COLORADO RIVER INVESTIGATIONS I

JULY - AUGUST 1982

NORTHERN ARIZONA UNIVERSITY/MUSEUM

OF NORTHERN ARIZONA

COLORADO RIVER INVESTIGATIONS I

July - August 1982

Prepared by:

Students and Staff of Biology 571-Geology 538

Instructors:

Dr. Stanley S. Beus, Northern Arizona University

Dr. Steven W. Carothers, Museum of Northern Arizona

Submitted to:

Mr. Richard W. Marks

Superintendent

Grand Canyon National Park

Grand Canyon, Arizona

December 1982

Black rock
marked against the clouds of stars
Contemplating vastness as they
in their stillness, watch
with inscrutable patience
as eons tick by, they watch
Their time is grand and still.

Melody Glass
Grand Canyon
August 1982

Rio Cañon

Swift sound, silent murmur, vast cliffs guarding
Life in the change, self forgotten, and the stars...
It flows! It flows!
Hot sun of the days, deep well in the night
Moon at the edge, feelings remembered, and the others...
It rises! It rises!
Green shores, soft slopes along the walls, steep sides
Heart of a former age, scenes that lift my heart...
It lasts! It lasts!
And my soul is laved with new enduring peace.

Anthony J. Rose
Colorado River, Grand Canyon
August 1982

COLORADO RIVER INVESTIGATIONS I

JULY-AUGUST 1982

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NAU Geology (Beus)	1
NAU Library	1
Participants	22
TOTAL	33

December 20, 1982

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CHAPTER I. INTRODUCTION

S.S. Beus and S.W. Carothers

This report represents the product of a 5-week, 6-semester-hour course (Biology 571-Geology 538) offered through Northern Arizona University (12 July - 13 August 1982) and sponsored through a tri-partite agreement between the National Park Service at Grand Canyon, the Museum of Northern Arizona and Northern Arizona University.

The class design included approximately 3 weeks of lecture and field trips prior to a fourteen day research expedition down the Colorado River through Grand Canyon.

Table I-1 presents a generalized version of the course syllabus and overall schedule.

The research projects presented in chapters II-IX reflect the diverse array of projects undertaken during the river expedition. Chapter XI consists of student comments on issues relating to current Grand Canyon management concerns. The student comments are written in an "open letter" format to Grand Canyon Superintendent Richard W. Marks.

Table I-2 is a complete listing of the river expedition participants. This report represents a cooperative venture between all participants.

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TABLE I-1. COURSE SYLLABUS, BIOLOGY 571 - GEOLOGY 538, NORTHERN ARIZONA UNIVERSITY, JULY-AUGUST 1982.

"The Biology and Geology of the Grand Canyon and the Colorado River" is a five week summer session course for upper division undergraduate and graduate students.

The principal emphasis of the material covered is on reviewing the ecological and geological history of Grand Canyon National Park with special consideration given resources management problems, needs, and the need for a working relationship between scientists and managers.

In Grand Canyon, baseline ecological and geological research efforts (1969-1982) have provided a specific body of literature and unpublished reports that can be of immediate (applied, problem-oriented studies) or less immediate (basic research) use to National Park Service managers in the decision-making process as that process relates directly to the stewardship of park lands. The relationship between, and the need for, basic and applied research efforts as they influence park management is emphasized using Grand Canyon National Park as a case history.

Specific topics considered include:

Biology - regional ecological community structure, aquatic and terrestrial systems, the influence of man on park resources, and recreation management.

Geology - Colorado Plateau structure, the formation of Grand Canyon, evolution of the Colorado River, rocks and minerals, igneous processes, geologic time, and canyon stratigraphy.

Table I-1 (Continued)

SCHEDULE

Date	Lecture-discussion Topic	Laboratory
July 12	Registration/orientation Presentation by resources management personnel, Grand Canyon	Student research topic selection α initial library review
July 13	Introduction to Grand Canyon geology; ecological systems/ resource management considerations	Rock forming minerals
July 14	Ecological research in G.C. (1869-1982); igneous rocks	Feral burros in G.C.: exotic vs. native plants and animals - the management dilemna
July 15	Volcanoes, lava flows; Boulder Dam/Lake Mead - ecological changes and influences on G.C.N.P.	Recreation management, data needs, and research designs in natural areas; the eventual conflict
July 16	Sedimentary rocks; Glen Canyon Dam/Lake Powell ecological changes and influences on G.C.N.P.	Igneous and sedimentary rocks
July 17	Field Trip (all day) Wupatki and Sunset Crater National Monuments Geological processes, ecological community structure; concepts of visitor use/abuse and NPS management considerations	

Table I-1 (Continued)

July 19	Geologic structures; Colorado River dynamics and Glen Canyon Dam - hydrologic considerations	The process of erosion and deposition; student research reports
July 20	Geologic time; aquatic ecology of Colorado River (vegetation, benthos, fishery)	Geologic maps of G.C.; student research reports
July 21	Field trip to Grand Canyon, South Rim (all day); Resources, management personnel interviews, library research - student reports, collections and park structure	
July 22	Grand Canyon stratigraphy and fossils; terrestrial ecology of Colorado River (vegetation, birds, mammals, reptiles, amphibians)	Fossils and paleontologists in Grand Canyon
July 23	History of the Canyon formation; river recreation management/ political and economic considerations, carrying capacity concept	Geologic investigations in Grand Canyon, current research needs

Table I-1 (Continued)

July 24 25 26	Field trip to southern Utah - Bryce, Zion, Cedar Breaks	Two-night campout, emphasis on Colorado Plateau geologic and ecologic diversity, on-site interviews with resources management personnel, problems in management of park systems
July 27 28	Student research reports preparation	
July 29- August 11	Colorado River research expedition	
12-13 August	Course summary, research report final compilation, evaluation	

TABLE I-2. LIST OF TRIP PARTICIPANTS

STUDENTS

Benson, Anne 1115 Rockridge Flagstaff, AZ 86001	M.S. in Biology--Nursing 526-76-1095
Biddle, Jack W. 1105 E. Ponderosa Parkway Flagstaff, AZ 86001	Science Teacher 269-40-3462
Byars, Betty 30-150 SAC, N.A.U.	Zoology Undergraduate 460-88-2788
Glass, Melody 301 Richards St. Iowa City, IA 52240	Geology-Astronomy Senior 547-94-1643
Iaquinta, Phyllis 175-A Bedford Road Pleasantville, NY 10570	Elementary Teacher 151-30-8636
Lojko, Frank B. 1334 E. Harrison Springfield, MO 65804	Science Teacher
Lynam, Mayo 3804 Leland, Apt. 5 Louisville, KY 46215	High School Teacher 405-54-3369
McAfee, G. Brent 1924 Dawn Odessa, TX 79762	Assoc, Professor/Geology 449-52-6159
Opalak, Mary 325 East 83rd Street New York City, NY 10028	Science Teacher 049-18-6640
Perry, Lorna 2600 East 4th Ave. Flagstaff, AZ 86001	Jr. High School Teacher 526-15-0214
Peterson, Kathy 9645 Genesee, G-2 San Diego, CA 92121	Biology Student 570-35-2916
Rose, A.J. 510 West Philomena Dr. Flagstaff, AZ 86001	Engineering-Business 321-20-7721

Table I-2 (Continued)

Trimble, John M. 1416 College Ave. Tempe, AZ 85285	High School Teacher 526-21-5700
Mickler, Robert 5545 Chowning Way Columbus, OH 43213	Teacher 281-58-3595
Dancis, Dale 306 East 54th St. New York, NY 10016	Elementary Teacher

FACULTY

Dr. Stanley S. Beus
Department of Geology
Northern Arizona University
Flagstaff, AZ 86011

Dr. Steven W. Carothers
Museum of Northern Arizona
Rte 4, Box 720
Flagstaff, AZ 86001

CREW

Bill Leibfried
Rte 4, Box 720
Flagstaff, AZ 86001

Marion M. Sharp
Rte 4, Box 720
Flagstaff, AZ 86001

Tomas Olsen
644 Lake Mary Road
Flagstaff, AZ 86001

Richard Romero
271½ N. Main
Flagstaff, AZ 86001

William Wasley
OCSR Box 14
Flagstaff, AZ 86001

Howie Usher
OCSR Box 14
Flagstaff, AZ 86001

CHAPTER II. RIVER EXPEDITION REPORT: SOCIOLOGICAL DATA

by A.J. Rose

INTRODUCTION

This report summarizes field notes compiled during a Grand Canyon Colorado River expedition. These notes were compiled according to instructions for National Park Service (NPS) Patrol trips. The instructions, taken from the NPS Sociological Data Collection Handbook are available from the Division of Resources Management. Data gathered include details on daily river contacts (river-river, river-shore, and shore-river) plus attraction site or camp contacts (shore-shore) and aircraft encounters. In addition, the trip schedule including locations of all camps and research site locations is also presented herein.

SCHEDULE

Since this was a research project involving students and faculty from Northern Arizona University and the Museum of Northern Arizona, a large number of stops (27) were made compared to normal river trips, solely for the purpose of conducting necessary tests and research activity. These stops are identified in the Trip Schedule at Table II-1 as Beach Research (BR). Eight more of these research stops were made coincident with camping for a total of 35. Stops also occurred at eight attraction points and once each for boat checkout (Lees Ferry) and phone calls (Phantom Ranch). A total of fifty stops, including Diamond Creek (exit) were recorded. No record was kept of several brief stops to survey major rapids prior to passage. All camp stops were for a single night except at Blacktail Canyon, where a two-night stop occurred to accomodate a full day of geological research in that area.

Table II-1. Trip Schedule: 29 July - 11 August 1982.

Stop No.	Location	River Mile	Arrive Time	Arrive Day	Depart Time	Depart Day	Reason for stop
0	Glen Canyon Dam	-15	----	--	1320	1	Start
1	Beach	-14	1340	1	1445	1	Beach Research (BP)
2	Beach	-13.5	1445	1	1600	1	BR
3	Beach	-11	1640	1	0715	2	BR and C (Camp)
4	Beach	-10.5	0735	2	1835	2	BR
5	Beach	-9.5	0905	2	1010	2	BR
6	Beach	-7	1100	2	1230	2	BR
7	Beach	-3	1350	2	1540	2	BR
8	Beach	-2	1620	2	1720	2	BR
9	Lees Ferry	0	1810	2	1830	2	Boat checkout
10	Badger Creek Lower	8	2015	2	0855	3	BR and C
11	Brown	12	1000	3	1030	3	Attraction Pt. (AP)
12	House Rock Lower	17	1220	3	1240	3	BR
13	20 Mile Beach	20	1340	3	1515	3	BR
14	25 Mile Rapid	25	1630	3	1645	3	AP
15	Tiger Wash	27	1730	3	0745	4	C
16	Shinumo Wash	29	0845	4	1000	4	BR
17	Vassey's Paradise	34	1045	4	1120	4	AP
18	Nautaloid	36	1235	4	1340	4	AP
19	42.5 Mile Beach	42.5	1615	4	1000	4	BR and C
20	Anasazi Bridge	47	1110	5	1140	5	BR
21	Nankoweap Lower	53	1305	5	1425	5	BR
22	Chuar Lower	66	1715	5	0930	6	BR and C
23	Unkar Creek	72.5	1040	6	1120	6	BR
24	Neville's (75 Mi. Cr.)	75.5	1200	6	1245	6	BR
25	Hance Upper	76.5	1300	6	1420	6	BR
26	Phantom Ranch	87.5	1700	6	1740	6	Phone
27	Salt Creek	92.5	1755	6	0750	7	C
28	Granite Rapid Upper	93	0812	7	0945	7	BR
29	103 Mile Rapid	103	1300	7	1345	7	AP
30	Bass Canyon	108	1515	7	1540	7	BR
31	Shinumo Creek	108.5	1550	7	1615	7	AP
32	Shinumo Rapid Lower	109	1620	7	1640	7	BR
33	114 Mile Beach	114	1735	7	1810	7	BR
34	Blacktail Canyon	120	1905	7	0927	9	BR and C
35	Stone Creek	132	1245	9	1430	9	BR
36	Tapeats Creek	133.5	1500	9	1035	10	BR, C and AP
37	Deer Creek	136	1120	10	1247	10	BR
38	137 Mile Beach	137	1300	10	1400	10	BR
39	Old Canyon	145.5	1651	10	1711	10	BR
40	Upset Rapid Lower	150	1815	10	0915	11	C
41	Havasu Creek	157	1045	11	1420	11	AP
42	National Canyon	166.5	1615	11	0950	12	BR and C
43	Prospect Canyon	179	1213	12	1302	12	BR
44	Lava Falls	179.5	1410	12	1537	12	AP
45	186 Mile Beach	186	1640	12	1727	12	BR

Table II-1 (Continued)

Stop No.	Location	River mile	Arrive Time	Arrive Day	Depart Time	Depart Day	Reason for stop
46	194 Mile Canyon	194.5	1835	12	0850	13	C
47	Parashont Wash (Upper)	198	1030	13	1130	13	BR
48	Granite Canyon	209	1320	13	1600	13	BR
49	220 Mile Canyon	220	1829	13	0709	14	BR and C
50	Diamond Creek	225.5	0834	14	----	--	End

AP - Attraction Point
BR - Beach Research
C - Camp

CONTACTS

Contacts with groups totaled 74. As expected, a large number of contacts were made with private fishing boats above Lees Ferry on Day 2 (from -11 to 0 river miles). En route the majority of contacts were shore to river because of the many stops for beach research. Repeated contacts were made with two oar groups through most of the trip. The largest number of contacts on any one day below Lees Ferry was on day 11 at Havasu Creek and was due to a three hour midday stop there coincident with the presence/arrival of eight other boat groups. The number of hikers met there was not recorded as they were overwhelmed by the simultaneous presence of over 150 people from the boats. A summary of group contacts by day is presented in Table II-2. Grand totals for the trip are (P-private, C-commercial, T-total) as follows:

River-river			River-shore			Shore-river			Totals		
P	C	T	P	C	T	P	C	T	P	C	T
12	8	20	8	2	10	21	23	44	41	33	74

The duration of encounters with motor-powered craft was significantly less than with oar-powered, but the former were more numerous and noisier. Some could be heard both before and after being seen.

Table II-2. Group Contacts.

Day	River Mile	River-River			River-Shore			Shore-River			Total		
		P	C	T	P	C	T	P	C	T	P	C	T
1	-15 to -11	2	0	2	0	0	0	2	0	2	4	0	4
2	-11 8	10	1	11	3	0	3	16	1	17	29	2	31
3	8 27	0	1	1	1	0	1	0	0	0	1	1	2
4	27 42.5	0	2	2	1	0	1	1	2	3	2	4	6
5	42.5 66	0	0	0	0	0	0	1	1	2	1	1	2
6	66 92.5	0	1	1	1	0	1	1	0	1	2	1	3
7	92.5 120	0	0	0	1	0	1	0	2	2	1	2	3
8	at 120	0	0	0	0	0	0	0	4	4	0	4	4
9	120 133.5	0	0	0	0	0	0	0	3	3	0	3	3
10	133.5 150	0	0	0	0	0	0	0	1	1	0	1	1
11	150 166.5	0	3	3	0	0	0	0	5	5	0	8	8
12	166.5 194	0	0	0	0	1	1	0	1	1	0	2	2
13	194 220	0	0	0	0	1	1	0	2	2	0	3	3
14	220 225.5	0	0	0	1	0	1	0	1	1	1	1	2
	GRAND TOTALS	12	8	20	8	2	10	21	23	44	41	33	74

Note: P - Private

C - Commercial

T - Total

AIRCRAFT

The rule used for recording the aircraft encounters was that the aircraft had to be both seen and heard. The casual high-altitude airliner or military aircraft passage was not recorded (as being a normal phenomenon, on or off river). Aircraft encounters were high above Lees Ferry on day 2, principally because of eight encounters with a helicopter performing photographic surveys. They were also high on days 7, 8, and 9 (Phantom Ranch to Tapeats Creek and Thunder River) and on day 12 (Lava Falls, Vulcan's Throne). A summary of encounters by day is presented in Table II-3. Grand totals are (P-private, C-commercial, T-total) as follows:

Single engine			Multi-engine			Helicopter			Totals		
P	C	T	P	C	T	P	C	T	P	C	T
37	3	40	6	25	31	0	21	21	42	52	94

(Distinction between private and commercial aircraft may be inaccurate in some instances, especially for the smaller aircraft encounters). There were only two instances of flight altitude at or just above 500 feet altitude above the river. One was the repeated passes (eight) on day 2 of the aforementioned helicopter. The other was two passes on day 8 at river mile 120 (Blacktail Canyon) by a helicopter (N5782X).

CAMPSITES

At camp stops we were alone except day 2, river mile 8, where two groups of hikers (totaling 9 persons) were also present.

AVERAGES

A series of averages for daily and group contacts and aircraft encounters are presented in Table II-A. Total average group contacts were 5.29 per day and total average aircraft encounters were 6.71 per day.

Table II-3. Aircraft Encounters.

Day	River Mile	Single Engine			Multi Engine			Helicopter			Total		
		P	C	T	P	C	T	P	C	T	P	C	T
1	-15 to -11	2	0	2	0	1	1	0	0	0	2	1	3
2	-11 8	2	0	2	0	1	1	0	10	10	2	11	13
3	8 27	6	1	7	0	0	0	0	0	0	6	1	7
4	27 42.5	2	0	2	0	1	1	0	0	0	2	1	3
5	42.5 66	1	0	1	1	0	1	0	0	0	1	1	2
6	66 92.5	2	0	2	0	0	0	0	2	2	2	2	4
7	92.5 120	3	1	4	0	3	3	0	6	6	3	10	13
8	at 120	2	0	2	1	3	4	0	2	2	3	5	8
9	120 133.5	2	1	3	1	2	3	0	1	1	3	4	7
10	133.5 150	0	0	0	0	2	2	0	2	2	0	4	4
11	150 166.5	3	0	3	0	2	2	0	0	0	3	2	5
12	166.5 194	9	0	9	6	9	12	0	0	0	3	2	5
13	194 220	2	0	2	0	1		0	0	0	2	1	3
14	220 225.5	1	0	1	0	0	0	0	0	0	1	0	1
	GRAND TOTALS	37	3	40	6	25	31	0	21	21	45	52	94

*Eight helicopter encounters were with the same craft, occurring over a period of several hours.

Table II-4. Averages of Group and Aircraft Encounters.

1. Group Contacts

a. Per day - total trip

River-River			River-Shore			Shore-River			Total		
P	C	T	P	C	T	P	C	T	P	C	T
.86	.57	1.43	.57	.14	.71	1.50	1.64	3.14	2.93	2.36	5.29

b. Per day - less day 1 (1/2 day) and day 14 (1/2 day)

River-River			River-Shore			Shore-River			Total		
P	C	T	P	C	T	P	C	T	P	C	T
.83	.67	1.50	.58	.17	.75	1.58	1.83	3.41	3.0	2.67	5.67

2. Aircraft Encounters

a. Per day - total trip

Single Engine			Multi-Engine			Helicopter			Total		
P	C	T	P	C	T	P	C	T	P	C	T
2.64	.21	2.85	.43	1.79	2.22	0	1.5	1.5	3.0	3.71	6.71

b. Per day - less day 1 (1/2 day) and day 14 (1/2 day)

Single Engine			Multi-Engine			Helicopter			Total		
P	C	T	P	C	T	P	C	T	P	C	T
2.83	.25	3.08	0.5	2.0	2.5	0	1.75	1.75	3.25	4.25	7.50

CHAPTER III. STUDY OF BEACH PROFILES AS A MEASURE OF BEACH EROSION ON THE COLORADO RIVER

S.S. Beus, J.W. Biddle, P. Iaquinto, F.B. Lojko and B. McAfee

INTRODUCTION

In 1974 some 20 beach sites along the Colorado River in Grand Canyon were examined and surveyed using a telescopic alidade (Howard, 1975). Topographic profiles from campsite areas to the beach shore face were constructed and at least two semi-permanent survey stations (benchmarks) were established at each site. In 1982 we attempted to re-occupy some of the same stations and repeat the survey and profiles of the ground surface at the present-day beach and campsite areas. Although only two sites were surveyed satisfactorily the results show some significant changes.

SURVEYING PROBLEMS

Some difficulties were encountered in occupying the survey stations as follows.

1. At the first site surveyed in 1982, Blacktail Canyon, the compass readings for the profile were measured from true north whereas the original survey, as we learned later, apparently used magnetic north. This would introduce an error in the direction of the beach profile traverse of 14½°. However, this would have produced only a slight error in the actual beach profile because the line of traverse for the profile was nearly perpendicular to the beach trend in both surveys.

2. At the second site, Granite Park, only one of two survey stations was recovered. The second was either buried or obliterated by natural causes. The station that was found and reoccupied is the nearest to the line of traverse for the beach profile. The resulting 1982 survey of the profile is considered to be reasonably accurate for the purposes of comparison with the 1974 profile.

PRELIMINARY RESULTS

Profiles from the two beaches surveyed are shown in Figures III-1 and III-2. Comparison of the two profiles (1974 and 1982) on each beach show only minor changes of the Blacktail Canyon Site (mile 120) (Fig. III-1). At the Granite Park Site, mile 108.8, however, the two profiles indicate a substantial retreat of the beach shore face (III-2). If the 1982 survey figures are accurate the beach at Granite Park has been eroded back at least 8 feet in 8 years, or at a rate of 1 foot per year! The cut bank at Granite Park does exhibit evidence of recent erosion in the form of recently exposed tree roots hanging out over the water at the beach profile survey site. It seems clear that the river is consuming the beach at a rapid rate.

It is recommended that a more thorough study of these sites be done in the future to determine what changes have occurred at the other 18 beaches not covered in this preliminary study.

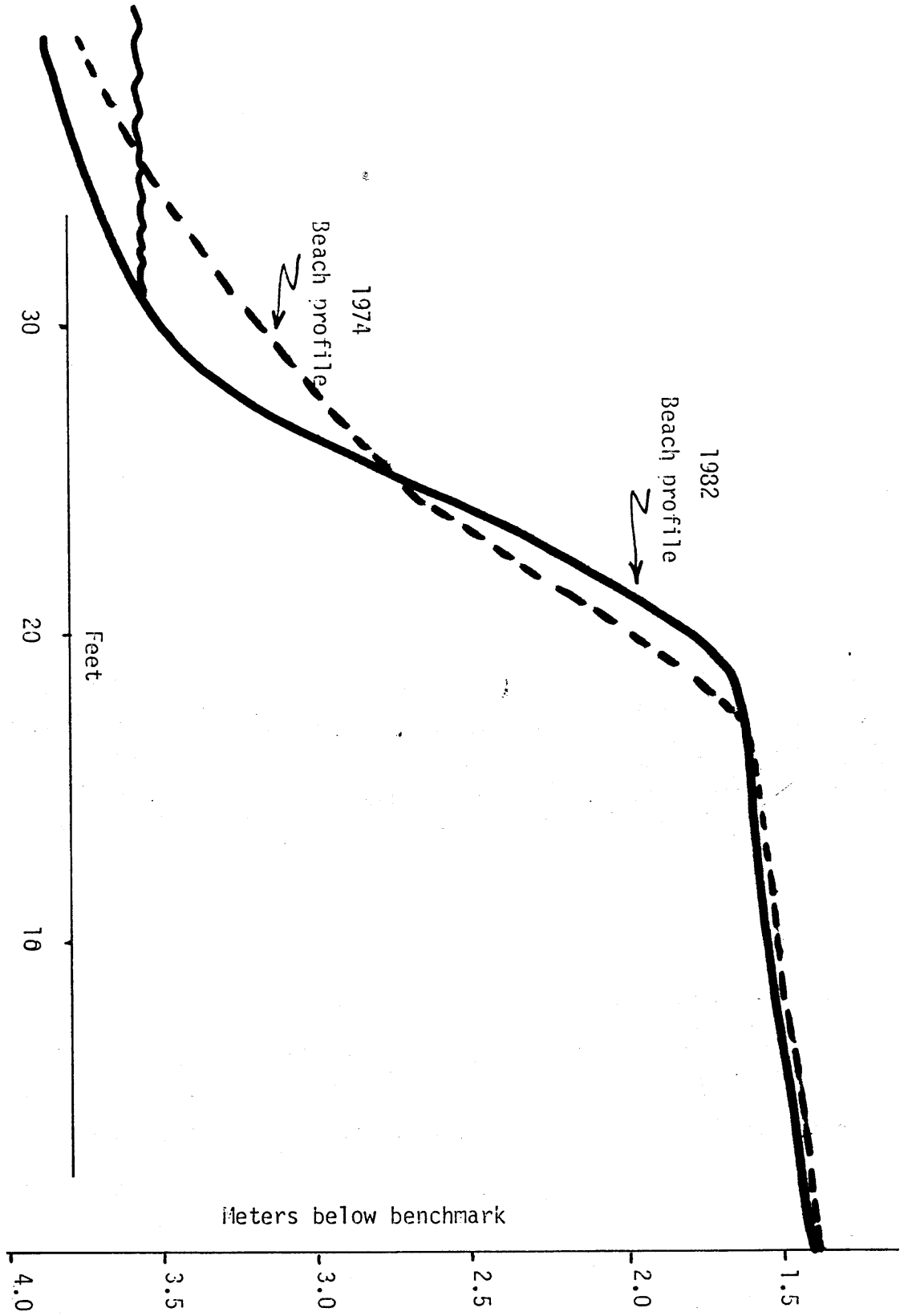

Figure III-1. Beach profiles at Blacktail Canyon, mile 120.

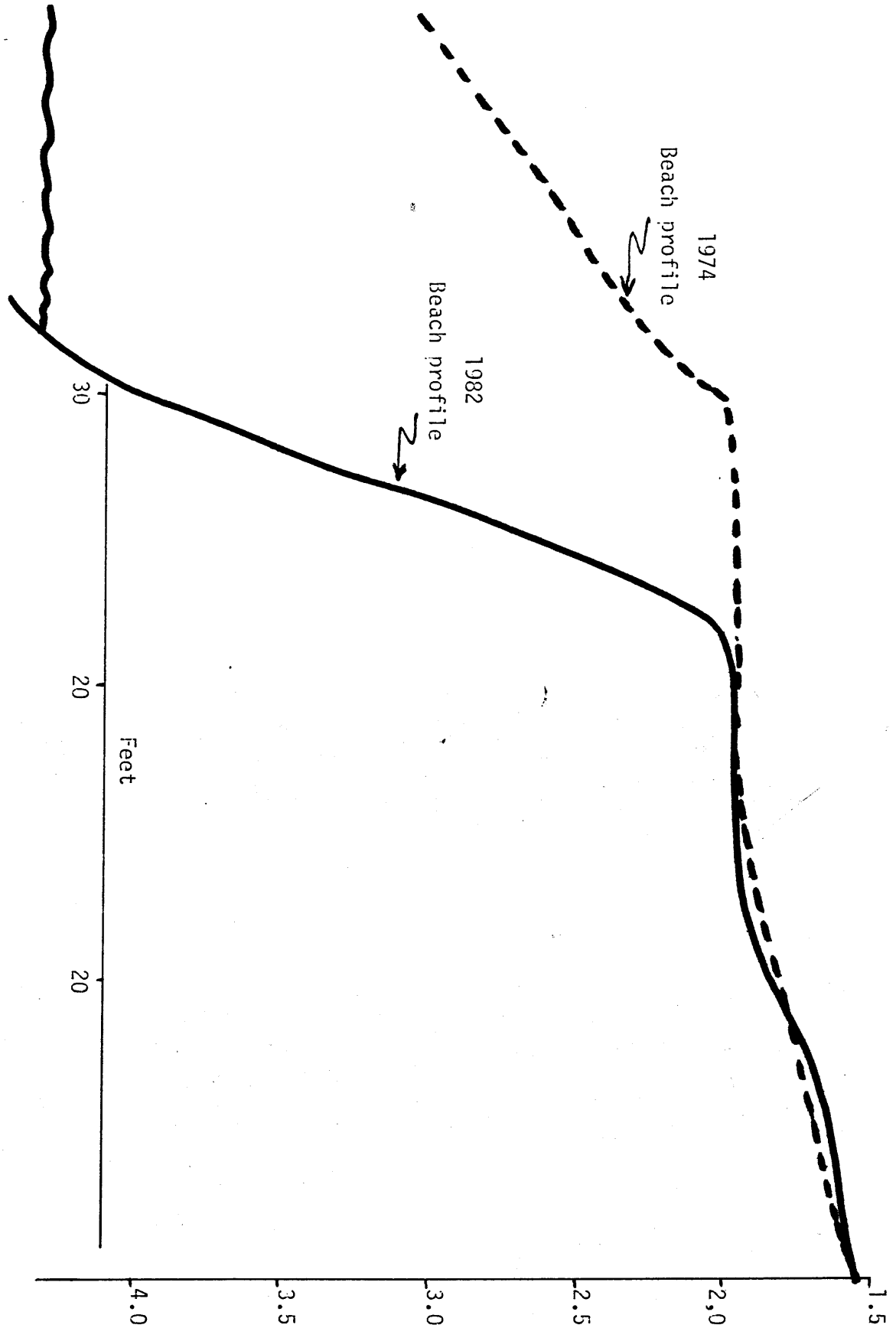

Figure III-2. Beach profiles at Granite Park, Mile 208.8

CHAPTER IV. BEACH SAND GRAIN SIZE ON THE COLORADO RIVER FROM GLEN CANYON TO DIAMOND CREEK

S.S. Beus, J.W. Biddle, M. Glass, P. Iaquinto, F.B. Lojko and B. McAfee

INTRODUCTION

Beach sand samples were taken from 20 beaches in lower Glen Canyon and Grand Canyon during a 2-week period of July 24 - August 11, 1982. The samples were analyzed for grain size and composition as a means of determining mean sand size and resistance to erosion. This report presents the results of the grain size analysis together with a plot of the approximate current velocity required to initiate erosion of the mean sand grain size at each beach.

SAMPLING TECHNIQUE

Four types of sites were sampled as follows:

1. Surface beach sample approximately at the average high water mark (about 25,000 cfs level) at the shore.
2. Surface sample at randomly selected points on a tape stretched across the camping area of the beach...generally 1 - 3 meters higher than the level of 1 above.
3. Near surface samples, where a growth of predominantly tamerisk or predominantly willow vegetation occurred at selected beaches.
4. Spot samples of selected beaches to a depth of up to 40 cm from trenches dug into the beach.

Beach samples (60 - 80 gm) were collected in small plastic vials at or near the surface of the beach at the approximate local high water mark (the 25,000 cfs level). The sample sites selected were those that appeared to have relatively little disturbance by human traffic. The campsite samples on the

higher part of the beach were taken from randomly selected sites along a metric tape transect within the campsite area. At two beaches--Anasazi Bridge (mile 43) and National Canyon (mile 166)--vertical trenches dug into the beach were sampled to a depth of 40 cm. At the latter site two rubber latex peels were made of the sand layers exposed in the trench walls to preserve a record of the bedding structures within the beach sand (Plate IV-1).

The samples were sieved through a standard set of 3-inch diameter sieves graduated in $\frac{1}{2}\,\phi$ sizes. Each sample was hand-shaken for 10 minutes using a clamping device that held two sieve sets together (Plate IV-2). Each size fraction was weighed and tabulated and the results summarized in a histogram. Approximately half the samples were saved for future reference.

SAND SIZE ANALYSIS

The beach sands are, with one notable exception, all fine- to very fine-grained size (Table IV-1). The mean grain size is generally between 4.0 ϕ (1/16 mm diameter) and 2.0 ϕ ($\frac{1}{4}$ mm diameter) (Figure IV-1). Three-mile beach in Glen Canyon is composed of coarse sand having a mean size of 0.7 ϕ (nearly 1 mm diameter). The Glen Canyon beaches as a group have more variation in grain size than the beaches downstream from Lee's Ferry.

Most of the beach shoreface samples are moderately to well-sorted; some have 98% of the grains within 1 ϕ size (i.e. 3/8-3/16 mm diameter). Beach campsite samples show slightly poorer sorting. The one high beach terrace sample, taken at three-mile beach in Glen Canyon, contained about 20% silt and clay size grains too fine to be separated by sieving (Figure IV-2).

higher part of the beach were taken from randomly selected sites along a metric tape transect within the campsite area. At two beaches--Anasazi Bridge (mile 43) and National Canyon (mile 166)--vertical trenches dug into the beach were sampled to a depth of 40 cm. At the latter site two rubber latex peels were made of the sand layers exposed in the trench walls to preserve a record of the bedding structures within the beach sand (Plate IV-1).

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SAND SIZE ANALYSIS

The beach sands are, with one notable exception, all fine- to very fine-grained size (Table IV-1). The mean grain size is generally between 4.0 ϕ (1/16 mm diameter) and 2.0 ϕ ($\frac{1}{4}$ mm diameter) (Figure IV-1). Three-mile beach in Glen Canyon is composed of coarse sand having a mean size of 0.7 ϕ (nearly 1 mm diameter). The Glen Canyon beaches as a group have more variation in grain size than the beaches downstream from Lee's Ferry.

Most of the beach shoreface samples are moderately to well-sorted; some have 98% of the grains within 1 ϕ size (i.e. 3/8-3/16 mm diameter). Beach campsite samples show slightly poorer sorting. The one high beach terrace sample, taken at three-mile beach in Glen Canyon, contained about 20% silt and clay size grains too fine to be separated by sieving (Figure IV-2).

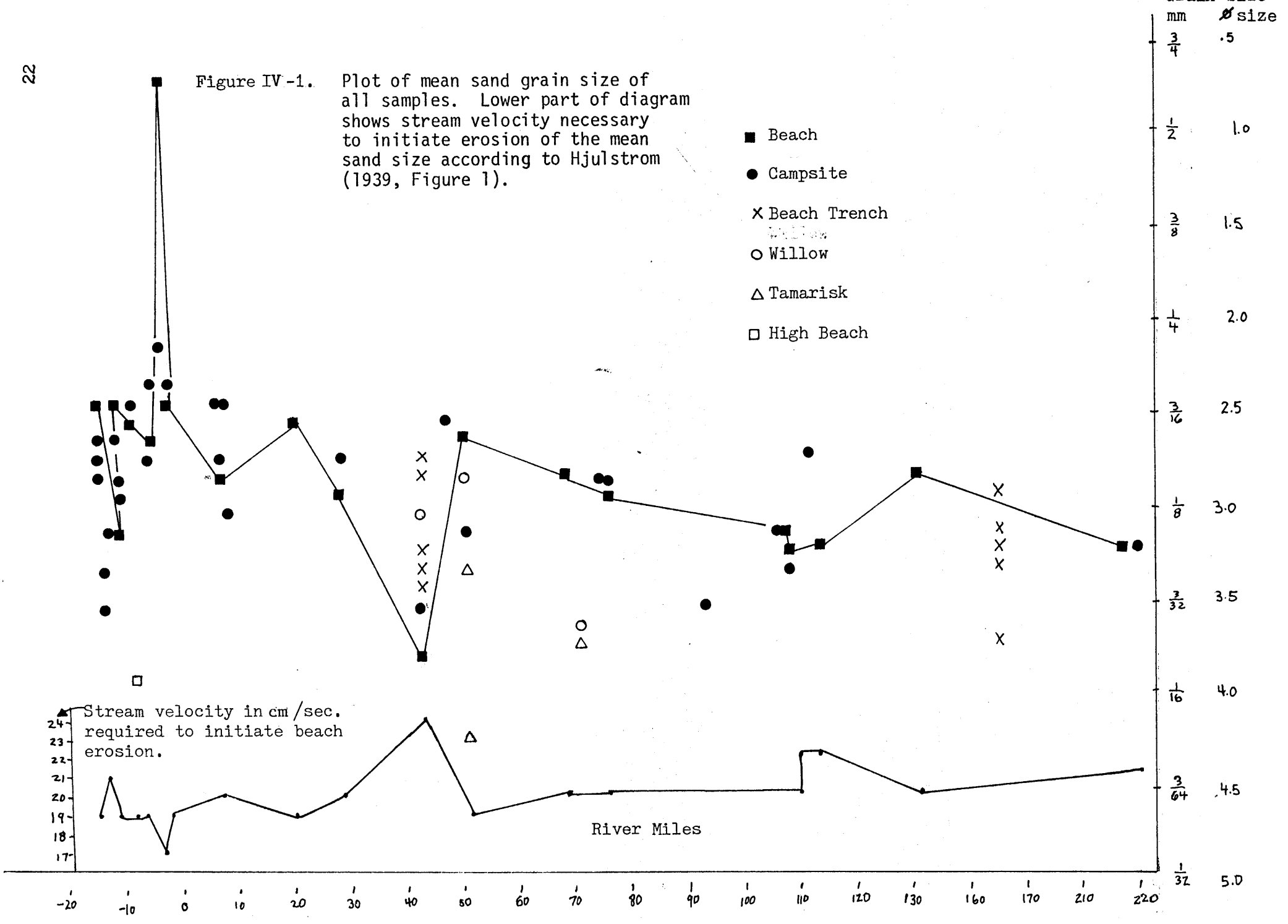

Figure IV-1. Plot of mean sand grain size of all samples. Lower part of diagram shows stream velocity necessary to initiate erosion of the mean sand size according to Hjulstrom (1939, Figure 1).

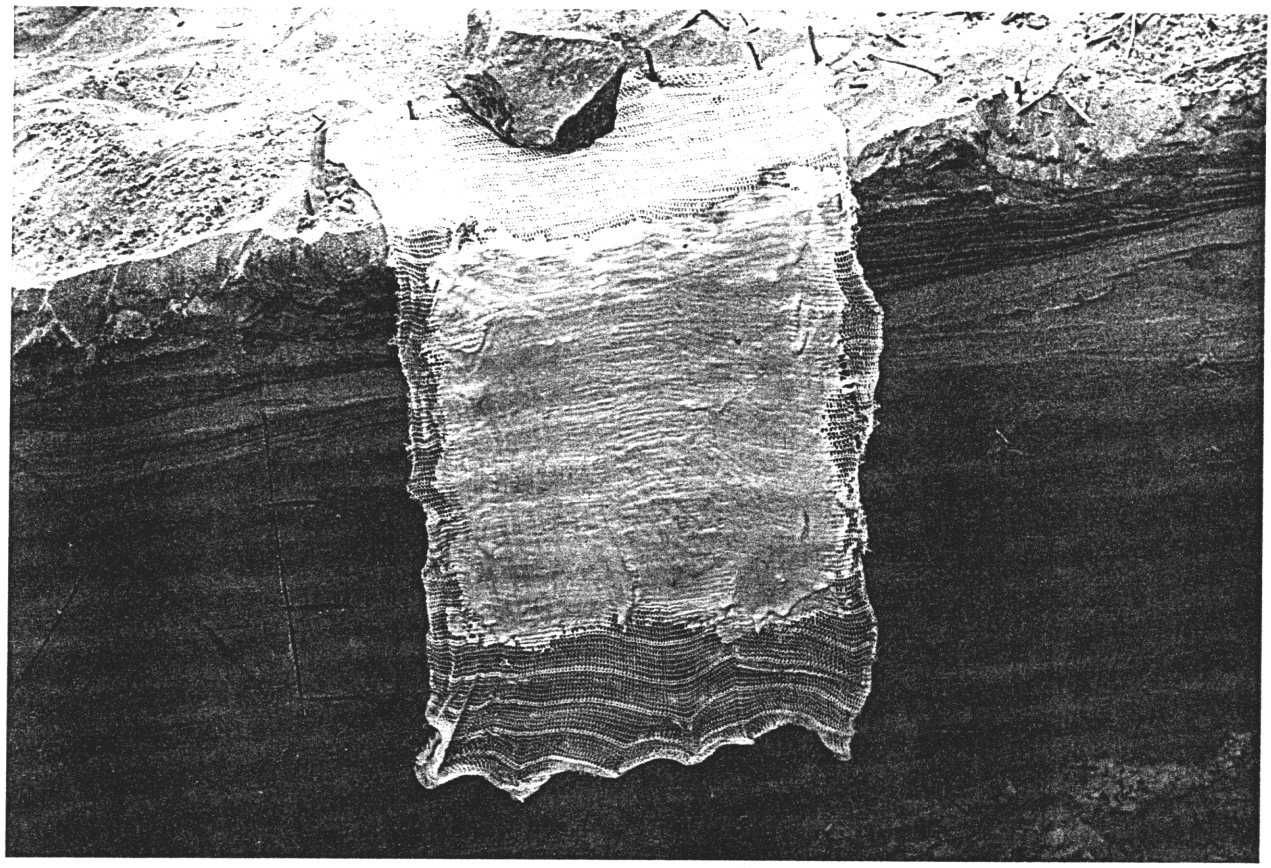

Plate IV-1. Rubber latex peel of bedding in beach sands at national Canyon (mile 166).

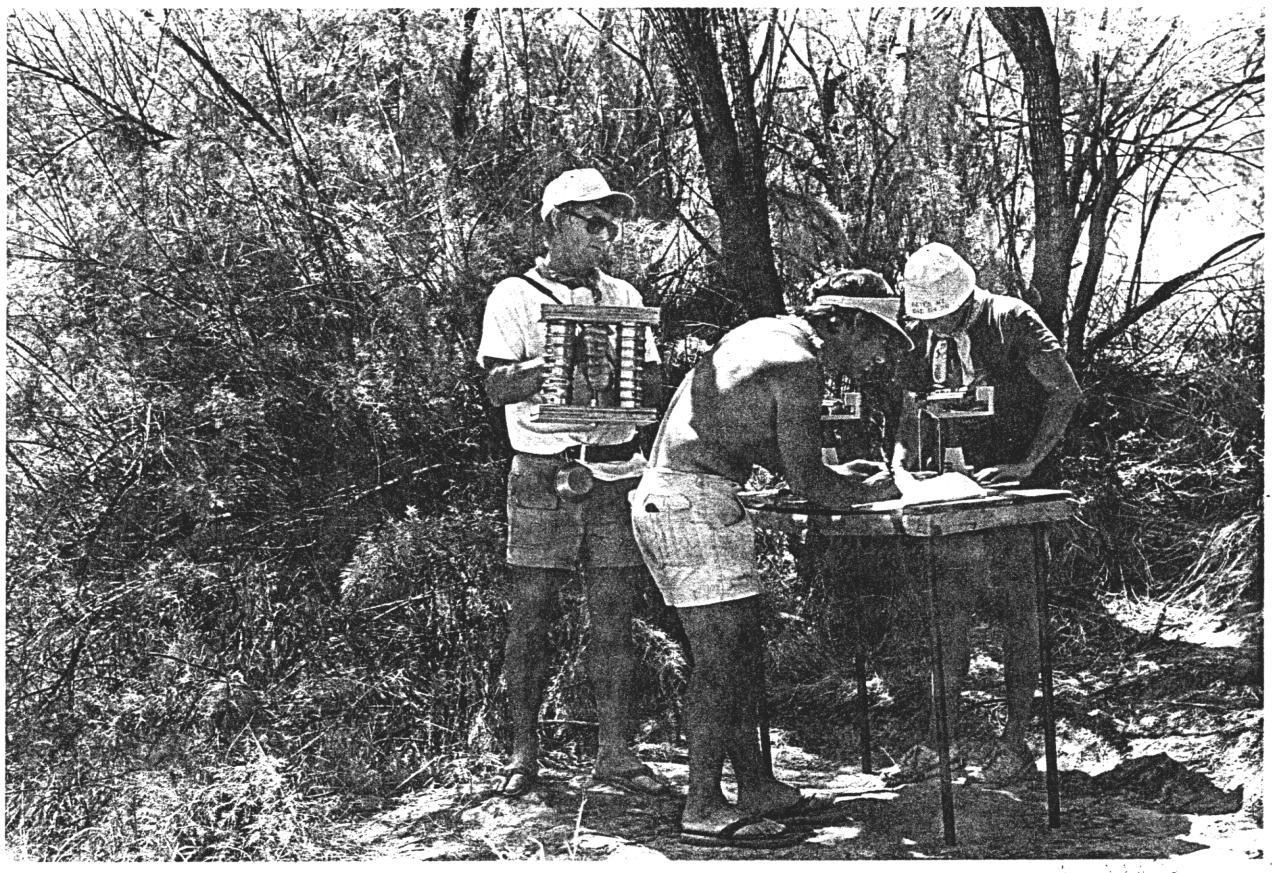

Plate IV-2. Sand sample measurements. Person on the left has clamping device used to hold sieve sets for hand shaking.

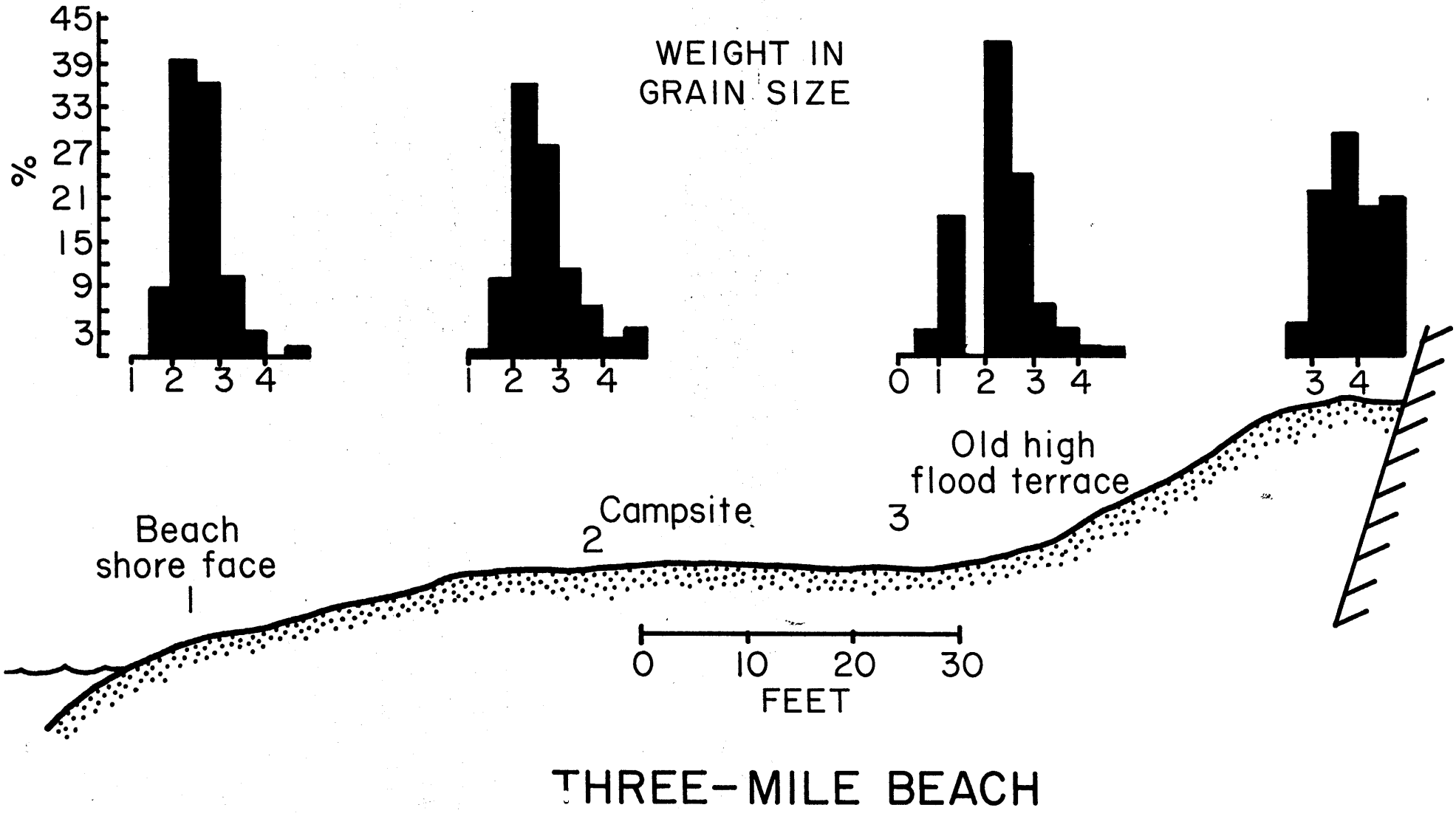

Figure IV-2. Beach profile and histograms of sand size at Three-Mile beach Glen Canyon. Unusual bimodal pattern at site 3 is probably due to mixing of fine material from the old high flood level terrace sands (site 4) and the lower coarser-grained beach sands.

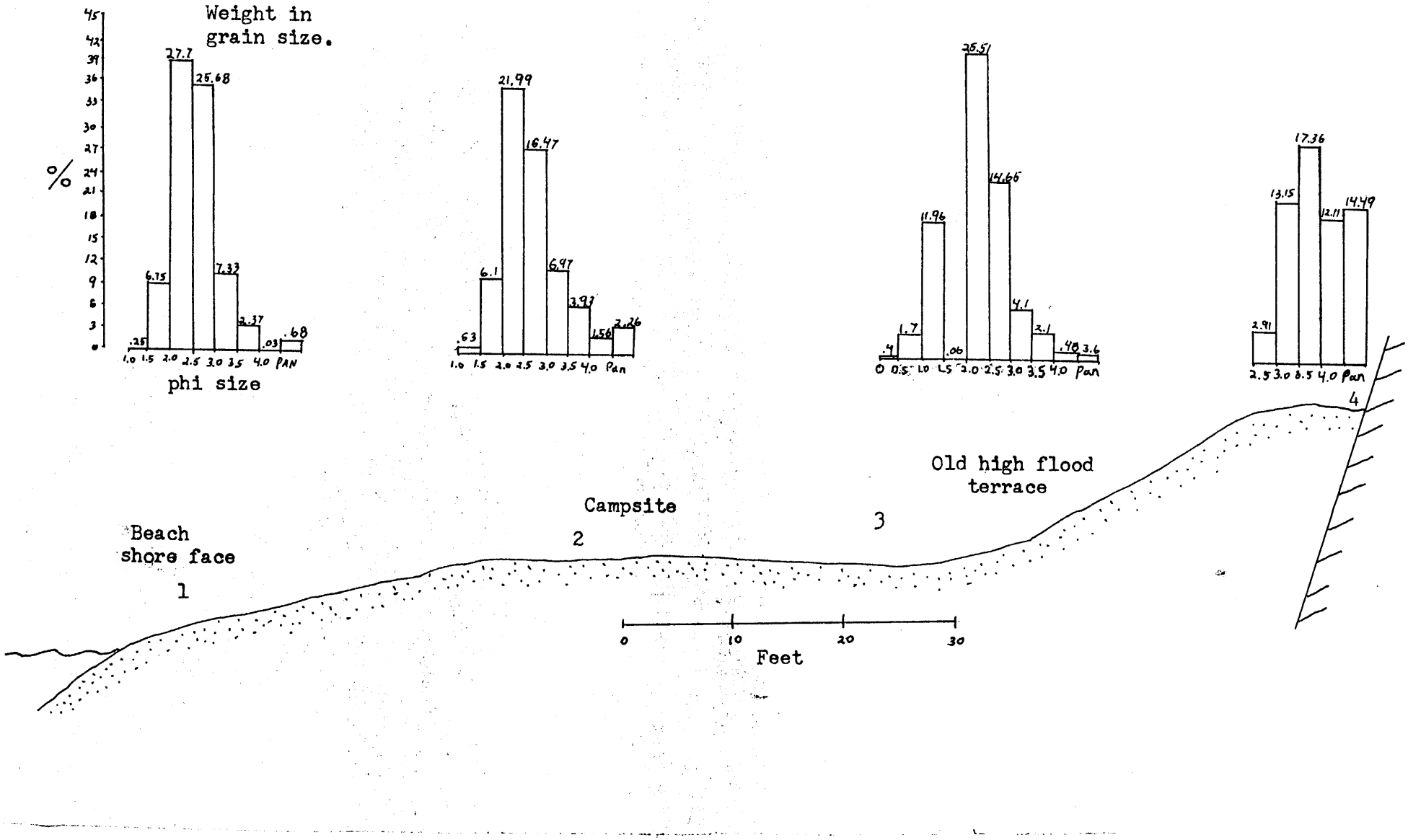

Figure IV-2. Beach profile and histograms of sand size at three-mile beach in Glen Canyon. Unusual bimodal pattern of site 3 is probably due to mixing of fine material from the old high flood level terrace sands (site 4) and the lower coarser-grained beach sands.

Grain sizes of samples taken selectively from sites of predominantly tamarisk growth (3) and predominantly willow growth (3) show a generally finer mean size for the tamarisk sites, however, a larger number of samples is needed to determine if this is a significant difference.

A preliminary examination of the grain composition indicates mainly quartz with minor amounts of feldspar, rock fragments, magnetite and other rare dark minerals. Sand grains are mostly subrounded to subangular in shape.

BEACH EROSION POTENTIAL

Figure IV-1 illustrates the velocity required to initiate erosion of loose sand deposits according to experimental data from Hjulstrom (1939). A current velocity of 18 to 22 cm per second is sufficient to erode the mean grain size of any of the beach sands sampled in this study.

CONCLUSIONS

Beach sands along the Colorado River in lower Glen Canyon and Grand Canyon are generally fine- to very fine-grained. The sand is predominantly quartz with minor amounts of magnetite, feldspar, mica and rock fragments. The grains are mostly moderately to well sorted. A water current velocity of 18-22 cm/second in the river at the beach sites would be sufficient to initiate erosion of any of the beaches studied.

TABLE IV-1. MEAN SAND GRAIN SIZE IN MM ON COLORADO RIVER BEACHES.

River Mile	Area	Beach	Campsite	Tamarisk	Willow	Beach Trench	High Beach Terrace
-14	Water Plant	0.20	0.15, 0.16, 0.18				
-13.5	Ropes		0.09, 0.11, 0.12				
-11	Ferry Swale	0.20	0.18				
-10	Faatz Camp						
- 9.5	Rock Art Beach	0.19					
- 7.5	Finger Rock Beach	0.18	0.16, 0.23				0.07
- 3	3-mile Beach	0.7					
- 2	2-mile Beach	0.20	0.23				
7.8	Badger Rapids	0.15	0.16, 0.20, 0.20				
8	Jackass Canyon		0.13				
20	20-mile Beach	0.09	0.13				
22	North Canyon Pt.	0.19					
29	Shinumo Wash Beach	0.14	0.16			0.10, 0.11, 0.11	
43	Anasazi Bridge Beach	0.08	0.09			0.15, 0.16	
47	Saddle Horn		0.19				
52	Nankoweap Beach	0.18	0.12	0.06, 0.11	0.15		
68.5	Tanner Mine Beach	0.15					
73	Unkar Beach			0.08	0.09		
75	Nevilles Rapids		0.15				
76	Hance Rapids	0.14	0.15				
94	Granite Park		0.09				
108	Lower Bass	0.12	0.12				
109	109-mile	0.11	0.11				
114	Upper 114	0.11	0.16				
132	Stone Creek	0.15	0.16			0.08, 0.11, 0.11	
166	National Canyon Beach					0.12, 0.14	
219	219-mile	0.11	0.11				

CHAPTER V. INSECT DENSITY AND DIVERSITY ON COLORADO RIVER BEACHES

Part I. Sweep Net Trapping

Betty Byars

INTRODUCTION

The beaches along the Colorado River in the Grand Canyon are an area in which the plant species can be divided into four ecological zones:

I. Riparian - occurs at the edge or very close to the river; it is dominated by Salt Cedar and willow.

II. Open beach behind the riparian zone; Arroweed is the dominant plant.

III. Old river terrace - occurring at the high water level which existed prior to Glen Canyon Dam; mesquite and Acacia thickets are the dominant vegetation.

IV. Talus slopes dominated by "Desert Scrub" communities of plants.

There are many insects that make their living on the dominant plants in these zones. Environmental conditions (abiotic) in the zones differ primarily in the amount of water available, soil type, and the high and low temperatures attained in the zones during a 24-hour period.

HYPOTHESIS

This investigation was concerned with finding out whether or not there were differences in the diversity and the density of insects on the plants that dominate the different ecological zones on the river beaches.

METHODS

Insects were collected with a sweep net from the dominant plants in each ecological zone. They were then identified as to order and family (where possible) and counted. Approximately 200 sweeps per plant in a zone were used to collect insects at each sample of that zone. The number of samples of a given zone differs due to time available and weather conditions. After the data were collected and organized by zone they were utilized to give a percentage (by family and order) of insects utilizing the dominant plant(s) in that zone. Graphs were drawn to illustrate the relationships.

RESULTS AND DISCUSSION

There are a total of nine insect orders (Homoptera, Hemiptera, Diptera, Orthoptera, Lepidoptera, Neuroptera, Odonata, Hymenoptera, Coleoptera) present when all orders of all zones are counted together (Table V-1). A certain similarity in orders present occurs among zones, although the number of insects from a particular order varies considerably among zones. The Desert Scrub community is unique in that it is the only area where Lepidoptera are present, probably due to flowering cacti.

The greatest diversity of insects (indicated by the largest number of families - 16 - being present) occurs on willow (Figures V-1 and V-2) and the greatest density occurs on Salt Cedar (Figure V-3), where the number of insects is almost four times greater than on Salix (see Table V-2). Arroweed has a moderate amount of diversity with a low density (Figure V-4). Mesquite/Acacia is low in both diversity and density (Figure V-5). One wonders why they are comparatively depauperate. The Desert Scrub was sampled the least number of times (two) because of the heat. It does show a fairly high diversity and density (Figure V-6) if the low sample number is kept in

mind. It appears to be an older, stable community in which there has been long coevolution between plants and insects.

Among the different orders, Homoptera, Hymenoptera, and Diptera are the top three in terms of numbers of insects. From the nineteen different families, the top five are Cicadillide, Cicadidae, Halictidae, Miridae, and Coccinellidae. One wonders if the presence and distribution of these insects is enhanced by a greater ability to tolerate heat and aridity, or if some other factor(s) is at work.

The numbers of predatory insects are not high. The predators occur in four families (Asilidae, Miridae, Coccinellidae, Phasmatidae) plus two orders (Neuroptera, Odonata).

Table V-1. Orders of insects found on riparian plant species along the Colorado River, August 1982. (Number in parentheses denotes number of sample times per vegetative species.)

Order	Willow (5)		Salt Cedar (7)	Arroweed (4)	Mesquite/ Acacia (4)	Desert Scrub (2)
Coleoptera	24	33	6	1	14	
Diptera	22	56	1	6	10	
Hemiptera	23	17	23	1	15	
Homoptera	24	238	7	38	28	
Lepidoptera	0	0	0	0	2	
Neuroptera	1	1	0	0	0	
Odonata	1	1	0	0	0	
Orthoptera	5	12	6	0	6	
Total Orders	8	8	6	5	7	
Total Insects	115	424	55	51	80	
Number/Sample	23	61	14	13	40	

Table V-2. Families of insects found on riparian plant species along the Colorado River, August 1982.

Family		Willow	Salt Cedar	Arroweed	Mesquite/ Acacia	Desert Scrub
Acrididae	4	12	6	0	6	
Aphidae	3	0	0	0	1	
Apidae	1	0	0	1	0	
Asilidae	1	4	1	0	3	
Bombyliidae	8	22	0	0	0	
Cicadellidae	9	192	4	4	23	
Cicadidae	15	46	3	34	5	
Chrysopidae	1	0	0	0	0	
Coccinellidae	7	28	2	1	0	
Curculionidae	0	0	0	0	13	
Elateridae	5	0	0	0	0	
Formicidae	0	0	3	0	1	
Hemerobiidae	0	1	0	0	0	
Halictidae	6	36	4	1	3	
Miridae	12	8	21	0	0	
Pentatomidae	1	5	0	0	15	
Phasmatidae	1	0	0	0	0	
Sphecidae	7	23	4	3	0	
Vespidae	1	7	1	0	0	
Unknown	33	40	6	7	10	
Total Families		16	12	10	6	9

CONCLUSIONS

The differences in diversity/density of insects between the riparian zone (Willow and Salt Cedar) and the old river terrace (Mesquite/Acacia) and talus slopes (Desert Scrub) are quite marked. This leads one to the question of a possible change in insect diversity/density from lower in pre-dam times to higher at the present time due to insects migrating (either from outside the canyon or from other types of vegetation in the older zones) into the new riparian zone created by Glen Canyon Dam. Thus, I feel that Glen Canyon Dam must be considered as a major factor influencing the ecology of the Colorado River beaches in the Grand Canyon. The chain of relationships would be something like this:

	Glen Canyon Dam	
mammal populations	plant communities	
	insect populations	
raptor populations	reptile populations	bird populations

Much more intensive study needs to be done on each of these levels to determine precisely how and to what degree they influence each other.

INSECT DENSITY AND DIVERSITY ON COLORADO RIVER BEACHES

Part II. Black Light Trapping

M. Sanderson, H. Usher, B. Leibfried and B. Byars

At each of the expedition campsites, Black Light (ultraviolet light) Trapping was undertaken for the purpose of sampling insects throughout the river corridor.

The black light was run from one to several hours and captured insects were containerized and preserved in alcohol and stored for later identification.

After returning to Flagstaff, the insect samples were given to Dr. Milt Sanderson who identified the insects and produced the taxonomic lists and comments presented on the following pages.

One of Dr. Sanderson's most interesting findings is the large number of biting flies (Cerato pogonidae) found throughout the river corridor. River runners who have a multi-year perspective on the overall conditions of the beach systems have, over the years, noticed an increase in "biting" small insects. The Cerato pogonidae breed in the wet sand of the intertidal zone. Any increase in the size of the intertidal zone (very high and very low flows alternating frequently, i.e., peaking power dam operational scenario) would naturally produce more breeding habitat for this group of flies.

Grand Canyon Site #1--11 miles above Lee's Ferry

July 29, 1982; overcast, slight downstream breeze. Light on river bank near Tamarisk stand.

Light on 8:15 (air 20°C); Light off 9:45 (air 25°C)

COLEOPTERA

- Carabidae--2
- Anthicidae--14
- Scarabaeidae--3
- Chrysomelidae--1
- Lathridiidae--1
- Staphylinidae--35
- Elateridae--3

HYMENOPTERA

- Miscell. families--25

HOMOPTERA

- Cicadellidae--22
- Aphididae--3

MISCELLANEOUS

- Drifting spiders--1
- Tetragnatha (Argiopidae)--1

HEMIPTERA

- Miridae--17
- Coreidae--1
- Coreidae--5

THYSANOPTERA

- Franklinella--10

LEPIDOPTERA

- Miscell. families--10

DIPTERA

- Ceratopogonidae--125
- Chironomidae--300
- Miscellaneous--100

NEUROPTERA

- Chrysopidae--1

Comments: Diptera dominated this collection. Those not Ceratopogonidae or Chironomidae probably are not aquatic. The collection suggests that there was little variety in vegetation. Only aquatics were Diptera.

Grand Canyon Site #2--Mile 8--Badger Wash

July 30, 1982, Clear sky, ½ moon; slight breeze; tamarisk; large boulder

Light on 8:50 (air 24°C); Light off 12:50 (air 22°C)

COLEOPTERA

- Elateridae--7
- Scarabaeidae
  - Diplotaxis--8
  - Ataenius--1
- Carabidae--5
- Melandryidae--5
- Staphylinidae
  - Carpelimus--2
  - Aleocharinae--9
- Anthicidae--3
- Oedemeridae--1

HYMENOPTERA

- Formicidae--25
- Miscell.--4

HOMOPTERA

- Cicadellidae--150

HEMIPTERA

- Miridae--8
- Tingidae--1

THYSANOPTERA

- Franklinella tritici--200

LEPIDOPTERA

- Miscell. families--100

DIPTERA

- Simuliidae--7
- Miscell.--5
- Chironomidae--2000
- Ceratopogonidae--

NEUROPTERA

- Myrmelionidae--1

Comments: Trichoptera, Ephemeroptera, Plecoptera absent, suggesting no permanent or intermittent lateral streams. Simuliidae undoubtedly came from rapids in river. The dominant cicadellid possibly from Salix or Tamarisk. Franklinella from flowers, possible some variety. Miscell. families of Lepidoptera indicate variety of vegetation, possibly some plants above floodplain. Chironomids from river, ceratopogonids from wet banks.

Grand Canyon Site #3--27 miles below Lee's Ferry

July 31, 1982; Clear; moderate upstream breeze, some moonlight, boulder desert scrub

Light on 8:45 (air 25°C); Light off 10:15 (air 25°C)

COLEOPTERA

- Carabidae--38
- Alleculidae-1000
- Elateridae--28
- Scarabaeidae--12
- Tenebrionidae--1
- Cleridae--1
- Chrysomelidae--4
- Coccinellidae--1
- Anthicidae--19
- Staphylinidae--12
- Hydrophilidae--29

HYMENOPTERA

- Mixed families--50

HOMOPTERA

- Cicadellidae--55
- Aphididae--4
- Fulgoridae--4

NEUROPTERA

- Myrmelionidae--3
- Coniopterygidae--1

HEMIPTERA

- Miridae--65
- Anthocoridae--43
- Tingitidae--1
- Corixidae--1
- Pentatomidae--3
- Reduviidae--1
- Nabidae--1
- Lygaeidae--8

THYSANOPTERA

- Franklinella--many

LEPIDOPTERA

- Various families-100

DIPTERA

- Simuliidae--300
- Chironomidae--thousands
- Ceratopogonidae--200
- Miscell.--50

MISCELLANEOUS

- Spider mites--1

Comments (Site #3 Continued):

The many Simuliidae indicates riffles. Most of the hydrophilids in genus Berosus, indicating some standing water. The alleculids suggest desert conditions. Variety of leafhoppers indicate variety of plants. The many anthocorids indicate flowers, as do the many thrips. Chironomids probably came out of the river. No Trichoptera which indicates river probably too cold, or little permanent water in the wash. Note the virtual absence of small beetles. This is a more diverse spot than Site #1. Spectacular flight of alleculids (Hymenorus), and I suspect that the larvae live in moist soil or moist debris, possibly containing some wood.

Grand Canyon Site #4--Mile 43--Anasazi Bridge Camp

August 1, 1982; Cloudy, slight upstream breeze; intermittent drizzle

willow stand near beach.

COLEOPTERA

- Scarabaeidae
  - Diplotaxis--4
  - Ataenius--1
- Anthicidae--4
- Chrysomelidae--2
- Hydrophilidae
  - Chaetarthria--1
- Elateridae--1
- Carabidae--1
- Staphylinidae
  - Scopaeus--7
  - Carpelimus--12
  - Oxytelus--1
  - Aleocharinae--20

HYMENOPTERA

- Formicidae--9
- Mixed families--12

NEUROPTERA

- Myrmelionidae--1

HOMOPTERA

- Aphididae--3
- Fulgoridae--1
- Cicadellidae--20

HEMIPTERA

- Saldidae--1
- Miridae--6
- Anthocoridae--4
- Lygaeidae--1

THYSANOPTERA

- Frankliniella--hundreds

LEPIDOPTERA

- Mixed families--50

DIPTERA

- Tipulidae--2
- Simuliidae--2
- Chironomidae--thousands
- Ceratopogonidae--

Comments: No Trichoptera, Plecoptera, ephemeroptera; no lateral streams. Chaetarthria suggests small beach pool. Staphylinidae suggest a var. of moist

(Site #4 Continued)

(debris) situations. A number of families of lepidoptera, also Hymenoptera (suggesting var. of vegetation). Possibly many flowers (thrips). Tipulidae suggest a seep area nearby. The saldid probably came from the dam to wet beach.

Grand Canyon Site #5--Mile 66--Chuar Canyon Camp

August 2, 1982; partly cloudy, strong breeze downstream; rain before light set up; beach with willows

Light on 8:30 (air 22°C); light off 10:00 (air 22°C)

COLEOPTERA

Anthicidae--2

Carabidae--1

HYMENOPTERA

Formicidae--15

Other families--3

HOMOPTERA

Cicadellidae--33

HEMIPTERA

Miridae--1

Lygaeidae--1

THYSANOPTERA

Frankliniella--6-12

LEPIDOPTERA

Mixed families--15

DIPTERA

Chironomidae--500

Ceratopogonidae--6

Simuliidae--1

NEUROPTERA

Myrmelionidae--6

TRICHOPTERA

Mydropsychidae--1 (female)

Hydroptilidae--3 (females)

Comments: The first Trichoptera appeared in these collections, obviously from Chuar Creek. The low tempeatures, strong breeze, and rain preceding the light setup probably accounted for the light collection. Possibly there is little plant diversity at this site.

Grand Canyon Site #6--Mile 93

August 3, 1982; Clear; no wind early, slight at 10:10; Tamarisk

Light on 8:38 (air 25°C); light off 10:10 (air 25°C)

COLEOPTERA

Scarabaeidae

Ph. bilobatata--9m, 2f

Ph. timida--1m

Diplotaxis--22

Cyclocephala--1

Glaresis ?--1

Elateridae--59

Cicindelidae--1

Carabidae--4

Cleridae--1

Alleculidae

Hymenorus--34

Oedermerida--1

Melandryidae--12

Chrysomelidae

Phyllotreta--1

Anthicidae--2

Curculionidae--1

Lathridiidae--1

Staphylinidae--15

HEMIPTERA

Lygaeidae--2

Miridae--7

Anthophoridae--1

THYSANOPTERA

Frankliniella--ca 50

LEPIDOPTERA

Aq. Pyralidae--1m

Misc. families--225

DIPTERA

Chironomidae-- ca 100

Miscell.--ca 100

Tipulidae--3

Muscoidae--1

Ceratopogonidae--45

NEUROPTERA

Mantispidae--3

Myrmelionidae--6

TRICHOPTERA

Philopotamidae

Chimarra--2

Hydroptilidae--3

(Site #6 Continued)

HYMENOPTERA

Formicidae--60 (variety)

Miscell--5 (variety)

HOMOPTERA

Cicadellidae--87

Fulgoridae--1

Cicadidae--1

CORRODENTIA

Genus ?--1 (apterous)

Comments: The apterous Corrodentia possibly was wind blown into the trap, or less likely attached to a flying insect (phoresy). The two families of Trichoptera indicate a stream other than the river, but the Hydroptilids could have come from a seep. There was no indication in Liebfried's notes of either habitat. There was a considerable drop in numbers of Chironomids at this site. Also the first Phyllophaga (Scarabaeidae) at this site. Both occur as far north as the Sedona-Flagstaff area, and are common in the desert of southern Arizona. Also note the larger number of families of Coleoptera than in other samples. Cicadidae are not often taken at lights, so must have been abundant at this site. Also note aquatic pyralid--a suggestion also of a stream nearby other than the Colorado River.

Grand Canyon Site #7--Mile 120--Blacktail Canyon

August 4, 1982; Partly cloudy; no breeze; full moon 10:15; desert scrub

Light on 8:45 (air 31°C); light off 10:15 (air 29°C)

COLEOPTERA

- Scarabaeidae
  - Ataenius--3
  - Diplotaxis--9
  - Ph. timida--1 (male)
- Elateridae--7
- Bostrichidae--1
- Caragidae--18
- Staphylinidae
  - Carpelimus--50
  - Aleocharinae--4
- Chrysomelidae
  - Altica--2
  - Pachybrachys--1
  - Chaetocnema--1
  - Longitarsa--3
- Melandryidae--32
- Alleculidae--2
- Anthicidae--12
- Hydrophilidae
  - Chaetarthria--2

HOMOPTERA

- Cicadellidae--130
- Cicadidae--1
- Fulgoridae--3

HEMIPTERA

- Pentatomidae--1
- Reduviidae--1
- Miridae--4
- Anthocoridae--5
- Coreidae--4

THYSANOPTERA

- Frankliniella-100

LEPIDOPTERA

- Miscell.--85
- AQ. Pyralid--1

DIPTERA

- Chironomidae--4000 (discard 500)
- Ceratopogonidae--50
- Tipulidae--1 (discard)
- Miscell.--500

NEUROPTERA

- Coniopterygidae--1
- Myrmelionidae--4

(Site #7 Continued)

HYMENOPTERA

Formicidae--150

Others--12

TRICHOPTERA

Hydroptilidae--6

Comments: The few Trichoptera suggest a seep rather than a stream. Many mites attached to the chironomids. The two Chaetarthria (Hydrophilidae) suggest a pool (streamside and warmer than river temp.) Some variety of Lepidoptera indicating var. of vegetation. The 10 fams. of Coleoptera suggest a variety of sites at this location. It is quite sandy here as indicated by the Myrmelionidae and Formicidae. The only beetle not taken in previous samples was the Bostrichidae-associated with dead wood. The single aquatic Pyralidae does indicate a stream other than the river but this could have flown from miles away.

Grand Canyon Site #8--Mile 133--Tapeats Creek, perennial stream
August 6, 1982; Near creek in Baccharis; willow/horsetail; partly to total clouds; no breeze.
Light on 9:17 (air 24°C); light off 11:27 (20°C).

COLEOPTERA
- Chrysomelidae
  - Pachybrachys--1
  - Phyllotreta--1
  - Longitarsa--60
- Scarabaeidae
  - Diplotaxis--4
  - Cyclocephala--1
- Anthicidae--1
- Bostrichidae--1
- Carabidae--3
- Melandryidae--2
- Staphylinidae
  - Homaeotarsus--1

HYMENOPTERA
- Formicidae--75
- Miscell.--20

HOMOPTERA
- Cicadellidae--35
- Fulgoridae--9

HEMIPTERA
- Anthocoridae--2
- Miridae--16

THYSANOPTERA
- Frankliniella--100

LEPIDOPTERA
- Miscell.--290
- AQ. Pyralidae--13

DIPTERA
- Chironomidae--125
- Ceratopogonidae--23
- Tipulidae--6
- Asilidae--1
- Miscell.--50

NEUROPTERA
- Myrmelonidae--8
- Mantispidae--1

TRICHOPTERA
- Hydroptilidae--15
- Hydropsychidae
  - Hydropsyche--54 (38 males)
- Rhyacophilidae
  - Rhyacophila--5 (4 males)
- Glossosomatidae
  - Glossosoma--10 (1 male)

(Site #8 Continued)

Comments: The 85 caddisflies representing 4 families is indicative of a nearly permanent stream. This applies also to the aquatic pyralids. It is notable that few Chironomidae occurred in this collection compared with other sites. Possibly some could have come from the river as well as from the smaller stream. The tipulids could have come from the smaller stream or possibly a nearby seep.

Grand Canyon Site #9--Mile 153

August 7, 1982; Below Upset Rapid (Hotel); on side canyon; partly cloudy; light breeze 9:30 near beach.

Light on 8:00 (air 25°C); light off 9:30 (air 25°C).

COLEOPTERA

- Staphylinidae
  - Carpelimus--few
  - Platystethus--2
  - Aleocharinae--100
- Scarabaeidae
  - Diplotaxis--2
- Elateridae--2
- Lampyridae--1
- Carabidae--2
- Oedemeridae--1
- Meloidae--1
- Ptiliidae--1
- Melandryiidae--3
- Anthicidae--2
- Hydrophilidae
  - Chaetarthria--1
- Chrysomelidae
  - Phyllotreta--1
  - Genus?--2

HYMENOPTERA

- Formicidae--25
- Fams.--10

HOMOPTERA

- Cicadellidae--25
- Aphididae--3

HEMIPTERA

- Lygaeidae--13
- Anthocoridae--1
- Miridae--8

THYSANOPTERA

- Frankliniella--100

LEPIDOPTERA

- Pyralidae--1
- Fams.--95

DIPTERA

- Simuliidae--6
- Tipulidae--1
- Chironomidae--250
- Fam.?--250
- Ceratopogonidae--250

NEUROPTERA

- Myrmelionidae--1
- Mantispidae--2

TRICHOPTERA

- Hydroptilidae--5

(Site #9 Continued)

Comments: The only suggestion of a lateral stream is the presence of Simuliidae which live in cold water. But the river may be too cold for them. The Hydroptilidae as well as the Tipulidae could have come from a seep. The Aleocharinae indicate a moist area, possibly debris. The Chaetarthria indicate a sluggish stream margin of a small pool. The Pyralidae(1) indicates a stream somewhere nearby. I doubt that its larva lives in the river.

Grand Canyon Site #10--Mile 166

August 8, 1982; slight downstream breeze, slight cloud cover, tamarix

Light on 8:00 (air 26°C); light off 9:30 (air 28°C)

COLEOPTERA

- Pselaphidae--2
- Scarabaeidae
  - Diplotaxis--3
  - Ataenius--13
- Hydrophilidae
  - Berosus--4
  - Chaetocnema--1
- Carabidae--39
- Cicindelidae--7
- Curculionidae--2
- Melandryidae--3
- Anthicidae--100
- Chrysomelidae
  - Phyllotreta--6
  - Genus--5
- Elateridae--37
- Coccinellidae--2
- Oedemeridae--1
- Staphylinidae
  - Paederinae--2
  - Carpelimus--2
  - Aleocharinae--50

HEMIPTERA

- Neididae--8
- Miridae--50
- Anthocoridae--30
- Lygaeidae--75
- Coreidae--2
- Pentatomidae--2
- Cydnidae--2

THYSANOPTERA

- Frankliniella-1000
- Others-100

LEPIDOPTERA

- Aquatic Pyralidae--7
- Mis. fams.--95 (var.)

DIPTERA

- Tipulidae--2
- Simuliidae--3
- Ceratopogonidae--500
- Sciaridae--25-50,000
- Others-200

NEUROPTERA

- Chrysopidae--1
- Coniopterygidae--2

(Site #9 Continued)

HYMENOPTERA

Formicidae--25

Others--50

HOMOPTERA

Cicadellidae--35

Fulgoridae--17

Psyllidae--1

TRICHOPTERA

Hydropsychidae--3

Hydroptilidae--27

ISOPTERA

--1

Comments: The Hydrophilidae indicate small pools or a sluggish stream. The Aleocharinae suggest moist debris, possible beach drift. This also is indicated by the thousands of Sciaridae. Their larvae live in fungi in decayed vegetation. The aquatic Pyralidae indicate a stream with boulders. Simuliidae also would be found in this situation but doubtfully the main stream. The Hydropsychidae could have come from a seep, also the Tipulidae, but the Hydropsychidae are stream species, not the main stream. Since the lower beach is periodically flooded, the Ceratopogonidae very possibly would live in the damp to wet sand near or at the high tide level.

Grand Canyon Site #11--Mile 194

August 9, 1982; clear; moderate upstream breeze.

Light on 9:00 (air 30°C); light off 10:30 (air 24°C)

COLEOPTERA

- Meloidae--1
- Scarabaeidae
  - Diplotaxis--1
  - Genus--1
- Elateridae--1
- Anthicidae--2
- Melandryidae--9

HYMENOPTERA

- Formicidae--6
- Miscell.--5

HOMOPTERA

- Cicadellidae--70

HEMIPTERA

- Cydnidae--1
- Miridae--16
- Lygaeidae--11

THYSANOPTERA

- Frankliniella ?--1

LEPIDOPTERA

- Pyralidae--4
- Miscell.--85

DIPTERA

- Simuliidae--1
- Ceratopogonidae--100
- Chironomidae--100
- Sciaridae-100
- Miscell.--5

NEUROPTERA

- Coniopterygidae--3

TRICHOPTERA

- Hydroptilidae--30

Comments: The aquatic Pyralidae and Simuliidae indicate a lateral stream with rocks. The Hydroptilidae could come from such a stream, also from a seep. It is noteworthy that relatively few Chironomidae occurred in this collection.

Grand Canyon Site #12--Mile 220

August 10, 1982; Moderate downstream breeze; clear; Tamarix/beach; intermittent stream.

Light on 9:30 (air 32°C); light off 11:00 (air 28°C)

COLEOPTERA

- Scarabaeidae
  - Diplotaxis--31
- Elateridae--3
- Anthicidae--2
- Melandryidae--2
- Chrysomelidae--2
- Staphylinidae
  - Aleocharinae--2
- Hydrophilidae
  - Berosus--1
- Carabidae--1

HYMENOPTERA

- Formicidae--13
- Miscell.--9

HOMOPTERA

- Cicadellidae--11
- Fulgoridae--1
- Aphididae--1

THYSANOPTERA

- Frankliniella--200

ORTHOPTERA

- Tridactylidae--2 (nymphs)

HEMIPTERA

- Lygaeidae--10
- Anthocoridae--1
- Miridae--27
- Neididae--2

LEPIDOPTERA

- Miscell.--66
- Aquatic Pyralidae--2

DIPTERA

- Simuliidae--8
- Ceratopogonidae--15
- Chironomidae--35
- Sciaridae--75
- Miscell.--50

NEUROPTERA

- Myrmelionidae--2
- Coniopterygidae--1

TRICHOPTERA

- Hydroptilidae--8

ODONATA

- Anisoptera--1

(Site #12 Continued)

Comments: Although this locality has an intermittent stream, possibly the Pyralidae and Simuliidae only came from it. Only the caddisfly family Hydroptilidae occurred in this collection, and larvae could have occurred in the stream or in a seep. Berosus (Hydrophilidae) indicates a small pool. This is the first Odonata in this series of light trap collections, and it may have come from the intermittent stream. The Tridactylidae (pygmy mole crickets) are nymphs, and occur in damp places, possibly along the intermittent stream. Nymphs are of course wingless, and their occurrence in the trap is accidental.

CHAPTER VI. SMALL MAMMAL POPULATIONS IN RIPARIAN AND DESERT HABITATS WITHIN THE COLORADO RIVER CORRIDOR

M. Trimble, M. Opalak, L. Perry and P. Iaquinto

This project was designed to determine small mammal use in three distinct habitats along the Colorado River corridor in Grand Canyon. Homogeneous stands of salt cedar, willow, and mesquite/acacia or desert scrub were sampled for small mammal density. The salt cedar and willow habitats constitute the true riparian zone of the river and the mesquite/acacia-desert scrub habitats represent the old pre-dam high water level and the desert and talus vegetative associations that are out of the river influence zone.

METHODS

During the 14-day river expedition, eight nights and seven beaches were available for sampling small mammals. The sample beaches by colloquial name and river mile were as follows: Ferry Swale (-11), Anasazi Bridge (40), Chuar Canyon (66), Blacktail I (120), Blacktail II (220), Tapeats Creek (134), Lower National (166), and 220 Mile Beach (220). One hundred Sherman live traps were run and captured mammals identified to species at first light the following day. The traps were divided evenly between the habitats available for trapping. In some cases, only two zones with 50 traps each were set as a third habitat type was unavailable or in insufficient quantity to sample. After capture the animals were released unharmed.

RESULTS

Table VI-1 presents the results from the sampling effort. In 800 trap-nights of sampling, 60 individual mammals representing six species were

captured for an average of 7% trap success per night.

The most abundant species was the cactus mouse, Peromyscus eremicus, with 40 individuals captured. The cactus mouse was distributed fairly evenly in the three habitats sampled, with 30% captured in salt cedar, 33% in willow, and 37% in the mesquite/acacia-desert scrub habitats. The next most common animal taken was the woodrat Neotoma albigula, with a total of 7 animals captured, most of which (43%) were found in the mesquite/acacia-desert scrub habitat. Two woodrats each were found in the salt cedar and willow habitats. Other animals captured include the white-footed deer moise, Peromyscus maniculatus, all five of which came from the salt cedar habitats, the canyon mouse, Peromyscus crinitus, three from the mesquite/acacia-desert scrub and one from the salt cedar, and a single specimen of the rock pocket mouse was found in the desert habitat. In total, 35% of all captures were in salt cedar, 25% in willow, and 37% in the mesquite/acacia-desert scrub.

DISCUSSION AND CONCLUSIONS

Due to the small sample size it is impossible to draw any significant conclusions as to habitat partitioning by vegetative zone in small mammals along the Colorado River in Grand Canyon. Peromyscus eremicus is the most common species of the area being equally distributed in each of the three habitat types measured. Peromyscus maniculatus was only found (n=5) in the salt cedar habitat and this supports conclusions arrived at earlier relative to the recent colonization of this species in the Grand Canyon, apparently in response to the invasion of the salt cedar after Glen Canyon Dam prevented flooding in the inner canyon (pers. comm., S.W. Carothers).

Table VI-1. Small mammal trap results* by habitat type, Colorado River, August 1982.

Species	Habitat			
	Salt Cedar	Willow	Mesquite/Acacia-Desert Scrub	Total
Peromyscus eremicus	12 (30%)	13 (33%)	15 (37%)	40
Peromyscus maniculatus	5 (100%)	0	0	5
Peromyscus boyleii	3 (100%)	0	0	3
Peromyscus crinitus	1 (25%)	0	3 (75%)	4
Peromyscus intermedius	0	0	1 (100%)	1
Neotoma albigula	2 (29%)	2 (29%)	3 (43%)	7
				60

*800 trap nights total, 60 mammals captured = 7% trap success.

CHAPTER VII. TERRESTRIAL VERTEBRATE USE OF WOODY RIPARIAN VEGETATION IN COLORADO RIM HABITATS

T.G. Olsen, M.M. Sharp, D. Dancis, A. Benson and L. Perry

Within the riparian zone of the Colorado River in Grand Canyon there are four distinct "belts" of vegetation that are found throughout the length of the canyon. Although certain vegetational changes occur on an elevational gradient from Lee's Ferry to Lake Mead, consistent habitat zones are found on a gradient from the river's edge (Tamarisk, Willow, Seep Willow) to the main beach campsites inland (Arroweed, Tamarix) to the old pre-dam high water flood line (Mesquite, Acacia, Apache Plume) to the farthest inland association of the true desert or desert scrub species.

During this research project, the authors tested the hypothesis that the principal woody or tree-like species of vegetation were used with equal intensity by diurnal vertebrate wildlife species. The tree species for which data were gathered were as follows: (1) Salt Cedar, Tamarix chinensis; (2) Willow, Salix sp.; and (3) Mesquite, Prosopis juliflora.

METHODS

In an attempt to take advantage of the several stops at specified beaches for the sand discoloration project, one or more observers would slowly walk through a specified vegetation type and record all animals observed during a timed observation period. (For convenience, data have been converted to number of observations per hour or density/hour.) Since most riparian birds in the Grand Canyon have finished nesting by mid-August (the time of our surveys), better bird data would be available during an earlier part of the summer season. Nevertheless, this preliminary study showed an interesting trend.

RESULTS

Table VII-1 presents the standardized results of the observational data in three principal vegetation species, Tamarisk, Mesquite, and Willow. Data from other species were too limited to utilize. No statistical comparisons in animal use between the vegetative types are valid because of the amount of time spent in the Salt Cedar relative to the two other species and the overall low sample number; however, the data do show a strong trend indicating that the Salt Cedar is used more than the Willow or Mesquite. The average number of species and average number of individuals seen in the Salt Cedar per one hour of observations was 9.26 and 17.05 respectively. This is compared to 8.0 and 12.0 species and individuals per hour in the Willow and 5.0 and 7.0 in the Mesquite.

Table VII-2 lists the species seen by vegetative species during the timed observations. A total of 20 species was seen in the Salt Cedar, including both reptiles and birds and 12 species were seen in both the Willows and Mesquite.

DISCUSSION AND CONCLUSION

The Salt Cedar is an exotic species to the Grand Canyon environs. The introduction of the species into the southwestern United States apparently took place near the turn of the century, but it was not until Glen Canyon Dam prevented the annual scouring floods that Salt Cedar became abundant in the riparian zone of the Grand Canyon. Both the Willow and Mesquite species are native to the area; however, the dam-altered regimen of the river seems to favor the proliferation of Salt Cedar. There are many unanswered questions relative to the future condition of the riparian habitat of Grand Canyon, and in some areas it appears that Willows may be winning competitive interactions

with the Salt Cedar.

Our findings, although very preliminary in nature, indicate that the exotic Salt Cedar is being utilized by reptiles and birds to a greater extent (in both species and individual numbers) than the native Willows and Mesquites. A more comprehensive research program designed to statistically compare wildlife use in the various zones of vegetation on the Colorado River is needed.

Table VII-1. Diurnal vertebrate use on Salt Cedar, Willow, and Mesquite in the riparian zone of the Colorado River, August 1982.

Vegetation	Total Hours	Number of Species/hr.	Number of Individuals/hr.
Salt Cedar	10.6	*9.26	17.05
Willow	2.8	8.0	12.00
Mesquite	3.1	5.0	7.00

*data reflect average number of species on individuals observed per hour.

Table VII-2. Species of diurnal vertebrates observed in Salt Cedar, Willow, and Mesquite during timed observations, Colorado River, August 1982.

Species of Reptiles	Salt Cedar	Willow	Mesquite
Desert Spiny Lizard	X		X
Whiptail Lizard	X	X	X
Side-blotched Lizard	X		
Collared Lizard			X
Tree Lizard	X		
Grand Canyon Rattlesnake	X		
Species of Birds			
American Kestrel	X	X	X
Yellow Warbler	X		
Lucy's Warbler	X		
Yellowthroat	X		
Yellow-breasted Chat	X	X	
Bell's Vireo	X		
Ash-throated Flycatcher	X	X	X
Western Kingbird	X		
Say's Phoebe	X	X	X
Mourning Dover	X	X	X
Canyon Wren	X	X	X
Rock Wren		X	X
Blue-gray Gnatcatcher		X	X
Brown-headed Cowbird	X	X	X
House Finch	X	X	X
Blue Grosbeak	X	X	
Black-headed Grosbeak	X		
TOTAL	20	12	12

CHAPTER VIII. HUMAN IMPACT ON THE BEACHES OF THE COLORADO RIVER

S.W. Carothers, R. Mickler, J.W. Biddle, M. Opalak, R. Johnson, W. Wasley and R. Romero.

INTRODUCTION

Within the past 20 years two major and distinctly interrelated natural resource management problems have arisen along the river corridor of the Colorado River in Grand Canyon National Park. Specifically, the problems relate to 1) the extensive environmental changes that have taken place in the hydrological characteristics of the river as a result of Glen Canyon Dam and 2) the dramatic increase in recreational use of the system by river runners.

Although located 15 miles upstream of the National Park boundary, Glen Canyon Dam changed the very nature of the Colorado River in Grand Canyon almost as soon as construction began in the mid 1950's. Post-Dam changes in water flow, temperature and sediment discharge have all combined, often synergistically, to alter the Grand Canyon river ecosystem. On one side of Glen Canyon Dam, the wildly variable and raging Colorado River has been buried beneath the deep waters of Lake Powell; on the other side, the river we still call the Colorado is released through turbines and gates as a predictable, computer regulated, icy cold, sediment-free, and at least for the next several hundred years, partially tamed river. To further complicate the matter, the "new" dam-controlled Colorado River in Grand Canyon has recently proven to be one of the most popular white-water recreation areas in the world, with a strict National Park Service permit system regulating and allocating both private and commercial use of the 225 miles of Colorado River from Lee's Ferry to Diamond Creek (NPS 1981).

Given the above considerations, the present challenges to developing an

adequate system for resources management along the river corridor of Grand Canyon National Park include a) determining the eventual ecological "steady state" of the dam-altered river in terms of sediment erosion and deposition, vegetative and animal community composition and overall ecosystem stability relative to b) determining and evaluating the impacts of river recreationists[1] on the changing aquatic and terrestrial systems and c) mitigating such recreational impacts to the extent that natural park values are not compromised.[2]

As mandated by "The Planning Process of the National Park Service" in 1975, a Colorado River Management Plan (NPS 1981) was drafted to guide short- and long-term management of the riverine and riparian areas of Grand Canyon National Park. Subsequently, a monitoring program was initiated to analyze and quantify human impacts and to determine how changes in management policies influence present resource trends. This monitoring program was designed to gather baseline data and to show the impact (adverse and otherwise) of visitor numbers and use patterns on the riparian environment.

Heavy recreational use in other parks has caused changes in plant species composition, vegetation density and diversity (Burden and Randerson 1972; Whitson 1974; Dolan et al. 1974; Bates 1935; Dotzenko et al. 1967; LaPage 1967; Liddle 1975; Liddle and Greig-Smith 1975; Young and Gilmore 1976). Preliminary data from Grand Canyon (Carothers and Aitchison 1976) indicated that similar changes or impacts were taking place on the principal campsites (100 + popular campsites; Borden 1976) of the river corridor. All of these

[1]The definition of river recreationists here is expanded to include non-river running back country users who frequently utilize and potentially impact river beach campsites.

[2]On the Colorado River in Grand Canyon, Glen Canyon Dam has so altered the system, that an ecological/aesthetic definition of naturalness is not apparent.

campsites are on alluvial terraces (sand and silt/sand composition) that were deposited during pre-dam flood discharges. With flow levels presently regulated and floods virtually non-existent, these alluvial terraces are now permanently isolated from future floods. As such, vegetation, previously scoured from the beaches on an annual basis, now proliferates while human related debris incorporated into beach sands during normal camping activities accumulates. With no natural purging of recreation related debris (organic as well as inorganic) there exists the potential for popular beaches to fill "cat box style" with any number of forms of human waste products. Additional problems of a similar vein have recently been observed in back country campsites where recreational use is clearly in excess of the natural purging capacity of the system.

Early in 1976, approximately 25 Colorado River campsites in Grand Canyon were selected for the purpose of monitoring levels of recreational impact (see Carothers 1977). In 1980-81, 9 additional beaches in the 15 miles of Glen Canyon below Glen Canyon Dam were evaluated for levels of human impact (Carothers et al. 1981). Since 1976 the original Grand Canyon sites have been monitored and re-evaluated several times (Carothers and Johnson 1980).

This report presents human impact data for 35 beach sites in Glen and Grand Canyons, information gathered during our river expedition of 1982, and compares these data with the results of previous sampling efforts.

We also present herein a new methodology for evaluating the relative discoloration of beach sand.

OBJECTIVES AND METHODS

The specific objectives of our monitoring efforts were to monitor levels of incorporation of recreationally related debris into major river

campsites. As in the past, we concentrated our efforts into measuring the amount of litter and charcoal particles (greater than 1 cm in size) found along transects of the beach surface, and determine the amount of actual sand discoloration that could be attributed to human recreational activities.

The procedures are as follows:

1) A transect line is established through the principal use area of the beach; the length of the transect is a function of beach size, with the smallest line reaching 19 m and the longest 45 m.
2) Black and white photographs of the transect (with meter tape extended) are taken from each end of the transect.
3) Along each transect line, 10 - 1 m^2 plots are selected in evenly spaced intervals. The m^2 plot alternates from one side of the transect line with m^2 plot No. 1 positioned at line interval 0 to 1 m, on the river side of the transect. The m^2 plot no. 2 alternates to the shore side of the transect line, and so on.
4) Within each m^2 plot, all particles of human debris and charcoal particles (greater than 1 cm in size) are counted and recorded.
5) Within the center of each m^2 plot, a 50 cc sample of sand is taken and sieved through a 150 micron stainless steel mesh. Two additional sand samples are taken from the beach area as standards to compare with the transect line sand. One sample comes from the present sand water interface where the sand and water are in contact, and another sample is taken from beneath (0.5 m below) vegetated areas where it is assured human discoloration cannot exist.

During the present study, the sand discoloration was evaluated with a Colorguard II Reflectometer. This instrument, operating with an optical system, photocell amplifier, digital readout and portable power system, has

been developed to make reflectance measurements. Hence, with a digital readout display, reflected light can be measured from any source. We shake our sieved 50 cc sand samples (12 per beach) against no. 7 coarse grade white filter paper discs, then measure the amount of light reflected from the paper. The reflectometer is standardized prior to each beach sampling against a white standard (digital reading 86.1) and a grey standard (digital reading 42.6) to calibrate the instrument. Thus, the discoloration values for filter paper stained with filtered beach sand range from 47 (very dirty fire pit sand) to 70 (sand uninfluenced by humans).

RESULTS

The results of the sand sampling are presented in Table VIII-1 where the values recorded for the sand discoloration (reflectometer readings), charcoal accumulation and human debris are presented for each campsite, including the common name of the camp and river mile location. Figures VIII-1-3 compare each of the beaches for sand discoloration, charcoal and litter accumulations, respectively.

Table VIII-2 compares the data for charcoal and litter accumulation for each beach from 1976-1982. The sand discoloration data from previous years has not yet been converted to the same scale as the reflectometer data and will not be compared herein.

The difference in the quality of the beaches in Glen Canyon and Grand Canyon has been previously discussed in detail (Carothers et al. 1981) and will not be belabored here. Due to the lack of user control and stringent regulations against beach resource destruction in general, the Glen Canyon area is far more impacted by river recreationists than the downstream area in Grand Canyon. A program of fire and litter restriction and a human waste

Table VIII-1. Results of Human Impact Analysis on Beach Campsites in Glen and Grand Canyons, August 1982.

Camp-site No.	Camp-site Name	River Mile*	Sand Color Undisturbed	Sand Dis-coloration	Charcoal (¨1 cm)/m^2	Human Litter/m^2
			GLEN CANYON CAMPSITES			
1	Water Plant	-14.0	68.0	51.0	45.0	6.5
2	Ropes Trail	-13.5	65.1	53.1	16.1	2.3
3	Ferry Swale	-11.0	71.8	54.8	32.8	6.2
4	Faatz (control)	-10.0	70.6	67.8	0.0	0.1
5	Rock Art	-9.5	69.0	56.0	34.2	1.3
6	Finger Rock	-7.5	60.8	56.0	34.7	3.9
7	Three Mile Bar	-3.0	58.5	47.6	31.8	3.4
8	Two Mile Dune	-2.0	63.9	57.0	59.4	4.1
			GRAND CANYON CAMPSITES			
9	Badger	8.0	70.6	64.6	10.7	0.4
10	Twenty-Mile	20.0	54.4	58.8	1.0	0.5
11	Shinumo	29.0	70.3	62.9	1.0	0.5
12	Anasazi Bridge	43.0	67.3	64.8	0.2	0.1
13	Saddle Canyon	47.0	65.6	54.5	4.8	0.8
14	Nankoweap	52.0	6.7	59.5	9.0	0.0
15	Chuar	66.0	58.1	57.5	1.1	0.4
16	Unkar	72.0	64.4	64.3	1.9	0.1
17	Nevills	75.0	66.6	66.9	0.7	0.2
18	Hance	76.0	64.6	64.1	8.1	0.3
19	Granite	94.0	66.9	58.0	3.0	0.2

20	Lower Bass	108.0	64.5	59.4	3.6	1.2
21	Upper Hakatai	109.0	70.8	66.0	0.8	0.3
22	114 Mile	114.0	66.7	66.2	0.9	0.2
23	Blacktail	120.0	67.4	59.7	0.9	0.8
24	Dubendorff	131.0	61.4	64.4	1.2	0.3
25	Deer Creek	136.0	66.1	62.0	4.7	2.5
26	Pancho's Kitchen	137.0	63.8	62.3	1.6	1.3
27	Olo	145.0	--	--	0.4	0.0
28	Upper National	166.0	68.8	59.2	0.8	5.6
29	Lower National	166.2	70.2	66.7	9.0	0.4
30	Lava Falls	179.0	59.2	60.8	2.6	0.2
31	185 Mile	185.0	69.8	60.9	0.0	0.0
32	Parashant	198.0	67.2	63.5	10.8	0.5
33	Granite Park	209.0	62.6	60.4	7.7	0.3
34	219 Mile	219.0	59.4	64.9	1.2	0.3
35	220 Mile	220.0	64.0	62.3	13.8	0.4

*Negative sign indicates distance in miles above Lee's Ferry.

Table VIII-2. Comparisons of charcoal (¨1 cm) and human litter concentrations on campsite transects for 1976, 1979, 1980, and 1982 (Grand Mean only).

Camp-	Charcoal/m^2					Litter/m^2				
site No.	1976	1979	1980	1981	1982	1976	1979	1980	1981	1982
1	--	--	--	65.4	45.0(-)***	--	--	--	8.8	6.5(-)
2	--	--	--	43.7	16.1(-)**	--	--	--	6.2	2.3(-)***
3	--	--	--	24.9	32.8(+)	--	--	--	1.0	6.2(+)**
4	--	--	--	0.0	0.0(0)	--	--	--	0.0	0.1(0)
5	--	--	--	113.7	34.2(-)***	--	--	--	18.9	1.3(-)***
6	--	--	--	112.2	35.7(-)***	--	--	--	5.1	3.9(-)
7	--	--	--	50.1	31.8(-)	--	--	--	3.3	3.4(0)
8	--	--	--	76.0	59.4(-)	--	--	--	4.9	4.1(-)
9	23.5	4.0(-)	--	--	10.7(+)	0.3	0.7(+)	--	--	0.4(-)
10	--	--	--	--	1.0	--	--	--	--	0.5
11	2.0	6.2(+)	2.8(-)	--	1.0(-)	0.3	1.1(+)	1.1(0)	--	0.5(-)
12	1.0	1.0(0)	--	--	0.2(-)	0.2	0.1(-)	--	--	0.1(0)
13	4.3	1.6(-)	1.2(-)	--	4.8(+)	0.2	0.2(0)	0.8(+)	--	0.8(0(
14	20.9	12.4(-)	--	--	0.2(-)	0.9	0.4(-)	--	--	0.0(-)
15	10.0	8.6(-)	--	--	1.1(-)***	0.7	0.8(-)	--	--	0.4(-)
16	3.1	1.0(-)	--	--	1.9(+)	0.5	0.3(-)	--	--	0.1(-)
17	19.2	4.1(-)	2.8(-0	--	0.7(-)***	1.0	0.2(-)	0.6(+)	--	0.2(-)

18	12.9	19.3(-)	23.5(+)	--	8.1(-)	0.5	0.8(+)	1.2(+)	--	0.3(-)
19	19.5	4.8(-)	--	--	3.0(-)***	2.1	0.7(-)	--	--	0.2(-)
20	8.1	4.5(-)	2.5(-)	--	3.6(+)	1.1	0.3(-)	0.9(+)	--	1.2(+)
21	5.0	0.0(-)	--	--	0.8(+)	1.2	0.5(-)	--	--	0.3(-)
22	2.5	0.2(-)	1.6(+)	--	0.9(-)	0.6	0.2(-)	0.5(+)	--	0.2(-)
23	1.1	1.0(-)	--	--	0.9(-)	0.5	0.2(-)	--	--	0.8(+)
24	4.2	1.0(-)	--	--	1.2(+)	0.4	0.2(-)	--	--	0.3(+)
25	2.9	1.3(-)	1.0(-)	--	4.7(+)**	0.8	0.5(-)	0.1(+)	--	2.5(+)
26	7.3	0.7(-)	0.3(-)	--	1.6(+)	1.5	0.1(-)	0.3(+)	--	1.3(+)
27	1.2	0.0(-)	--	--	0.4(+)	0.6	0.2(-)	--	--	0.0(-)
28	8.4	0.6(-)	--	--	0.8(+)	1.5	0.2(-)	--	--	5.6(+)**
29	6.1	0.9(-)	1.5(+)	--	9.0(+)**	0.5	0.1(-)	0.3(+)	--	0.4(+)
30	11.3	0.3(-)	0.3(0)	--	2.6(+)	3.6	0.3(-)	0.5(+)	--	0.2(-)
31	0.4	0.0	--	--	0.0	0.4	0.0(-)	--	--	0.0(0)
32	2.4	1.2(-)	2.7(+)	--	10.8(+)**	0.4	0.0(-)	3.8(+)	--	0.5(-)
33	5.7	1.9(-)	5.3(+)	--	7.7(+)	1.0	0.4(-)	0.4(0)	--	0.3(-)
34	0.9	1.9(+)	0.2(-)	--	1.2(+)	0.2	0.1(-)	0.2(+)	--	0.3(+)
35	9.3	1.2(-)	2.2(+)	--	13.8(+)**	1.3	0.4(-)	0.2(-)	--	0.4(+)

(+), (-), and (0) indicate the direction of change since previous reading.

** indicates a trend for a significant increase in charcoal or litter.

*** indicates a trend for a significant decrease in debris.

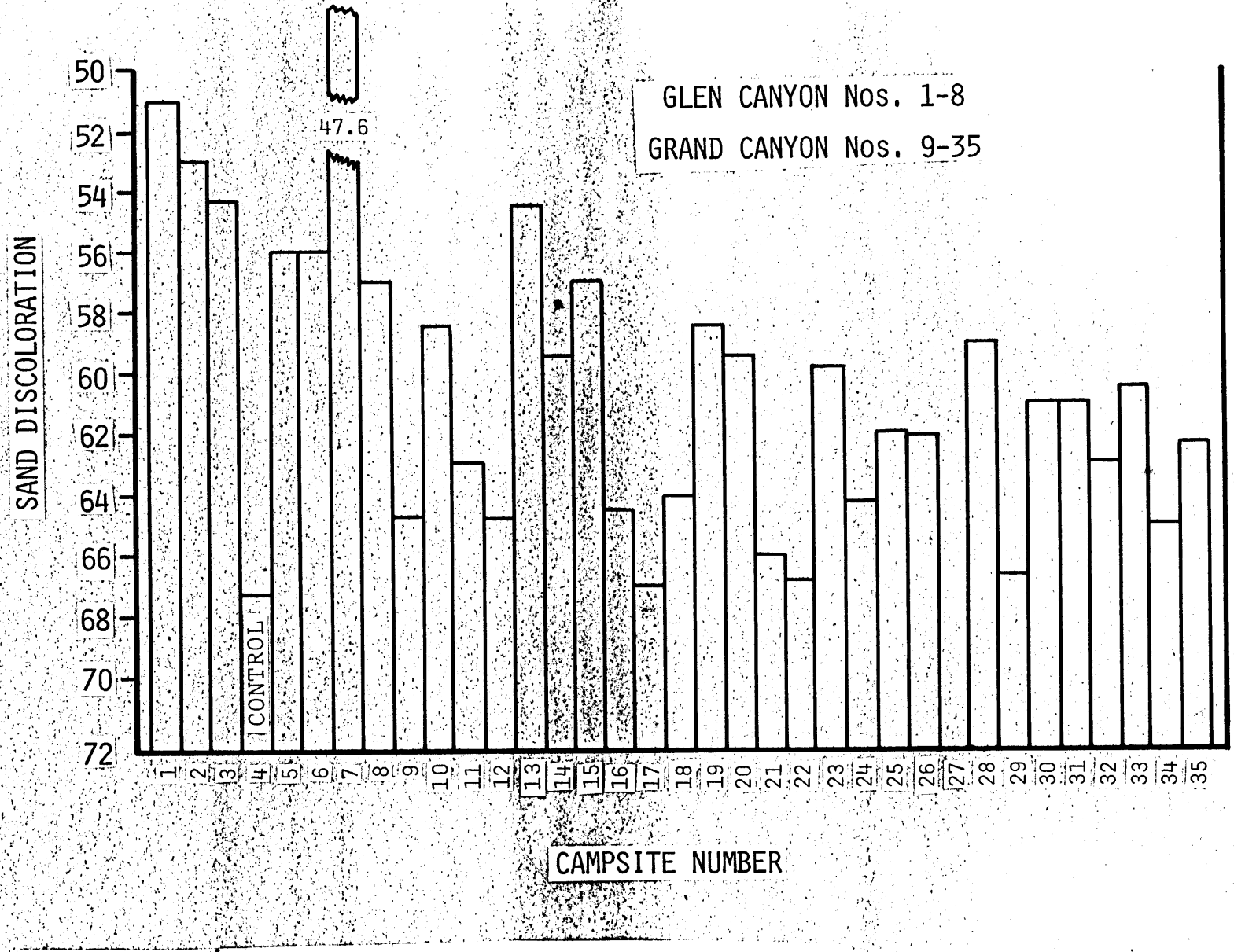

Figure VIII-1. A histogram showing sand discoloration values for 35 beaches in Glen and Grand Canyons.

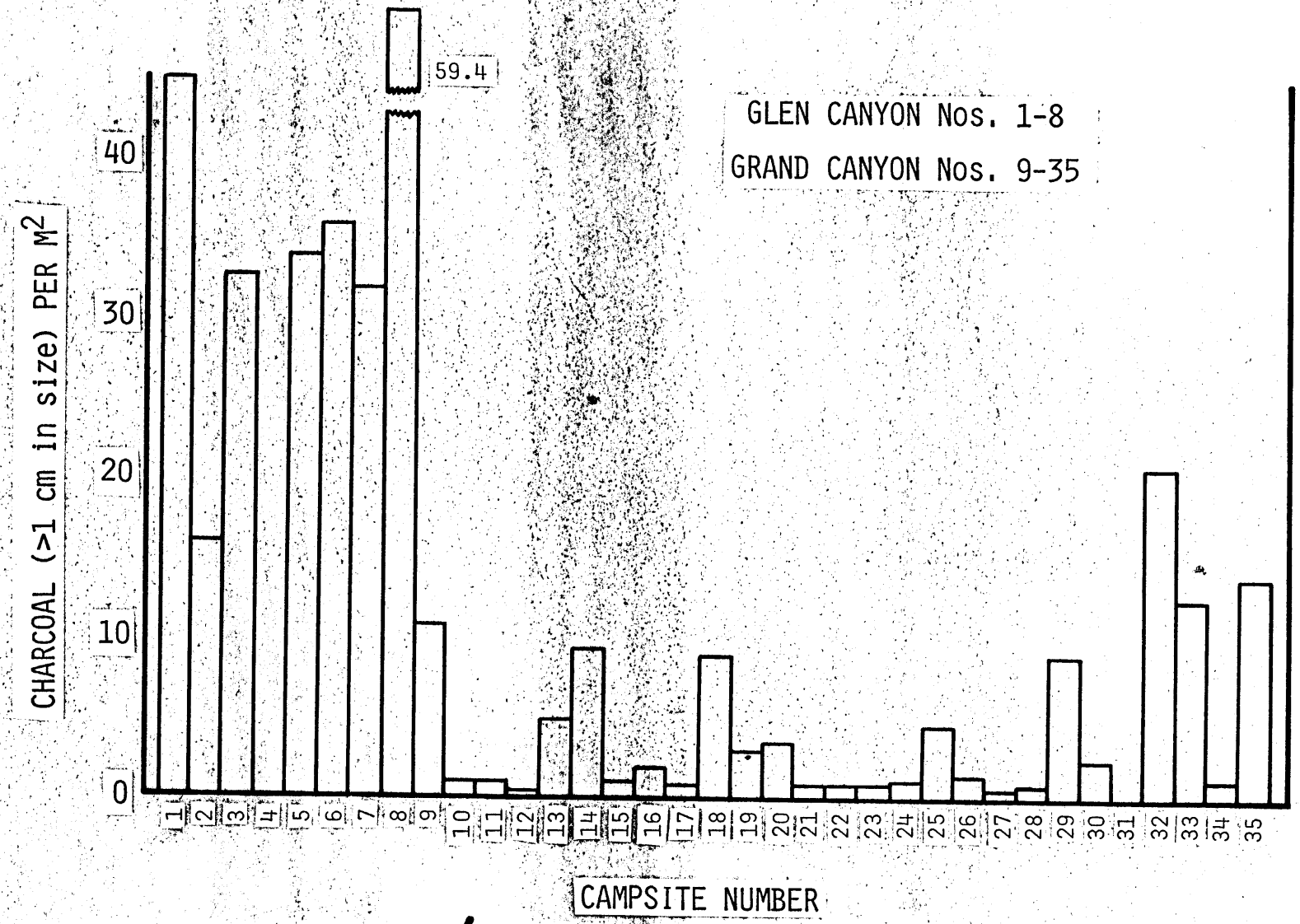

Figure VIII-2. A histogram showing the amount of charcoal/M^2 on 35 beaches in Glen and Grand Canyons.

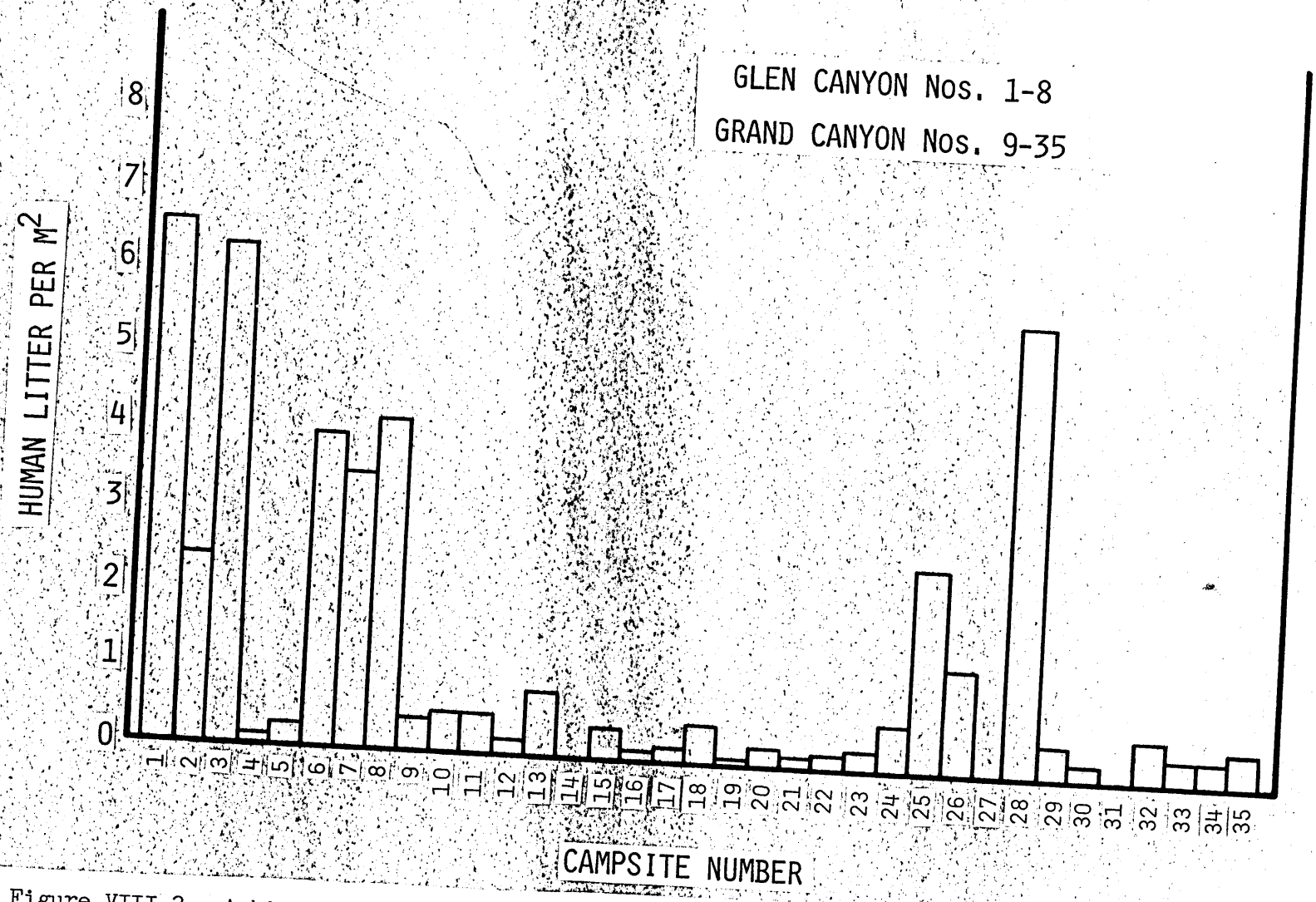

Figure VIII-3. A histogram showing the amount of litter/M^2 on 35 beaches in Glen and Grand Canyons.

disposal system are needed in Glen Canyon and the NPS in the recreation area is actively working toward those goals.

In general, the conditions of the beaches in Glen Canyon have improved since they were studied last in May 1981. In Glen Canyon, in 15 months time, four of eight beaches showed a significant decrease in charcoal accumulation and only one of the eight had any charcoal increase (Ferry Swale from 24.9 to 32.8/m^2). There is also a trend for decreasing litter in Glen Canyon, with two of the eight beaches showing dramatic decreases and all but one (Ferry Swale increase from 1.0 to 6.2) showing at least some decrease in accumulation of human debris.

It is important to note that NPS Resources Management personnel have been initiating specific actions toward improving the Glen Canyon area within the past 15 months and it appears as if some improvement is forthcoming. The apparent trend for a general improvement of the Glen Canyon Beaches is interesting in light of the fact that from October 1980 to May of 1981, the trend was the reverse, that is deteriorating conditions for all parameters measured (see Carothers et al. 1981).

The quality of the beaches in Grand Canyon demonstrates an overall trend for low incidence of charcoal and litter with little change from one study period to the next. There are however a few beaches where there is either an alarming increase in litter or charcoal, or a substantial decrease in these items since the project was initiated.

Three beaches in Grand Canyon, sites 15, 17, and 19, Chuar, Nevills and Granite respectively, show significant decreases in charcoal from 1976 to 1982. Four Grand Canyon beaches, however, have increases in charcoal/m^2, sites 25, 29, 32 and 35, Deer Creek, Lower National, Parashant and 220 Mile respectively. Dear Creek and site 28, Upper National also have substantially

more litter now than was present during the previous sampling.

CONCLUSIONS

The beaches in Glen Canyon are far more charcoal and debris laden than Grand Canyon beaches. The Glen Canyon beaches have however improved substantially in the past 15 months.

Grand Canyon beach quality has remained relatively stable over the past several years, with the exception of a few beaches that may need management attention. These beaches are Deer Creek, Lower National*, Parashant and 220 Mile.

*Note: Lower National now receives most of the camping activity that was previously shared by its sister camp, Upper National. A series of flash floods (National Camp) and the high water of June 1980 have all but removed the Upper National Camp.

CHAPTER IX. INTERACTIONS OF HARVESTER ANTS (POGONOMYMEX) AND RIVER RECREATIONISTS

by Kathy Peterson

INTRODUCTION

One of the most prevalent creatures in the Grand Canyon is the Harvester ant (Pogonomymex californicus). Found in a variety of forms and occupying diverse habitats, the Harvester is an ubiquitous element of canyon life, conspicuous only when members of its species are absent.

This report presents the findings of a project designed to test the hypothesis that Harvester ant densities along Colorado River beaches in Grand Canyon are higher in areas of heavy human recreational use.

Previous investigations on the ant/human interactions along the Colorado River have been limited to a single effort in July of 1977 (Hayden et al. 1977). In the work of Hayden et al., two basic habitat types were studied, that is, a) areas where river recreationists camped and b) areas for which no evidence existed that human use had previously taken place. Three types of data were collected, a) ant population density, b) total number of ant colonies, and c) observations on social behavior and foraging patterns. Based on data gathered it was clear that Harvester ant population densities were an order of magnitude greater in the areas utilized by river recreationists than in the non-utilized areas. Hayden et al. (1977) concluded "...the main cause of the variation in population density...is man as an agent adding food energy to the beach deposits and thereby altering and enhancing the food chain."

The 1977 study clearly shows that man is having a marked effect on the Harvester ant population. The next question to be asked is whether or not there is a positive correlation between Harvester ant density at a particular

campsite and the frequency with which that campsite is used.

THE HARVESTER ANT

This hymenopteran species ranges from Texas to Nevada and California. The workers are 5.0 to 6.5 mm in length, and are frequently described as being a ferruginous red. A characteristic of P. californicus is its ability to sting. When disturbed, the workers (sterile females) aggressively use their modified ovipositors against intruders.

P. californicus tends to nest in sand areas. Nests are distinctive, characterized by low, fan-shaped mounds on one side of the entrance. There is usually only one main entrance to the nest, and this is closed at night.

P. californicus is primarily a seed-eating ant. Seeds are a predominant energy source for ants living in dry habitats because this food resource has high nutrient value; they are rich in lipids and nitrogen, and metabolized seeds yield some free water. The foraging strategy adopted by a particular ant species is determined by the pattern of food distribution. Among species of ants, there are two common foraging strategies: 1) individual foraging and 2) group foraging. P. californicus is known to forage only during the day, and, fortunately for recreationists, is not active at night.

METHODS

The methods used in this summer's study were relatively uncomplicated. The only materials necessary were a measuring tape and compass.

First, the area of a campsite was measured, usually centered on the transect line used in the other human impact studies. Then, the number of anthills belonging to P. californicus within this area were counted. It is important to note that each anthill observed does not necessarily denote a

separate nest; single nests may have more than one entrance, and little-used side entrances are not unknown and warrant their own distinctive fan-shaped mound - in which cases only the main hill was noted.

RESULTS

The densities obtained were transformed into anthills/100 m^2 (see Table IX-1). These data were then graphed against the frequency of campsite use. Figure IX-1 suggests a positive correlation between anthill density and frequency of human use.

This is a rather crude study and is focused upon a single question: Is there positive correlation between anthill density and human impact, or frequency of campsite use? Other alternatives are possible, but, due to time constraints, were not explored on this trip. Other factors which may influence anthill density include: vegetation type, soil texture, and exposure to the sun. If this study is pursued further, there are suggestions for improving its quality. These suggestions are: 1) greater consistency in data collection, 2) a control site, and most importantly, 3) a more accurate measure of river campsite use; at this point the NPS has inadequate records of the frequency of campsite use, and our index of use was based upon the subjective evaluation of the experienced Grand Canyon boatmen present on our trip.

Table IX-1. A list of sample sites, Harvester ant density and the relative frequency of human recreational use of the sites.

Site	River Mile	Density (anthills/100 m^2)	Campsite Use
1	43	0.00	Low
2	47	1.40	High
3	52	1.10	High
4	76	0.56	High
5	94	0.56	High
6	108	0.00	High
7	109	0.98	High
8	114	0.48	Medium
9	120	0.49	Medium
10	132	0.00	Low
11	136	2.50	High
12	145	0.00	Low
13	166L	0.77	High
14	179	0.00	Medium
15	198	2.30	High
16	209	0.67	High
17	219	0.50	High

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CHAPTER XI. STUDENT COMMENTS TO SUPERINTENDENT RICHARD W. MARKS

On 21 July 1982 the entire class visited the Park facilities at Grand Canyon National Park. During Superintendent Richard W. Marks' presentation to the class he asked each person to write an essay dealing with the students' enlightened perceptions of Grand Canyon management problems and perogatives. Mr. Marks knew that each of the students was involved in a five-week study on a variety of historical, biological, geological, and management features of the Park and he indicated a genuine interest in the students' perceptions. Specific elements of concern for which Mr. Marks indicated a pressing need for public input are as follows:

1. Colorado River Management Issues

   Motors vs. oars
   Carrying capacity of the system
   Beach attractiveness and cleanliness
   Exotic vs. native species (Tamarisk)

2. The Concept of Appropriate Use of Park Resources

   Private vs. commercial use
   Educational use
   Research use
   No use

3. User Day Fees for Canyon Recreation

   River
   Hiker
   Mules

4. Changing Perspectives after Exposure to Grand Canyon

   Personal
   NPS management problems

On 8 August, at the Upset Hotel Camp, just below Upset Rapid (river mile 150), the morning discussion prior to breaking camp and proceeding down river centered on Mr. Marks' request. Dr. Beus and Dr. Carothers each presented their perspectives on the concepts and management needs reflected by the superintendent and it was agreed that the students would immediately begin writing essays in the form of personal letters to Mr. Marks. For the next several days (class ended on 11 August) the students used what precious spare time was left after each full day's work, often writing by candlelight, to prepare their responses. The following are the students' responses in their entirety.

Comments of Jack W. Biddle:

For the past year I have been a social studies/earth science teacher for the Flagstaff Public Schools. Since 1970, I have been very active with an organization out of Capitol University in Columbus, Ohio called International Field Studies. I have acted as a teacher, counselor, coordinator and advisor for many high school and college educational field trips. I have traveled to the majority of the national parks and monuments west of ther Mississippi River, including Alaska.

I believe there is no better way to teach students about a subject than a hands-on learning experience. The outdoor setting brings to life what a student learns from a textbook. Our two and one-half week classroom introduction to the Grand Canyon and Colorado Plateau set the stage for our outdoor learning experience. Dr. Beus and Dr. Carothers are excellent teachers and I can think of no better teachers than these two men. They made the class exciting and fun, while at the same time stressing the importance of our research work in the Grand Canyon.

The course has greatly enlightened me about the problems facing all our national parks and in particular, the Grand Canyon. I am more keenly aware of the massive scope of responsibility of the park service.

The Park Service has the very difficult job of trying to keep the mandate established by Congress. The constant problem of different Presidential Administrations makes it difficult to keep any kind of uniformity in the National Park Service, especially the Department of Interior, the present Secretary of Interior and the politics that constantly disrupt that mandate.

Through classroom lectures and our research trip through the Grand Canyon, I have become more aware of the Grand Canyon and its particular problems. I will not hesitate in the future to take an active role in any way that I can to save the pristine environment of the Grand Canyon and the Colorado River.

The physical carrying capacity has greatly improved in the Grand Canyon through the efforts of the Park Service and people like Dr. Carothers. The beaches have started to improve and become a more attractive place to camp. I know that this was no easy situation to overcome.

I am very happy that we had the opportunity to start our research trip at Glen Canyon Dam proper and be able to travel down to Lee's Ferry where most raft trips start. The shocking difference between Glen Canyon and post-Grand Canyon clean up is unbelievable. It really brought home the great amount of effort that the Park Service and concerned individuals have done to clean the beaches of firepits, human waste and human garbage.

Even as untrained observers, our group felt some kind of drastic action must be taken to clean up the area from Glen Canyon Dam down to Lee's Ferry. I know it will not be easy to train the many fishermen who use this area of the Colorado River, but it must be done before the damage is beyond repair of the beaches, riparian vegetation and the Colorado River itself.

I would not be adverse to seeing some kind of restrictions placed on Lee's Ferry that have been placed on the river runners through the Grand Canyon. Also, a user fee might be helpful in supporting the cost of the patrol of this area by the Park Service.

The biological carrying capacity has not yet been reached in the Grand Canyon, but I would like to qualify this statement. Because of the massive clean up effort and restrictions placed on the river runners, more people can now use the river without unsightly beaches like the ones found at Lee's Ferry. The question that I feel needs to be addressed is "do we want more, less or the same number of people on the river". I personally feel that the number of user days should be lowered or stay the same. Hopefully, in the future it will be lowered. This should be done in order to preserve the pristine environment in the Grand Canyon. If the river reaches the biological carrying capacity, it may become too late to stop the destructive forces that already transpired.

The sociological carrying capacity has not yet been reached in the Grand Canyon. But there is a big qualification to this statement. I went into this trip with a pre-conceived notion that the river was too crowded and that all motorized rafts should be taken off the Colorado River below Lee's Ferry.

As previously stated, I felt that only oar powered rafts should be on the river, but after careful consideration and talking to boatmen, my feelings have turned around. I still would like to see only oar powered rafts on the river, if for no other reason than the aesthetic value and solitude that makes for a very moving and personal relationship that one shares with the river.

If the Park Service went solely to oar powered rafts and kept the same number of user days that are now allotted, it would be bumper to bumper rafts. I would not personally like to see or experience this, but I still feel that for me this is what a true river trip through the Canyon is all about.

On the other hand, motor powered rafts serve a purpose on the river. They allow people who have a very limited amount of time to see and experience the wonders of the Grand Canyon and Colorado River. I personally feel that a person needs at least two to three weeks on the river to get a true feeling of the Grand Canyon. Many people cannot take this long and a one week trip gives them a chance to experience the unique wonders the Canyon offers.

I found the motorized raft tours to be very responsive to the environmental needs of the Grand Canyon, and they seemed to share the common concern of keeping the Canyon in a pristine state. The motorized boatmen were very conscious of the oar powered rafts. They, as a whole, slowed down when approaching and passing an oar powered raft so as not to cause too much noise, smell or wake. Once they had passed us, and at a reasonable distance, they resume their normal speed. They were only within eyesight and earshot for a very brief period of time and then were gone. The large number of people that they carried did not seem to make us feel that the Canyon was overcrowded.

Now for my "qualification". If the motorized and oar powered rafts would have to be constantly vying for the same campsites it would <u>definitely make the Canyon seem to be very overcrowded</u>. The reason why this doesn't

happen very often is that there is a very good working relationship between the boatmen of both groups. They mutually agree as to where they plan on camping for the night. In this way one doesn't feel that the beaches and campsites are overcrowded. Without this good working relationship, the Grand Canyon would definitely seem to have reached its sociological carrying capacity.

As a recommendation to the Park Service, I feel that they and not the commercial tour companies should set up the scheduling of raft trips on the Colorado River. Trips should be staggered so as not to have too many of one kind of trip on the river at any one time. This could be very easily done by the use of a computer based upon the used days of each commercial and private trip. I am sure the commerical tours would not like this but they would just have to adjust to the new situation.

Another concern I would like to address now is how does the Park Service go about enforcing the rules and regulations in the Grand Canyon and the Colorado river in particular. I feel that this problem must be resolved and in a hurry. At Havasu Creek we saw almost a whole boatload of Tour West people using soap and shampoo in Havasu Creek. The boatmen were there but did not try to stop them. After talking to several people it seems that Tour West has a reputation at times of not following common river courtesy and park regulations. If the boatmen cannot, or will not, police their own customers, who will? The question must be answered! Do you fine the boatmen for not enforcing the rules or do you fine the customer causing the infraction or both? It is a very long river and the Park Service cannot always be there at the right time to stop these violations. There must be something that can be done with these infractions of the rules.

The question of exotic vs. native vegetation species is a very tough question to answer. There are pros and cons to each side. Congress has mandated that the responsibility of the National Park Service is to preserve the pristine environment as it was originally found when the National Park Service was first established. This raises some serious questions concerning such issues as the tamarisk and trout.

Glen Canyon Dam has created a whole new environment. The question of exotic vs. native species becomes a moot point. One must start looking at the question after the building of Glen Canyon and not pre-Glen Canyon.

I am only going to address the issue of the tamarisk because of the amount of space that many of the other issues would take up.

To the average tourist going down the river, the tamarisk is not a major problem, but to someone who has to work in the riparian zone it is a real headache.

The tamarisk has many good points. First, it provides shade for humans, birds, insects and animal life. Second, its root structure helps to slow the erosion of beaches. Finally, it provides a breeding place and feeding ground for many birds, insects and animals along the river.

The disadvantage of tamarisk is that it may be forcing out some of the native plants along the river's edge. It seems to grow at a very rapid

pace. With little human activity on the beaches it would very quickly cover the whole beach.

In conclusion, the tamarisk provides a great number of beneficial things, but at the same time it can cause some harm. The tamarisk is firmly established in the Canyon now because of Glen Canyon. The Park Service needs to monitor its spread and in certain instances, clear or destroy some areas of high density tamarisk.

The question of user fees/days in some instances is a very good idea. I see nothing wrong with charging one dollar a day per person for going down the Colorado River. It would help defray the cost of maintaining park patrols and other environmental projects that the Park Service may be involved in.

I do not feel that a user fee should be paid by people who want to hike the trails in the Grand Canyon or any other national park. One of the major purposes of the National Park Service is to let people use and experience our nation's natural wonders. We should not have to pay for this right.

User fees should be enforced if a commercial venture is involved in making a profit from the Park Service - for example - raft trips, mule trips and even helicopter trips.

For the past twelve years I have personally had a major complaint concerning the Grand Canyon National Park and now I have a chance to air my views. In 1970 I had my first experience hiking the trails in the Grand Canyon. Being from the midwest at the time, I was not used to the altitude and was not in the best physical condition since it was early spring. I greatly resented having to see, smell and step around, over or through the mule feces. The National Park Service expects human feces to be properly taken care of in the parks and wilderness areas. It should also expect the same for horse and mule feces.

The commercial mule tours serve a very important group of people who come to visit the Canyon. Those who are not physically able to hike the Canyon trails. Personally, as a hiker, I don't want them on the trail even though they do serve a valid purpose. My contention in this issue is that the commercial mule tours (Fred Harvey) is making a profit from the mules, therefore he should be responsible to clean up the mule feces in some kind of manner set by the National Park Service. Anytime a profit is made by a commercial venture, they have the moral and financial responsibility to take care of the environment in which they work.

Hikers should not have to put up with the smell and sight of mule feces on the trails. There are many more hikers using the trails as compared to the number of people using the commercial mule tours.

I personally feel that the commercial tours should pay for the cost of the clean up operation. If this is not satisfactory, then a user fee of one dollar per person should be levied to clean up the feces left on the trail.

Research groups are an appropriate way of using the Grand Canyon. Much valuable information can be gained by the Park Service, as well as the research groups. There should be a number of carefully selected groups

allowed each year to work in the Canyon.

Personally, I feel that the good working relationship between the Park Service, Museum of Northern Arizona and Northern Arizona University should continue in the future. All three organizations can greatly benefit from a yearly joint venture, and if possible, more than once a year.

Our research group was a very unique project and I would hate to see it end after a one year trial. This joint venture should be nurtured to bring about the greatest benefit for each organization.

The research projects done by our group were very interesting to do and observe. I gained a great deal of insight into the geology and biology of the Grand Canyon. The projects concerning beach impact, ant population, and the different kinds of insects, birds and animal life found in the tamarisk and willow.

There should be on going projects in the future. I would like to see a follow up of the measurement of the beaches to see how much they have eroded in the past seven years. Just from a preliminary study on this trip, we could see a tremendous amount of erosion. This should be a priority project for the next year. The big question that arises is if there is massive beach erosion, what can be done in the future? There are no longer yearly floods in the Canyon to add and change the composition of the beaches.

Hopefully, my comments and viewpoints were what you were looking for at our meeting with you at the Grand Canyon. I tried to be as honest and objective as I could concerning the different topic areas. I would be more than willing to talk to you about any or all of these subjects.

Comments of Betty Byars

I am an undergraduate student at NAU majoring in botany/entomology and minoring in history. I intend to continue my studies after I finish my bachelor's degree, either in botany, entomology, or ecology.

I think it is an excellent idea to combine classroom instruction (theory) with research (practical experience). They compliment one another and provide a more in-depth learning experience than just classroom instruction alone. This is especially true if the opportunity to enter the area under study is provided; such was done with this class.

Through my recent exposure to Grand Canyon, I have gained a much greater appreciation of the Park Service and more insight into the difficulties involved in administering the Parks and managing both recreational and preservation needs. The Grand Canyon has provided an excellent case study.

Biologically speaking, I think that the river system would not be adversely impacted if more people were there, provided that they adhered stringently to the regulations concerning human waste and trash disposal. They would need to be careful not to destroy plants and not to feed the mammals, either intentionally or unintentionally. From a sociological perspective, I think the numbers of people now using the river are okay. I don't think that an increase would be beneficial to an individual's wilderness experience or peace of mind. To encounter more people than we did, especially at popular areas such as Havasu Creek, would be very irritating.

Most of the beaches were fine in the Grand Canyon itself. Glen Canyon definitely has problems with charcoal from campfires, trash, and human excrement. Installation of more trash cans and chem-cans with regular cleaning procedures would greatly help improve the matter. The chem-cans that I did see had not been cleaned for a long time and were unendurable. This forced people into the brush to defecate and soiled the area. People using Glen Canyon should be encouraged to build fires in fire pans and carry out their ashes and charcoal. The sidestreams appeared to be in good condition, but I do have reservations about the overflow of Kayenta's sewage into the river and about the dumping of toxic and hazardous materials into drainages that reach Kanab Creek and thence the Colorado River. In my opinion there should be much stricter regulation of what comes into the river drainage from above the rim.

Let's have both motors and oars; it doesn't bother me and it does provide two types of river experience. Also, there are some people whose work schedule or other factors make it impossible for them to take an oar trip. As to environmental damage, I'm not aware that any definitive research has as yet been undertaken.

I would rate beach attractiveness and water quality high except for Glen Canyon (beaches) and Kanab Creek (water). I do wonder if urinating and dumping kitchen waste water in the river is the best idea. Maybe it is, I don't know. It's a little difficult to get used to drinking water that others have urinated in or dumped kitchen waste waster in. Is the river flow sufficient to take care of this problem?

Most of the exotic plants have colonized the new riparian zone created by Glen Canyon Dam and they provide new habitat for insects, lizards and other reptiles, amphibians, birds, and mammals. This increase in diversity is very positive and aesthetically pleasing. The native plants are usually found in areas of the canyon that the exotics cannot colonize. The contrast between the areas is very interesting to study and contributes to the aesthetic experience.

The implementation of a user day fee is an excellent idea for river-runners and those who ride the mules. It would provide much-needed revenue for Park Service programs and maintenance.

I am in favor of continuing mule trips just as is done now. Hopefully, I'll be able to take one sometime. I hike regularly and have learned to simply ignore livestock scat on a trail. I enjoy seeing the animals as they pass by.

The research and education experience part of the program was very high. It's given me a much better appreciation for the Grand Canyon and increased my concern with issues affecting the ecology of the Canyon system. It has improved my knowledge of the Canyon's biology and geology and made me aware how complex and difficult management decisions can be. I greatly enjoyed my research project and learning about the research projects of others in the class. I also feel that I am a better student and person for the experience. I hope that this class will be continued so that others may have the same opportunity I had. I also hope that what we have done will be of value to the Park Service.

Comments of Melody Glass:

I am a General Science senior at the University of Iowa, with a concentration in geology.

The Grand Canyon is, in my opinion, one of the most appropriate classrooms I can think of.

The number of people using the river must be limited. Carrying out all waste is absolutely necessary and practical. I would prefer to wait longer for a river-trip, even years, and find a relatively pure and undisturbed river environment. The state of Glen Canyon beaches gives a startling example of waht happens when use is not controlled.

I feel carrying capacity has been reached, any more people would cause damage that could not be reversed. These very small beaches can stand only so much human impact. They are already discolored, there are many signs of human debris, urine, etc.

Personally, I would not have had as good an experience if more people had been present. Solitude and wilderness is what we all seek in the canyon. There were areas, for example at Havasu Creek, where these qualities were lost because there were simply too many people present. Man is no longer alone with nature, and many of the tangible values of this great natural environment are obscured.

Whether motor or oar, personally the motor-boats do not affect my experience of the canyon very much, as they pass on quickly. They carry greater numbers of people through more rapidly, and therefore probably have less impact on the environment than those who stay long. Also, if the same number of people were divided up into smaller boats, the river would be more crowded, and one would have the constant company of other parties.

In Grand Canyon, there is often a distinctive smell of urine on the beaches, but considering the amount of people that pass through, they are surprisingly clear. Educating people to urinate close to the river has certainly made a difference. Glen Canyon beaches are much more grossly polluted. The chemical toilets are often impossibly dirty and rank (e.g., Glen Canyon, Diamond Creek).

I do not feel there is a need to eliminate the Tamarisk, as nature will take its course. They provide shade, and seem well adapted.

A one dollar user day fee is a small fee to charge, and minimal in the perspective of the individual, but would probably be a great bonus for the canyon's upkeep and protection. I definitely think it should be instituted.

The spoor of mules on the trails is definitely distasteful to hikers. The smell is exceedingly pungent, and distracts from the experience of the canyon.

I feel very strongly about protecting this incomparably beautiful place which is unique on earth and has values for the human soul far beyond those that can be measured. I will always lend my support to any action that may

protect it, practical or otherwise.

For me, I plan to make the canyon a lifelong educational experience. I plan to return again and again, to experience, learn and understand as much as I possibly can about this wondeful place. If I should ever teach, I should bring my students here. I will bring my children here, my children's children.

I feel the research that has been done on this trip is a valid and useful way to utilize the canyon. The more research is done on human impact, etc., the better we may be able to protect the canyon's resources. I feel it should be done again, and as often as necessary to find new ways to determine how the canyon is affected by recreational use.

The National Park Service is certainly fulfilling its mandate to the people. Making an experience easy is not necessarily synonymous with making it good. The trip through the canyon is certainly an educational experience, and a profound experience for the inner man. In these days where instant satisfaction of needs and desires is so highly prized, we may be tempted to destroy the very things we seek in nature by making it too accessible. There is time and room for everyone who truly wishes to learn from the canyon.

Comments of Frank B. Lojko

I teach Earth Science, grades 9th-12th at Central High School in Springfield, Missouri, which is basically considered an inner city school. I have taught 7 years at Central and have developed an awareness of the needs and requirements to achieve quality education for a conducive learning environment. My goals in education are broad and quite detailed. One way I achieve my standards is to improve my teaching materials, my method of teaching, and my subject knowledge. I achieve this through several options, such as attending workshops, seminars, lectures, and enrollment in college courses. This is one of the major reasons why I am on the Grand Canyon/Colorado River educational research trip. I wish to improve and add greater depth to my educational programs and learn more about the "how to" field research. My broad general goals which I set forth prior to this class are as follows: learn more about the geology of the Canyon, i.e. formations, sediments, beaches, deposition, erosion, volcanoes, dikes, sills, rocks, faults, monoclines, etc; gain a better understanding of the hydrology systems in the Grand Canyon, i.e., rapids, tributaries, falls, discharge, springs, etc.; learn more about the purpose and operation of the National Park Service, learn the proper procedures to field research, and last, a better understanding of the ecosystems and interaction of physical and biological processes in the Canyon. All these items mentioned above have been achieved through classroom activities, field trips, lectures, materials, and the Colorado River trip. However, my learning experiences are not limited to my pre-set basic educational goals. I personally feel that the knowledge I have gained from this course enables me to evaluate and judge my entire experiences in a professional and objective manner without prejudice or emotions. Therefore, I feel obligated to expound and clarify my viewpoints regarding these positive, rewarding and wonderful experiences, these being a small part of the interrelationship that exists in the Grand Canyon and Colorado River.
Recommendations:
1) From Glen Canyon Dam to Lee's Ferry the beaches are not clean, debris and human waste are an eyesore. Recommendation: Better regulations and enforcement for the Glen Canyon areas. Justification: I have noticed from our research the beaches are cleaner down from Lee's Ferry to Diamond Creek. The reason must be attributed to the cooperation between the Park Service and all river runners. Apparently the campers and fishermen in the Glen Canyon area do not have the same attitude, appreciation, or understanding of protecting our natural resources.
2) Enact or establish some type of user fees for three areas; charge commercial river trips based on user days, the revenue to be used for maintenance of the river beaches, research and park operations. A fee should be charged to the (Fred Harvey, Inc.) commercial operation of the mule trail rides. The revenue from the rides to be used to maintain the trails. A user fee should be assessed to operators in the Glen Canyon area. The revenues should be used for maintenance of the camp area and general Park operations.
3) The commercial river operators on the Colorado River which run the motor boats should increase their staff to provide better supervision and guidance. The reason for this recommendation is based on personal observation of several unacceptable incidents which are due to unsupervised groups. One boatman per 15 or 20 tour river runners is not an adequate ratio to insure the necessary services and supervision.
4) Either the Park Service or the commercial mule trail ride company should remove the mule feces from the trails. The abundance of feces and

unacceptable odors spoils one's personal experience hiking the trails in the Grand Canyon. It might be more feasible to limit the mule rides to one particular trail.
5) I personally don't enjoy or feel the total wilderness experience when I hear or see airplanes or helicopters flying overhead. It spoils my solitude and involvement in the pristine environment. I would recommend some type of compromise with the FAA to regulate the flight activity over the Grand Canyon National Park.
6) I would recommend better scheduling intervals for river runners so that group units are more spatial and less congested.
7) I strongly recommend that this type of class research group continue its productive endeavors. It does fulfill its intention and objectives. It provides an excellent base to build character, develop research capabilities, solve problems, seek solutions, and gain a better understanding of nature and the geological processes.
8) I would strongly suggest that research be done on approximately twenty beaches research and investigating beach erosion, deposition, and grain sizes from Lee's Ferry to Diamond Creek.

Commendations:
1) The National Park Service programs and services were excellent at Grand Canyon, Bryce, and Zion. The staff personnel in all these areas gave an excellent geology slide presentation.
2) The Grand Canyon National Park and Colorado River areas have been maintained and preserved what I would consider in natural environment close to a pristine condition, noting, however, the exceptions of exotic species to this area. The exotic species happen to have been an attribute to the entire ecosystem of this region.
3) The Carothers Crapper system is environmentally appropriate and effective. The urination in the high water mark on the beach or in the river is better than individuals urinating in the campsite area resulting in a buildup of unpleasant odors.
4) The river trip experience has been fruitful, educational, and adventurous. The opportunity to sense, to search, to grow, and to learn have definitely prevailed in this educational expedition. The research projects and students' reports have provided an additional enlightenment and understanding of the Canyonlands. Thank you for giving us the opportunity of a lifetime to learn and to enjoy the wonders of the Canyon and River.

Comments of Mayo Lyman:

I teach ninth grade physical science and tenth grade biology in a high school with 1600 students in Louisville, Kentucky. I enrolled in these two courses on the geology and biology of the Grand Canyon in order to have some new ideas for my classes during the upcoming year.

Certainly, the Grand Canyon and Colorado River systems are appropriate settings for a classroom which few can experience. If what was learned through this class can be transferred to some small extent to my students, the time spent out here will be invaluable.

After having floated through Glen Canyon and Grand Canyon and comparing the beach sites in the two areas, it seems that the Grand Canyon is the much better managed of the two. In Glen Canyon one's senses were battered after looking at charcoal-littered beaches, with disposable diapers, toilet paper, cans, and other sorts of garbage. If they are going to have latrines up there, they should maintain them properly. In contrast, the beaches in the Grand Canyon seemed much cleaner with much less charcoal, hardly any noticeable litter, and a generally cleaner appearance. It seems that careful management keeps the beaches cleaner.

As far as the carrying capacity of the river goes, it seems that a place as big as the canyon gives enough room for all those who float the river. Only a few times when in such popular spots as Deer Creek or Havasu was one conscious of many people. That was okay with me because they were enjoying the canyon, too.

Seven years ago I took a trip through the canyon on a motor-powered raft. I liked it so well that I wanted to do it again. The oar-powered trip this time was enjoyable too and probably I felt the waves, the sounds, the sights more on it. However, I think there is a place for both in the Grand Canyon.

I think people would be willing to pay a river user fee for the time they spend on the river. It seems that people should start having to pay their way, and that money can be used to help maintain the quality of the beaches in the park. If one is paying a thousand dollars for a trip, another fifteen dollars will hardly be missed if they charged a dollar a day.

My perspective of the National Park System is that it is for the people, and it should be used to the fullest extent without destroying it for the generations to follow.

Comments of G. Brent McAfee

I am an Associate Professor of Geology at Odessa College, Odessa, Texas. My students are both geology or science majors and non-science freshman and sophomore level students.

I am very grateful to have had the recent opportunity to experience and study the Grand Canyon and the Colorado River for the first time with two very competent professors. Dr. Carothers and Dr. Beus gave us a thorough biological, geological, and historical development of the Grand Canyon and Colorado River during the first three weeks of classroom instruction. This instruction and interaction gave us information and an understanding of the Grand Canyon and Colorado River which make it possible to interrelate additional observations and research activities as we progressed through the Park for fourteen days.

The Grand Canyon and Colorado River have been a tremendous laboratory reflecting most geological, biological, and ecological concepts and principles. I took many photographs which will be very useful in the classroom.

Obviously, the Colorado River and Grand Canyon have undergone some post-dam biological and physical modification. This is a normal adjustment of speciation and sedimentary processes which always adjusts or becomes modified to changing conditions. Some species are not able to adapt, and become extinct; while exotic species will become introduced and adapt or take advantage of the modified newer habitats. These species could not have adapted or competed in the pre-dam or pristine system. These new species are not necessarily a negative element in the modified system. For example, post-dam beaches and lower slopes are characterized by Tamarisk, which provides shade for people as well as other organisms and has resulted in a newer expanded habitat for greater organism density and some new species of insects, reptiles, birds, and mammals. Many of the species which have taken advantage of this post-dam habitat are exotics. Many of the native or indigenous species have increased their densities due to an increased food supply and shade in this new expanded habitat.

The National Park System has been very effective in maintaining clean, beautiful campsites, tributaries, and the Grand Canyon National Park in general. An ongoing monitoring program and a periodic evaluation should always be an integral part of the resource management program. In contrast, the Glen Canyon Recreational Area between the dam and Lee's Ferry should require some type of clean-up program and resource management policy which would maintain the campsites.

The carrying capacity of the Colorado River seems reasonable at the present time from my observations. This should always be a priority in resource management decisions concerning any increases.

I would encourage and support user day fees for people who float the Colorado River on commercial tours, mule rides, and for those who fish between the dam and Lee's Ferry.

I have no major objection to mule utilization in the park as it is now managed.

Careful consideration should be given to peaking power policy. My observations reflect that it would be detrimental to the riparian habitat. Erosion of the beaches and destruction of the vegetation and wildlife would likely result. Our research indicates a considerable amount of beach erosion at the present time without peaking power.

My reaction to this experience in the Grand Canyon has been very positive. It has resulted in an understanding, an appreciation, and a desire to utilize more in the future. I hope to maintain an awareness of political issues and to assist if possible in the protection of the park in the future.

My experience in this program will be extremely helpful in the classroom and could result in a field course study from Odessa College to this region.

Again, I am very grateful to NAU, the National Park System, and to the Museum of Northern Arizona for making this program possible.

Comments of Kathy Peterson:

I am a recent graduate of the University of California, San Diego, where I received a B.A. in General Biology. I've always loved the outdoors and in high school I became interested in field biology and ecology. Unfortunately, most of the ecology courses at UCSD are theoretical in nature; rather than providing practical experience in the field problem solving and data collection - they concentrated on the derivation of abstract equations.

Eager to increase my experience in the field, I was very excited to learn about NAU's new summer class - The Biology and Geology of the Grand Canyon and the Colorado River. I realize the phrase is overused, and a bit trite, but it's true - the Grand Canyon is a unique and exciting classroom. Geologists and paleontologists have known this for years - since 1869 when J.W. Powell first explored this section of the Colorado. Nowhere else is the earth's ancient geologic history better exposed than here. The Canyon is the ultimate pilgrimage for any student of geology.

It seems only relatively recently that the biologists have discovered Grand Canyon. Not only does one find many unique terrestrial and aquatic communities to study in the Canyon, but one is also provided with the opportunity to scrutinize and evaluate man's impact on the same. It's unfortunate that the biologists didn't discover the Canyon before man left his distinct mark, be it burros, mines, or dams.

The Grand Canyon has always been a special place for me. I was delighted to have the opportunity to learn more about its biology and geology this summer, as well as to have the opportunity to actually work within the Canyon itself. The class was well-prepared and well-presented by an unbeatable team - Beus and Carothers. The lectures and labs were an excellent preparation for the climax of the class - the two-week river trip.

Although the subject had been discussed in lecture, I was still unprepared for the overwhelming differences in beach attractiveness between Glen Canyon and Marble and Grand canyons. The differences are sharp and distinct. The beaches located on the 15 miles between Glen Canyon Dam and Lee's Ferry are simply described as filthy and unattractive; fire pits, scattered charcoal, and various forms of human waste and debris were found on every beach. Although the latrines provided by the Park Service are an honest attempt to help alleviate human impact, they are themselves an eyesore and unpleasant to approach. I find it difficult to believe that the beaches in the Grand Canyon were once in a similar condition. Except for those beaches accessible to hikers, the Grand Canyon beaches we saw are clean and relatively free of human traces.

It seems reasonable that the beaches in Glen Canyon could be cleaned up also. Since the river itself is no longer allowed to scour the beaches clean, it's the responsibility of the people who use them to clean and maintain them. Strict standards should be developed and enforced. Granted, it will be difficult to enforce these standards since it's primarily private parties who utilize these beaches. Increased fees might help pay for an initial clean-up program and future enforcement. Increased fees and responsibilities are a small price for sportsmen to pay - after all, aren't they taking advantage of one of the richest sporting areas in the United States?

National Parks are meant to be accessible to everyone. Those who visit a National Park pay a small nominal fee for the care and upkeep of the Park. In the case of the Grand Canyon, the average visitor spends 1-3 hours at the Park; he parks at the Visitor Center, takes a picture, and leaves. However, there is always a small minority of visitors who use the Park to a greater extent than others.

In the Grand Canyon, this minority includes backpackers, muleriders, and river runners (who never even see the Park entrance). Since they are responsible for greater use, and therefore greater impact than the average visitor, it's only fair that they should be assessed greater fees to cover this use. Greater use leads to greater impact, resulting in more costly management. This additional fee need not be excessive, but it would certainly help ease the strain on the overtaxed Resource Management funds at both Glen and Grand Canyon Park units.

With regard to the riverside campsites, it's difficult for me to say whether or not a physical or biological carrying capacity has been reached. It's been said before, but it's worth repeating - it's not the number of people that use a campsite which is significant, but the behavior of those people which is responsible for the degree of impact. In other words, ten ignorant fools can wreak greater havoc than 100 informed, ecologically aware visitors. Witness the difference in beach appearance between Glen and Grand Canyon. The Park Service has done a remarkable job in the past few years of cleaning up and maintaining beaches in Grand Canyon. Continued monitoring of these beaches is necessary before one can justify an increase or decrease in use.

I was shocked when I discovered that there is no careful monitoring of beach use by the Park Service in Grand Canyon. How can human impact on river campsites be properly assessed without an accurate picture of human use? Perhaps the river runners are already overwhelmed by bureaucracy, but how difficult is it for them to submit a card after each trip listing the beaches used and the number of people using them? It seems that the Park Service should show a greater concern for its resources, and the river runners a greater concern for the river that makes their livelihood possible.

In addition to the question of biological or physical carrying capacity, is the question of sociological carrying capacity. Although it would be a pleasure to travel down the Colorado without seeing another river party, the idea is unrealistic. The question is not whether other river parties can be avoided, but, rather, how many parties can be encountered before destroying the experience.

Before our trip, I had the preconception that it would be difficult to tolerate other people on the river. However, I was surprised! Encounters were no problem; motorized trips were quickly past, oar-powered rafts were only briefly encountered, and most of the people on other trips seemed friendly and pleasant. I was only annoyed once, and that was at Havasu, where it was estimated that there were well over 250 people in addition to our group. Of course, this situation was expected, therefore making it a bit easier to deal with the Disneyland atmosphere.

Another aspect of the sociological carrying capacity problem is the argument over motors vs. oars. I had a negative attitude towards the motorized rafts when we first set off on our field trip; I had pictured them as noisy, vulgar creatures. My opinion was quickly changed, however. The operators of these vehicles seemed well aware of the possible impact of their motors on other rafters and were careful to reduce the engines when they approached smaller boats. There was no problem with smell or exhaust, and the noise from the engines was quickly dissipated. Although I would prefer to be on an oar-powered raft, I see no justification in eliminating motorized travel through the Grand Canyon.

From what I've heard, and from an experience or two on the river, I can understand why oar-powered rafts can also cause problems. Since oar-powered rafts travel at relatively the same speed, if two trips latch on to one another difficulties can arise - another party is always in view and there can be competition over campsites. What is needed is a balance between motorized and oar-powered rafts.

An unexpected source of annoyance were the aircraft flying over the canyon. These aircraft could be heard long before and after they were seen. These craft were especially noticeable the first few days of the trip, from Glen Canyon Dam to Lee's Ferry and around Lava Falls.

Another important question being addressed to Resource Management is how to deal with exotic species in the canyon. In the early 1970's, the feral burros in the canyon were finally removed after severely damaging resources and having a detrimental effect on native species. What about the other exotics in the Grand Canyon? Should other exotics be eliminated in order to recreate the "natural" environment of the park, or should the Park be managed keeping these new species as part of the new, post-dam natural order?

One species which springs to mind is the Tamarisk or Salt Cedar. After the construction of Glen Canyon Dam, this species quickly spread throughout the new riparian zone created by the drop in river level. There has been talk of eliminating the Tamarisk, much like the burros were eliminated. Even if such a plan were feasible, it simply isn't justified.

The riparian community is a relatively new life zone, non-existent before the construction of Glen Canyon Dam. Although the Tamarisk quickly became a dominant species in this zone, it has not been to the exclusion of other species. Is this really a climax community, or is the Tamarisk simply a pioneer species which, in time, will be overwhelmed and replaced by native species? The Tamarisk is also a very important species in the riparian zone - it supports the greatest diversity of species and number of animals, and provides welcome shade during the day. How could eradication of this species be carried out without disrupting other vegetation and creatures? Besides, is it ethical to eliminate this exotic species without eliminating the exotic, and recreationally important, fish which have flourished in the Colorado River system also as a result of Glen Canyon Dam?

I can think of no nobler use of the Grand Canyon than as a classroom - not only in the biological and geological sense, but as a place in which to learn more about oneself. Humbled by the vastness, the splendor, the age, one tends to develop a greater sense of being a part of nature, rather than apart

from it. I was glad to be a part of a project designed to protect this canyon and preserve it for the future. I can only hope that the NPS will be as generous in the future and allow this class and others like it the opportunity to work in the Grand Canyon.

Comments of Anthony J. Rose:

I came to the Grand Canyon late in my life, having retired from military service and choosing Flagstaff. In the several years since I have become increasingly interested in the natural environment of the area. This interest has led me to active participation in a hiking club and various archaeological, biological, geological, and historical programs of Northern Arizona University, Museum of Northern Arizona, the U.S. Forest Service, and the National Park Service. I have crossed the Canyon and hiked elsewhere therein, including the Hermit Trail and Clear Creek. Most recently I have had the experience of the river trip. This paper reflects that and my previous exposure.

In a way, I suppose I have been attracted more and more to the Canyon, not only for its powerful and unique presentation of a series of vistas, but perhaps of at least equal importance, because it provides such a special way to study and even test man's relation to environment. I have come to realize that the Canyon is a place unto itself - one that has created its own environment. Also, because it has been so inaccessible (relative to most of the scenic areas of our nation), that environment has changed but little in the last century since exploration disclosed its nature. Thus it is a veritable treasure not only for enjoyment but also as a means for sensitizing people to the value of environmental preservation and learning how to mitigate the effects of use. I believe it is appropriate to consider the Grand Canyon as a vast classroom. I further believe that the mission of the National Park Service to preserve and protect has an added dimension in time - to preserve and protect not only for the future but in the future. Thus there is the need to educate, so that those who come after us today will know this need and the ways of actively working to satisfy it, hopefully even better than we today. I am convinced that this inferential mission is imperative. I know that the resources available to the National Park Service are limited. Thus I see a clear mandate and an urgent necessity for cooperative efforts with other institutions on an enduring basis to lay down long range programs that will reach large numbers of people, most especially those people who can further the knowledge through education of youth. In my own case, I have been greatly sensitized by my experiences and exposure and this process has been amplified by the intensive nature of organized class activities.

I have found both challenge and much knowledge in all of the trail and river experiences I have had. If I were to describe this in a summary fashion, the one word that stands out in my mind is tranquility. By this I mean more than mere quiet or solitude. It is a matter of extending one's self-understanding by accepting nature and thinking in a cooperative way rather than as a contender. The awesome majesty of natural change so evident in the Grand Canyon forces a direct and honest reaction and for me, a harmonious and joyful synthesis as a result. As a consequence, I do not find the presence of others in one way or another particularly bothersome. I am not concerned about maintaining a contemplative, monasterial approach. I am willing to respect that need for those caught up in initial reaction at the Canyon, but in the Canyon I find personal pleasure in the natural exuberance of happy people. I view the trails and the river boats as means to enable people to experience the Canyon. I don't like the acrid odor of mule excrement on the trail, or the stench of exhaust fumes on the river. I would like to see both phenomena alleviated if possible, but I am horrified at the

idea of banning mules or motors because that would mean banning experience in the Canyon for many who could not otherwise participate. What a pity that would be. To conclude this portion, the effect of my own experience, notably on the river trip, is perhaps best expressed in the short poem which is attached.

I am no expert on the river management task. I can say that I was most favorably impressed by the neatness of the beaches, the mutual respect and courtesy of the contacts between those who ply the river on a regular basis, and the obvious general regard for the environment. The passengers were a different story. Most were fine people, sharing and appreciative, but I saw a few instances of offensive behavior. I believe a river patrol is a necessity for several reasons. Its existence is useful as a deterrent to keep private groups at the highest standard of river and beach use. Its existence is also useful to commercial operators in the same way as a "last resort" disciplinary threat. Perhaps most important than either of these, however, is its value to the Park Service to know what is going on over time to keep track of trends and the efficacy of control measures. I can also see a need for the river patrol as a training device for Park Service personnel and to provide a needed relief through change of duty from time to time. It is an absolute necessity, pending the introduction of other effective control measures, in order to maintain even a modicum of control in the portions of the river upstream from Lee's Ferry.

The Glen Canyon to Marble Canyon stretch of the river (Dam to Lee's Ferry) provides a most striking comparison with the Grand Canyon area. The poor condition of the beaches and other human impacts evident in the former are an example of the value of the mitigation efforts applied downstream. There is no doubt in my mind that the area upstream from Lee's Ferry should be cleaned up and kept that way. This takes time and effort. I believe the people who enjoy this area should bear the main burden of the cost of the necessary resources and the sooner the better. As the reputation for trophy fish has grown to an almost international extent, the increased pressure can be controlled by establishing a charge for use which will, at the same time, provide the needed resources for cleanup and maintenance. The struggle to decide this, inevitably political in nature, should start now.

This brings up the subject of carrying capacity. I have touched on some aspects earlier in terms of contacts, beach conditions, odors, etc. The idea of carrying capacity is one of tradeoffs - access versus annoyance, damage versus enjoyment. I see no alternative but constant attention. I do not know of any one criteria by which the tradeoff can be determined on a lasting basis. An example is beach sand discoloration as evidence of almost irreparable damage under the new flood conditions imposed by the dam. Who is to say that darker beaches actually lessen enjoyment and if so by how much if there is no health hazard. Another example is the number of contacts. How many noisy power boat passings can one stand per day? Or how often can one put up with seeing the same groups of "slow-mover" oar boats on a trip of many days? Only the public can come up with answers as to what is tolerable and what is not and that can change, too, over decades and generations. The cost of surveys could easily be financed by a small charge per river day, as could others costs of maintenance, such as trail work, river patrol, etc. I believe it is fair that users pay the lion's share of costs. I know the parks are for everyone and I have no objection to capital funding for major improvements but

the maintenance costs should be paid entirely by fees from users.

I have previously implied the importance of research in the sense of the Grand Canyon as a classroom. I would like to be more direct by stating that emphasis on education, including justified research projects, should have priority over private and commercial river trips, but not to the exclusion of either.

Lastly, I was bothered by aircraft and helicopter noise only in the case of the repeated low-altitude passes of a movie helicopter (8) in the Glen canyon area over Lee's Ferry. (I realize this was a special situation due to a movie production).

Comments of Mike Trimble:

I am a native Arizonan and teach high school and college science courses in Tempe. I have been a previous visitor to the Canyon by backpack and motorized raft. Each experience has been extremely enjoyable, recreational, educational, and beneficial in every sense of the word. I would like to express, however, the superiority of this latest expedition in respect to the above qualities.

As a student in ASU's Geology of Arizona course, a field trip down the Bright Angel Trail provided an excellent first-hand inspection of this fantastic laboratory. Later, as an instructor, I too brought students down the Canyon to experience the natural wonders. Again, I was fortunate enough to return to the Canyon in a community college field Biology/Geology class for a nine-day motorized river trip. The approach again was classical Natural History studies.

These experiences gave me an opportunity to compare with a critical eye the differences between "educational opportunities" in the Grand Canyon. The format used in the five-week NAU/MNA course is by far the most effective I have participated in yet. The major strengths of this program were:

1) Proper and adequate classroom preparation for field activities. Time was given for a good orientation in:
   a) Grand Canyon - regional history and management
   b) Natural History of Grand Canyon
   c) Research techniques - management and academic in nature
2) Supportive field trips to other Parks and discussions with management personnel at various levels and perspectives
3) Top quality field experience by means of:
   a) Expert professors and authorities in respective area for this region
   b) Researchers-boatmen combination was a bonus for additional expertise
   c) The 14-day raft trip itself
   d) Opportunity to participate in current research projects - both group and individual
   e) Philosophical and attitudinal aspects of the designers, implementers, and participants of this expedition

My views on the river management aspects of the Grand Canyon have been modified and clarified since participating in this course. After experiencing Glen Canyon, it is clearly evident for the need of more strict management policies in this area. The management guidelines provided within the Grand Canyon National Park demonstrate that high use doesn't necessarily mean disruption or destruction of the natural environment. I believe the procedures for wastes, charcoal, etc. found in Grand Canyon should be extended to include Glen Canyon.

I was impressed with the general quality of each beach we sampled within Grand Canyon. The management practices appear to be working well.

It also appears to me that it is the attitude of the river runners that makes this sytem work. Cooperation at this level is the key factor to successful management. It is this spirit of respect and reverence for the

Canyon which must be extended to the general public (fishermen) at Glen Canyon. Establishment of proper attitudes through positive education should be the primary means of enforcement. Regulations should only be used as the back-up to strengthen communication and education between the Park Service and John Q. Public.

On our trip, we studied the riparian environment in depth. Since the establishment of Glen Canyon Dam, the subsequent creation of a "new" river has changed this ecological community drastically. It has constituted a new "natural state". It is from this perspective, I believe management should begin. That is, Tamarisk, the dominant exotic, is merely one more player in this stage of imposed man-made influences. The dam, the cold water, sediment changes, the fluctuation, the increased river use, has created a non-pristine, unnatural environment. An artificial environment that has now become fairly established and could never return to pre-dam conditions. To alter further (i.e., cutting down Tamarisk) would be destructive to the ecological community now thriving and becoming more stable and complex in nature. In fact our insect and rodent studies tend to show diversity and density is greatest in the Tamarisk/willow/Baccharis zones along the river. Increased fluctuations in water levels may alter this zone and have an extreme impact on wildlife and beaches.

From a sociological perspective, I believe the Canyon could handle more people only with better scheduling. Limited contact with outside parties is an extremely important part of the Canyon experience for myself.

I favor the current permit system and their distribution among motor, oar, and private. There is a need for all three and I believe the proportions are fair to do the most good for the most people.

Fees for river use or mule use in the Canyon appear very cost-effective and an efficient way to collect funds. However, fees for trail use cannot be tolerated. The Park Service has a philosophical obligation to keep something as basic as trails free for all to enjoy.

In summary, the course has helped me appreciate the complexity of Park Management and inspire me to include these aspects more heavily in my teaching. The course, I believe, gave me the optimum opportunity to explore the Canyon's multi-dimensional lessons in the grandest fashion. I strongly encourage you to proceed further in these types of educational endeavors and allow others the opportunity for this in-depth analysis of the Grand Canyon.

Comments of Rob Mickler:

The five week Biology/Geology course on the Grand Canyon was a valuable experience to me. It fulfills my objectives to get an educational overview of the Canyon. I don't think there could have been any better teachers than Dr. Beus and Dr. Carothers; having an abundance of knowledge and familiarity with this grand site.

My interest lies in the beautiful Southwest as well as all the Parks across the country. I view them as an outlet to protect natural resources as well as a setting for people to observe a well protected natural environment. Although I have a college degree in accounting, unlike most of the science people in this class, my interest stems from a previous year spent working in an educational field study company called International Field Studies. We have used your Grand Canyon Park, as well as most of N.P.S. facilities literally hundreds of times as lodging and a natural setting to take youngsters of all ages out of the classroom and expose them to the natural environment.

I have seen the success of this type of teaching, the field as the classroom. I feel this class the past five weeks has been enormously successful. One must get into the field to observe first hand. Dr. Carothers and Dr. Beus did a tremendous job in providing background material preparing us with as much of an overview as could be possible in the short time we had. On the river, we moved at a tremendous pace fighting the conflict of the miles to cover as well as being able to spend time to observe and learn as much as possible. The canyon classroom is a necessity in learning. I feel privileged to be a part of it.

I think this is a fabulous opportunity for the Park Service and should not be ignored in the future. It gives you the chance for 15 people (and some good minds) willingly, even paying, to go down to do needed research. Providing the right direction is the key to making the most of this. Much can be accomplished to benefit the Park Service need; as well as providing a meaningful learning experience for the participant.

River management seems to be working in the Grand Canyon area of the Colorado River. For the great number of beaches, they are fairly free of litter. No more fire pits are being used and other than pieces of charcoal, there evidence is not great. Charcoal remnants mixed in with the beach sand and dark lines coming into the beaches from water flow seem to be apparent everywhere; but this scar seems much less harmful than possible other beach disarray on other less monitored beaches. The river boatmen seem to be working out their own code of strict compliance to keep the beaches clean. Using a porta-potty seems to be working well too. There should be regulations making these practices mandatory in Glen canyon, too, i.e., pans, porta-potty, etc. I also suggest no showering facilities (portable) which would cause much erosion to the beach environment.

The future may bring more commerical trips with more luxurious portable facilities coming with the boats. Regulations should prohibit any of these that are not natural to the environment or those which would destroy habitat or beach resources. A strong education program of all users should be appropriate. Hopefully, the commercial boat runners are proud enough to keep a strict monitoring and enforcement themselves for their users.

I don't think the use of motor rafts has destroyed the environment. They seem few between compared to the time spent on the river. Whenever approaching they were always careful to keep from being too loud or aggressive, never crowding the boats. On this large expanse of miles and relatively wilderness areas I feel it is necessary to have some motor boats, at least for quick emergency relief if it were necessary.

In my opinion, the river has not been overcrowded. One must expect to see others in a public park. Everyone should have a right to use the facilities. Along with that must be a closely monitored system of the impact. Caution should be used to keep things from getting out of hand before problems are noticed and time for things to be done about them. The permit system is good and should be continued. A one dollar per day fee for river users as well as those on mules sounds reasonable. It could provide a good source of revenue and is not too much of a burden.

Although I would not like to see park use get out of hand, I don't think prohibiting use or trying to ban air flights over the area is a fair solution. Use is a problem and we must deal with and keep a close hand on what is going on. The setting is for those to enjoy but must also be watched for future degradation. I think the river management people are meeting these conflicting demands.

I feel decisions on wildlife and exotic species should be made on future quality of the park. Even though a plant is not native, I don't feel it is always bad. On the other hand, a native species may get out of hand and should be controlled or eliminated. Its impact on the future of the park should come before the question of historical significance there. Things like tree burning selectively, is far more important in the long run than the short term destruction of views from choke, and should be considered for a continued future of the park.

I thought the trip has been helpful to research the park as well as educate the participants on the trip. It opened the eyes of all of us and provided us with background as well as motivation to become aware of the park's future and watchdogs to influence its protection. The research days that NPS provided were put to good use; much should come from it; everyone on the trip is grateful for this.

In closing, the Glen Canyon River system was much of a contrast to the controlled well kept up Grand Canyon River system. Similar actions must take place. A good system is at work in Grand Canyon protecting the beaches, keeping foreign matter from destroying them. A strong fight must be initiated to put Glen Canyon on a par with the Canyon beaches.