Susan Hueftle

Results of Lake Powell-Tailwater monitoring:

The Hydrograph:

The August water quality monitoring trip found the reservoir at a steady elevation of 3680 ± 0.1 ft (1121 m). The hydrograph reflects the drought conditions that pervaded the Colorado river basin for water year 2000 (WY00-Oct. 1999-Sept. 2000). By September, the basin was still 83% of normal precipitation. Lake Powell inflows totaled 8,134,423 af or about 71% of damera average, while releases totaled 9,378,000 af or about 96% of post dam releases (USBR Hydromet database).

Typically the spring inflow begins in February and peaks in early June. This year inflows didn't increase significantly until May and the bi-modal peak was on May 12th and June 3rd (30,600 cfs and 40,600 cfs, respectively, figure 1).

The Profiles:

Figure 2 provides orientation for some of the terminology and general characteristics of the reservoir. There, and in the main channel isopleths for the reservoir (figure 3), the effect of the depressed inflows is apparent. These profiles demonstrate physical conditions (temperature, conductivity (or salinity), pH, etc.) along the thalweg of the Colorado river in the reservoir. The dimensions of the spring flood plume, as observed by the fresher water extending across the top of the lake (figs. 3c & 3d) in the conductivity plots, is less extensive than in past years which had greater inflow. Further, the specific conductance of the base inflow near Hite Marina was over 1100 µS, as opposed to the low of 470 µS at the peak of the spring runoff last May '00. By contrast, May of 1997, reflecting one of the highest inflow years in the last 14 years, had a minimum conductance of 356 µS, and the fall of that year had a maximum inflow conductance of 960 µS. The conductance of the inflow is dictated by the volume of runoff combined with other seasonal characteristics including irrigation runoff and temperature. Long-term trends near the dam are demonstrated in figure 4.

Winter mixing drove the thermo-/ chemo-cline (zones of steepest change gradient) to the depth of the penstocks (~50-60 m from the lake's surface) in January. By the peak of summer warming in August, the upper boundary of the thermocline started at 10-12 m and extended to the depth of 30-40 m throughout the lake (figures 2, 3a-3d, 4). Because of the reduced inflow volume, this year's thermocline is shallower than in recent years' (fig.4).

Lake-wide dissolved oxygen content is decreasing after last spring's lake-wide enrichment which reached a 15 year high. This was a result of 2 processes last spring and winter. For the 2nd consecutive winter Lake Powell experienced a late winter oxygenated underflow plume (figures 3a-3c). As a result of high inflows since 1993 and continuing dilution of overall ion concentrations, the density gradient separating the epilimnion from the hypolimnion has weakened, allowing the penetration of cold, well-oxygenated water into the deepest layers of the lake. This process was significantly enhanced by the use of the jet-tubes in 1996 for the experimental flood, as well as high steady dis-

Figure 2: Temperature profile for the main channel of Lake Powell, Aug. '00, including some terminology.

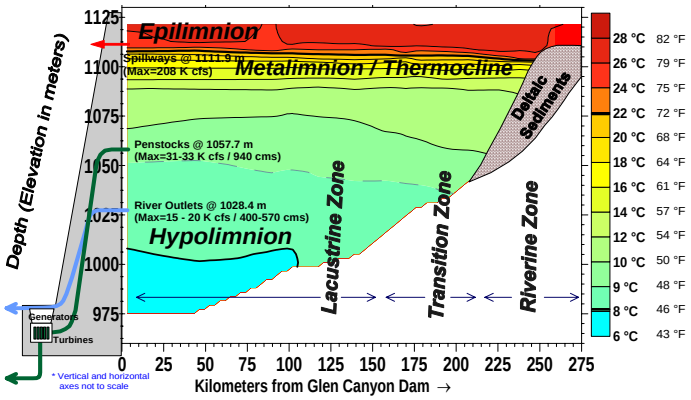


Figure 1: Hydrograph for Lake Powell elevation, inflow and outflow for Oct 1, 1999 to September 30, 2000.

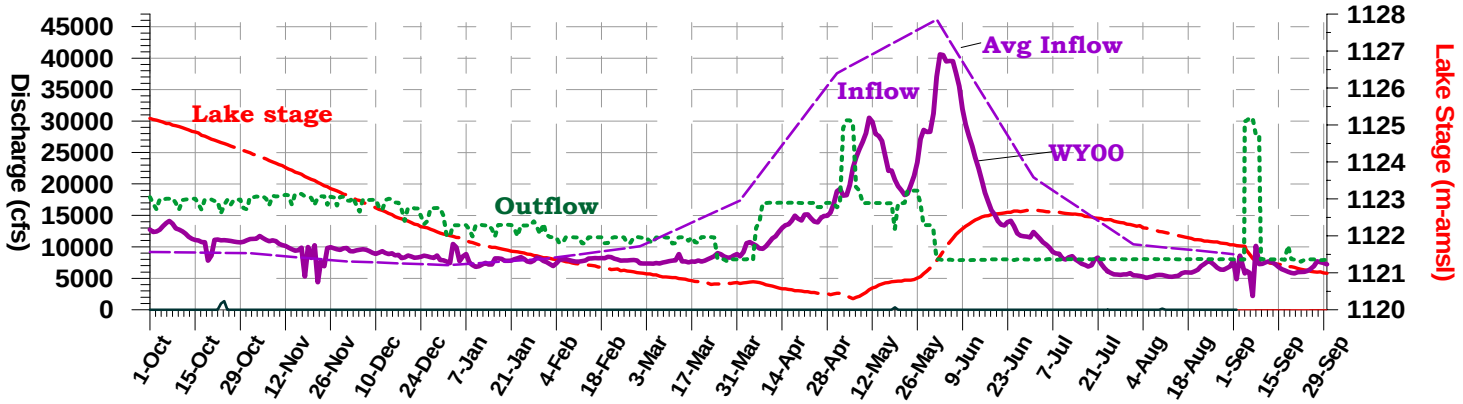
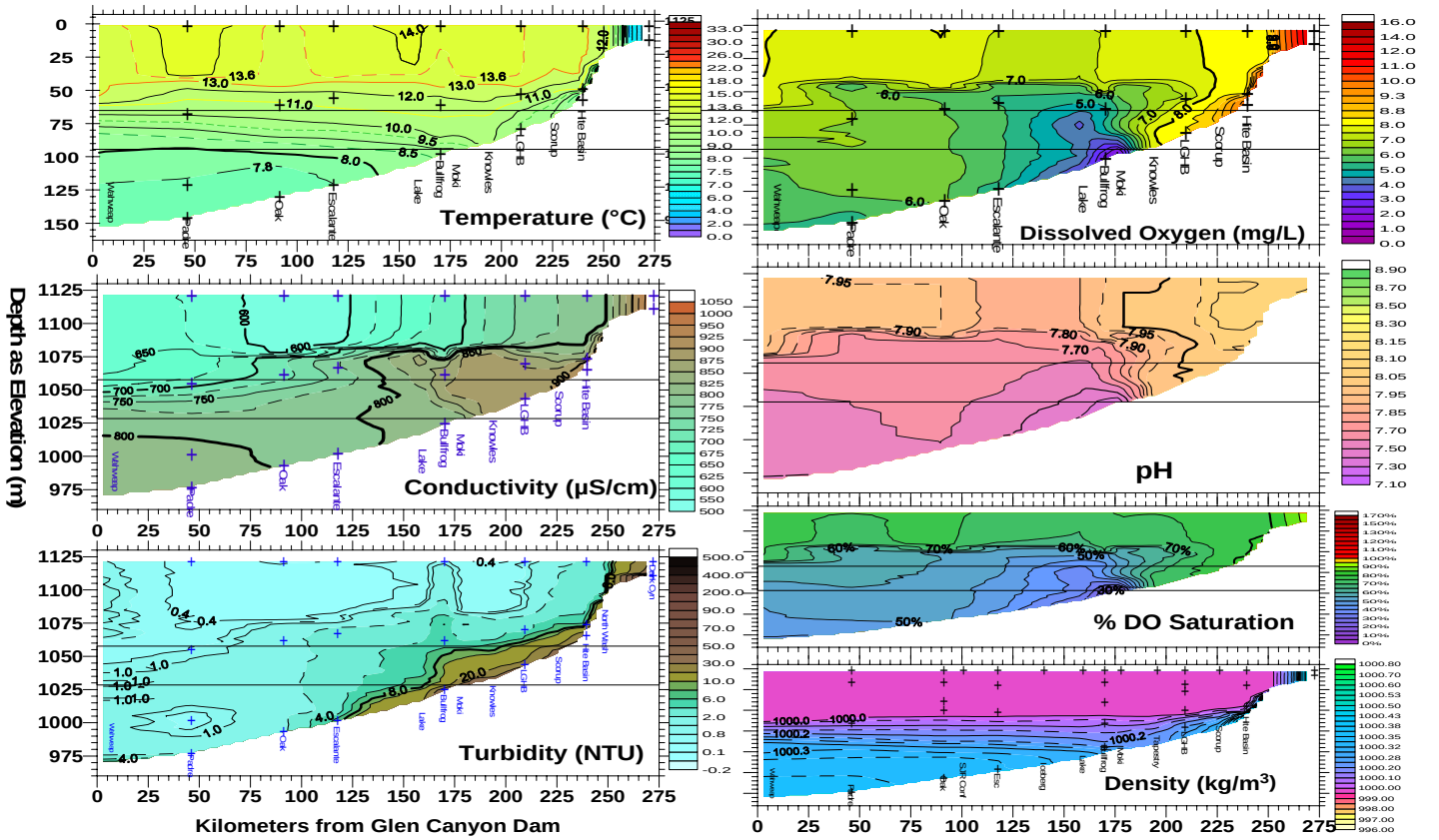
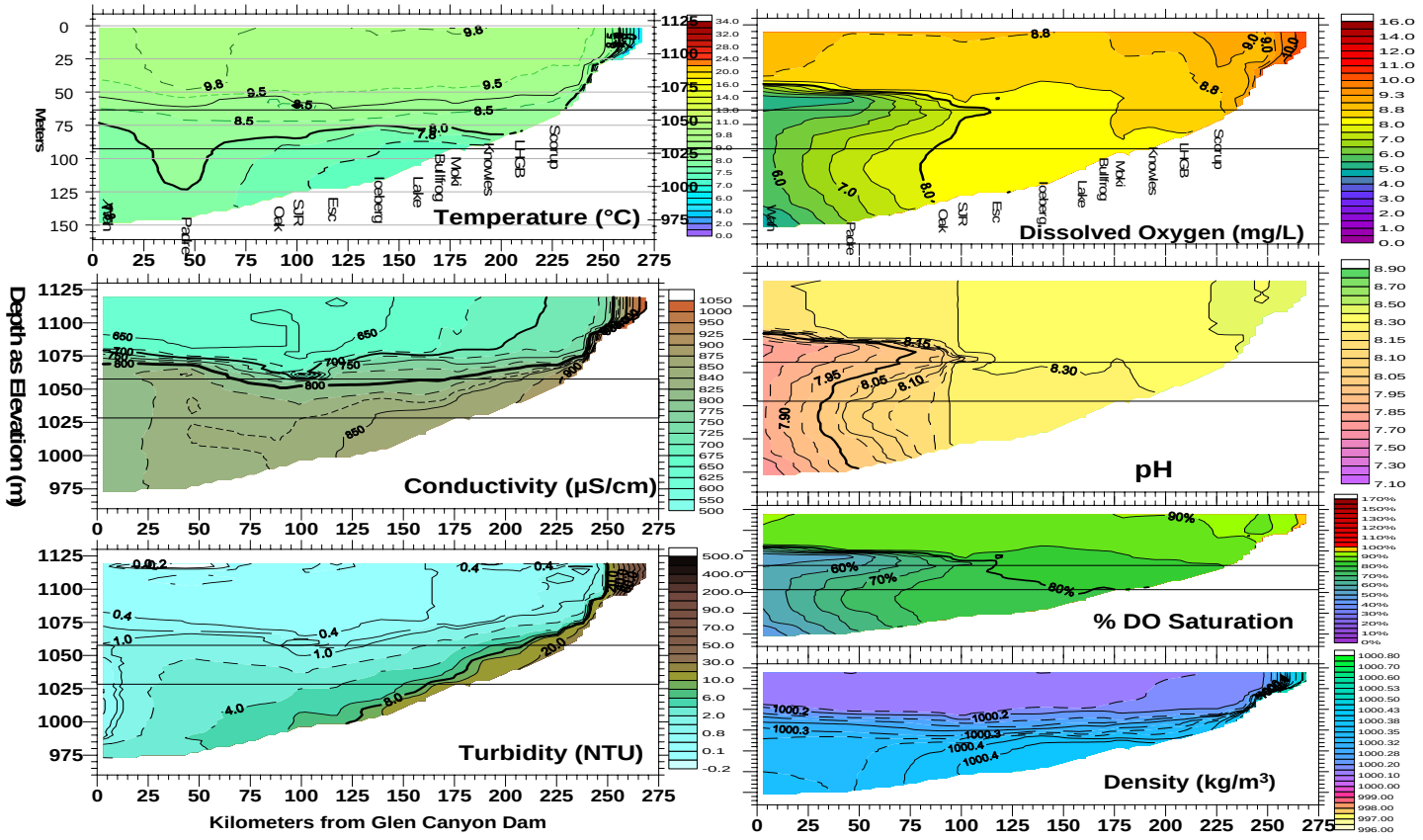


Figure 3. Isopleths of the Colorado channel of Lake Powell.

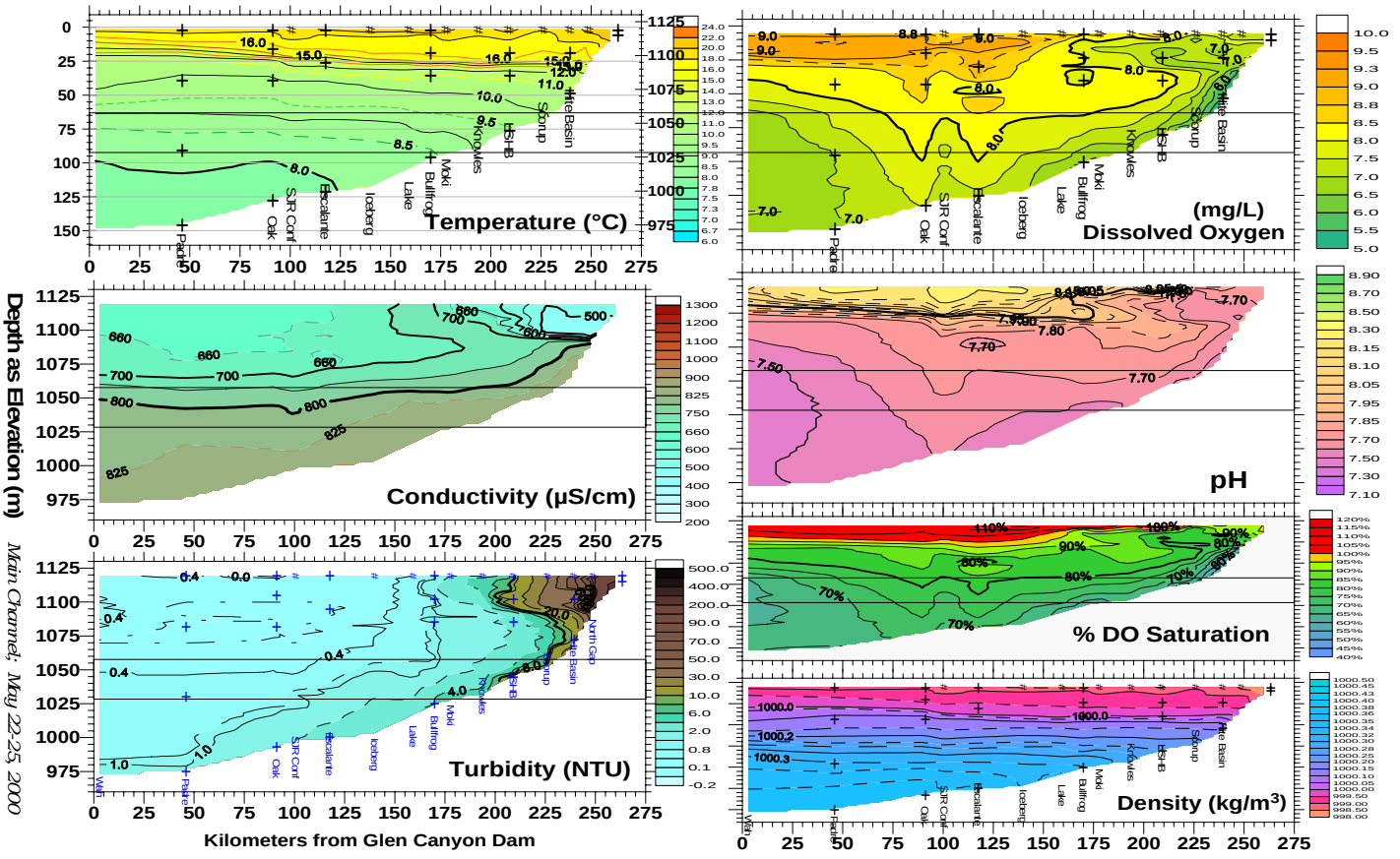
3 A. December 6-11, 1999, Lake elevation 1122.9 m (3684 ft)



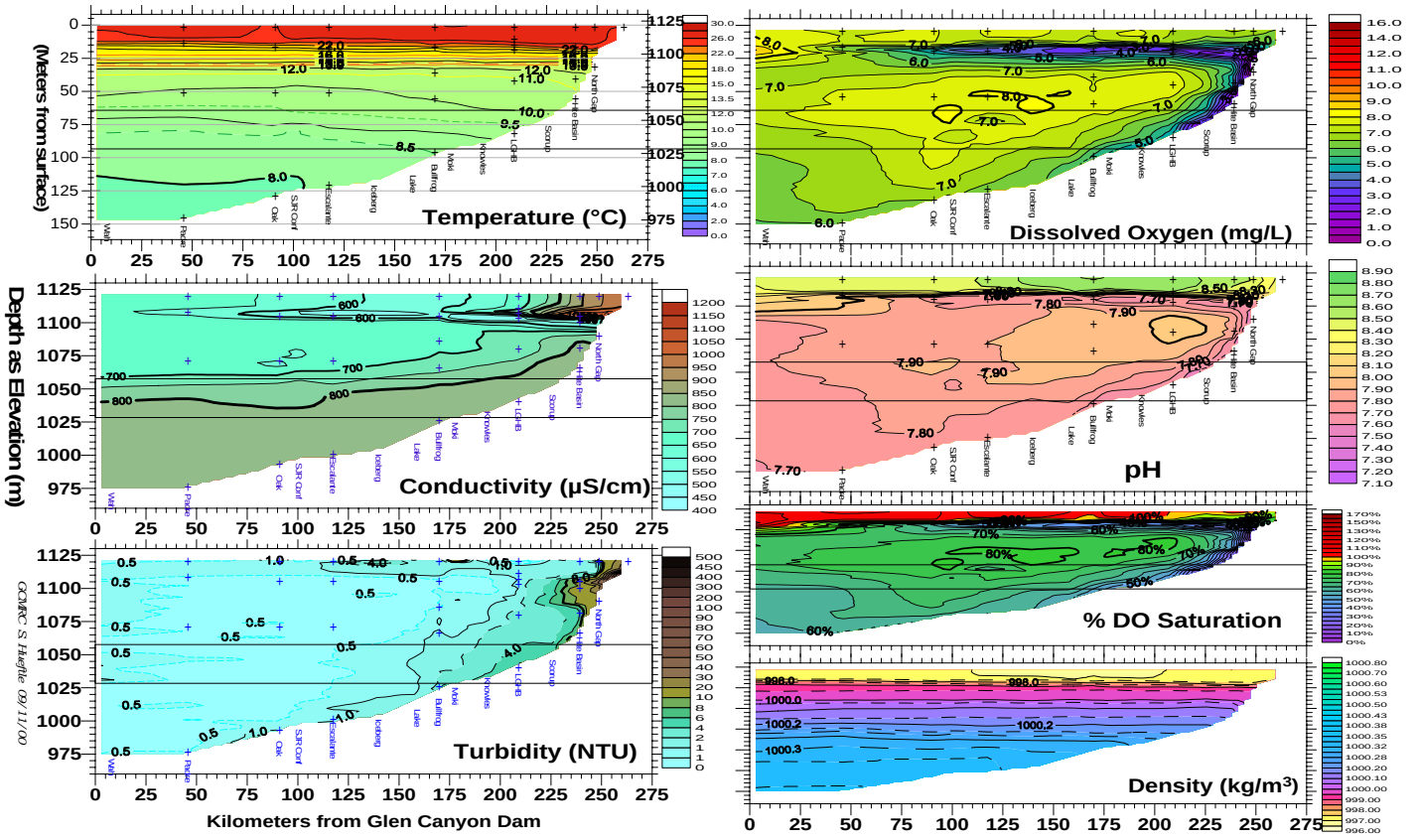
3 B. February 25-29, 2000, lake elevation: 1121.1 m (3678 ft)



3 C. Main Channel; May 22-25, 2000. Lake elevation =1120.8 m (3677.1 ft)



3.D. Main Channel; August 25-28, 2000. Lake elevation = 1121.8 m (3680.5 ft)



charges that followed. Given the low levels of hypolimnetic dissolved oxygen that existed prior to 1997 and the hazards of discharging low oxygen, this may offer a tool for managing hypoxia (low O_2) levels in the future.

Nutrient results:

Although results are provisional, nutrient levels throughout Powell demonstrate a response to recent climatic trends. Figure 7 displays surface nutrient values from Lees Ferry to the Colorado inflow stations, and generally represents or even exaggerates trends throughout depths of the reservoir. Across the lake and in the tailwaters, phosphorus values have increased since 1993. This could be a result of the increased inflows in recent years, or could be associated with biotic interactions, and will receive extensive study in the future. Ortho-phosphate, though often near detection limits, shows similar results. Nitrate-nitrite nitrogen alone demonstrates consistently decreasing concentrations paralleling conductance trends on the reservoir. As would be expected, nutrient levels are highest at the inflow and decrease toward the dam. Seasonal trends produce the highest concentrations associated with the inflow event, with nutrients metabolized, mixed and diluted through fall and winter.

Biological results:

Much of the plankton data is in the early stages of analysis. Figure 7 summarizes the data from an aerial perspective, showing the levels of phytoplankton biovolume and zooplankton biomass present in the reservoir and tailwaters for the last year. It shows that productivity for both peak in spring and summer. Primary productivity increases as early as February resulting in the high spring saturation levels of oxygen in the lake. Blooms of algae and zooplankton often follow winter turn-over. Increasing nutrients and warmer temperatures continue to favor productivity until predation and excessive heat drive productivity lower in the water column by late summer and fall.

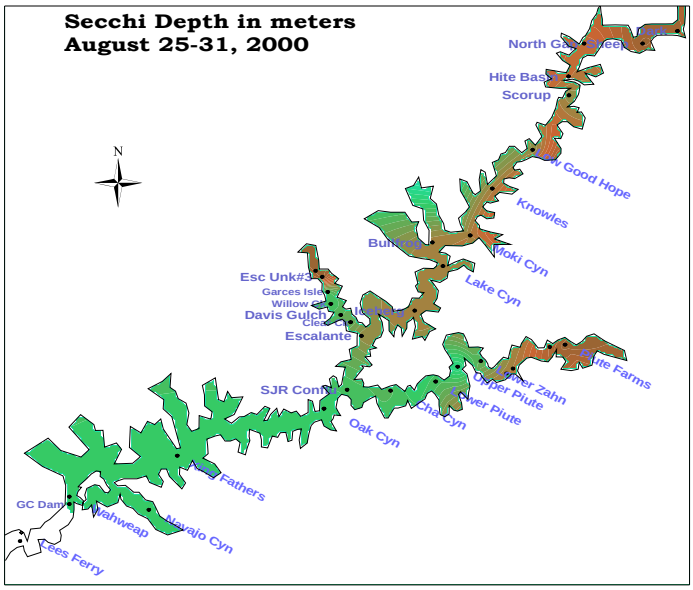
For August, secchi depths (table I, map 1) reflected heightened productivity from phytoplankton (see chlorophyll levels, table I, fig.6), suspension of sediments from the spring flood (a minor contributor this year with lower inflows), as well as some "whiting" of the lake in the lacustrine zones from super-saturation of calcium carbonate, a fairly common occurrence in late summer. Chlorophyll values ranged from 0.5 to 3 mg/m^3 in the down-lake portions of the reservoir, 2 to 10 mg/m^3 in the transitional portions, and 5-10 mg/m^3 in the inflows, reflecting seasonal peaks.

The ranges of nutrients and primary productivity are indicative of a large reservoir system with distinct zones (riverine to lacustrine) and this generally demonstrates a system which transitions from moderate or mesotrophic productivity in the transition zone to primarily oligotrophic (low nutrient, low productivity) in the lower reaches of the lake.

Findings on the reservoir included some unusual events on-shore. In May, the appearance of mosquitoes in two bays at the lower end of the lake was experienced for the first time in many years. This may be an effect of the fairly stable lake elevation during this spring. On the first night of the August trip, Mark Anderson of Glen Canyon National Recreation Area had a misadventure with a rattlesnake. "I thought I kicked a cactus". A sound bite on the toe lead to a midnight helicopter out, but he returned to the trip in a day and a half, gaining the Trooper Award. Other unusual wildlife included an impressive but fairly benign giant hairy scorpion *Hadrurus spadix*, and the rarest sighting, a freshwater jellyfish, *Craspedacusta sowerbyi*. The jellyfish was found by a park visitor in Oak Canyon. This is the only known species of freshwater jellyfish in the U.S., but though seen on rare occasions, it appears not to be documented in Lake Powell.

Acknowledgments:

The Integrated Water Quality Program wishes to thank Glen Canyon National Recreation Area for assistance of personnel and equipment. Appreciation is extended to GCMRC staff and the many supporters of the IWQP and volunteers who assisted in collections.



Map 1: August '00 secchi depths across Lake Powell with map of stations sampled in WY2000. Lake length along the main channel is 272 km (154 miles) from dam to Dark Canyon.

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Figure 4: Wahweap (forebay station above dam) profiles from Jan 1993 to September 13, 2000. Penstock and jet tube depths indicated.

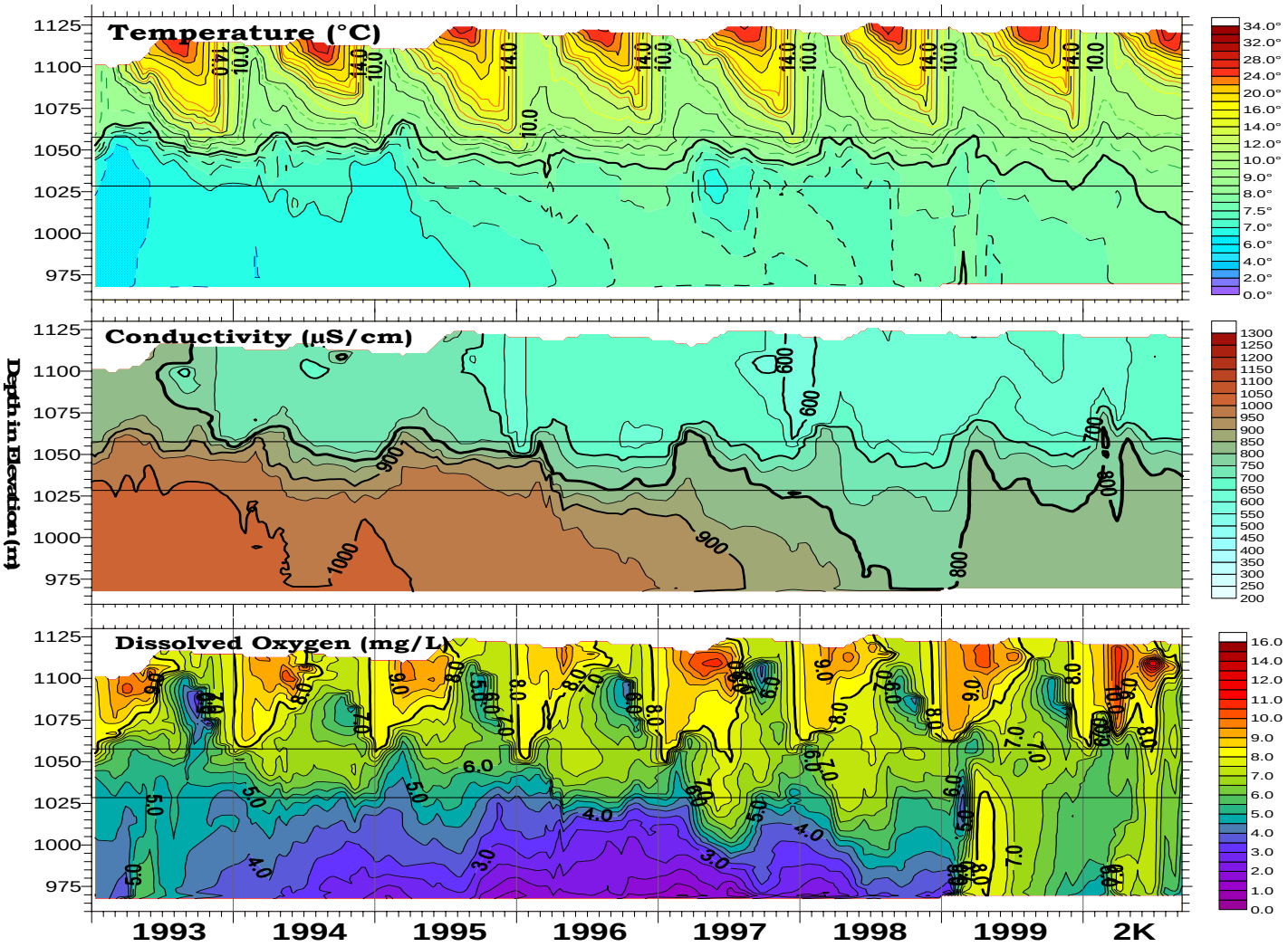

Table 1: Secchi depth (m) and surface chlorophyll-a (mg/m3) values for Feb '92 through August 2000. Storet numbers refer to Lake Powell stations, reach (CR= Colorado River, ESC=Escalante, SJR= San Juan, NVC= Navajo Cyn.; and river kilometer from Glen Canyon Dam.

Site Name	Storet# ↓	Maximum Secchi Disk readings (m) for Feb '99 to August '00							Surface Chlorophyll-a (mg/m^3) for WY99-00						
	Quarter →	9902	9906	9909	9912	2K02	2K05	2K08	9902	9906	9909	9912	2K02	2K05	2K08
Lees Ferry	LPCR-249								2.16	1.43	1.13	1.24	0.66	0.69	0.41
GC Dam	LPCR-001								0.15	0.06	0.14	0.31	0.03	0.04	0.10
Wahweap	LPCR0024	16.7	11.2	10.8	7.9	15.5	12.7	7.6	0.46	0.45	0.98	0.40	0.31	0.44	0.91
Xing Fathers	LPCR0453	15	9.3	8.3	16.1	18.3	10.25	7.9	0.96	0.37	0.89	0.42	0.41	0.28	1.08
Oak Cyn	LPCR0905	12.95	9.4	7.9	15.5	15.7	12.5	7.9	0.49	0.46	1.68	0.28	0.51	0.12	1.29
SJR Confluence	LPCR1001	13.5	8.6	6.5		14.15	11	7.4	0.45		1.86		0.46	0.70	1.67
Escalante Confluence	LPCR1169	15.1	7.9	7.4	15.1	15.8	12.1	4.7	1.47	0.86	1.6	0.95	0.41	0.26	1.81
Iceberg	LPCR1395	14.9	6.5	6.7		15.8	11.4	4.1	1.43	0.909	1.64		0.44	0.40	3.40
Lake Cyn	LPCR1587	13	7.3	6.7	11.1	16.2	9.7	4.3	2.49	2.064	1.98	0.39	0.39	0.18	2.95
Bullfrog	LPCR1692	10.8	5.4	6	8.3	13.5	6.8	4.15	1.45	1.94	2.83	0.75	0.32	0.41	1.84
Moki Cyn	LPCR1772	8.6	4	8	8.8	11.8	4.2	3.95	2.55	1.84	2.39	0.54	0.62	0.61	1.72
Knowles	LPCR1933	12.3	3.2	7.3	9.5	12.5	2.5	4.2	1.56	1.22	3.69	0.18	0.75	0.30	4.15
Low Good Hope	LPCR2085	12.9	2.3	7.4	7.4	12.3	2.7	5	1.53	1.15	4.43	1.21	0.70	1.04	3.29
Scorup	LPCR2255	10	3.2	6	4.4	7.8	0.55	4.8	1.44	1.53	4.285	0.70	0.40	2.25	3.41
Hite Basin	LPCR2387	10.4	0.9	2.73	3.9	9	0.35	3.4	2.14	2.75	6.97	1.17	0.52	2.31	4.94
North Gap	LPCR2483	10.45	0.34	3.8	3.1	7.2	0.25	3.4	0.81	2.16	6.88	0.11	0.12	3.95	9.57
Sheep	LPCR2626e	0.45	0.2				0.2	0.35	1.31	0.81				3.08	5.27
Dark Canyon	LPCR2713e			0.28	0.47	0.28					2.6	0.93	1.02		
Clear Ck	LPESC072e	7.95		5.2		14.2	12.1	6.4	1.08		1.61		0.26	0.69	1.48
Davis Gulch	LPESC119	9.6	10.4	6.1		14.15	12.1	6.5	1.1	0.24	1.13		0.21	0.21	1.20
Willow Ck	LPESC200	12	10.6			7.6	11	7.5	0.55		1.13		0.20	0.27	0.97
Garces Isle	LPESC273e		10.5	5.15		4.8	8.8	7.1	0.4		2.42		0.24	0.43	1.00
Esc Unk#3	LPESC347e		0.9	0.08		0.48	0.35	0.28	1.18	0.32	3.67		7.11	2.22	6.10
Navajo Cyn	LPNVC124	5.8		10.1		9.7	12.7	7.5	5.84		0.89		0.66	0.16	0.30
Cha Cyn	LPSJR193	11.6	7.7	7.3	10.35	10.3	10.8	6.9	1.009	0.55	1.28	0.97	0.84	0.53	1.16
Lower Piute	LPSJR329	12	9.7	6.9	6.7	11.3	10.8	7.2	0.91		1.48	0.77	0.55	0.40	1.25
Upper Piute	LPSJR431	13.3	7.5	4.7	6.3	10.3	8.7	9.2	0.87	0.39	3.755	0.46	0.30	0.51	0.52
Lower Zahn	LPSJR625	11.4		2.45	5.5	8.3	5.5	6.6	1.49		4.46	1.56	0.71	1.07	0.50
Mid Zahn	LPSJR686		0.25			2.05	5.8		0.91	2.135			1.47		4.37
Piute Farms	LPSJR850e			0.45	0.8	0.4	0.15	0.12			3.82	1.00	0.96	3.64	5.94

Figure 5: Chlorophyll values (mg/m^3) for WY00 for Lake Powell and tailwaters. Samples were collected at 1m depth.

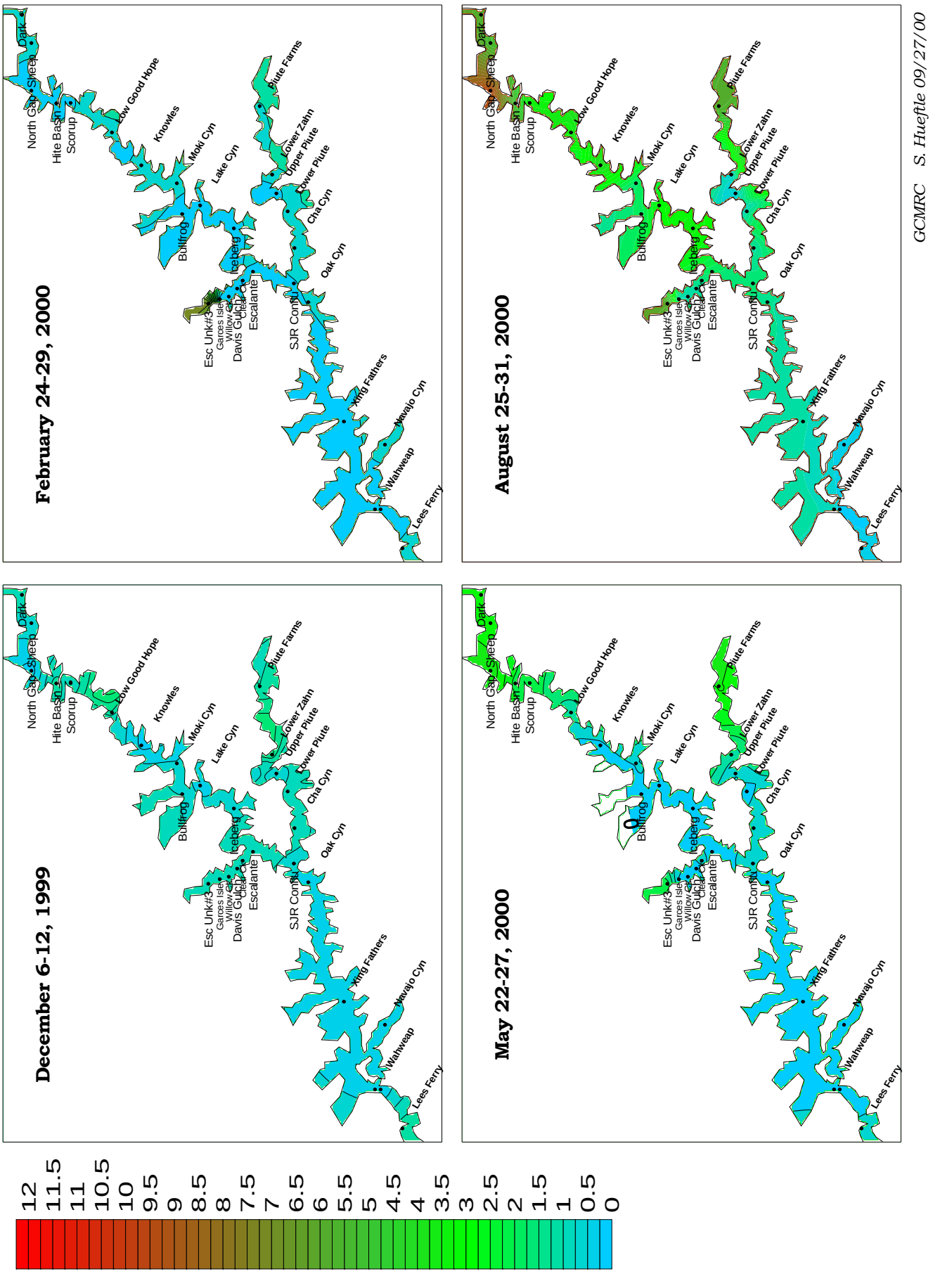

Figure 6: Phytoplankton biovolume (µm³/L) and Zooplankton biomass (µg DW/cm² —analogous to µg/L) estimates for Sept '99 to May '00 quarterly trips. Zoop samples compiled for 0-30m & 30-60m tows.

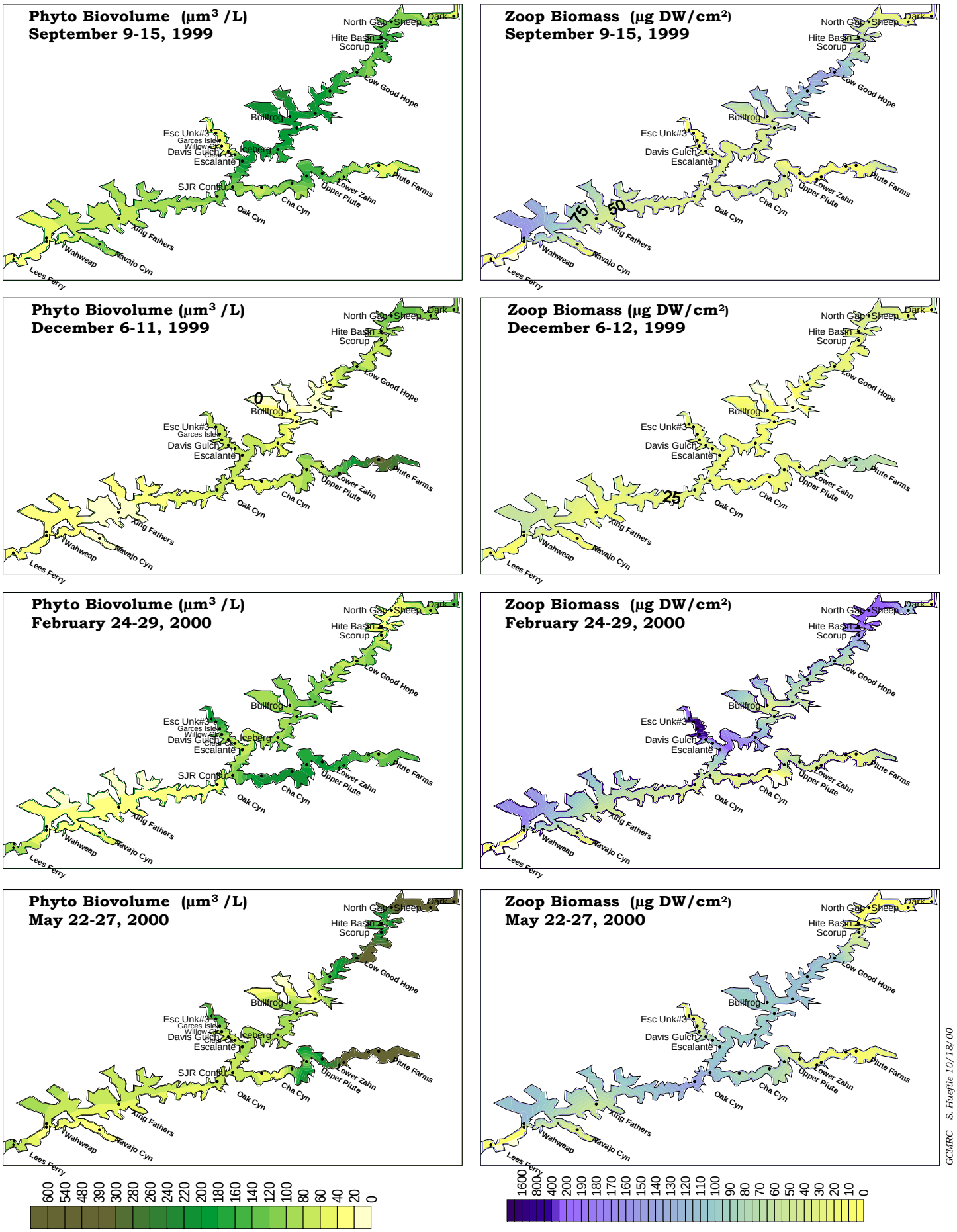

Figure 7: Surface Nutrient Values in the Main Channel and tailwaters of Lake Powell, Sept. 1991 to May 2000 (0 to -2m). Values below detection levels indicated by striped areas. PROVISIONAL DATA: Stars indicate low suspect values; crosses indicate high suspected values. Ammonia values are particularly variable.