Phyto-benthic response to the 2000 and 2003 ecological restoration flows in the Colorado River below Glen Canyon Dam

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Aquatic Food Base Project
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Objectives

1) Abiotic influences on the aquatic community structure

2) Summary of 2000 Ecological Restoration Flows

3) Comparison of 2000 and 2003 Eco-Flows
   - Experimental Design - Hydrographs
   - Water Quality
   - Cladophora Biomass
   - New Zealand Mudsnail Biomass

4) Conclusions

5) AMP Recommendations

1) Abiotic influences on the aquatic community structure

A)Tributary input of sediment

LCR Grand Wash Cliffs 2002

Crystal Rapid

Lava Falls

1) Abiotic influences on the aquatic community structure

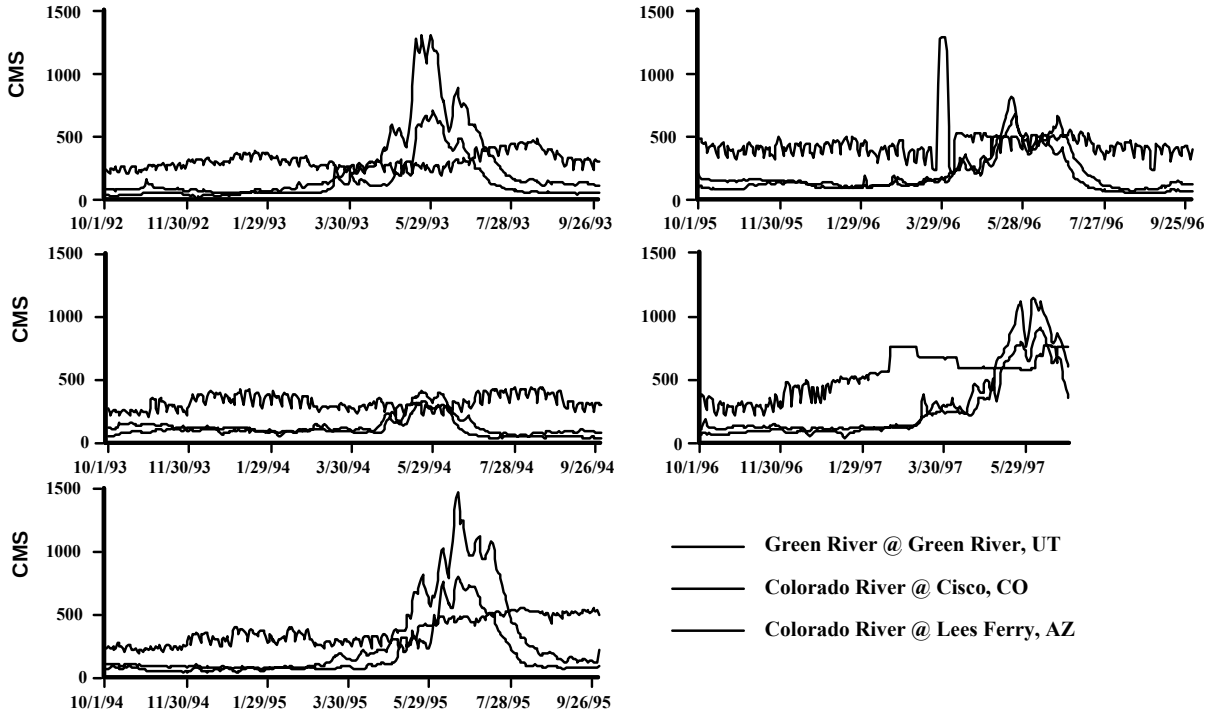
A) Tributary input of sediment

B) Glen Canyon Dam Operations

Glen Canyon Dam
Hydraulic Variability

Annual volume		8.32	maf
Annual discharge		142-708	m^3/s
Monthly/Daily		170	m^3/s
		227	m^3/s
Hourly	up-ramp	400	m^3/s
	down-ramp	200	m^3/s
Weekend-Holiday		reduced flows	

Hydrograph


CMS
1500
1000
500
0
10/1/92
11/30/92
1/29/93
3/30/93
5/29/93
7/28/93
9/26/93
10/1/95
11/30/95
1/29/96
3/29/96
5/28/96
7/27/96
9/25/96
10/1/93
11/30/93
1/29/94
3/30/94
5/29/94
7/28/94
9/26/94
10/1/96
11/30/96
1/29/97
3/30/97
5/29/97
10/1/94
11/30/94
1/29/95
3/30/95
5/29/95
7/28/95
9/26/95
Green River @ Green River, UT
Colorado River @ Cisco, CO
Colorado River @ Lees Ferry, AZ

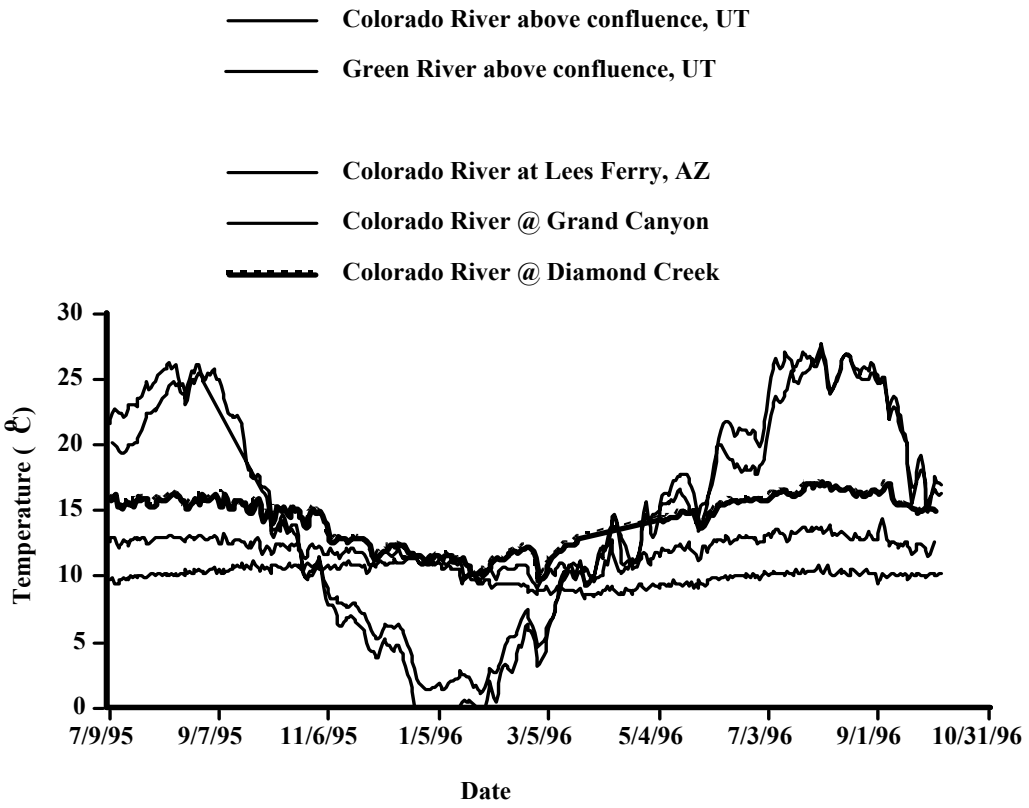
1) Abiotic influences on the aquatic community structure

A) Tributary input of sediment

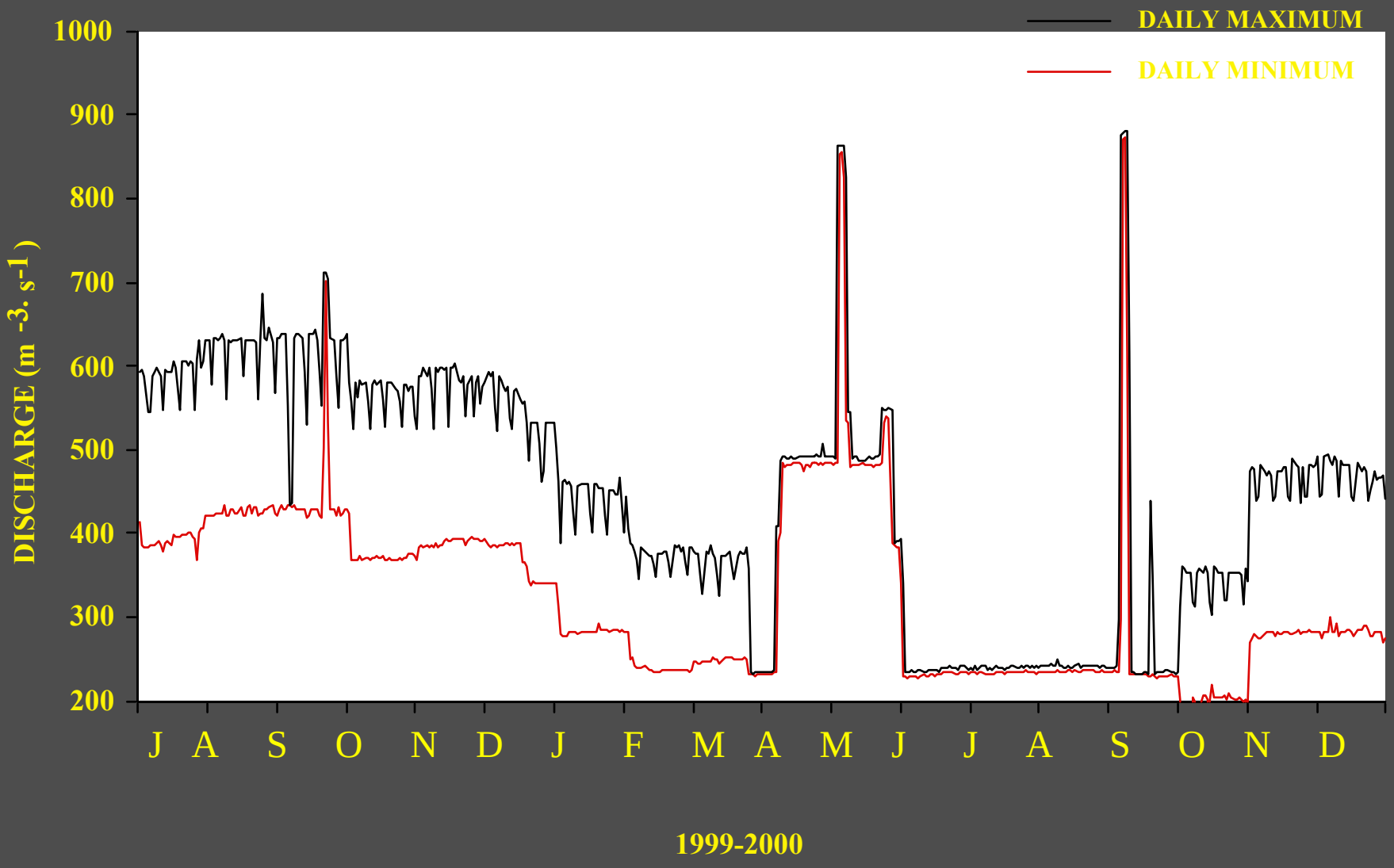
B) Glen Canyon Dam Operations

C) River Temperature

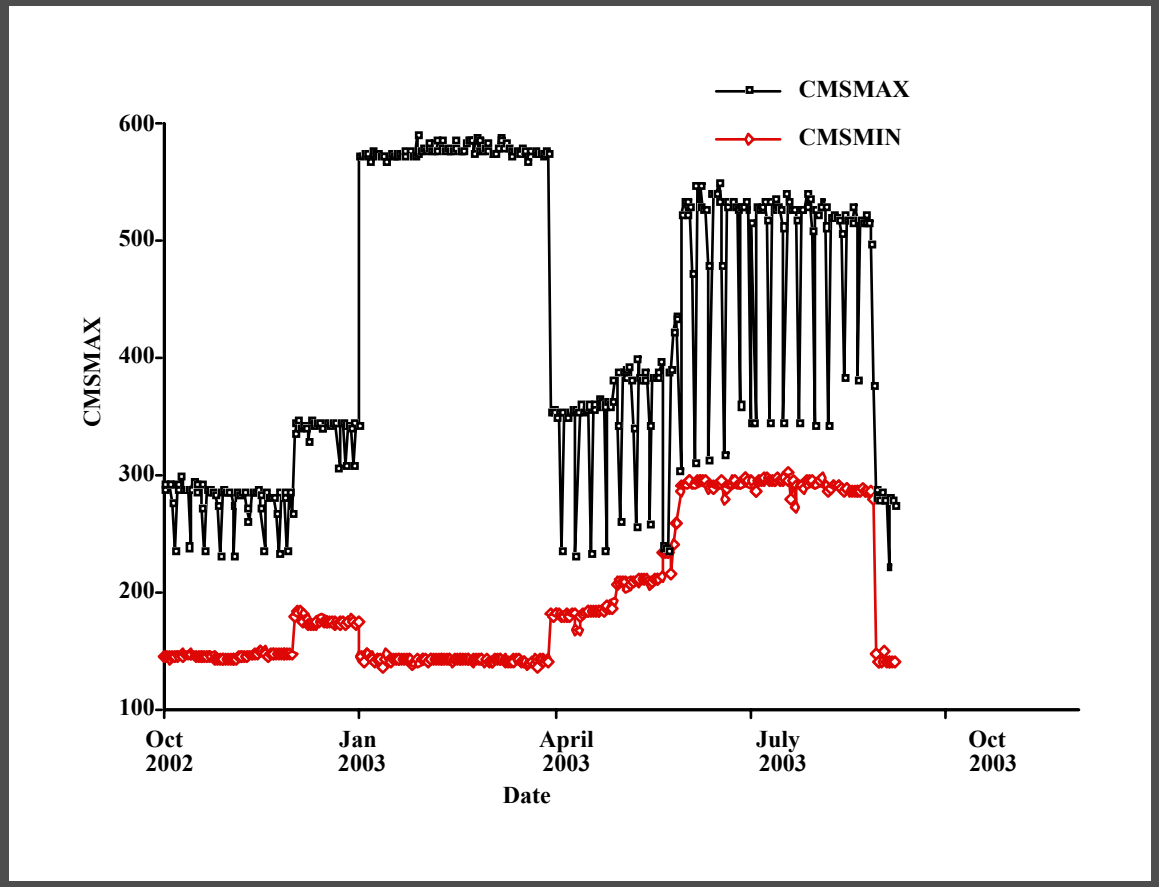
Thermal Regime



2000 ECO-FLOW



2003 Eco-Flows



2) Summary of 2000 Ecological Restoration Flows

A) River Temperature

Channel 9.4 ˚C at Lees Ferry in September during the spike flow
Channel19.1 ˚C at Diamond Creek in June during steady flows.
Shoreline warming ~ 1 ˚C in the first 110 rkm and ~ 2 ˚C 200 rkm
Terrestrial temperatures - 8.4 to 60.5 ˚C.

B) Primary Producers - Study site average estimates

June Cladophora biomass	4.0 g AFDM/m2 (± 2.1 se)
September Cladophora biomass	8.2 g AFDM/m2 (± 7.5)
June MAMB biomass	47.0 g AFDM/m2 (± 30.9)
October MAMB biomass	11.5 g AFDM/m2 (±5.1)

C) Organic Drift-

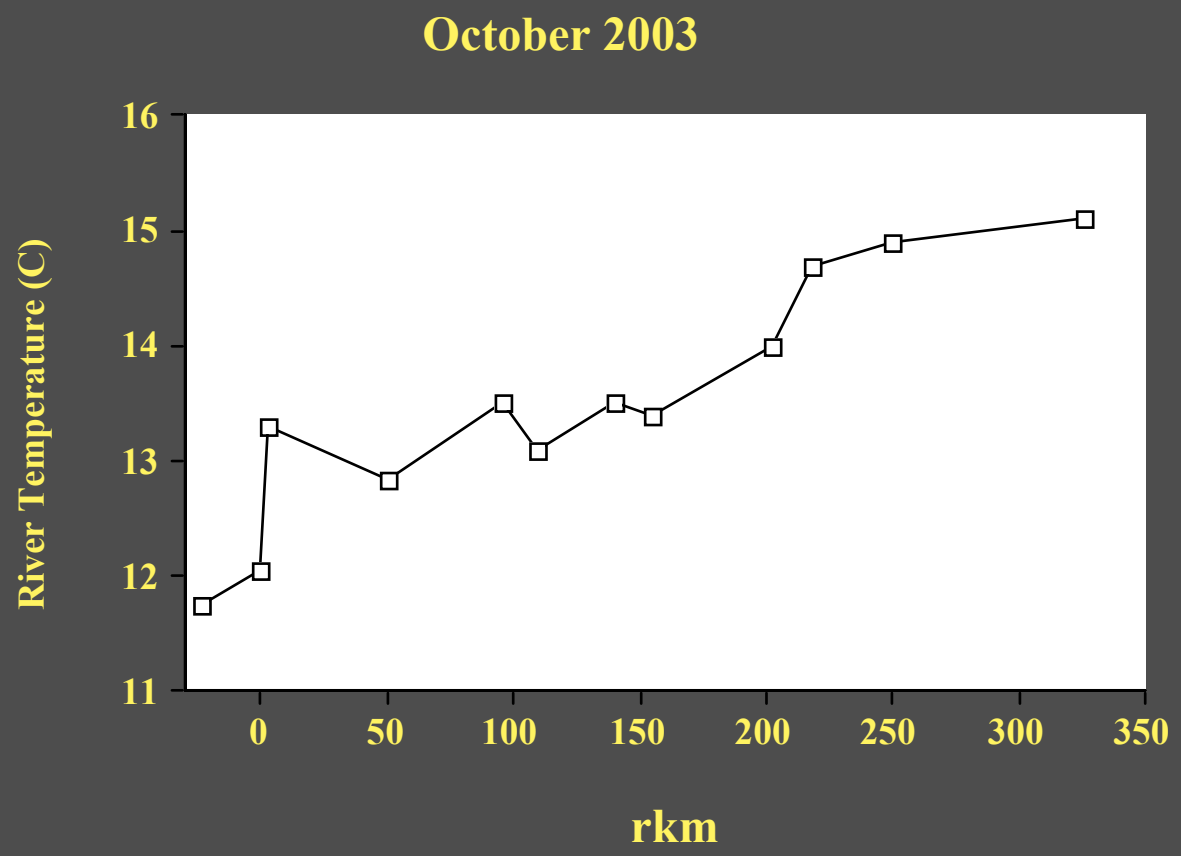
2000 vs 1997 CPOM estimates Insig. (Wilks' Lamda 0.9; p=0.14).
14.0 (±0.91) mg/m3/s AFDM at Lees Ferry
447.0 (± 156) mg/m3/s AFDM at Middle Granite Gorge

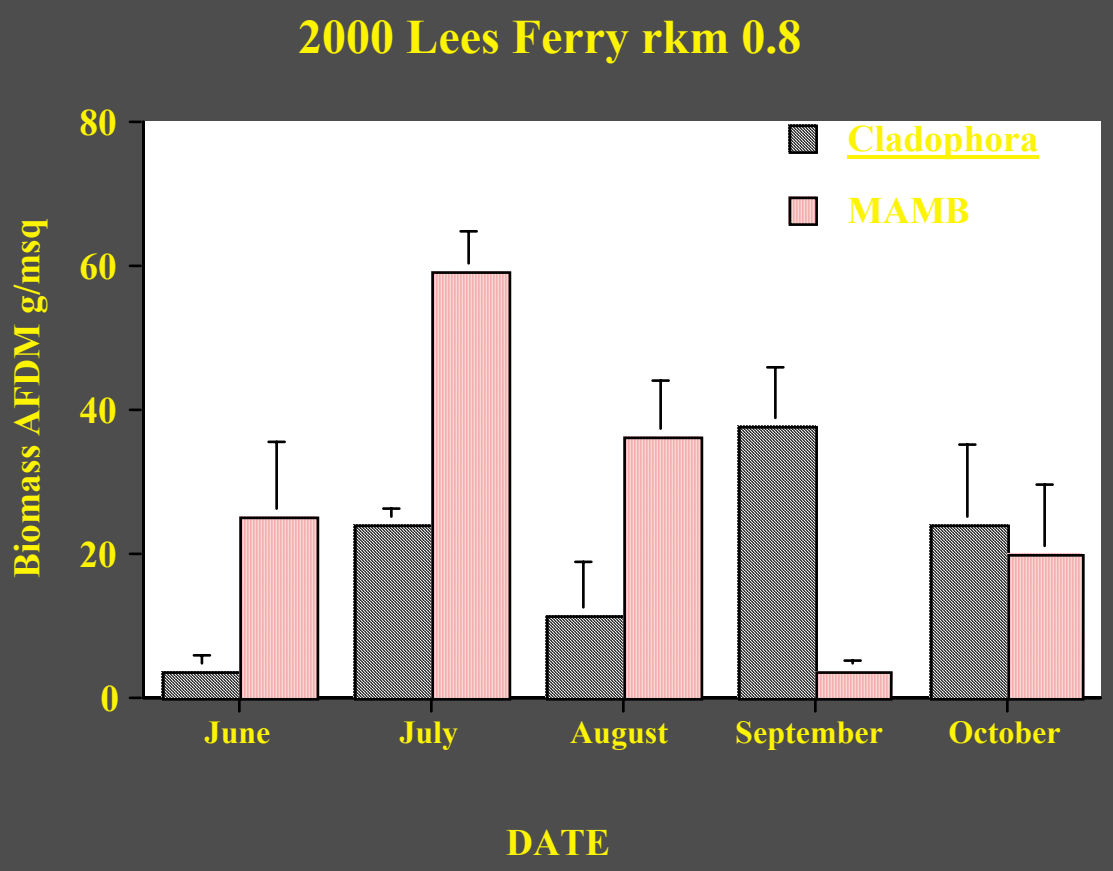
D) Minnow Trap Experiment

2000 - 12 vegetation, 4 cobbles, 0 sand and 10 artifical vegetation
1997 - 26 vegetation, 12 cobbles, 0 sand and no artifical vegetation

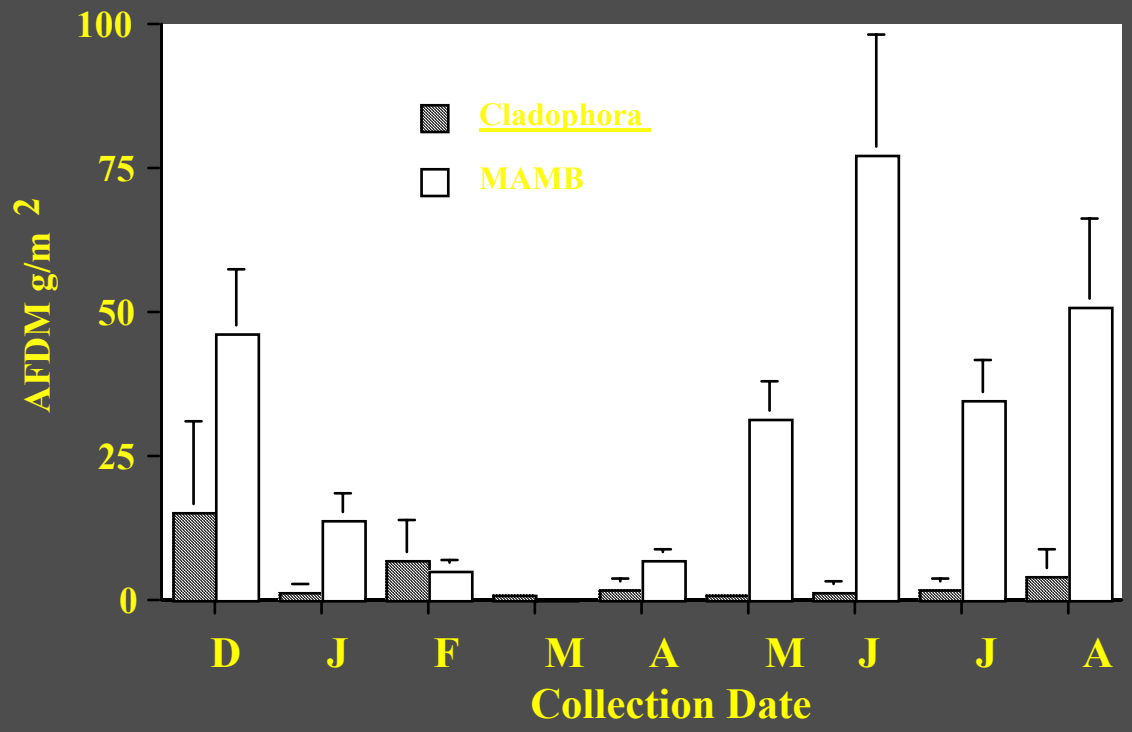
Water Quality - Comparison

	2000 (sd)	2003 (sd)
pH	7.5 - 7.9 (0.2)	7.2 - 8.2 (0.5)
DO (mg/l)	9.3 - 12.3 (2.5)	7.1 - 10.12 (0.5)
Conductivity (mS)	0.73-0.83 (0.001)	0.78 - 0.83 (0.1)
Temperature (^{0}C)	10.1-11.2 (0.4)	8.3 - 11.01 (0.4)
TDS (PPT)	0.40 - 042	0.51 - 0.61

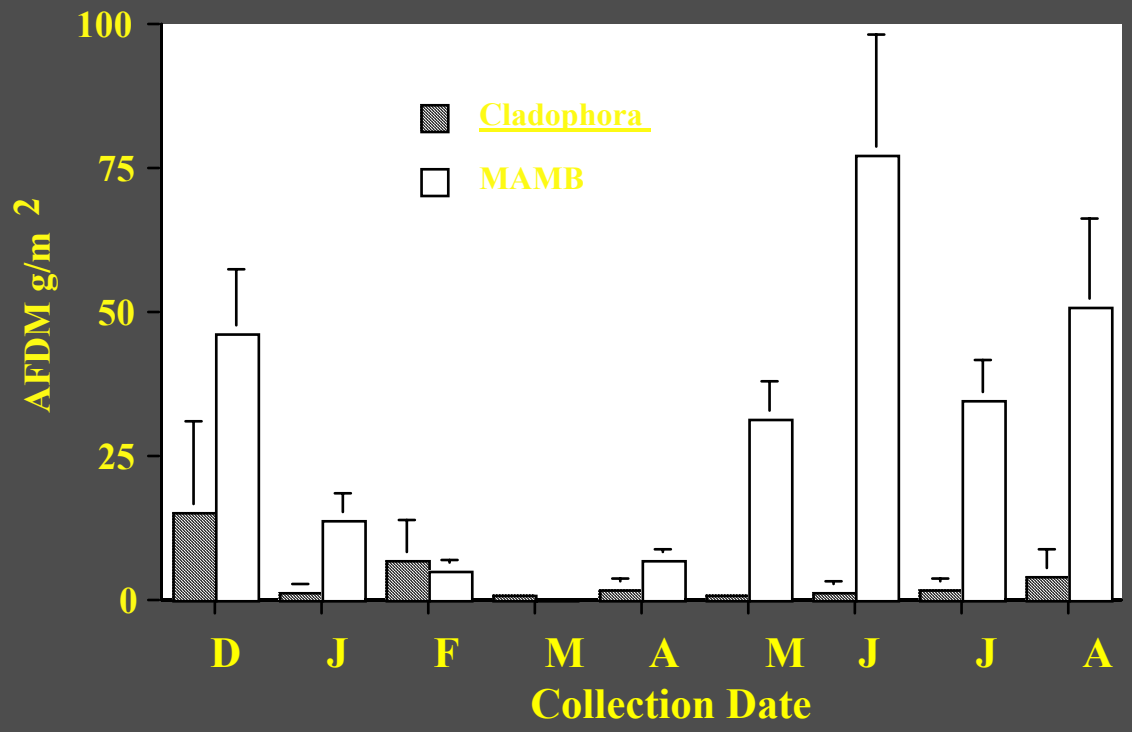

October 2003
River Temperature (C)
16
15
14
13
12
11
0
50
100
150
200
250
300
350
rkm

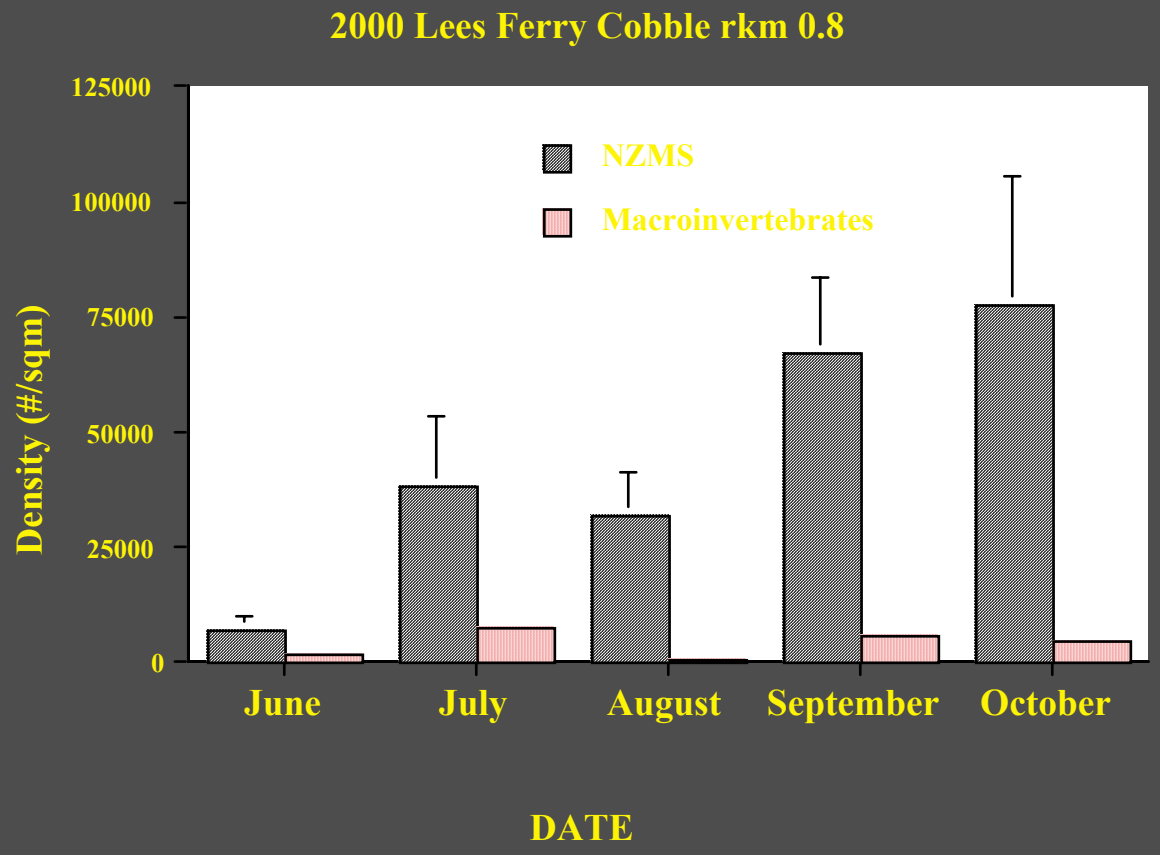

2000 Lees Ferry rkm 0.8
Biomass AFDM g/msq
80
60
40
20
0
Cladophora
MAMB
June
July
August
September
October
DATE

2003 Lees Ferry Cobble

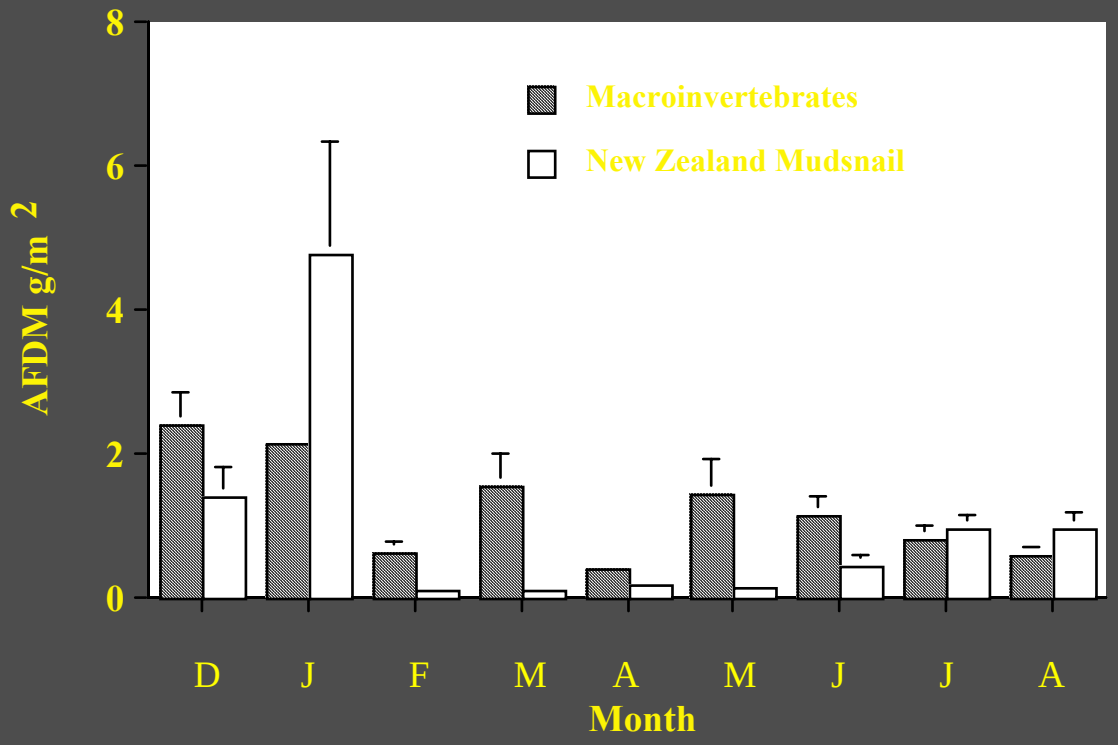


2003 Lees Ferry Cobble

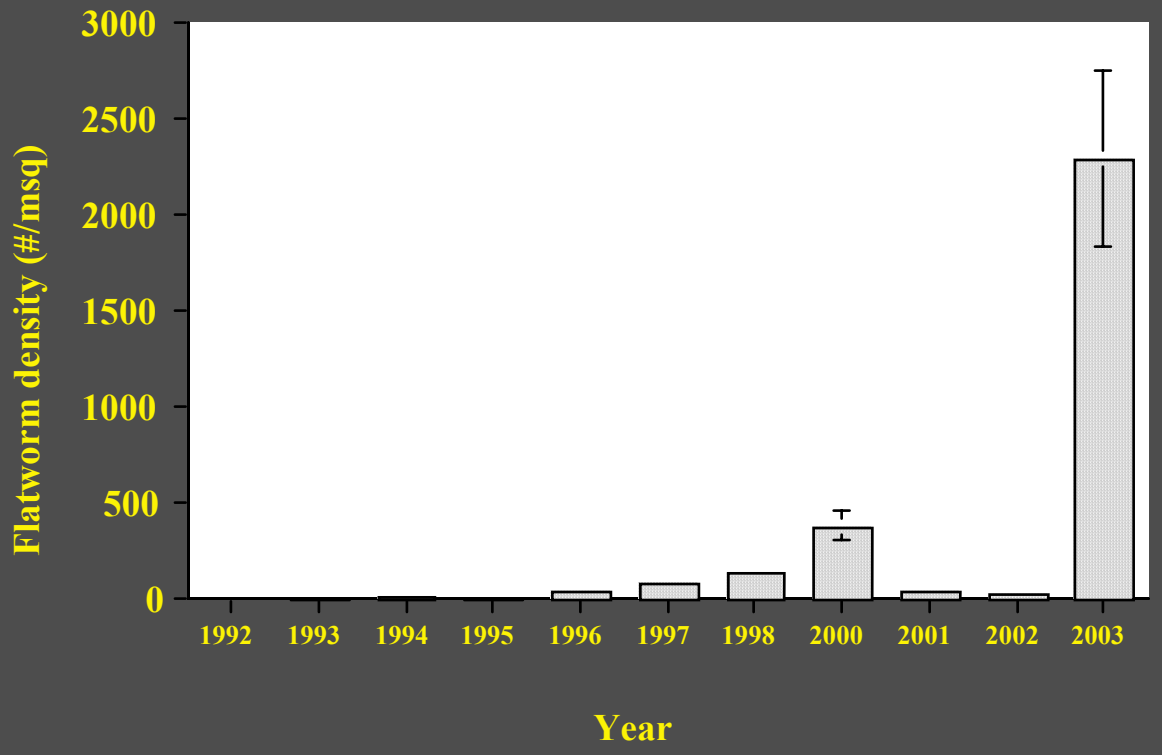


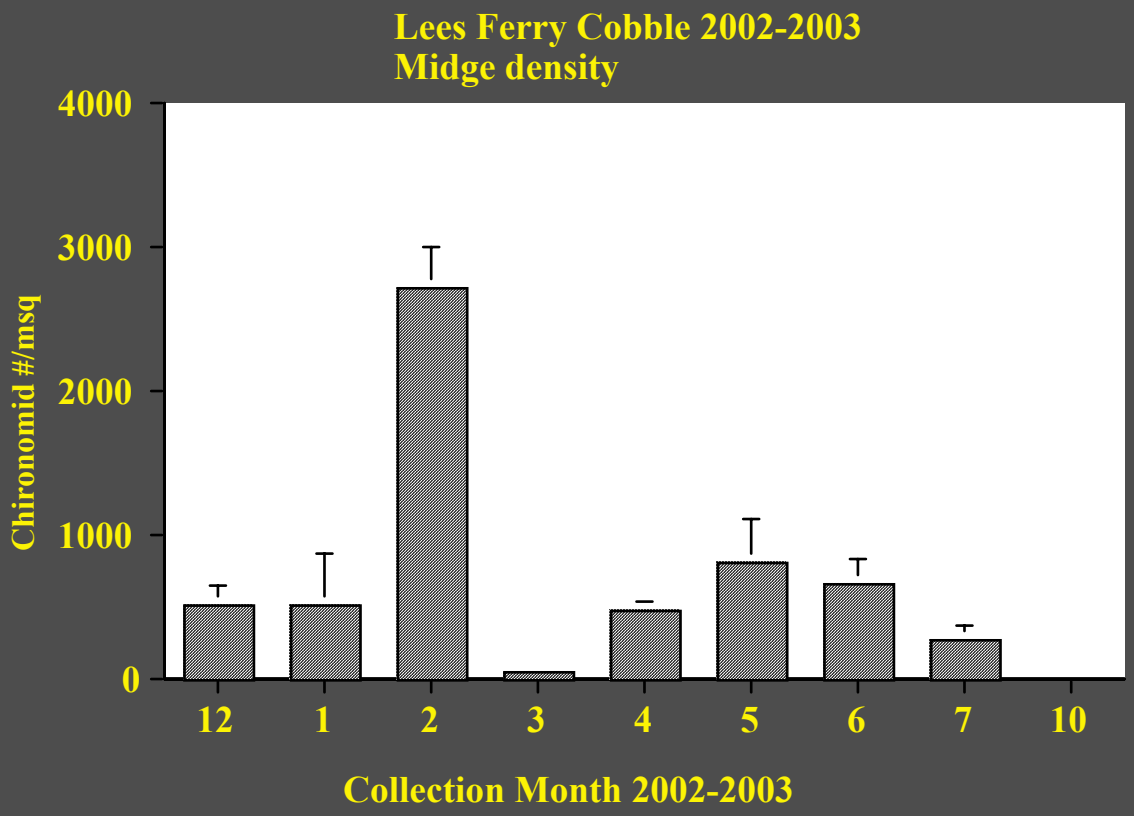

2000 Lees Ferry Cobble rkm 0.8
125000
100000
75000
50000
25000
0
Density (#/sqm)
NZMS
Macroinvertebrates
June
July
August
September
October
DATE

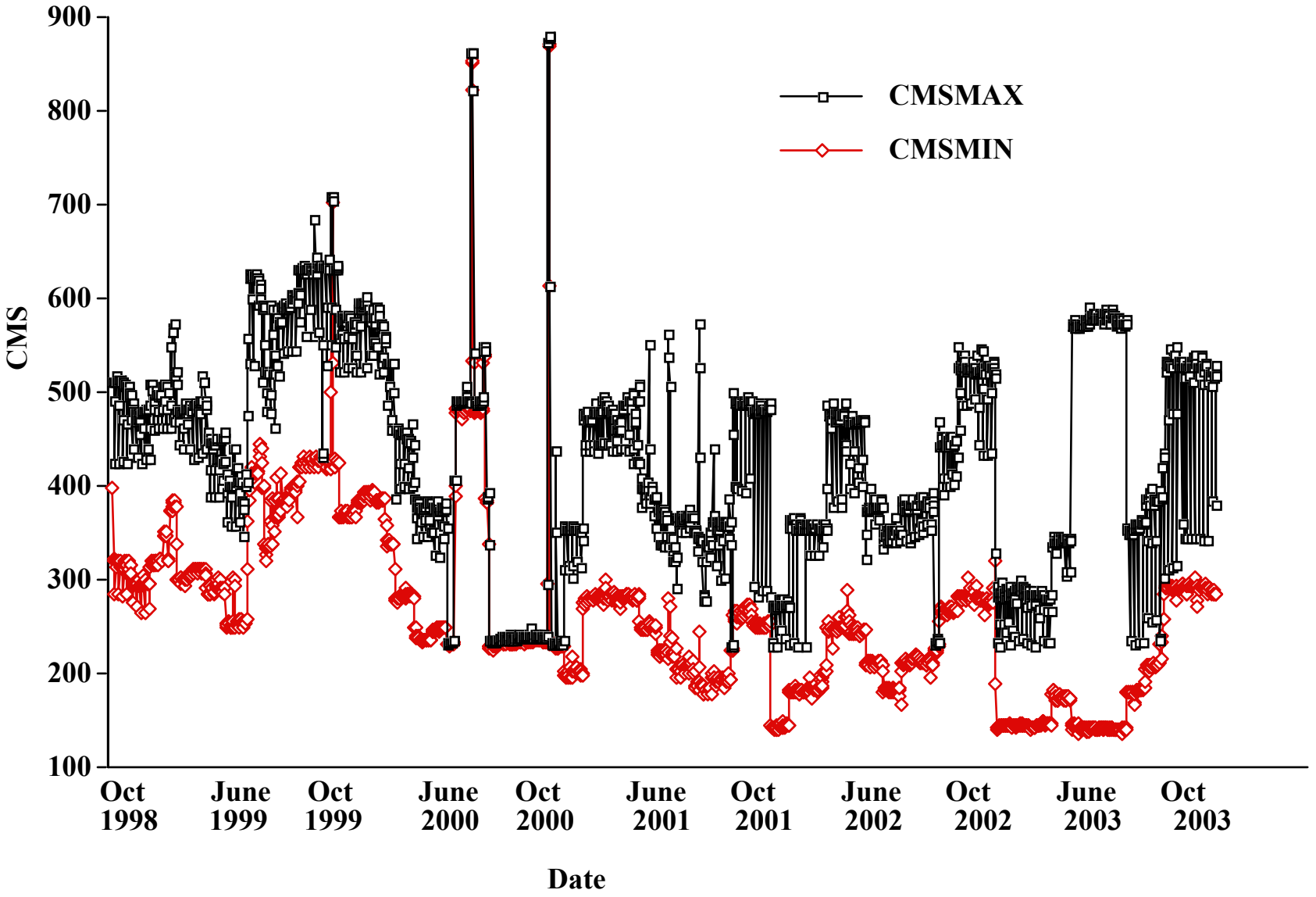
2003 Lees Ferry Cobble

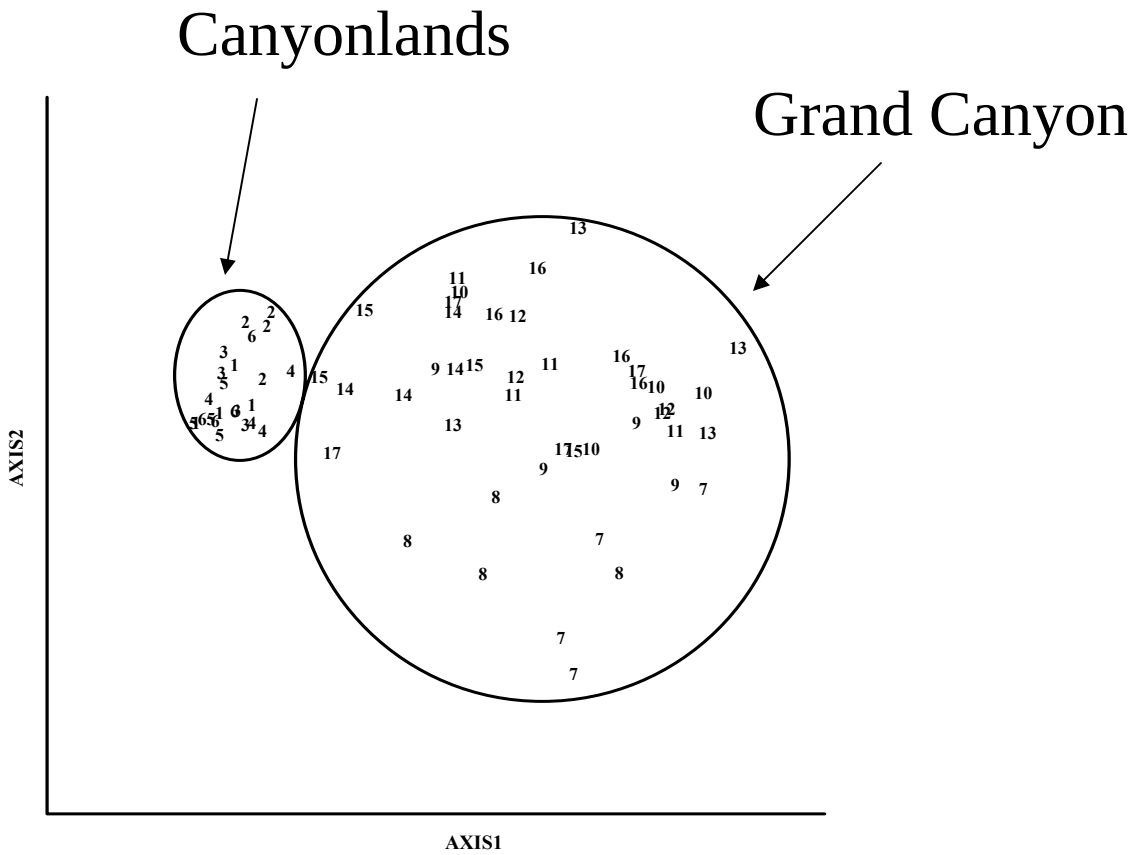


Lees Ferry Cobble rkm 0.8
Dugesia spp.




Lees Ferry Cobble 2002-2003
Midge density
Chironomid #/msq
4000
3000
2000
1000
0
12
1
2
3
4
5
6
7
10
Collection Month 2002-2003


CMSMAX
CMSMIN
CMS
900
800
700
600
500
400
300
200
100
Oct 1998
June 1999
Oct 1999
June 2000
Oct 2000
June 2001
Oct 2001
June 2002
Oct 2002
June 2003
Oct 2003
Date



2D NMDS Ordination (Haden 1997)

Conclusions

1) 2000 and 2003 Eco-Flows had varying water quality -Temperature

2) Cladophora has been replaced by MAMB

3) NZMS populations remain high
   - Boundary layer concept
   - Schreiber, Quinn and Lake (2003) disturbance study

4) Experimental flow design needs to allow for biological response time
   - 3 + year designs
   - Match a pre-dam hydrograph
   - Moving Sand ≠ Ecosystem Management

5) Eco-flows will be of limited success because of EIS constraints
   - Increased variability
   - Glen Canyon Dam is a large scale impact
   - Eco-Flows are a very small scale impact
   - 1,000 to +100,000 cfs (Rinne and Minckley, 1983)

Glen Canyon Dam AMP Suggestions

1) Monitoring programs need to be established and removed from administrative personnel turn-over and political agendas.

2) Competitive Science = Quality Science
All monitoring and research

3) Establish an annual RFP time frame so that the river science community knows what to expect and when

4) Competitions should be for all aspects of the scientific process not just for labor as the USGS/GCMRC does now