REPORT FOR

AQUATIC BIOLOGY COURSE 569

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UNDERC - LAND O'LAKES, WISC.

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INTRODUCTION

This paper is a specific recapitulation of various aquatic biological and chemical data recorded during August, 1982, in the Aquatic Biology course 569 at the University of Notre Dame Environmental Research Center. UNDERC is located in the Upper Peninsula of Michigan, straddling the border with Wisconsin west of both Watersmeet, Michigan and Land O'Lakes, Wisconsin, in Gogebic & Vilas Counties, respectively. The land is kept in a totally natural state since about the early 1900's, when logging was prosperous in the area.

The writing begins with a short introduction to Tuesday Lake's chemical and biological properties and species. The same sequence is followed for Kickapoo Lake. Following these is a comparison of the two lakes emphasizing the significance of various combinations of physical, biological and chemical aspects of each lake.

TUESDAY LAKE

General Description

Tuesday Lake is a small bog lake (1.2 hectares) surrounded by a very large sphagnum mat. Pitcher plants, orchids, leather leaf, numerous tamaracks and a few black spruce clumps comprise the majority of the mat's flora. The hills surrounding the mat and the lake are covered by various deciduous and coniferous species.

This body of darkly stained water has a maximum depth of approximately twenty meters. A cold anoxic hypolimnion represents a large percentage of its volume. Tuesday Lake supports an enormous minnow population which preys upon a fairly diverse collection of plankters. No larger teleos fish are present in the lake. No notable current exists in the lake, although water from Tuesday eventually finds its way into neighboring Bay Lake.

Physical/chemical Data

The statistics representing the dissolved oxygen curve, temperature curve, and thermal stratification of Tuesday Lake are as follows:

Z (m)	Degrees C.	O_2 (ppm)	
.5	22	5.6	
1.0	22	5.5	(epilimnion)
1.5	22	4.5	
2.0	18	0.1*	
2.5	14	0.2*	
3.0	10	0.1*	
3.5	9.5	0.1*	
4.0	5.9	0.1*	(hypolimnion)
5.0	4.5	0.1*	
6.0	4.0	0.1*	
7.0-10.0	4.0	0.1*	

*Hydrogen sulfide (H_2S) positive test results account for the false oxygen readings.

Graph for these data on appendix page A.

		Epilimnion	Hypolimnion
Acidity:	Methyl Orange	0	0
	Phenolphthalein	74	72
Alkalinity		Less than 2	Less than 3
pH		5.0+	5.3
Apparent Color		112 units	110 units
True Color		73 units	72 units
Conductance		18 µmhos	21 µmhos
Hardness (ppm)	- Total	19.5	19.8
	Ca++	10.5	10.7
	Mg++	9.0	9.1

Clarity 1% surface incident light penetrated to a depth of 3.4 meters with the Secchi disc reading of 1.7 meters at ~~about~~ noon, with sunny skies and very light breeze, but a clam surface.

H_2S was distinctly present in Tuesday Lake.

(Tuesday Lake, Physical/Chemical Data)

NUTRIENT CONCENTRATIONS

	Epilimnion	Hypolimnion
Nitrates (ppm)	1.3	1.5
Orthophosphates	1 .1 2 .4 3 .3	1 .3 2 .2 3 .4
Average	.26 mg/l	.33 mg/l
Total	1 .2 2 .5 3 ___	1 .4 2 .4 3 .5
Average	.3 mg/l	.43 mg/l
Sulfates	6.9 mg/l	7.8 mg/l

RELATIVE ABUNDANCE OF PLANKTON SPECIES IN TUESDAY LAKE DETERMINED BY USING A SEDGEWICK-RAFTER COUNTING CELL (Extremely dark, dense sample)

Species	Abundance/ml
Keratella cochlearis	3,872
Kellicottia longispina	22
Nauplius Larvae	154
Bosmina	968
Peridinium tabulatum	9,218
Eucuclops agilis	814
Asterionella	55
Ceratium	44
Aphanocapsa	appr.5,000+
Tabellaria	363
Polyarthra trigla	22
Desmodium	appr.2,000+
Pentacerum	121
Xanthidium	77
Staurastrum	33
Copepodite	22

KICKAPOO LAKE

Genral Description

Kickapoo Lake has heavy macrophyte growth, shallow murky water and an unconsolidated mucky bottom only three and one half meters below the surface. The lake has two inlets. Drainage into Kickapoo at the West end of the Lake comes from Plum Lake, and water entering the Lake via the north shore flows in from Emelin Lake.

The majority of the surrounding terrain is not solid, rather is marsh vegetation which grows in the flowing water. Along the northern shore runs a ridge of solid ground which supports mixed deciduous and coniferous trees. Muskies, Pike, crappie and perch are all found in Kickapoo's waters along with various minnow species and quite a large selection of plankton.

Physical/Chemical Data

The statistics representing the dissolved oxygen curve, temperature curve and thermal stratification of Kickapoo Lake are presented below:

Z (m)	Degrees C.	O_2 (ppm)	
.5	21	7.1	
1.0	21	6.9	Epilimnion
1.5	19	1.0	
2.0	17.5	0.4	
2.5	16.5	0.3	Hypolimnion
3.0	15	0.2	
(3.5	15	0.1)	unconsolidated substrate

Graph for these data on appendix page A.

		Epilimnion	Hypolimnion
Acidity mg/l	Methyl Orange	0	0
	Phenolpthalein	40	30
Alkalinity mg/l		35	35
pH (wide range indicator)/(at lake)		7.1/6.0+	6.0/6.5+
Apparent color		45 units	90 units
True Color		35 units	units
Conductance		65 µmhos	70 µmhos
Hardness mg/l	- Total	45	65
	Ca++	35	45
	Mg++	10	20

Clarity 1% surface incident sunlight penetrated to a depth of approximately 2.6 meters, with a Secchi disc reading of 1.3 meters. The reading was made on a mostly cloudy, very windy morning at 9:30.

H_2S was not present in Kickapoo Lake.

NUTRIENT CONCENTRATIONS

		Epilimnion			Hypolimnion	
Nitrates (mg/l)		0.1			0.2	
Orthophosphates	1	0.22		1	0.12	
	2	0.13		2	0.10	
	3	0.13		3	0.15	
Averages		.16	mg/l		.12	mg/l
Total	1	0.19		1	0.19	
	2	0.17		2	0.18	
	3	0.22		3	0.22	
Average		.19	mg/l		.196	mg/l
Sulfates		2.0	mg/l		3.5	mg/l

(Kickapoo Lake, Physical/Chemical data)

RELATIVE ABUNDANCE OF PLANKTON SPECIES IN KICKAPOO LAKE

DETERMINED BY USING A SEDGEWICK-RAFTER COUNTING CELL
(Relatively Clear Sample)

Species	Occurance/ml
Keratella cochlearis	792
Cyclops	121
Diaptamus	121
Polyarthra trigla	11
Asplanchna	33
Asplanchnapus	11
Bosmina	484
Asterionella	275
Ceratium	330
Tabellaria	231
Chrysoperlla	77
Nauplius Larvae	66
Donobrium (colomes)	484
Diaphanosoma brachyurum	132
Pentacerum	22
Anabaena	594
Copepodite	22

OBSERVATION

Tuesday and Kickapoo Lakes have a significant number of chemical differences. Tuesday is a small, very deep lake (20m) with a notably low epilimnion/hypolimnion ration, while Kickapoo is larger and shallower with a high epilimnion/hypolimnion ratio. In the case of a lake like Kickapoo, which has a large surface/atmosphere interface, turbulence can be a source of oxygenation of the epilimnion. Physical oxygenation of Tuseday's epilimnion is far less efficient due to its small surface/atmosphere ratio and protective surroundings reducing winds.

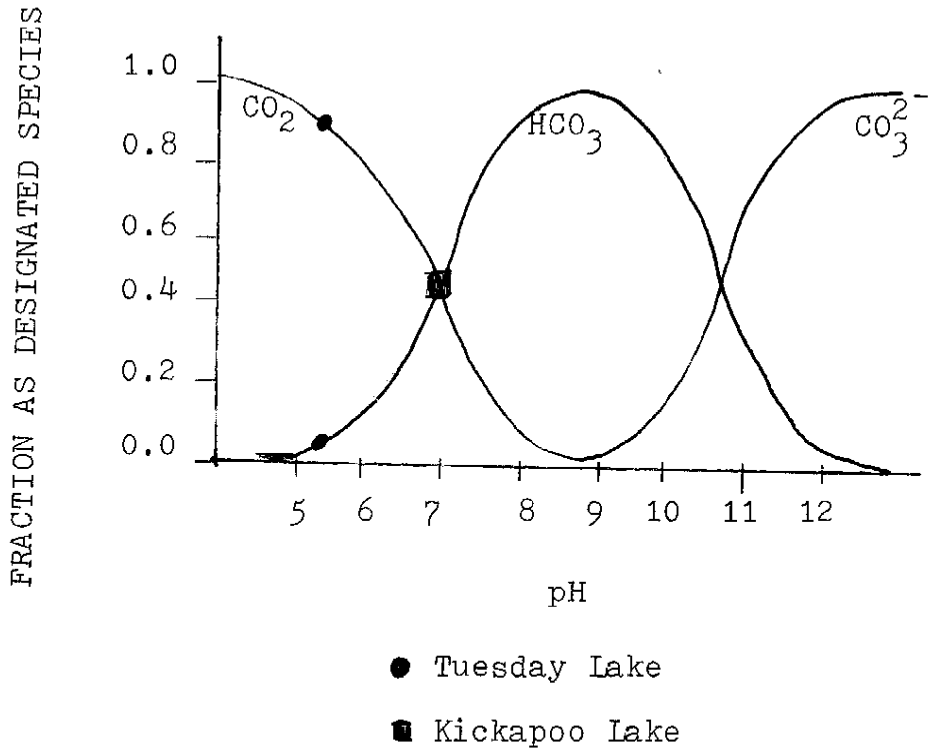
In Kickapoo, the oxygenation aids in the turnover process, making an isothermal condition easier to obtain. Turnover does occur biannually in Kickapoo, and increased biological activity may be the result of the mixing. Tuesday Lake, with its four degree Centigrade water located only one quarter of the distance from the surface to the bottom, is not able to turn over. This situation is an important distinguishing characteristic between the two lakes considering that the hypolimnion has no direct source of oxygen. Based on this fact, hydrogen sulfide is present in Tuesday Lake and absent in Kickapoo. Tuesday Lake has anoxic depths while Kickapoo does not.

Kickapoo has a largely diminished oxygen concentration

in its benthic region mainly due to aerobic bacterial degradation and photosynthetic consumption.

In the winter, ice restricts the vertical circulation in a stratified body of water such as Tuesday Lake. An isothermal, destratified condition would be difficult to establish there.

The diagram below shows the distribution of the carbon species CO_2, HCO_3^{2-}, and CO_3^{2-}, as a function of pH.



This figure shows that the bicarbonate ion is the dominant carbon species in the pH range of many natural waters, with carbon dioxide predomination in more acidic waters. Tuesday Lake has a pH of 5.3; therefore carbon dioxide is the dominant species.

The principle behind the partial dissociation of CO_2 in water,

$$CO_2 + H_2O \rightleftharpoons H + HCO_3^-$$

is what the preceeding diagram is based upon.

The following reactions represent the dominant species distribution in response to the amount of H^+ or pH of the water.

$$HCO_3^- + H^+ \rightleftharpoons CO_2 + H_2O$$

$$CO_3^{2-} + H^+ \rightleftharpoons HCO_3^-$$

(add acid $\longrightarrow$ / $\longleftarrow$ add base)

High concentrations of carbon dioxide in water may adversely affect respiration and gas exchange of the present flora and fauna. The relationship (equilibrium) of carbon dioxide in the water, and atmospheric CO_2

$$(\text{water})CO_2 \rightleftharpoons CO_2 \text{ (atmosphere)}$$

has a strong buffering effect upon the pH. The relationship between carbonate ions in solution and solid carbonate would represent the same respective reaction in extremely basic waters. A large part of the carbon dioxide found in

Tuesday and Kickapoo is the product of bacterial breakdown of organic matter. Even algae produce CO_2 in their photosynthetic dark cycle.

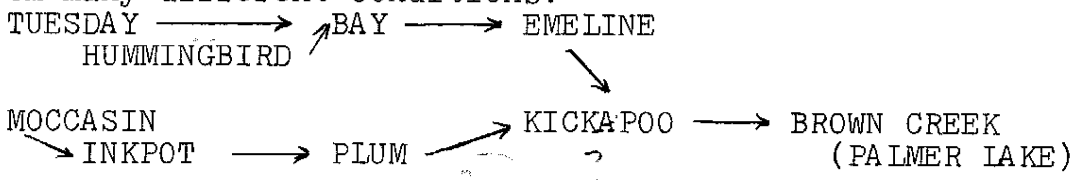
Nutrient concentrations in general were a bit lower than they would be in the beginning of the growing season due to the length of time in which the increasing numbers of consumers had to consume.

Alkalinity, hardness and conductance values are all considerably higher in Kickapoo than they are in Tuesday. Alkalinity is very important in determining the body of water's ability to support algal growth, as well as other more advaned forms of aquatic life. One might go as far as to refer to alkalinity as the measure of water fertility. Kickapoo has a much higher alkalinity (33 mg/l) than does Tuesday Lake (2.5 mg/l). Kickapoo also contains more hard water ions (total Hardness $\approx$ 50 mg/l) than Tuesday does (Total Hardness $\approx$ 20 mg/l), so it is reasonable that Kickapoo's specific conductance should also be higher - which it is. Kickapoo has a specific conductance of $\approx$ 68 μmhos/cm while Tuesday has only 19 of the same units.

Microorganisms play an essential role in determining the chemical compositions of water. They are living catalysts and primary producers of biomass, which are responsible for many sediment and mineral deposits. Some species are the reducers responsible for degradation.

Tuesday Lake has a very small, almost non-existant, littoral zone, with only a few water lillies growing in the extreme southwestern end of the lake. On the contrary, Kickapoo has an extensive littoral zone characterized by dense marophytic growth. Tuesday has an extremely low biomass of benthic invertebrates and completely lacks larger teleos fish due to low oxygen concentrations, shallow light penetration and the cold temperature of its water. Kickapoo, on the other hand, with its extensive littoral zone, has a comparatively large benthic biomass. This is represented by the higher two and one half meter apparent color result, and the presence of larger oxygen-requiring teleos species. Potamagetons, or the broad leaf pond weeds, for example, are classic Muskie indicators, and these grow well in Kickapoo.

Origins of the water which make up these two lakes must be considered in addition to their chemical composition regarding respective biomasses. Tuesday has no inlets and no current, although some of the water in Bay Lake originally came from Tuesday through underground flow. Kickapoo's water is the result of miles of flowage, through and from many different conditions.



FLOW CHART OF KICKAPOO'S AFFLUENT AND EFFLUENT WATERS

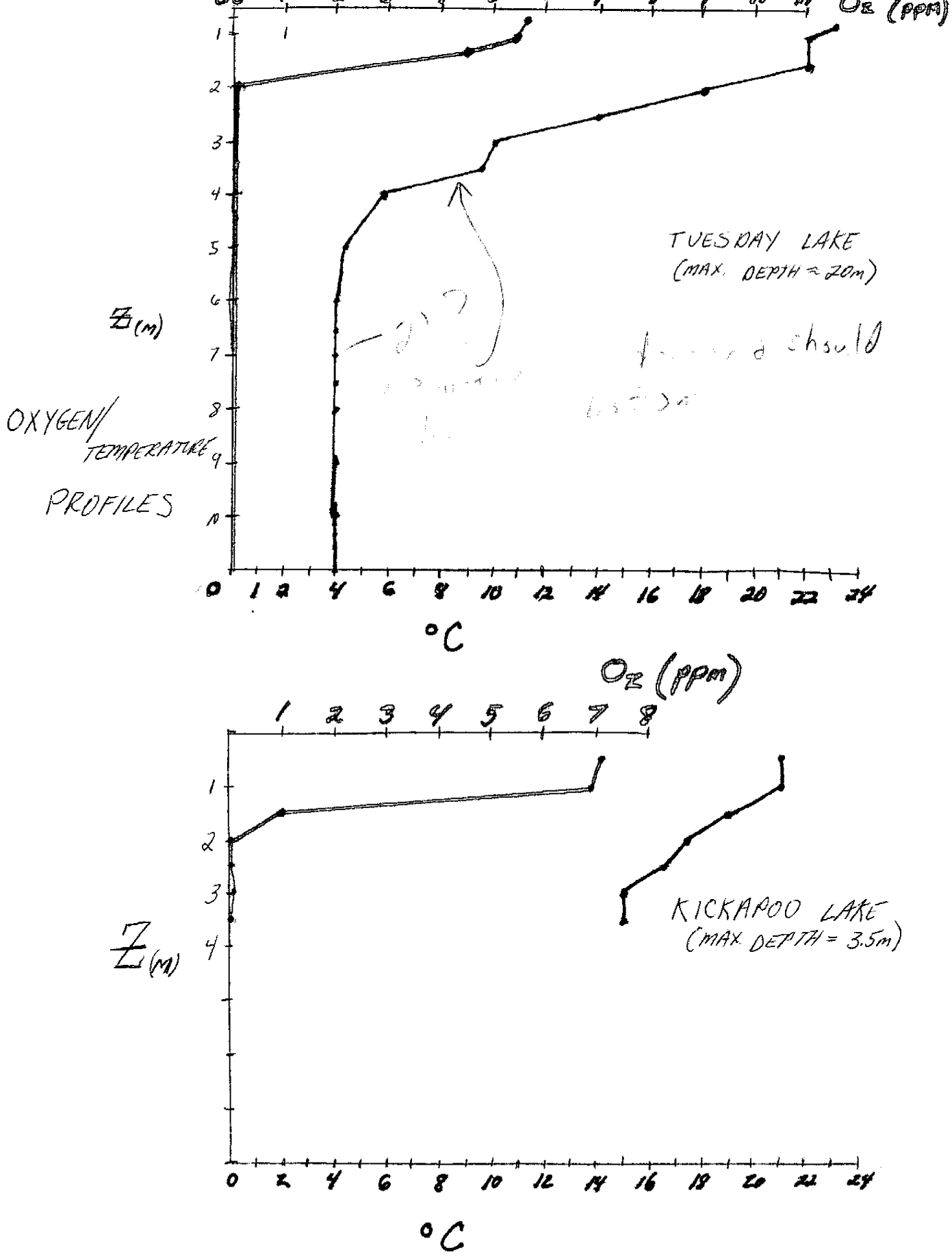
Diversity of species is the main advantage of receiving water from various locations. The cattail marsh, which the northwestern end of Kickapoo resembles, is considered one of the most productive freshwater ecosystems. Tuesday's lack of submergent macrophytes and abundant sphagnum moss pave the way to decreasing productivity and eventually the filling-in process of bogs. The sphagnum and stagnant water ultimately determines the acidity and pH, thereby selecting out plant and animal species according to their tolerances.

Kickapoo could be classified as being a less oligotrophic lake than Tuesday, perhaps in the mesotrophic state. Mesotrophic simply meaning approaching nutrient richness with relatively high productivity. Tuesday would be categorized in the direction of being an oligotrophic lake with a low productivity rate. The differences in productivity between the two lakes can be illustrated by a hypothectical aquatic food chain for each lake.

TUESDAY	KICKAPOO
1* Bosmina Eucyclops agilis Nauplius, etc.	1* Cyclops, Diaptamus, Bosmina, etc.
2 Cyprinids & perhaps Darters	2 Cyprinids, fingerlings 3 Crappie, Perch 4 Pike, Muskie

*Numbers represent various increasing trophic levels.

I have been unable to draw up legitimate comparisons for aquatic insect species at the two lakes, not having done samplings at either. Based on the contents of this writing, I think it is safe to say that a greater diversity of insect species could exist in Kickapoo Lake than in Tuesday Lake. I did recognize various Coleopterans, backswimmers, and dytiscid beetles at Tuesday, along with a few leeches. I noticed large leeches, amphipods and the gastropods, Bulimnea megasoma, and a few Heliosoma species at Kickapoo. I also found a sisyrid (Neuroptera) in a sample of freshwater sponge, and some stonefly (Plecoptera) and mayfly (Ephemecoptera) larvae at Kickapoo. The northern leopard frog (Rana lipiens), wood frog (Rana sylvatica) and green frog (Rana clamitans) were represented at both Kickapoo and Tuesday Lakes.


OXYGEN/
TEMPERATURE
PROFILES
Z (m)
TUESDAY LAKE
(MAX. DEPTH ≈ 20m)
°C
O₂ (ppm)
KICKAPOO LAKE
(MAX. DEPTH = 3.5m)
Z (m)
°C