

# Iliamna Lake Study



HDR

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November 29, 2007

# Introduction/Discussion Topics

- Overview and Objectives of the Iliamna Lake Study
- Field Methodology
- QA/QC
- Results and Discussion
  - Surface Water Quality
  - Sediments
  - Freshwater Mussels
  - Zooplankton
- Summary

# Objectives

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- Characterize baseline conditions at sites in the northeast end of Iliamna Lake for water quality, zooplankton, mussel tissue and sediments
- Collect data for consideration during future project design and permit applications





# Program Summary

Pebble Project - Site Period Of Record Index Iliamna Lake Study 2005 - 2007													
Sample Location	Year	Period Of Record Iliamna Lake Study											
	Month	J	F	M	A	M	J	J	A	S	O	N	D
Pile Bay	2005					Q	Q	Q	Q	Q	Q		
	2006												
	2007					Q	Q	Q	Q	Q	Q		
Knutson Bay	2005					Q	Q	Q	Q	Q	Q		
	2006												
	2007					Q	Q	Q	Q	Q	Q		
Northeast Bay	2005					Q	Q	Q	Q	Q	Q		
	2006												
	2007					Q	Q	Q	Q	Q	Q		
Roadhouse Bay	2005					Q	Q	Q	Q	Q	Q		
	2006												
	2007					Q	Q	Q	Q	Q	Q		
Upper Talarik (Outlet)	2005					Q	Q	Q	Q	Q	Q		
	2006												
	2007					Q	Q	Q		Q	Q		
Key:		Q= Surface-water quality, zooplankton samples - work completed.											


# Program Summary (cont.)

Pebble Project - Site Period Of Record Index Iliamna Lake Study 2005 - 2006														
Sample Location	Year	Period Of Record Iliamna Lake Study												
		Month	J	F	M	A	M	J	J	A	S	O	N	D
Flat Island	2005							A			A			
	2006							A			A			
Finn Bay	2005							A			A			
	2006							A			A			
Whistlewing Bay	2005							A			A			
	2006							A			A			
Bucket Lake	2005							A			A			
	2006							A			A			
Key:		A= Surface-water quality, freshwater mussel, sediment samples - work completed.												

# Surface Water Field Methodology

- Field Parameter Measurements
  - YSI 556 combination meter – Temp., DO, pH, Cond., ORP
  - Hach 2100P Turbidimeter
  - Secchi Disk – water transparency measurement



- Surface-Water Samples
  - 8-L Niskin sampler
  - 3 depths 
  - Bottles placed on ice in coolers in the field
  - Dissolved Metals filtered by field team with 0.45 micron filter
  - Samples transferred to Shaw Alaska for shipping to laboratories

# Water Quality Analytes

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- Laboratory parameters
  - 23 total and dissolved trace metals
  - 9 major cations and anions
  - pH, TDS, TSS, alkalinity, hardness
  - Cyanides (total, weak acid dissociable (WAD), thiocyanate)
  - Organics (two events per year)
    - Semi-volatile Organic Compounds (SVOC)
    - VOC
    - Pesticides/PCBs
    - GRO, DRO, RRO



# Sediment Collection Methodology

- Sediment Samples
  - Ekman dredge
  - Samples shipped to laboratories
    - Polynuclear aromatic hydrocarbons (PAHs)
    - Total Metals
    - Mercury
    - Cyanide
    - Chloride
    - Fluoride
    - Sulfate
    - Ammonia as N

# Mussel Tissue Collection Methodology

- Mussels are as sensitive to metals as zooplankton and can be more sensitive than fish and aquatic insects (Keller and Zam, 1991)
- Freshwater Mussel Tissue Samples
  - *Anodonta beringiana*
  - Mussels collected using clam basket
  - Samples shipped to laboratory
    - Polynuclear aromatic hydrocarbons (PAHs)
    - Pesticides/PCBs
    - Total Metals



# Zooplankton Collection Methodology

- Zooplankton Samples
  - Plankton tow net (80 micrometer)
  - Vertical tows collected at each site (substrate to surface or 20 meters depth)
  - Samples brought to Anchorage, processed by HDR scientists
    - Specimens identified to Class (Order when possible)



# Quality Assurance and Control

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- Pebble Project QAPP
- Field Sampling Plan
  - Clean Hands/Dirty Hands; other clean procedures
  - Sampling equipment cleaned with Alconox and DI water between sites
  - 10% duplicate and triplicate frequency
  - 5% equipment rinse blanks
  - One DI blank per trip
  - One Hg trip blanks per event
- Field Audits (one per year conducted by Shaw Alaska)

# Iliamna Lake Study Results

## Surface Waters

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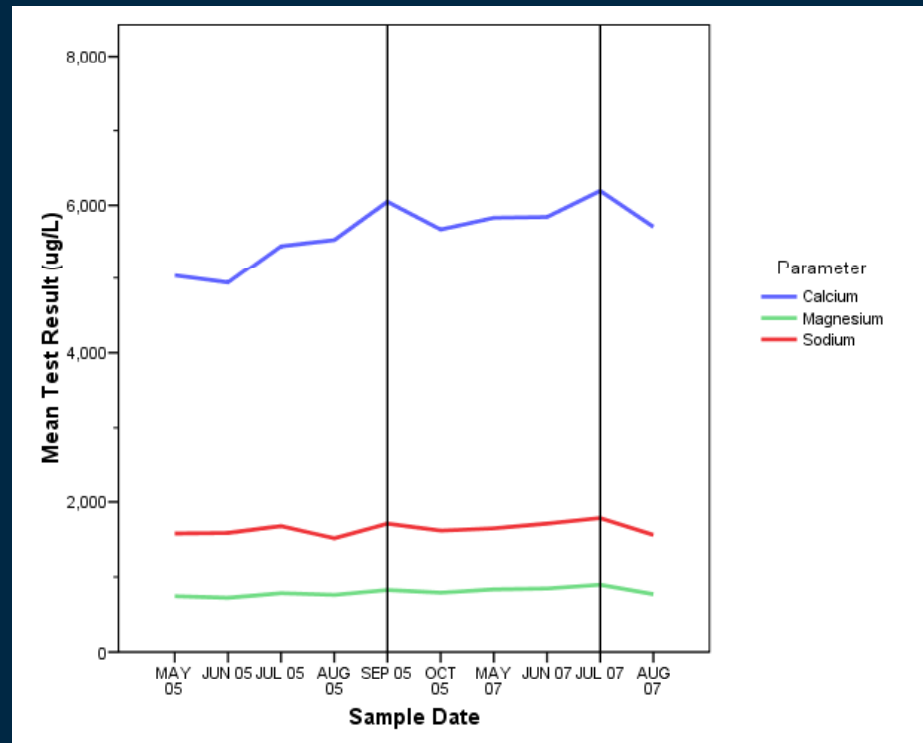
- Nitrogen and phosphorous levels were low and were typical of oligotrophic lakes in the region
  - Nitrogen Low
    - ✓ Nitrate+nitrite-N – 98.6% <0.2 mg/L (2 outliers)
  - Phosphorous low (<0.170 mg/L except UT1B in Jul 2005)
- TDS were low (10-71.3 mg/L)
- Low-level mercury and cyanide were undetected or below the MRLs



# Iliamna Lake Study Results

## Surface Waters

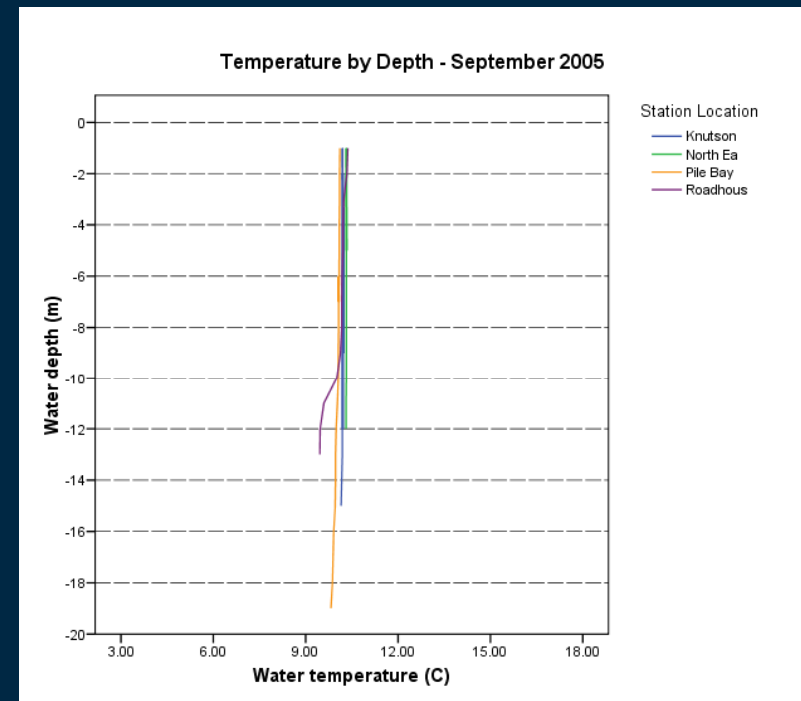
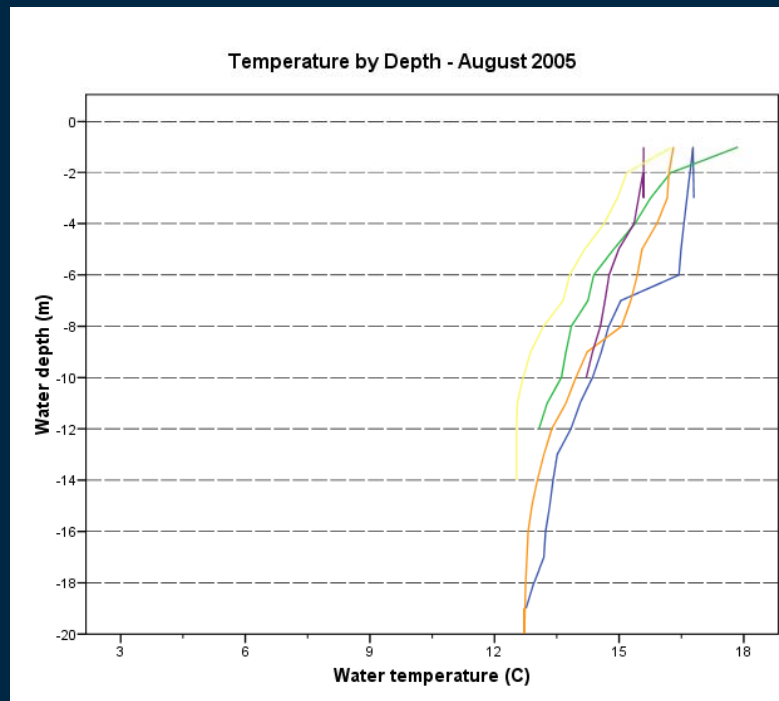
- Ca>Mg>Na in most natural waters (Hem, 1985)
- Ca>Na>Mg in Iliamna Lake
- Results = Donaldson, 1967; Na nearly doubled



# Iliamna Lake Study Results

## Depth Stratification

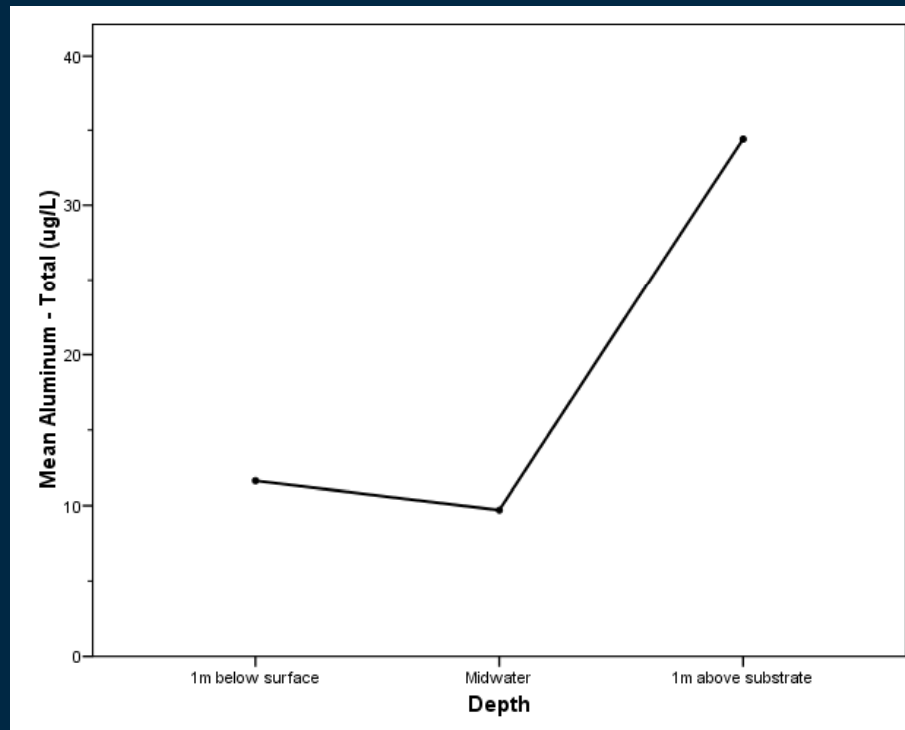
- In 2005 temperature profiles suggest a period of turnover in September/October; no evidence in 2007
- No trend in DO, conductivity by depth in 2005 or 2007
- Potential pH decrease by depth in 2007



# Iliamna Lake Study Results

## Depth Stratification

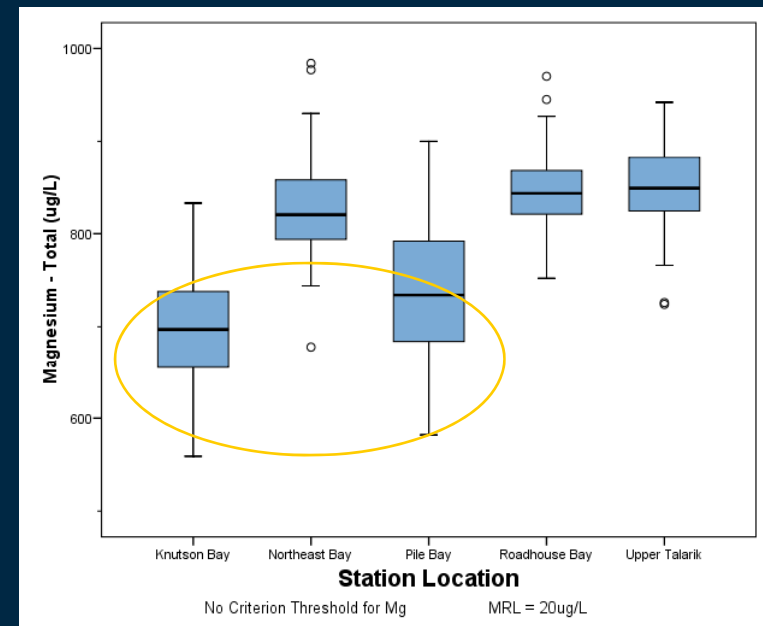
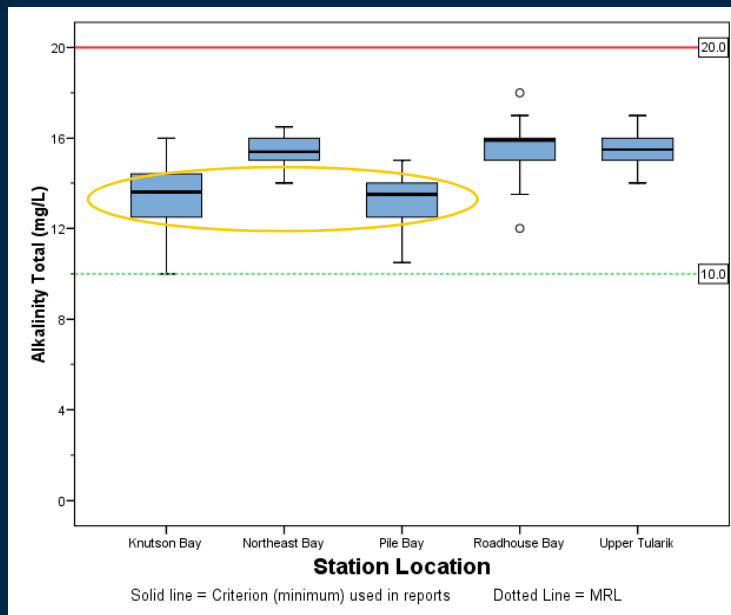
- No difference in major ion and trace elements by depth ( $p > 0.05$ ) except Total Aluminum [ $F_{2,148} = 3.661$ ,  $p = .028$ ]



# Summary of WQ Results

## Major Ions & Alkalinity

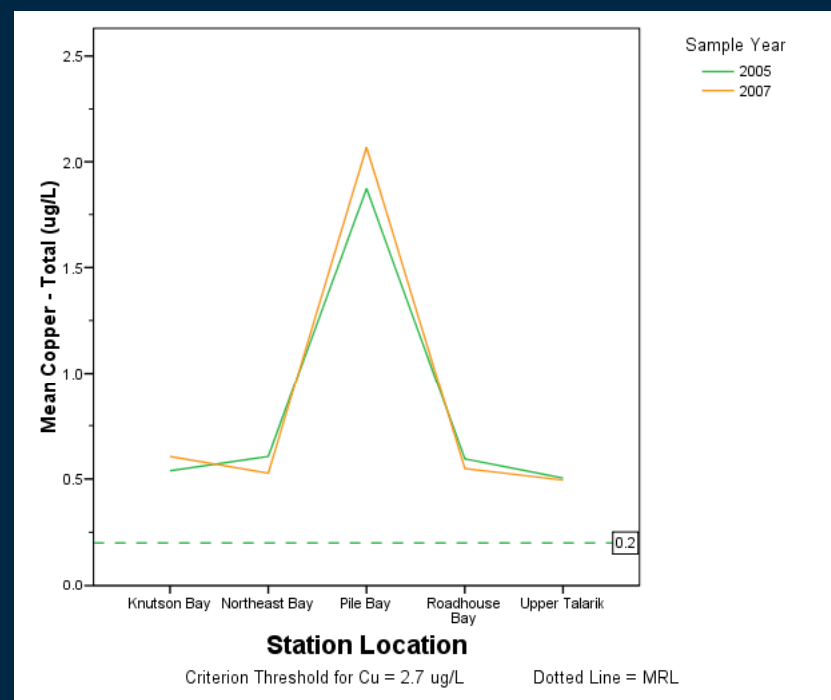
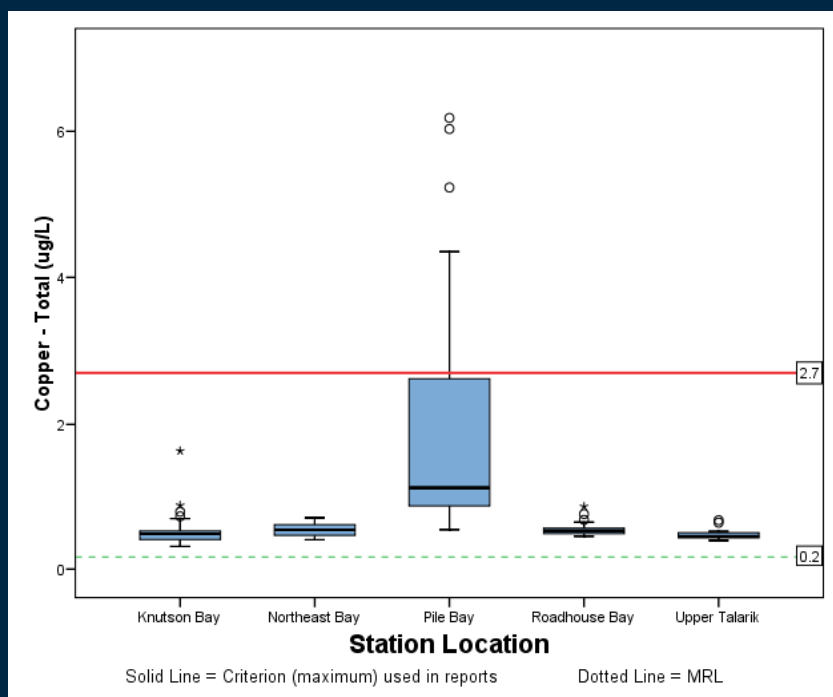
- Knutson Bay and Pile Bay had lower Total Alkalinity
- Knutson Bay and Pile Bay analyses show generally lower K, Mg, and Na than other three sites



# Summary of WQ Results

## Copper – Dissolved & Total

- Copper (Dissolved & Total) higher and more variable in Pile Bay
- No real difference between 2005 and 2007 results for all sites





# Iliamna Lake Study Results

## Sediment

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- Highest concentrations of Total Cu at Northeast Bay
- Highest concentrations of Zn, Pb, Al and Ni were present at Bucket Lake
- Mercury concentrations ranged from 0 to 63.7  $\mu\text{g}/\text{kg}$
- Strong correlation between sediment and mussel mercury concentrations ( $R=0.91$ )
  - Where mercury was present in sediments, higher concentrations in mussel tissues
- Cyanide concentrations were typically below the MRL
  - Results ranged from 0 to 0.43  $\text{mg}/\text{kg}$  (Median=0.046  $\text{mg}/\text{kg}$ )

# Iliamna Lake Study Results

## Mussel Tissue

Sample Location	Date	Parameter (mg/kg)		
		Cu	Pb	Zn
Bucket Lake	Jun-05	6.37	0.85	165
	Sep-05	8.97	0.73	158
	Sep-06	8.13	0.88	216
Flat Island	Jun-05	9.12	0.11	130
	Sep-05	7.15	0.05	106
	Sep-06	10.60	0.11	145
Finn Bay	Jun-05	8.33	0.26	145
	Sep-05	15.50	0.13	115
	Sep-06	7.54	0.07	190
Whistlewing Bay	Jun-05	7.29	0.14	165
	Sep-05	--	--	--
	Sep-06	9.28	0.1	170

- Mercury concentrations ranged from 53.3 to 282  $\mu\text{g}/\text{kg}$ 
  - Highest concentrations at Bucket Lake

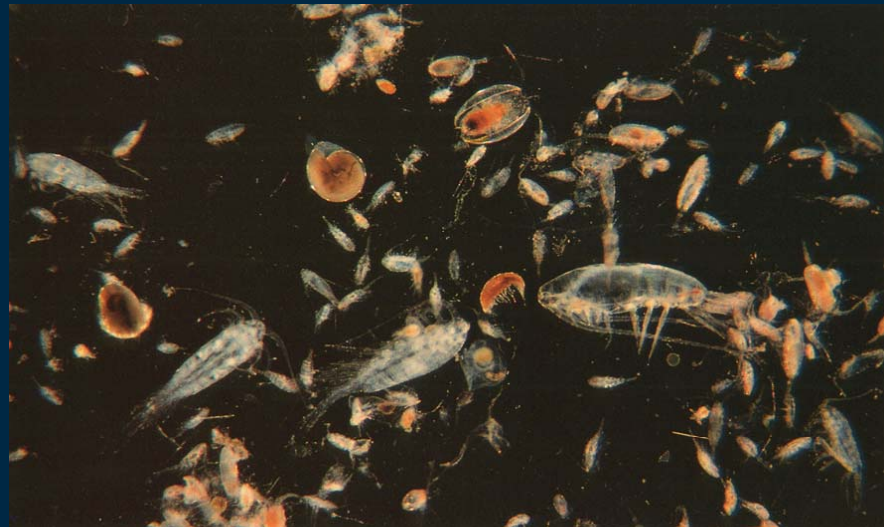


# Iliamna Lake Study Results

## Zooplankton Overview

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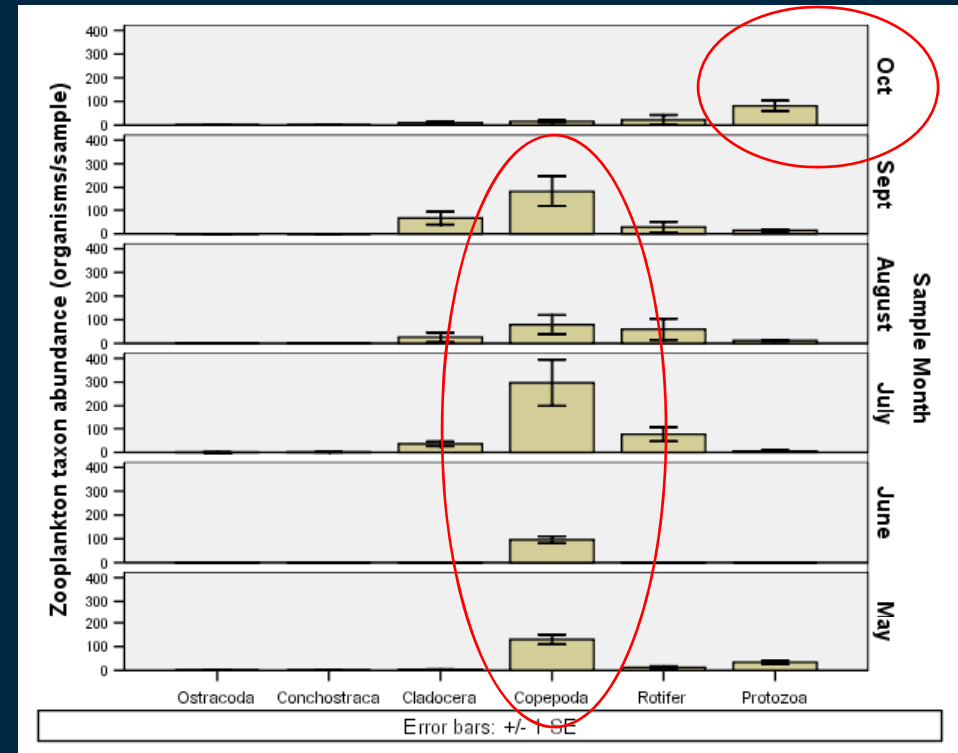
- Zooplankton in freshwaters typically consist of protozoans, rotifers, cladocerans and copepods (Wetzel 2001)
- Iliamna Lake = taxa above plus *Ostracoda* and *Conchostraca*



# Iliamna Lake Study Results

## Zooplankton

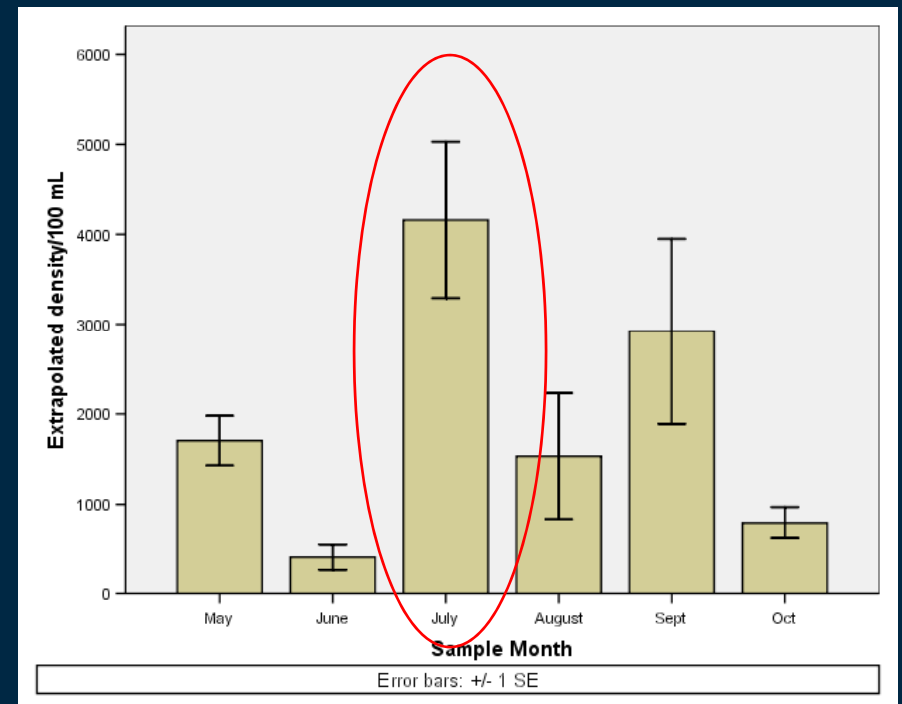
- Shift from *Copepoda* dominance to *Protozoa* dominance at most sites in October
  - “Top-down” effect from juvenile sockeye salmon?
    - Copepod populations decrease through the summer in salmon bearing lakes (Hoag 1972)



# Iliamna Lake Study Results

## Zooplankton

- Densities averaged 188,500 organisms/L
  - Significantly greater density in July than all months except September ( $p=0.001$ )
- Sites did not significantly differ ( $p>0.05$ )
  - Lowest median density occurred at Upper Talarik (91,300 organisms/L)
  - Highest median density occurred at Pile Bay (211,500 organisms/L)





# Results Summary

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- Ca>Na>Mg in Iliamna Lake
- Unlike 2005, no clear turnover event(s) evident in 2007
- pH shows significant variation between depths in 2007 only
- No difference in major ion and trace elements by depth except Aluminum
- Knutson Bay and Pile Bay different than other sample locations for multiple water quality parameters
- Analysis of sediment and mussel data suggests correlation of Mercury concentrations
- In 2005, zooplankton is mostly dominated by copepods in all months except October

# Thank you



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