/2007	0.0	26.13289	17.3037	29	
		0.5	20.68477	17.3853	37	
		1.0	19.83985	17.3823	2	
		1.5	18.79724	17.2832	2	
		2.0	35.92275	17.212	26	
		2.5	22.84115	17.2006	2	
		3.0	20.54593	17.1876	5	
		3.5	20.32842	17.1736	4	
		4.0	19.59796	17.1624	6	
		4.5	20.60296	17.1552	7	
		5.0	21.07604	17.124	11	
		5.5	20.16749	16.9931	7	
		6.0	19.67668	16.1277	4	
		6.5	18.98048	14.3431	6	
		7.0	18.91663	13.0243	5	
		7.5	18.9167	11.8604	6	
		8.0	19.82109	11.0098	5	
		8.5	20.31003	10.7748	5	
		9.0	26.49719	10.2714	8	
Homestead Lake	9/4/2007	0.0	8.325673	17.6588	41	
		0.5	7.740245	17.6821	7	
		1.0	7.599328	17.6941	9	
		1.5	7.689791	17.6961	13	
		2.0	7.56025	17.6821	13	
		2.5	7.541863	17.6589	12	
		3.0	7.521789	17.5603	10	
		3.5	7.503869	17.5109	11	
		4.0	7.491593	17.5348	13	
Vera Lake	9/4/2007	0.0	64.14431	17.3422	46	
		0.5	61.40465	17.3534	13	
		1.0	61.20228	17.3359	11	
		1.5	60.93009	17.3099	11	
		2.0	60.80639	17.2943	12	
		2.5	60.90797	17.2811	10	
		3.0	60.65191	17.2501	11	

2007 Nutrient Lakes
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		3.5	60.1226	17.2309	11
		4.0	60.05515	17.14	12
		4.5	59.75945	17.0441	10
James Lake	9/5/2007	0.0	11.64007	16.9865	45
		0.5	11.67471	16.9001	10
		1.0	12.387	16.6433	24
		1.5	11.73165	16.506	33
		2.0	11.53855	16.4296	33
		2.5	11.46866	16.3012	29
		3.0	11.51739	16.1997	34
		3.5	11.28304	15.9828	42
		4.0	11.19944	15.6061	43
		4.5	11.38574	13.5939	38
		5.0	11.07165	11.3471	32
		5.5	13.27971	9.9917	110
Loonsong Lake	9/5/2007	0.0	57.67035	16.7012	7
		0.5	58.09268	16.7709	43
		1.0	57.87405	16.761	16
		1.5	57.95414	16.7508	14
		2.0	57.82747	16.7491	12
		2.5	57.93854	16.7387	13
		3.0	57.93002	16.7256	12
		3.5	57.92886	16.7231	12
		4.0	58.89746	16.7309	13
		4.5	67.13218	16.7008	1
Redshirt Lake	9/5/2007	0.0	67.83605	16.9898	48
		0.5	67.83608	16.9002	24
		1.0	67.83338	16.8288	30
		1.5	67.82752	16.8102	24
		2.0	67.85949	16.7971	30
		2.5	67.90598	16.7866	31
		3.0	67.95375	16.7798	33
		3.5	67.99319	16.7782	25
		4.0	67.97649	16.7752	20
		4.5	67.94194	16.7705	22
		5.0	67.90183	16.7609	29
		5.5	67.85875	16.2254	22
		6.0	67.81816	14.8047	23
		6.5	67.26879	13.7238	20
		7.0	66.16757	12.909	15
		7.5	64.83035	11.6642	15
		8.0	63.63953	10.798	13
		8.5	62.45525	9.9028	17
		9.0	61.88044	9.4966	15
		9.5	60.90014	9.0586	14

		10.0	61.06876	8.7496	15
		10.5	61.38188	8.5373	18
		11.0	62.73342	8.2822	34
Shell Lake	9/5/2007	0.0	27.07988	15.8642	38
		0.5	27.11899	15.8436	9
		1.0	27.13358	15.831	16
		1.5	32.14193	15.822	17
		2.0	35.45981	15.8162	20
		2.5	34.18922	15.8128	16
		3.0	34.20592	15.7982	18
		3.5	33.17604	15.76	17
		4.0	32.32197	15.7216	17
		4.5	31.62448	15.7011	15
		5.0	31.33796	15.6832	17
		5.5	31.32301	15.6664	17
		6.0	29.84899	15.65	14
		6.5	28.83057	15.6061	12
		7.0	27.74621	15.1486	8
		7.5	27.05211	13.6995	10
		8.0	27.09679	12.1705	15
		8.5	26.32351	11.3738	10
		9.0	25.44405	11.0162	12
		9.5	25.09874	10.3868	12
		10.0	24.46598	10.0542	13
		10.5	24.37834	9.7899	14
		11.0	24.28327	9.6367	18
		11.5	24.28157	9.5595	13
		12.0	23.65157	9.4294	11
		12.5	23.35554	9.3398	9
		13.0	22.90602	9.2196	14
		13.5	22.9818	8.9869	24
		14.0	22.94054	8.7303	19
		14.5	22.86695	8.6615	15
		15.0	22.86837	8.6387	10
		15.5	22.87821	8.5905	10
		16.0	22.89323	8.5338	15
		16.5	22.90607	8.5031	11
		17.0	22.83319	8.45	16
		17.5	22.93652	8.3794	15
		18.0	22.90838	8.3472	25
		18.5	22.76096	8.2699	45
West Papoose Lake	9/5/2007	0.0	48.41397	16.912	4
		0.5	48.40145	16.9244	45
		1.0	48.38797	16.9163	18
		1.5	48.38574	16.9063	15
		2.0	48.37643	16.8985	14

2007 Nutrient Lakes
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		2.5	48.37695	16.893	9
		3.0	48.49366	16.8902	12
		3.5	48.36206	16.8868	10
		4.0	48.5364	16.8806	9
		4.5	48.49298	16.874	11
		5.0	48.61497	16.8547	11
		5.5	48.37604	16.7661	13
		6.0	48.36609	15.5826	10
		6.5	48.64238	13.8574	10
		7.0	48.23616	11.8647	9
		7.5	48.50208	10.4019	10
		8.0	52.26186	9.5125	8
		8.5	59.22934	9.0066	9
		9.0	74.66176	8.5886	10
Wasilla Lake	9/6/2007	0.0	185.0049	15.8907	3
		0.5	184.8394	15.9014	42
		1.0	184.7972	15.8569	14
		1.5	184.7498	15.7883	15
		2.0	184.7062	15.7522	14
		2.5	184.6586	15.7262	14
		3.0	184.6188	15.7063	13
		3.5	184.5871	15.6902	13
		4.0	184.5843	15.6578	12
		4.5	184.5949	15.606	12
		5.0	184.5972	15.5013	14
		5.5	187.0456	14.1471	11
		6.0	200.3557	12.8754	11
		6.5	207.4134	12.0168	13
		7.0	217.0731	10.9938	9
		7.5	217.6484	10.0154	7
		8.0	218.1691	8.7752	7
		8.5	219.5048	8.0019	9
		9.0	220.8639	7.5663	8
		9.5	222.3887	6.9667	9
		10.0	221.7712	6.5919	8
		10.5	220.0705	6.4136	7
		11.0	219.6062	6.2434	7
		11.5	221.1247	6.0015	14
Jim Lake	9/6/2007	0.3	151.0795	14.71643	57
Lake Lucille	9/7/2007	0.0	211.8454	15.5372	22
		0.5	210.1006	15.5537	55
		1.0	210.0805	15.5441	29
		1.5	210.0621	15.5262	25
		2.0	210.0752	15.5229	40
		2.5	210.6524	15.5129	36

2007 Nutrient Lakes
Seabird 19 Data

		3.0	211.4843	15.4902	33
		3.5	211.517	15.4489	28
		4.0	211.45	15.322	39
		4.5	211.3788	15.3185	27
		5.0	211.5586	15.3609	43
		5.5	213.4033	15.4928	19
Threemile Lake	9/7/2007	0.0	115.9277	16.2714	12
		0.5	115.8903	15.6494	49
		1.0	115.8855	15.6119	37
		1.5	115.8772	15.5159	25
		2.0	115.8774	15.3901	21
		2.5	115.8775	15.2276	18
		3.0	115.8776	15.0563	26
		3.5	115.8777	14.7924	18
		4.0	117.6201	14.451	19
		4.5	135.6082	14.0992	10
Big Lake	9/7/2007	0.0	123.0	16.9236	6
		0.5	122.8	16.9308	44
		1.0	122.8	16.8263	17
		1.5	122.8	16.7523	21
		2.0	122.7	16.7138	25
		2.5	122.7	16.6777	34
		3.0	122.7	16.6428	37
		3.5	122.8	16.6116	32
		4.0	122.8	16.5848	33
		4.5	122.8	16.5687	34
		5.0	122.9	16.5528	22
		5.5	122.9	16.5486	23
		6.0	122.9	16.5425	26
		6.5	122.9	16.3092	17
		7.0	122.8	14.1349	18
		7.5	122.9	12.5505	30
		8.0	122.0	11.0904	38
		8.5	119.8	10.025	28
		9.0	117.5	9.3304	25
		9.5	116.3	8.9048	20
		10.0	113.1	8.5816	23
		10.5	113.6	8.2472	33
		11.0	111.6	7.9735	30
		11.5	108.4	7.6479	35
		12.0	106.6	7.4428	12
Lake Louise	9/7/2007	0.0	128.1832	13.985	14
		0.5	124.4548	13.9846	33
		1.0	122.8106	13.9819	27
		1.5	121.8655	13.9774	18

2007 Nutrient Lakes

Seabird 19 Data

2.0	121.6256	13.9735	15
2.5	121.5028	13.972	21
3.0	121.5062	13.9717	18
3.5	121.4991	13.9702	18
4.0	121.5124	13.9653	21
4.5	121.5314	13.9639	30
5.0	120.6918	13.9619	23
5.5	120.1141	13.9616	20
6.0	120.2843	13.9611	13
6.5	120.1737	13.9606	12
7.0	120.151	13.9603	15
7.5	120.1252	13.9576	16
8.0	120.0937	13.9441	15
8.5	120.0672	13.9126	14
9.0	120.0432	13.1024	13
9.5	120.021	11.9459	13
10.0	119.9964	11.0294	14
10.5	119.025	10.5418	12
11.0	117.9576	10.2964	10
11.5	116.3911	10.116	9
12.0	115.8919	9.9764	11
12.5	116.2818	9.8943	11
13.0	115.0922	9.8457	10
13.5	113.935	9.7452	13
14.0	112.4113	9.6313	12
14.5	111.9157	9.5837	18
15.0	112.5128	9.5303	19
15.5	112.3789	9.4591	17
16.0	111.2677	9.3717	11
16.5	110.9817	9.2934	8
17.0	110.1031	9.1862	10
17.5	109.9587	9.0572	12
18.0	109.0747	8.8982	11
18.5	107.991	8.6649	12
19.0	106.9401	8.4162	13
19.5	107.5138	8.243	19
20.0	107.0022	8.0503	16
20.5	106.7482	7.8599	23
21.0	106.4908	7.709	15
21.5	106.2203	7.6375	11
22.0	106.2319	7.4822	22
22.5	104.1853	7.3855	26

Nutrient Criteria Development Plan
Lakes sampled in 2007 by DEC and UAF

Lake Name	Date Sampled	Lake sampled?	Arrival Time	Precip	Surface Conditions	Lat	Lon	Depth (ft)	Depth Samples Collected (m) Top-Mid-Bot			Nutrient Samples Collected Top-Mid-Bot			Chlorophyl-a Samples Collected Top-Mid-Bot		
Lalen Lake	9/3/2007	Yes	12:04	None	Flat	61.60104	149.69048	12.2	>1	2	4	Nut 1	Nut 2	Nut 3	Chla 1	Chla 2	Chla 3
Zero Lake	9/3/2007	Yes	14:16	None	Flat	61.64794	149.80600	30.6	>1	5	10	Nut 4	Nut 5	Nut 6	Chla 4	Chla 5	Chla 6
Vera Lake	9/4/2007	Yes	13:05	None	Flat	61.71444	150.13974	17.3	>1	12	15	Nut 7	Nut 8	Nut 8	Chla 7	Chla 8	Chla 9
Homestead Lake	9/4/2007	Yes	15:53	None	Flat	61.51595	149.85535	15.7	>1	6	12	Nut 10	Nut 11	Nut 12	Chla 10	Chla 11	Chla 12
Loonsong Lake	9/5/2007	Yes	9:25	None	Flat	61.46799	149.94843	14.8	>1	6	12	Nut 13	Nut 14	Nut 15	Chla 13	Chla 14	Chla 15
West Papoose Lake	9/5/2007	Yes	11:00	None	Flat	61.53682	150.09546	33	>1	5	10	Nut 16	Nut 17	Nut 18	Chla 16	Chla 17	Chla 18
Redshirt Lake	9/5/2007	Yes	11:45	None	Flat	61.62325	150.17119	37.1	>1	5	11	Nut 19	Nut 20	Nut 21	Chla 19	Chla 20	Chla 21
Shell Lake	9/5/2007	Yes	12:47	None	Flat	61.95455	151.54263	58	>1	10	20	Nut 22	Nut 23	Nut 24	Chla 22	Chla 23	Chla 24
James Lake	9/5/2007	Yes	13:45	None	Flat	61.63729	150.08946	17.5	>1	2	3.5	Nut 25	Nut 26	Nut 27	Chla 25	Chla 26	Chla 27
Wolverine Lake	9/5/2007	Yes	14:31	None	Flat	61.66526	148.96277	5	>1	1		Nut 28	Nut 29		Chla 28	Chla 29	
Jim Lake	9/6/2007	Yes	11:04	Light	Flat	61.56297	148.94710	3.1	>1	1		Nut 30	Nut 31		Chla 30	Chla 31	
Wasilla Lake	9/6/2007	Yes	13:01	Light	Flat	61.58176	149.41806	39.7	>1	5	10	Nut 32	Nut 33	Nut 34	Chla 30	Chla 31	Chla 32
Mud Lake	9/6/2007	Yes	15:20	None	Flat	61.59772	149.34750	2	>1			Nut 35			Chla 35		
Johnson Lake	9/6/2007	Yes	16:10	None	Flat	61.56759	149.23633	5.6	>1			Nut 36			Chla 36		
Lake Louise	9/7/2007	Yes	11:00	None	Ripples	62.28861	146.52020	47	>1	7	14	Nut 37	Nut 38	Nut 39	Chla 37	Chla 38	Chla 39
Lake Lucille	9/7/2007	Yes	12:40	None	Flat	61.57750	149.46178	17.9	>1	2	5	Nut 40	Nut 41	Nut 42	Chla 40	Chla 41	Chla 42
Threemile Lake	9/7/2007	Yes	13:45	None	Flat	61.49754	149.75626	12.1	>1	1	3.5	Nut 43	Nut 44	Nut 45	Chla 43	Chla 44	Chla 45
Big Lake	9/7/2007	Yes	14:04	None	Flat	61.52923	149.93700	68.1	>1	10	20	Nut 46	Nut 47	Nut 48	Chla 46	Chla 47	Chla 48
Byers Lake	9/8/2007	Yes	12:15	Light	Ripples	62.73953	150.11482	450	>1	14	28	Nut 49	Nut 50	Nut 51	Chla 49	Chla 50	Chla 51

Nancy Lake	9/10/2007	Yes	9:15	Light	Flat	61.68750	150.00726	62.6	>1	10	20	Nut 52	Nut 53	Nut 54	Chla 52	Chla 53	Chla 54
Horseshoe Lake	9/10/2007	Yes	10:09	Light	Flat	61.57470	149.91785	16	>1	2	5	Nut 55	Nut 56	Nut 57	Chla 55	Chla 56	Chla 57

Lakes unable to Sample

Unknown #1 Lake	9/4/2007	No	No obvious signs of a lakes, unable to locate
Falk Lake	9/6/2007	No	Could not obtain homeowner premission to access
Unknown #2 Lake	9/7/2007	No	Lake too small to land floatplane and no road access

							Residential						
CTD Cast?	Secchi Disappears(m) Rep 1	Secchi Disappears(m) Rep 2	Secchi Reappears(m) Rep 1	Secchi Reappears(m) Rep 2	Clear to Bottom?	Comments	Residences	Maintained Lawns	Construction	Pipes, Drains	Dumping	Roads	Bridges / Causeways
Yes	2.3	2.5	2.5	2.3	No		H	L	L	L	L	L	
Yes	5.0	5.0	5.0	5.0	No		L						
Yes	4.0	4.1	3.8	4.0	No		M	L				L	
Yes	3.5	3.5	3.0	3.0	No		L	L				L	
Yes	2.9	3.0	2.8	2.8	No		L	L				L	
Yes	5.0	5.0	4.5	4.5	No		L	L				L	
Yes	5.0	5.0	4.5	4.5	No		L	L				L	
Yes	4.5	4.5	4.0	4.3	No	CTD may have been laying on bottom	L	L				L	
Yes	4.0	4.0	3.8	3.8	No								
No					Yes		L	L				L	
Yes					Yes							L	
Yes	2.5	2.8	2.0	2.5	No		H	L	L			L	
No					Yes	Site too shallow, took sample form shore	M	M	L			L	
No						access extremely limited, fenced along shoreline and only access point, took sample from shoreline			L			L	
Yes	6.0	6.0	5.5	5.5	No		L	L	L	L		L	
Yes	3.0	3.0	2.5	2.5	No		H	M	L			M	
yes	3.2	3.3	2.5	3.0	No		L	L				L	
Yes	8.5	8.5	8.0	8.0	No		H	M	L			M	
No	6.5	6.5	6.3	6.3	No	very deep site, unable to use sonar for depth, used weighted line;							

No	3.0	3.0	2.8	2.8	No		M	M	L	M
No	3.8	4.0	3.5	3.8	No		H	M	L	M

Lake/Catchment Site Activities and Disturbances Observed (Insentity: Blank= Not Observed, L=Low, M=Moderate, H=High)

	Recreational							Agricultural							Industrial								Lake Manage			
Sewage Treatment	Hiking Trails	Parks, Campgrounds	Private Parks Campgrounds	Resorts	Marinas	Trash Litter	Surface Film, Scums or Slicks	Crop Lands	Pasture	Livestock Use	Orchards	Poultry	Feedlot	Water Withdrawl	Industrial Plants	Mines / Quarries	Oil / Gas Wells	Power Plants	Logging	Evidence of Fire	Odors	Commercial	Liming	Chemical Treatment	Angling Pressure	Drinking Water Treatment
	L	L	L																							
L					L	L																			L	
L				L																						
	L																									
	L																									
		H		L																					L	
	L							L	L	L																
	L	L		L	L																					
	M			L																						
	L																									
	L	L		L	L																				L	
	L	L	L																							

ıment			General Lake Information						Shoreline Characteristics (% of Shoreline) R=Rare <5%, S=Sparse 5-25%, M=Moderate 25-75%, E=Extensive >75%								Qualitative Macrophyte Survey				
Macrophyte Control	Water Level Fluctuations	Fish Stocking	Hydrologic Type	Outlet Dams	Low Elevation Flight Hazards	Motor Boat Density	Swimability	Lake Level Changes	Forest	Grass	Shrub	Wetland	Bare Ground	Agriculture	Shoreline Mods (docks, riprap)	Development (Residential & Urban)	Emergent/ Floating Coverage	Submergent Coverage	Macrophyte Density	Photographs Taken?	Ecological Integrity
			Seepage	None	No	Low	Good		M	S	R	R	R	R	R	M	R	R	Sparse	Yes	Good
			Seepage	None	Yes		Good		E	R	S	R	R	R	R	R	R	R	Sparse	Yes	Excellent
	M		Drainage	None	No	Low	Good	Zero	M	R	R	S	R	R	R	R	R	S	Moderate	Yes	Good
			Seepage	None	Yes	Banned	Good		E	R	S	R	R	R	R	S	S	M	Moderate	Yes	Good
			Drainage	None	Yes	Low	Good	Zero	M	M	M	R	R	R	R	R	S	S	Sparse	Yes	Good
			Drainage	None	No	Low	Good	Zero	E	S	S	R	R	R	R	R	R	R	Sparse	Yes	Good
			Drainage	None	Yes	Low	Good	Zero	E	S	S	R	R	R	R	R	R	R	Sparse	Yes	Good
			Drainage	None	No	Low	Good	Zero	M	R	M	R	R	R	R	R	R	S	Sparse	Yes	Good
			Drainage	None	No	Restricte	Good	Zero	M	S	M	R	R	R	R	R	R	R	Sparse	Yes	Excellent
			Drainage	None	No	Low	Good	Zero	M	S	M	R	R	R	R	R	S	M	Moderate	Yes	Fair
			Drainage	None	No	Low	Not Swi	Zero	M	M	M	S	R	R	R	R	S	M	Moderate	Yes	Excellent
			Drainage	None	No	Low	Good	Zero	M	M	S	R	S	R	S	S	S	S	Sparse	Yes	Fair
			Drainage	None	No	Low	Not Swi	Zero	M	S	S	M	R	R	R	R	M	M	Moderate	Yes	Fair
			Seepage	None	No	Banned	Good	Zero	E	R	R	R	R	R	R	R	S	S	Sparse	Yes	Good
			Drainage	None	No	Low	Good		E	S	S	S	R	R	R	R	R	R	Sparse	Yes	Good
			Drainage	None	No	H	Good	Zero	M	M	S	S	R	R	S	M	S	M	Moderate	Yes	Good
			Drainage	None	No	Low	Not Swi	Zero	M	S	S	S	R	R	R	R	S	M	Moderate	Yes	Excellent
			Drainage	None	No	H	Good	Zero	M	M	M	R	S	R	S	M	S	S	Sparse	Yes	Good
			Drainage	None	No	Banned	Good	Zero	E	R	S	R	R	R	R	R	R	R	Sparse	Yes	Excellent

Drainag	None	No	Low	Good	Zero	M	S	S	R	R	R	R	R	S	S	Sparse	Yes	Good
Drainag	None	No	Low	Good	Zero	M	SMR	R	R	R	R	S	S	S	S	Sparse	Yes	Good

Qualitative Assessment of Environmental Values										
General Assessment	Wildlife Observed	Trophic Status	Visual Assessment	Algal Abundance	Nutrient Souces	Other	Recreational Value	Conditions	Observations	Comments
	Waterfowl	Mesotrophic					Good	Sunny clear skies, very light breeze	water skiiers presents, floatplands observed parked on lake and taking off	
only obsen	Waterfowl	Mesotrophic					Excellent	Sunny clear skies, very light breeze		
several hou	mussel she	Mesotrophi	very pleasant l	moderate benthic al	septic systems, fish stocking and alder		Good		4-wheel drive road only access, pulbic access limited	
limited but	Waterfowl	Mesotrophic		thick submergent ar	lawns, septic		Good	ptly cloudy, cool, breezy	boats around homes, but only paddleboats, no motorized, swimming launches in lake (2)	
visually ple	loons	Mesotrophic		sparse, along shore	septic, lawns, natural		Good	ptly cloudy, sunny, calm	boating, floatplanes along shoreline at homes	
	loons	Mesotrophic			septic, lawns, natural		Good	mostly sunny, clear calm day	caoes long homefronts, a few motorboats	
		Mesotrophic			natural, few lawns, or septics		Good	ptly cloudy, sunny, calm	few boats along homefronts, only 5 to 6 homes in entire shoreline	
	loons	Mesotrophic			natural, few lawns, or septics		Fair	sunny, clear calm day	very limited development aroung lake, dirt road only access to homes	
Within Nancy Lake Re		Mesotrophic			natural		Good	wind picking up, sunny beautiful day	no homes along shoreline, no boats along shoreline	
very shallo	ducks	Mesotrophic			natural, algea, lawns, septic systems		Good	sunny and windy	a few boats long shoreline, 6-8 houses along shoreline	
very shallo	a lot of bird	Mesotrophic			natural		Good	no wind, sunny, beautiful day	too shallow to swim- too thick veg mat at lake bottom	
heavily use	loons, birds	Mesotrophic			dogs, people, lawns,		Good	windy and ptly cloudy	heavily used for swimming, fishing, boating	
fewer homes along wa		Eutrophic	very shallow la	emergent veg surro	lawns, natural		Fair		also known as Little Cottonwood Lake	
entire lake	birds	Mesotrophic		emergent veg to sh	farming, agriculture		Poor		recently installed fence around small shoreline section	
large lake, resorts surr		Mesotrophic			natural, septic		Excellent	sunny, breezy, cool	limited motorboat use	
large lakes	waterfowl,	Mesotrophic			natural, lawns, septic		Excellent	ptly couldy, breezy	jet skiing, motorboats, high use in winter as well (snowmaching over lake)	
	Loons, wat	Mesotrophic		submerged vegetati	natural, septic		Good	sunny		
highly developed lake		Mesotrophic			lawns, septic, natural		Excellent		boats, girl scout camp at lake water skiing, jet skiing, motorboats, swimming, fishing, heavy use in winter snowmachines, trail system	
remote lake, other tha		Mesotrophic			natural		Excellent	overcast, rainy, cool	no motorized access allowed, including boats and floatplanes	

lake has st Loons, wat Mesotrophic	lawns, septic, natural	Excellent	overcast, rainy, breezy	boating, fishing, water skiing, swimming, high use in witner for snowmachines and ice fishing
well develo Loons, wat Mesotrophic	lawns, septic, natural	Good	overcast, cool, breezy	boating, fishing, water skiing, swimming, high use in witner for snowmachines and ice fishing