Alaskan Stickleback Lakes/Liminology Database Read Me File

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A. **LAKE NAME:** The names provided in the database represent the body of water from which samples were taken, usually as defined by topographical maps from United States Geological Survey (USGS) or from the Sport Fish lake records of the Alaska Department of Fish and Game (ADF&G). The word "Lake" has been omitted from the column for simplicity, but other bodies of water (rivers, streams, etc.) are denoted.

B. **FIELD NUMBER:** Each sample's field number as documented in Dr. Bell's 1990 field notes, which are archived in Bell's lab. Lake samples are divided into X and O field numbers because two crews operated simultaneously to gather data. XMAB90-n therefore represents the nth sample collected by the X crew in 1990. The same sample numbers (n) appear in both the X and O series, but do not represent the same data samples.

C. **DATE COLLECTED:** Collection date for the zooplankton and water chemistry samples.

D. **DATE SAMPLE:** Date on which these samples were analyzed by Koening's lab. The location column is used to delineate the geographic region in which the body of water was found, with Kenai representing the Kenai Peninsula and MatSu representing the Matanuska-Susitna Borough of Alaska.

E. **SAMPLE DEPTH:** Water chemistry measurements were taken from a depth of 1m below the surface when possible, using the procedure described in Koenings (1987). In bodies of water with depths less than 1 meter, samples were taken as close to the lake bottom as possible without disturbing benthic sediment. A depth of "s" represents surface water depth. For samples without marked sample depths, it is reasonable to assume this methodology.

F. **ELEVATION**: The height above sea level of the water surface in meters.

G. **AREA:** The lakes sampled were found in either the Matanuska-Susitna Borough (MatSu) or on the Kenai Peninsula (Kenai).

H. **LATITUDE.** North latitude of the approximate center of the lake surface. The units given are in degrees. The decimal points listed are fractions of degrees, which were obtained from degree-minute-seconds listings by multiplying minutes by 60, adding the seconds and dividing the sum by 3600. Obtained from USGS topographical maps. See AW for Google Earth latitude.

I. **LONGITUDE.** West longitude of the approximate center of the lake surface. The units given are in degrees. The decimal points listed are fractions of degrees,

which were obtained from degree-minute-seconds listings by multiplying minutes by 60, adding the seconds and dividing the sum by 3600. Obtained from USGS topographical maps. See AX for Google Earth longitude.

J. WATER DATE:

K. **TP:** The total phosphorus concentration in micrograms per liter. Inorganic phosphorus + organic phosphorus. TP measurements are not corrected for turbidity.

L. **FRP:** The filtered reactive phosphorus in micrograms per liter. A component of TP, FRP can be used to estimate dissolved particulate and organic phosphorus using the relationship TP-FRP= organic/particulate phosphorus.

M. **TKN:** The total Kjeldahl nitrogen in micrograms per liter. TKN is a widely used parameter for measuring nitrogen content, and is defined as the sum of ammonia/ammonium and organic nitrogen.

N. **AMMON:** The concentration of NH3+NH4+ in micrograms per liter. One component of TKN measurements.

O. **NITRATE:** The combined concentrations of nitrate and nitrite in micrograms per liter.

P. **RSI:** The concentration of reactive silicon in micrograms per liter,

Q. **ChlA:** The concentration chlorophyll A given in micrograms per liter.

R. **PHAEO:** The concentration of phaeophytin in micrograms per liter. Phaeophytin is the product of the degradation of free standing chlorophyll.

S. **ChlA+Pha:** The combined concentrations of chlorophyll A and phaeophytin given in micrograms per liter. Both phaeophytin and ChlA are important indicators of primary productivity. Some publications have used ChlA+ phaeophytin concentrations to estimate primary productivity, however Koenings recommends against this practice.

T. **SP COND:** Specific conductivity given in units of microsiemens per centimeters (equivalent to micromhos per centimeter). Conductivity typically varies with

temperature; the values reported in the database are were measured at room temperature.

U. **pH:** unitless measurement of relative acidity. Derived by the equation pH = -log[H+]

V. **ALKALIN:** The carbonate and bicarbonate ion concentration given in equivalent milligrams per liter of calcium carbonate. Alkalinity is used to quantify the buffer capacity of the water, with higher alkalinity values indicating a greater capacity for the neutralization.

W. **TURB:** Water turbidity is given in nephelometric turbidity units (NTU) which are defined as the amount of light scattered at 90 degrees from a beam transmitted through a water sample. The amount of light scattered is likely a function of both the type and density of suspended solid particles, and as such turbidity in NTU is correlated with the quantity of total suspended particles, although this correlation may be location specific.

X. **COLOR:** Water color is measured using platinum cobalt units (Pt). This measurement quantifies the optical density of water at 400 nanometers. This is primarily a function of the quantity of colloidal particles and dissolved organic matter.

Y. **CALCIUM:** The concentration of the dissolved calcium in milligrams per liter.

Z. **MAGNESIUM:** The concentration of dissolved magnesium in milligrams per liter.

AA. **IRON:** The concentration of dissolved iron in micrograms per liter.

AB. **REHAB:** This column indicates whether or not the lake has been treated with rotenone. Data here was collected from the sport fishing lake records of the ADF&G. These records were retrieved from Palmer in Mat-Su lakes and from Soldotna for lakes on the Kenai peninsula. “Yes” indicates a past rotenone treatment, while “No” indicates that the lake has not been rehabilitated.

AC. **INLET:** Indicates the existence of a surface tributary stream to the lake. “Yes” refers to the presence of a tributaries while “No” indicates that the lake has no known surface inlets.

AD. **I TYPE:** Qualifies the type of inlet source for lakes which have known tributaries. “Normal” refers to a continuous inlet stream, “periodic” refers to lakes which have seasonal or intermittently present inlet streams. The column is left blank for lakes which have no known surface inlets.

AE. **OUTLET:** Indicates the existence of a surface stream discharging water from the lake. “Yes” refers to the presence of an outlet stream while “No” indicates that the lake has no known surface outlets.

AF. **O TYPE:** Qualifies the type of outlet for lakes which have known discharge streams. “Normal” refers to a continuous outlet stream, “periodic” refers to lakes which have seasonal or intermittently present outlet streams. The column is left blank for lakes which have no known surface outlets.

AG. **MEAN PELV:** The mean pelvic score of *Gasterosteus aculeatus* populations in the lake. Units are dimensionless, with scores ranging from 0 (pelvic girdle absent) to 8 (fully expressed pelvic girdle). The ancestral condition of this trait is full expression (score = 8). See Bell et al. (1993) and Bell and Orti (1994) for methods, frequencies, sample sizes and analysis.

AH **MOD PELV:** The modal pelvic score of Gasterosteus aculeatus populations in the lake. Units are dimensionless, with scores ranging from 0 to 8. See AE: Mean pelv.

AI **PRED:** This column indicates the presence or absence of predatory fish and the origin of predatory species present in the lake. “Native” indicates natural predatory species present, “Intro” indicates invasive or introduced predators, and “Abs” indicates the absence of predatory fish. Predatory fish species that are included in this category include rainbow trout, dolly varden, king salmon, red salmon, silver salmon, arctic grayling, longnose sucker, and various species of sculpin. (A further breakdown of predator composition and source of origin in each lake is given in columns AN-AV.)

AJ **PRED ORIG:**

AK: **NEW PRED:**

AL **DURAT:** The period of time over which introduced species of predators were released into the lake, last updated in 1990. Short term introductions are defined as those occurring for less than 10 years. Long term introductions are defined as those occurring for more than 10 years.

AM **TIME:** The elapsed time since last introductions, as of 1990. Those introductions for which the last plant of predatory fish occurred prior to 1980 are indicated with “Old” while introductions which included plants after 1990 are marked “New.”

Columns AN-AV score the lakes based on the presence and origin of several fish species. All entries in this column are scores from 0 to 4 which correspond to the category of that particular lake with regards to each species. Information regarding the introduction by ADF&G was gathered from the sport fish lake records located in Palmer (MatSu lakes) or Soldotna (Kenai Lakes). The scale is as follows:

0 indicates the absence of the species.
1 indicates the species is present, native and has not been reintroduced by ADF&G.
2 indicates the species is present, native and has been introduced by ADF&G.
3 indicates the species is present, nonnative and has been introduced by ADF&G.
4 indicates the species is present (collected by MAB), but is nonnative, and has not been introduced by ADF&G. These species are not listed as present in the records of ADF&G.

AN. RT. Rainbow trout (*Oncorhynchus mykiss*) occurrence coded on a scale from 0-4 (see section header).
AO. DV. Dolly varden (*Salvelinus malma*) occurrence coded on a scale from 0-4 (see section header).
AP. SS. Silver/Coho salmon (*Oncorhynchus kisutch*) occurrence coded on a scale from 0-4 (see section header).
AQ. KS. King/chinook salmon (*Oncorhynchus tshawytscha)* occurrence coded on a scale from 0-4 (see section header).
AR. GR. Arctic grayling (*Thymallus arcticus*) occurrance coded on a scale from 0-4 (see section header).
AS. LS. Longnose sucker (*Catostomus catostomus*) occurrance coded on a scale from 0-4 (see section header).
AT. RS. Red/sockeye salmon (*Oncorhynchus nerka*) occurrence coded on a scale from 0-4 (see section header).
AU. CS. *Cottus* species (sculpins) occurrence coded on a scale from 0-4 (see section header). Species included into this column include *C.cognatus*, *C. aleuticus* and, rarely, *Leptocottus armatus*.
AV. Other fish. Some abbreviations not clear.

AW. GOOGLE LAT. North latitude of the collection sites as listed on google maps. Also listed in decimal degrees rather than degree-minute-seconds. Google coordinates are more reliable than those measured on maps.

AX. GOOGLE LONG. West longitude of the collection sites as listed on google maps. Also listed in decimal degrees rather than degree-minute-seconds. Google coordinates are more reliable than those measured on maps.

AY. MAP. The USGS topographical map which contains the lake as well as a plot of the specific collection site. These maps are available in Bell's lab.

AZ. RANGE: Approximate East/West location of the lake site on USGS topographical maps as defined by local grid system using a meridian based in Seward Alaska.

BA. TOWNSHIP: Approximate North/South location of the lake site on USGS topographical maps as defined by local grid system using a reference point (0) of unclear location. All sample sites are North of the reference line.

BB SECTION: Precise location of the lake on USGS topographical maps. The range-township (RT) grid system is further divided into sections, with one RT unit containing a 6x6 grid of sections marked 1-36. Every section in which a significant amount of lake surface is located is listed in this column, separated by commas.

BC. SURF KM: Lake surface area in square kilometers as calculated from scanned USGS topographical maps. Maps were scanned and area was digitally determined using image analysis software.

BD. SURF HA: Lake surface area in hectares, derived from BC: SURF KM using the relationship 1 hectare (ha) = 0.1 sq. km.

BE. EZD Pt: Estimate of euphotic zone depth using an equation given in Koenings lab manual. Uses a linear relationship between log-log transformation of EZD in meters and water color in pt. (These columns are marked red because they empirically do not seem correct and do not agree with each other.)

BF. EZD Ntu: Estimate of euphotic zone depth using an equation given in Koenings lab manual. Uses a linear relationship between log-log transformation of EZD in meters and turbidity in NTU. (These columns are marked red because they empirically do not seem correct and do not agree with each other.)

BG. Dilution Factor: Multiplier which describes the overall dilution of the original sample before the 1ml subsample was drawn. Used to calculate density estimate. Low dilution samples were had low densities of plankton to begin with, and higher dilution factors are for samples with higher densities of plankton. Cells in yellow do not have a corresponding plankton data set.

BH. Tow Length: The vertical length in meters that was sampled by the plankton net. Used to calculate density estimate

Plankton Density Estimates:

The water and zooplankton samples were made from a canoe or inflatable boat close to the middle of small lakes. We measured the depth of the water below the boat using a rope marked at 1 m intervals. A 20 cm diameter plankton net with a mesh size of 153 µm was lowered to 1 m less than the depth and pulled up as rapidly as possible. A 5 L water sample was made at 1 m depth using a van doorn sampler. The water sample was immediately placed in an ice chest with frozen gel packs, and the zooplankton sample was washed out of the net by dipping it repeatedly into the lake to wash plankton down its interior walls into the bucket.

The water sample was refrigerated in the dark for up to 48 hours at about 4^{o} C before transported in ice chests. It was filtered before processing to remove particulate material and frozen for later chemical and optical analysis. Methods to analyze water

chemistry, suspended particles, and chlorophyll were executed following protocols in Koenings et al. (1987).

The bucket from the plankton net was emptied into a 125 ml bottle and 100% neutralized formalin (37% formaldehyde) was added to make 10% (v/v) formalin/sample solution. The procedure for handling and diluting samples, as well as identifying individual species is given in Koenings et al. (1987). All plankton caught in the net was washed into a 125 ml poly-bottle. A 1 ml subsample was taken from this sample and diluted to a known volume (i.e., the dilution factor) from which individual plankton counts were taken. Species were identified according to Koenings (1987). Zooplankton counts were originally reported as 1 milliliter subsample on paper data sheets prepared by the ADF&G Limnology Laboratory within several months after sample collection. Plankton length data were also recorded but is not included in this database. However, the raw counts and length data are available in scanned PDF files. Columns marked Other species or Other eggs refer to uncommon or unidentifiable individuals isolated during counts. Qualitative descriptions of these others are also available in the PDF.

Cubic density was calculated according to the procedure listed in Koenings et al.

$$Density\ (\frac{individuals}{m\text{^}3}) = \frac{1ml\ subsample\ count\ (individuals) * Dilution\ factor}{Tow\ length\ (m) * Net\ area\ (m^3)}$$

These densities are given in number of individuals per cubic meter, unless the row is marked in gold. In these cases, the estimate is in individuals below 1 square meter (m^2) of the lake surface (the subsequent conversion to cubic estimate could not be performed due to lack of reliable tow length data.)

If individual zooplankton species were identified during analysis but reliable counts could not be obtained because of the relative density of these species compared with other species. During the dilution process, the actual density of these less numerous species would be several orders of magnitude lower than the more abundant species therefore the 1 ml subsamples were unlikely to contain any individuals. In these cases, they were marked as “present” on the original data sheet, and this designation was entered into the data base as the density estimate.

Some columns are entitled “other . . ..” See original data sheets to determine how to divide them up.

For eggs, the original data sheets refer to eggs being in a mother, and number given is the total for all mothers combined. “Other eggs” refers to free eggs by major taxon (e.g., Copepods, CH). CG is other copepods, CH is other copepod eggs. BV is other cladocerans, BU is other cladoceran loose eggs.

Other after rotifers is other rotifers (CQ)

BL-BV contains density estimates for cladocerans.

BI. Bosmina species
BJ. Daphnia longirimus
BK. Daphnia galeata
BL. Daphnia rosea

BM. Chydorinae species
BN. Holopedium species
BO. Polyphemus species
BP. Bosmina Eggs
BQ. Daphnia Eggs
BR. Holopedium Eggs
BS. Chydorinae Eggs
BT. Polyphemus Eggs
BU. Other Eggs
BV. Other cladocerans

BW-CH contains density estimates for copepods

BW. Cyclops species
BX. Diaptomus species
BY. Epischura species
BZ. Ergasilus species
CA. Harpactecoida species
CB. Heterocope species
CC. Cyclops eggs
CD. Diaptomus eggs
CE. Epischura eggs
CF. Copepod nautili
CG. Other eggs
CH. Other copepods

CI-CQ contains density estimates for rotifers

CI. Kellacotia species
CJ. Asplanch species
CK. Keratella species
CL. Conochilus species
CM. Conochiloides species
CN. Filinia species
CO. Ceratium species
CP. Polyarthra species
CQ. Other rotifers

FURTHER RECOMMENDATIONS:

An attempt was made to include euphotic zone depth as an additional variable to provide insight into the potential vertical distribution of zooplankton as well as to allow assumptions about the ecological structure of each lake. With accurate euphotic zone depth and the lake depths from bathymetric maps, the percent of the lake bed that is above the euphotic zone depth can be determined. If this percentage is high, the lake's primary productivity is likely dominated by rooted plants, and benthic feeding consumers will form the next trophic level. For lakes with low percentage of the lake bed above

euphotic zone, it can be expected that phytoplankton will be the dominant primary producers and zooplankton will form the next trophic level.

Euphotic zone depth can be calculated using a linear regression of the logarithmic transformation of water color vs euphotic zone depth in Pt. It can also be calculated as a function of water turbidity using a similar regression (Koenings et al 1987). The estimated euphotic zone depths that resulted from application of these equations differed by a factor of 200%, and these estimates seemed wrong considering the known visual quality of some lakes. These estimates of EZD were omitted from this report, but can be obtained from the original database. More study of the EZD in these lakes is recommended, perhaps incorporating secchi disc or photometer measurements which can be plotted against NTU or Pt to derive a relationship more suitable to this dataset.

Several values are highlighted because they appear to be the result of an error in recording or in analysis. Further analysis is required to determine their accuracy. These values should be addressed with repeat analysis, or otherwise excluded from analysis using this database.

Additionally, the presence or absence of ninespine stickleback in these lakes could be added to the database. During sample collection, ninespine stickleback were trapped along with the threespine used for pelvic reduction analysis in Bell et al 1993. These ninespine stickleback were preserved using the same methods and are available in Bells lab.