COLORADO RIVER INVESTIGATIONS IV

July-August, 1985

By
Students and Staff of Geology 538-626
Northern Arizona University

Under the Supervision of

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Edited By
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Museum of Northern Arizona

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Submitted To

Mr. Richard W. Marks, Superintendent
Grand Canyon National Park
Grand Canyon, Arizona

June, 1986

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CHAPTER I

INTRODUCTION

Colorado River Investigations IV presents results of a five-week, six-semester hour course (Geology 538-626) on the geology and biology of the Grand Canyon. Now in its fourth year, the course is offered each summer by Northern Arizona University in collaboration with the Museum of Northern Arizona and Grand Canyon National Park. While primarily designed to introduce teachers to the natural history of the Grand Canyon and to give them an opportunity to gather scientific information under the rigorous supervision of experienced researchers, the program also generates ongoing data about beach condition, vegetation, and aquatic and terrestrial fauna in the Colorado River corridor of the Grand Canyon.

In 1985, the course consisted of three weeks of classroom and laboratory instruction and about two weeks of field work, most of which was conducted on an 11-day research expedition down the Colorado River from Lees Ferry to Diamond Creek (August 1 through August 11). All field investigations were conducted under the supervision of Dr. Stanley S. Beus, a professor of geology at Northern Arizona University, or Dr. Steven W. Carothers, an adjunct professor at Northern Arizona University and an ecological consultant. Both scientists are Research

Associates with the Museum of Northern Arizona.

The research project reports submitted here are all at least partly outlined by students, and present results of a variety of investigations undertaken. Some of the projects, most notably the beach profile and human impact studies, have been underway since the course was first offered in 1982. The studies conducted this year (1985) are of special significance because they further document changes in Grand Canyon beach conditions after the exceptional high water flows of 1983 and 1984. The data collected, when compared to data collected in the previous three years, provides information about the effects of unusually high water discharges on the post-dam, downstream (Grand Canyon) environment.

The 1985 investigations included studies of beach profile changes, sedimentary structures in river beaches and bars, fish distribution and abundance in the Colorado River, damage sustained by fish as a result of electrofishing, growth and vigor of old high water line (OHWL) vegetation, harvester ant densities on camping beaches, reptile distribution, and human impact on camping beaches.

CHAPTER II

CHANGES IN SELECTED BEACH PROFILES ALONG THE COLORADO RIVER, GRAND CANYON, 1984-1985

S. S. Beus, J. Coffin, A. Doty, P. Messina, and D. Mail

INTRODUCTION

Sandy alluvial terraces along the Colorado River in Grand Canyon provide convenient campsite beaches for river recreationists. About 100 of these beaches are commonly used for campsites and thus constitute an important recreational resource in Grand Canyon.

Selcted campsite beaches have been monitored by transit surveys along beach profile lines over the past eleven years in order to determine what topographic changes are taking place on the beaches. Of the original 37 profiles on 20 beaches surveyed by Howard (1975) in 1974 and 1975, 23 profiles on 15 beaches were resurveyed by Dolan (1981), and 36 profiles covering all 20 beaches were resurveyed in the period of 1982 through 1985. One profile, CS2 at L87.1 (left bank at 87.1 miles below Lees Ferry), could not be redone because original bench marks were removed by erosion.

The summary data from the 1984 measurements (Beus and others 1985, Fig. III-3, p.42) show that gradual loss of beach sand on at least half of the beaches monitored over an eight-year

period (1974-1982) was more than compensated for by a net gain of beach sand on 14 beaches following the high water release "spills" of 1983 and 1984. However, five of the original beaches studied were so denuded of sand in 1984 as to be no longer, or only marginally, useful as campsites.

1985 DATA

In 1985, 41 profile measurements were taken on 22 beaches, three of which were new surveys (Table II-1). The results of the surveys are tabulated in Table II-2 and summarized in Figures II-1 and II-2. Individual beach profiles are shown in Figure II-3 through II- 51. The bar graphs in Figures II-1 and II-2 were constructed by averaging the loss or gain, in a vertical sense, of sand along each profile in the inner (shoreward) half and outer (riverward) half of the profile.

RESULTS

The results of all 1985 measurements, as illustrated in Figures II-1 and II-2, indicate that between 1984 and 1985 there was a net loss of sand on most of the beaches measured. Only three profiles on three beaches showed a gain, whereas 29 profiles on 19 beaches showed a loss of sand in the one year period. The three beaches surveyed for the first time in 1985 are not included in these data because no previous measurements are available with which to compare them.

One unexpected data point is CS2 at Upper Granite (L93.2), where a substantial addition of sand occurred at a site that had experienced a major loss in the preceding years, especially

during the high water "spills" of 1983 and 1984. It appears that Upper Granite campsite, which was almost wiped out, is rebuilding under the 1984-1985 river regimen.

CONCLUSIONS

It appears that the gradual depletion of sand from nearly all beaches studied is occurring throughout Marble Canyon and Grand Canyon with a few exceptions. The rate of sand loss is clearly variable from one beach to another and even on different parts of the same beach. Except for local flash flooding in the tributary canyons, and minor wind transport, the major cause of beach erosion must be attributed to shoreline processes related to the Colorado River flow and perhaps also to human activities at the campsite. The nature of the river currents and eddies along the shoreline adjacent to the beaches, and the variation in these processes at different campsites and at different flow levels, must be considered important factors in the overall beach maintenance. Some of these factors are currently under investigation by Jack Schmidt (1985, pers. comm.) and may also be further studied in future NAU Colorado River investigations.

It seems evident, based on an eleven-year record of selected beach campsite surveys, that the normal regulated flow of the Colorado River through the Grand Canyon can be expected to allow gradual depletion of sand from many campsite beaches. The high water "spills" in 1983 and 1984 built up many of the depleted beaches in a short period of time. Over the long haul, it may be that occasional high water flows for short periods of time through Grand Canyon can restore beach sand loss on some beaches.

REFERENCES

Beus, S. S. and others. 1982. A study of beach profiles as a measure of erosion. In Beus, S. S. and Carothers, S. W. (eds.), Colorado River Investigations I. Northern Arizona University/Museum of Northern Arizona manuscript report submitted to Grand Canyon National Park, p.16-19.

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Beus, S. S. and others. 1985. Topographic changes in fluvial terrace deposits used as campsite beaches along the Colorado River in Grand Canyon. In House, D. A. (ed.), Colorado River Investigations III, July-August, 1984. Northern Arizona University/Museum of Northern Arizona manuscript report submitted to Grand Canyon National Park, p.23-84.

Dolan, R. 1981. Analysis of the erosional trends of the sedimentary deposits in Grand Canyon. Manuscript report submitted to the Bureau of Reclamation, Water and Power Resources Service, Durango, Colorado, 22 p.

Howard, A. D. 1975. Establishment of bench mark study sites along the Colorado River in Grand Canyon National Park for monitoring of beach erosion caused by natural forces and human impact. University of Virginia Grand Canyon Study. Technical Report No. 1, 14 p.

Table II-1. Beach profiles surveyed.

River Mile	Beach Name	Number of Profiles Measured 1974	1975	1980	1982	1983	1984	1985
L18.2	Upper 18 Mile Wash		2			2	2	2
L19.3	19 Mile Wash		2	1		2		2
L34.7	Nautiloid Canyon	2	2			2	2	2
R53.0	Lower Nankoweap	3	3	1		1	1	2
R58.1	Awatubi (New 1984)						1	1
R61.8	Mouth of Little Colorado	1		1		1	1	1
L65.5	Tanner Mine	2		2		2	2	2
R72.2	Unkar Indian Village (gone)	1	1	3		2	1	
L75	Nevills Rapid (New 1984)						2	2
L81.1	Grapevine	2		2		2	1	2
L87.1	Lower Suspension Bridge		2	1				1
L93.2	Upper Granite Rapid	2		1		2	2	2
R109.4	109 Mile (gone)	2				1	2	
R112.2	Waltenberg Canyon (gone)	1		1		1	1	
R120.1	Blacktail Canyon	2		2	1	2	2	2
R122	122 Mile Beach (new 1985)							2
L122.8	Forster Canyon (new 1983)					3	3	3
L124.4	Upper 124 1/2 Canyon (gone)	2				1	1	
R131	Bedrock Rapid	2		2		2	2	2
R151.6	The Ledges	2	2			1	2	2
L166.5	National Canyon		2	1		1	2	2
L166.6	Lower National (new 1985)							2
R180.9	Lower Lava Falls	2		2		2	2	2
L190.2	190 Mile		1	1			1	1
L208.8	Granite Park	2	2	2	1	2	2	2
L220	220 Mile Beach (new 1985)							2

1974, 1975 data from Howard (1975)
1980 data from Dolan (1981)
1982 data from Beus and others (1982)
1983 data from Beus and others (1984)
1984 data from Beus and others (1985)
1985 data from this report

Table II-2. Summary of loss or gain in vertical feet of beach sand (from 1985 measurements)

Beach		Net gain or loss 1984 to 1985		Net gain or loss 1974-75 to 1985	
		Inner	Outer	Inner	Outer
L19.2	CS1	-	-0.5	-5.0	-5.0
	CS2	-1.0	-2.0	+6.0	+6.0
L19.3	CS1	-	-0.5	+1.0	
	CS2	-	-	-1.0	?
L34.7	CS1	-	-	+4.0	+6.0
	CS2	-	-2.0	+1.0	+1.0
R57.0	CS2	-	-	+1.0	+2.0
	CS3	-	-1.0	+1.0	+1.0
R58.1	CS1	-	-	-	-
		(first measured in 1984)			
R61.8	CS1	-1.0	-0.5	-0.5	-0.3
L65.5	CS1	-	-1.0	-	+0.7
	CS2	-	-0.5	-1.7	-0.5
R72.2		(no 1985 survey, beach much reduced)			
L75	CS1	+1.0	-	-	-
		(first measured in 1984)			
	CS2	-	-	-	-
		(first measured in 1984)			
L81.1	CS1	-1.5	-1.0*		
	CS2	-	-	+3.0	+2.5
L87.1	CS1	+1.5	-0.5	+1.5	-0.5
L93.2	CS1	-1.5	-1.5	+2.0	-2.0
		(steep slope)			
	CS2	-	+5.0		-3.0
R109.4		(no 1985 survey, beach gone)			
R112.2		(no 1985 survey, beach much reduced & under water)			
R120.1	CS1	-	-	+1.5	-2.0
	CS2	-	-5.0	+4.5	-
		(steep slope)			
R122		(first measured in 1985)			
L122.8	CS1	-	-0.5		
	CS2	-	-1.5		
	CS3	-0.5	-15.0		
		(steep slope)			
L124.4		(no 1985 survey, beach much reduced)			
R131	CS1	-	-1.0	+0.5	-0.5
	CS2	-	-	+0.5	-0.5
R151.6	CS1	-	-	-2.5	-6.0
	CS2	-	-	0	-2.5
L166.5	CS1	-0.5	-	-	-2.0
	CS2	?	-1.0	-	-3.0
L166.6		(first measured in 1985)			
R180.9	CS1	-1.0	-3.0	-3.0	-3.0
	CS2	-	+0.5	+2.0	+1.5
L190.2	CS1	-2.5	-1.5	-3.5	-2.0

Table II-2 continued.

Beach		Net gain or loss 1984 to 1985 Inner	Net gain or loss 1984 to 1985 Outer	Net gain or loss 1974-75 to 1985 Inner	Net gain or loss 1974-75 to 1985 Outer
L208.8	CS1	-	-2.5	+1.0	-
	CS2	-1.0	-1.5	+2.5	+0.5
L220		(first measured in 1985)			

*1983 to 1985

LIST OF FIGURES

Figure 1. Graph of the net gain or loss in vertical feet of sand on the Colorado River beaches in Marble Canyon and eastern Grand Canyon. Beach position identified by milepost below Lees Ferry and by left (L) or right (R) bank. I=inner, O=outer half of beach profile, CS=cross section number.

Figure 2. Graph of net gain or loss in vertical feet of sand in central Grand Canyon. Beach position identified by milepost below Lees Ferry and by left (L) or right (R) bank. I=inner, O=outer half of beach profile, CS=cross section number.

Figure 3. Cross section profile (CS1) at 18 Mile Wash, L18.2
4. " " " (CS2) at 18 Mile Wash, L18.2
5. " " " (CS1) at 19 Mile Wash, L19.3
6. " " " (CS2) at 19 Mile Wash, L19.3
7. " " " (CS1) at Nautiloid, L34.7
8. " " " (CS2) at Nautiloid, L34.7
9. " " " (CS2) at Nankoweap, R53
10. " " " (CS3) at Nankoweap, R53
11. " " " (CS1) at Awatubi, R58.1
12. " " " (CS1) at LCR, R61.8
13. " " " (CS1) at Tanner Mine, L65.5
14 " " " (CS2) at Tanner Mine, L65.5
15. " " " (CS1) at Nevills Rapid, L75
16. " " " (CS2) at Nevills Rapid, L75
17. " " " (CS1) at Grapevine, L81.1
18. " " " (CS2) at Grapevine, L18.1
19. " " " (CS1) at Suspension Bridge, L87.
20. " " " (CS1) at Upper Granite, L93.2
21. " " " (CS2) at Upper Granite, L93.2
22. " " " (CS1) at Blacktail, R120.1
23. " " " (CS2) at Blacktail, R120.1
24. Map of 122 Mile Beach
25. View of Mile 122 Beach
26. Location of BS1 (A) and BS2 (B) at 122 Mile, R122
27. Cross section profile (CS1) at 122 Mile, R122
28. " " " (CS2) at 122 Mile, R122
29. " " " (CS1) at Forster, L122.8
30. " " " (CS2) at Forster, L122.8
31. " " " (CS3) at Forster, L122.8
32. " " " (CS1) at Bedrock, R131
33. " " " (CS2) at Bedrock, R131
34. " " " (CS1) at Ledges, R151.6
35. " " " (CS2) at Ledges, R151.6
36. " " " (CS1) at National, L166.5
37. " " " (CS2) at National, L166.5
38. Map of Lower National Canyon Beach, L166.6
39. Location of BS1 (A) and BS2 (B) at Lower National
40. Cross section profile (CS1) at Lower National, L166.6
41. " " " (CS2) at Lower National, L166.6

Figure 42. Cross section profile (CS1) at Lower Lava, R190.9
43. " " " (CS2) at Lower Lava, R180.9
44. " " " (CS1) at 190 Mile, L190.2
45. " " " (CS1) at Granite Park, L208.8
46. " " " (CS2) at Granite Park, L208.0
47. Map of 220 Mile Beach, R220
48. Location of BS1 (A) and BS2 (B) at 220 Mile Beach
49. Cross section profile (CS1) at 220 Mile, R220
50. " " " (CS2) at 220 Mile, R220

Figure II-1. Net gain or loss in vertical feet of sand.

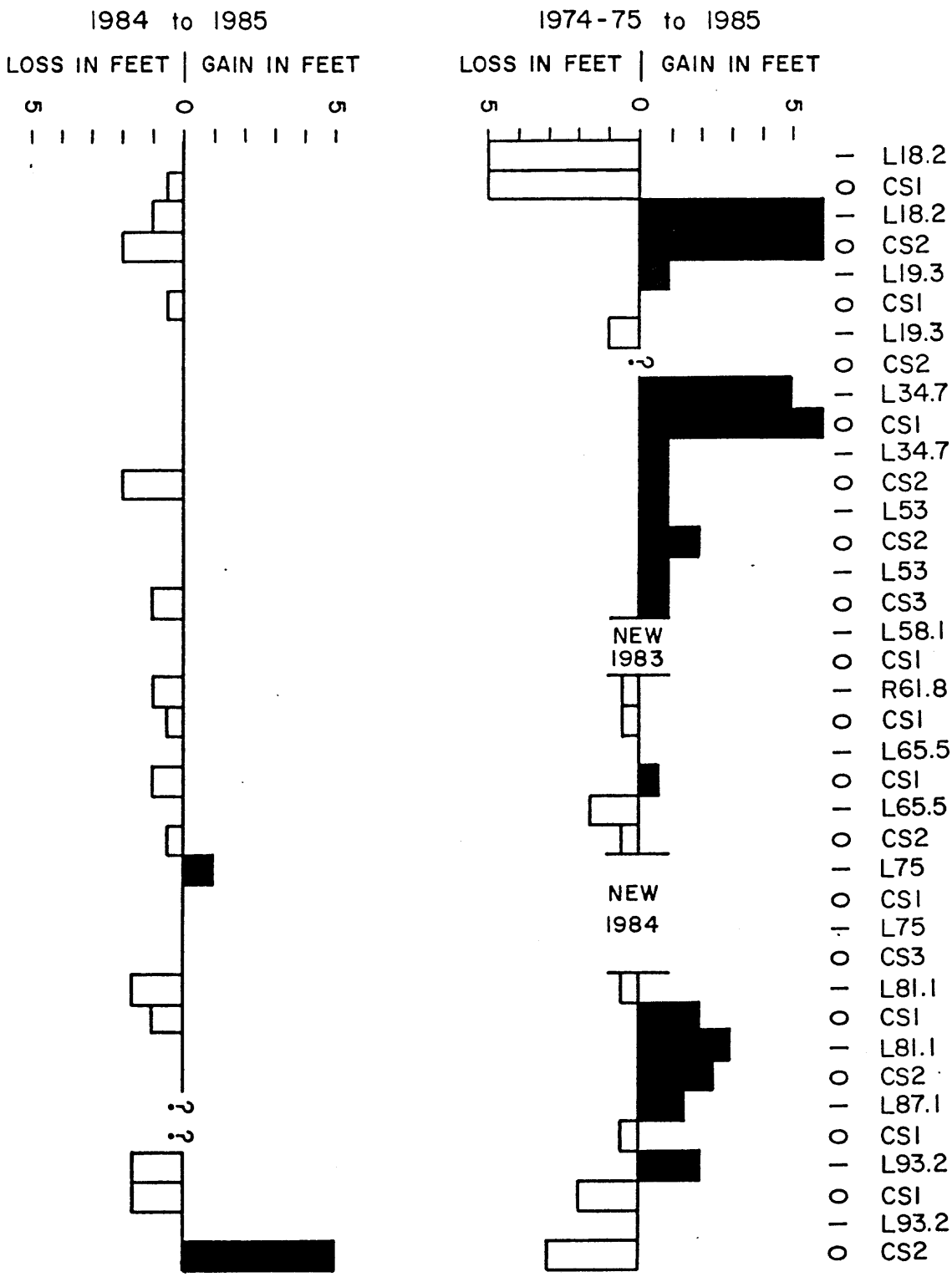
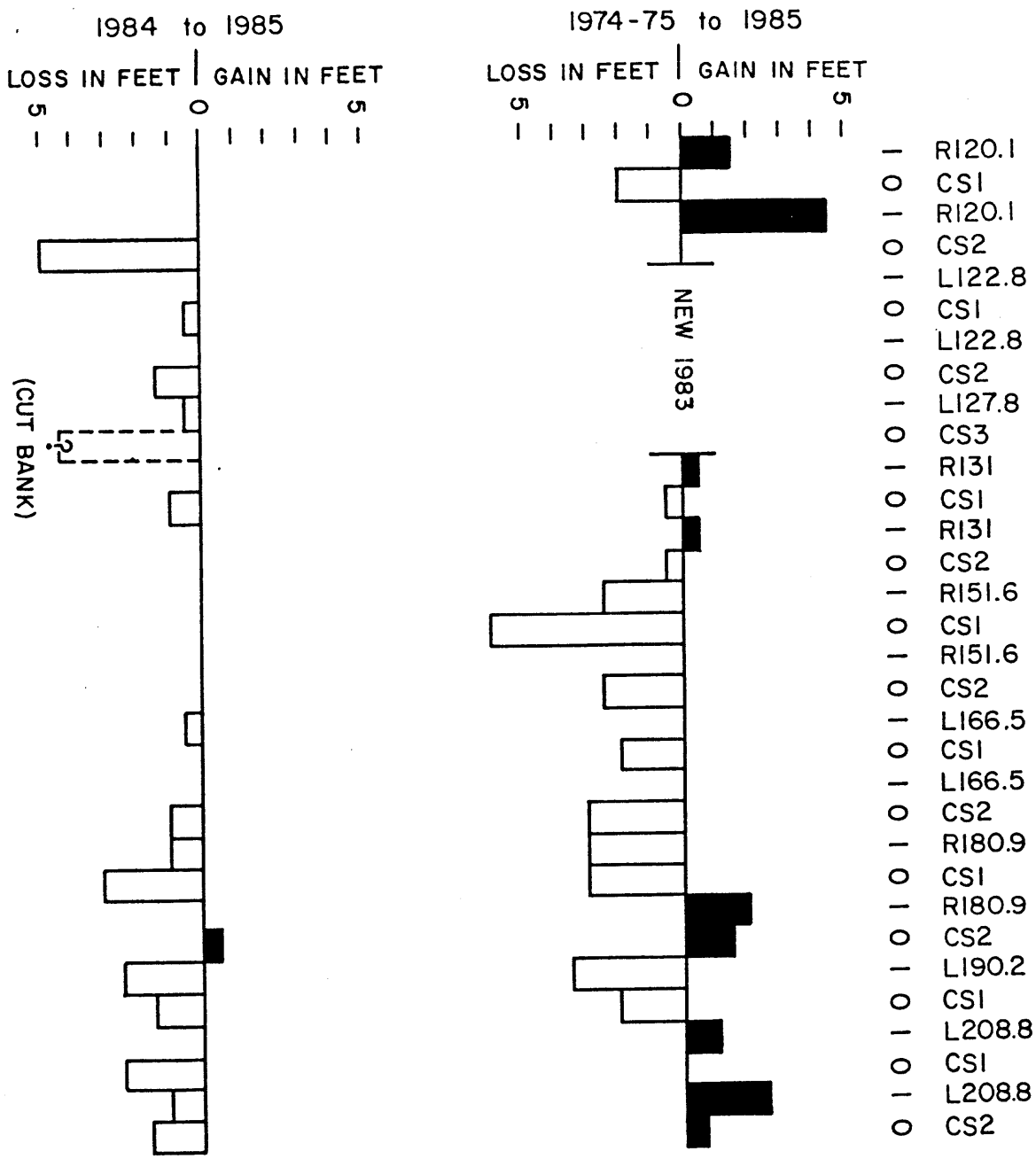


Figure II-2. Net gain or loss in vertical feet of sand.



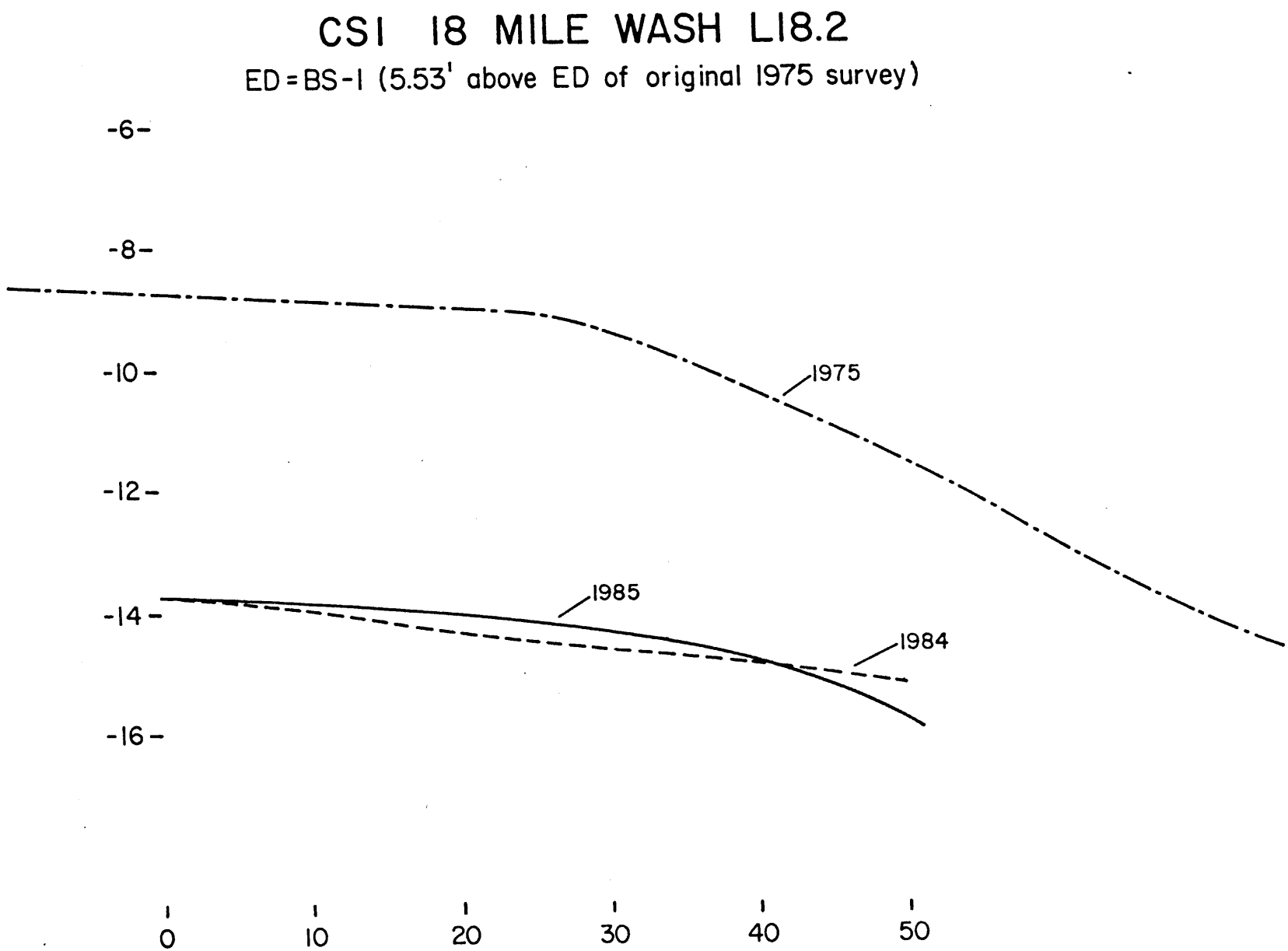

CSI 18 MILE WASH L18.2
ED=BS-1 (5.53' above ED of original 1975 survey)
-6
-8
-10
-12
-14
-16
1975
1985
1984
0
10
20
30
40
50

Figure II-3

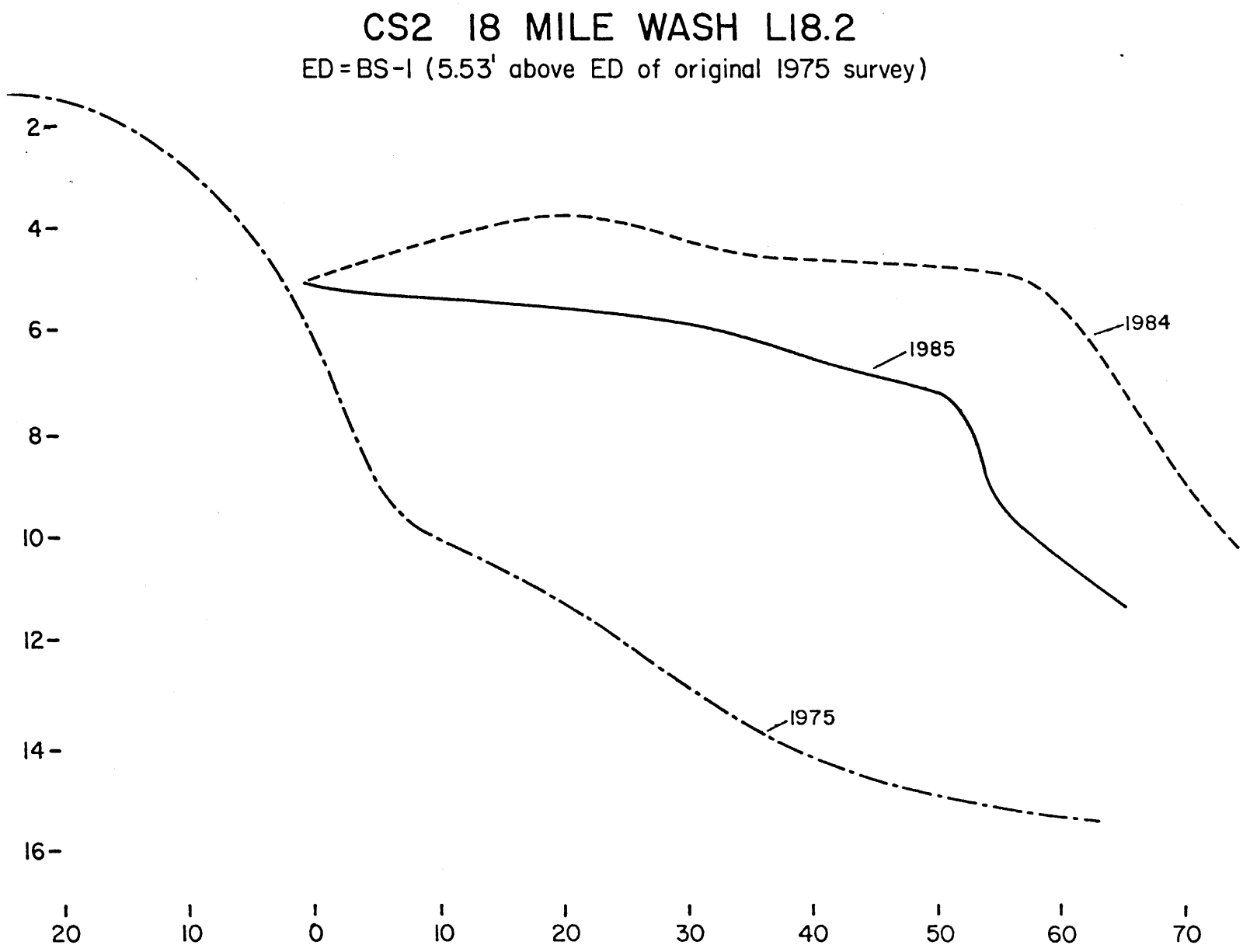

CS2 18 MILE WASH L18.2
ED=BS-1 (5.53' above ED of original 1975 survey)
2
4
6
8
10
12
14
16
20
10
0
10
20
30
40
50
60
70
1984
1985
1975

Figure II-4

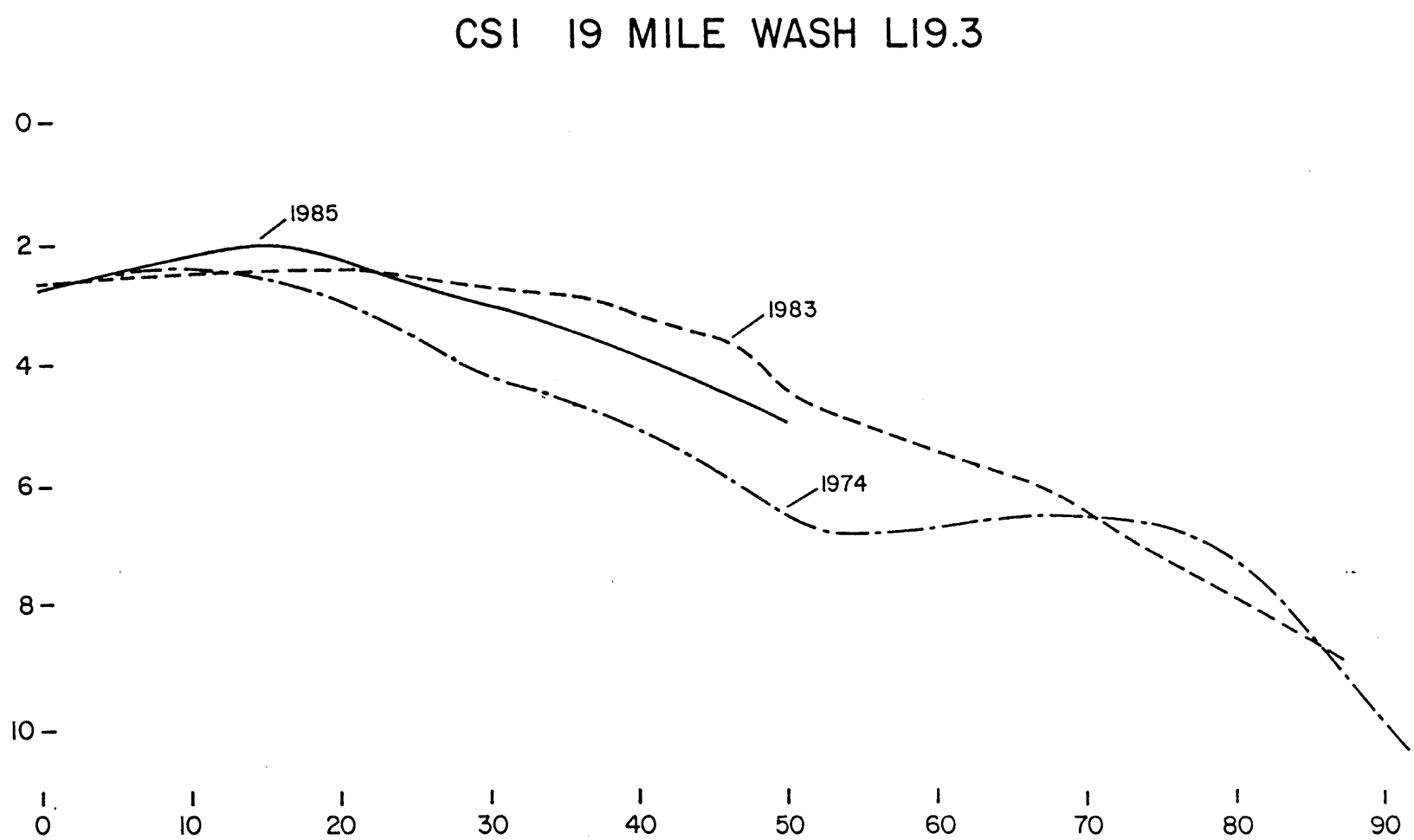

CS1 19 MILE WASH L19.3
0
2
4
6
8
10
1985
1983
1974
0
10
20
30
40
50
60
70
80
90

Figure II-5

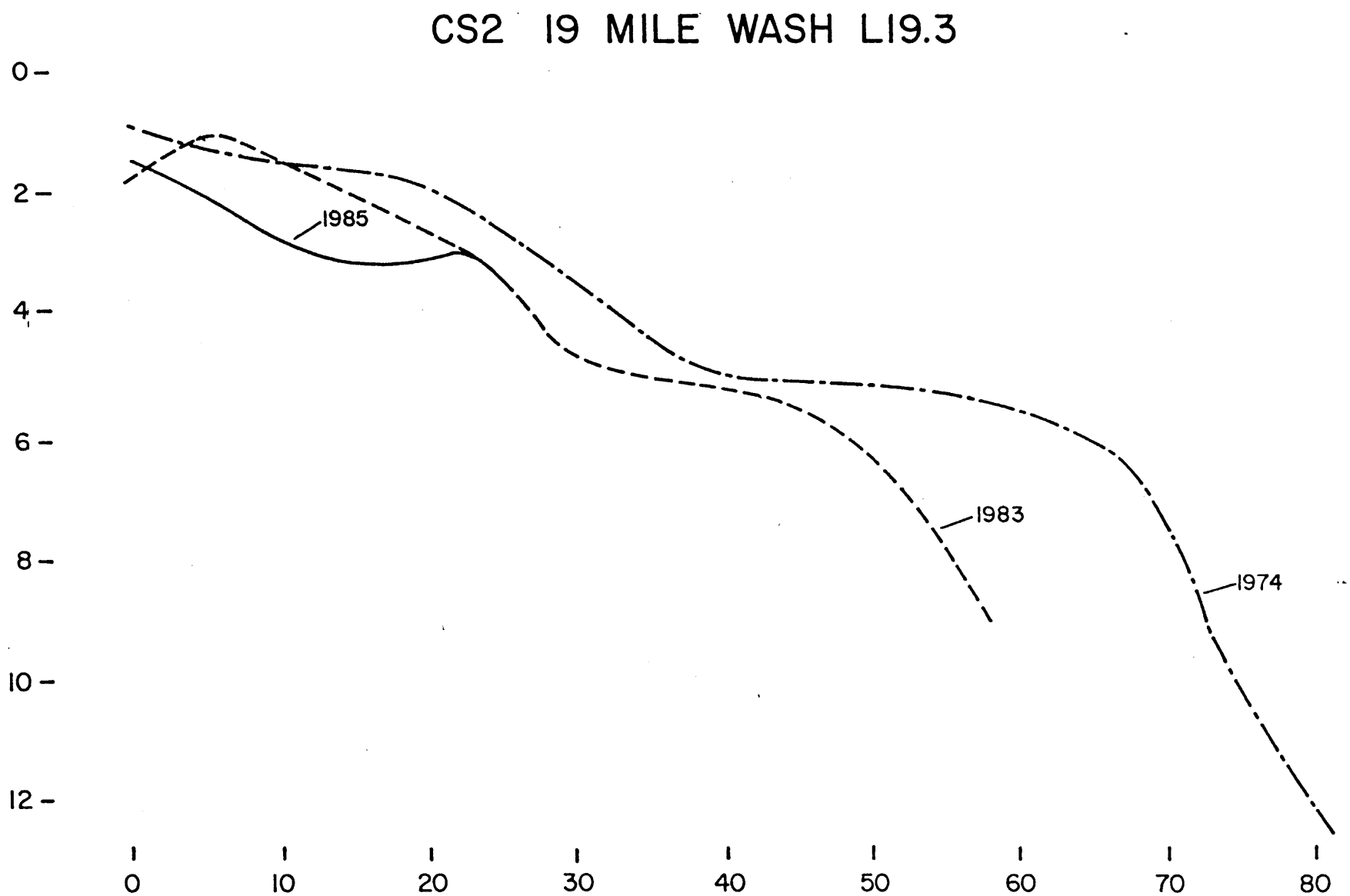
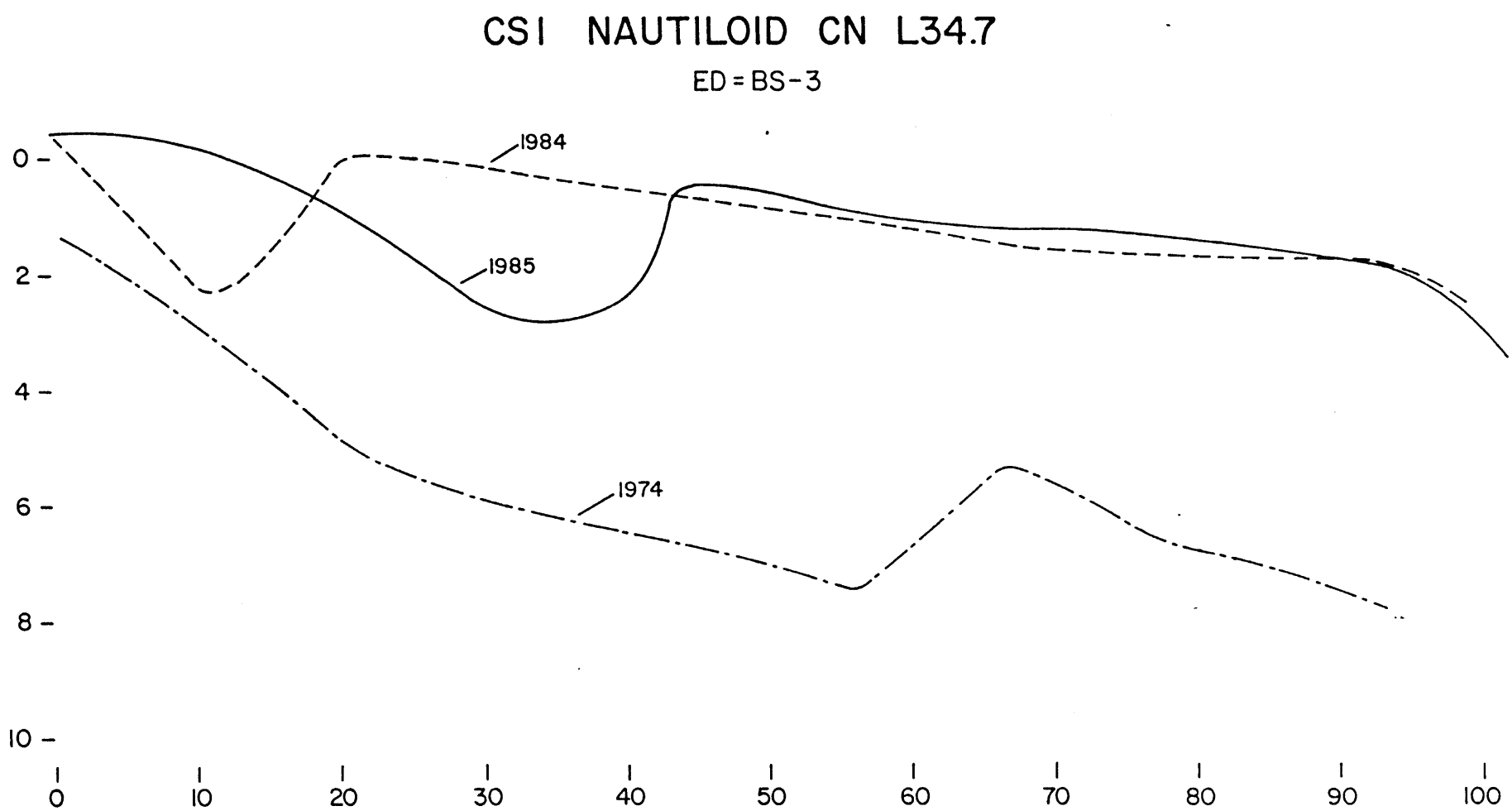

CS2 19 MILE WASH L19.3
0
2
4
6
8
10
12
0
10
20
30
40
50
60
70
80
1985
1983
1974

Figure II-6


CS1 NAUTILOID CN L34.7
ED = BS-3
1984
1985
1974
0
2
4
6
8
10
0
10
20
30
40
50
60
70
80
90
100

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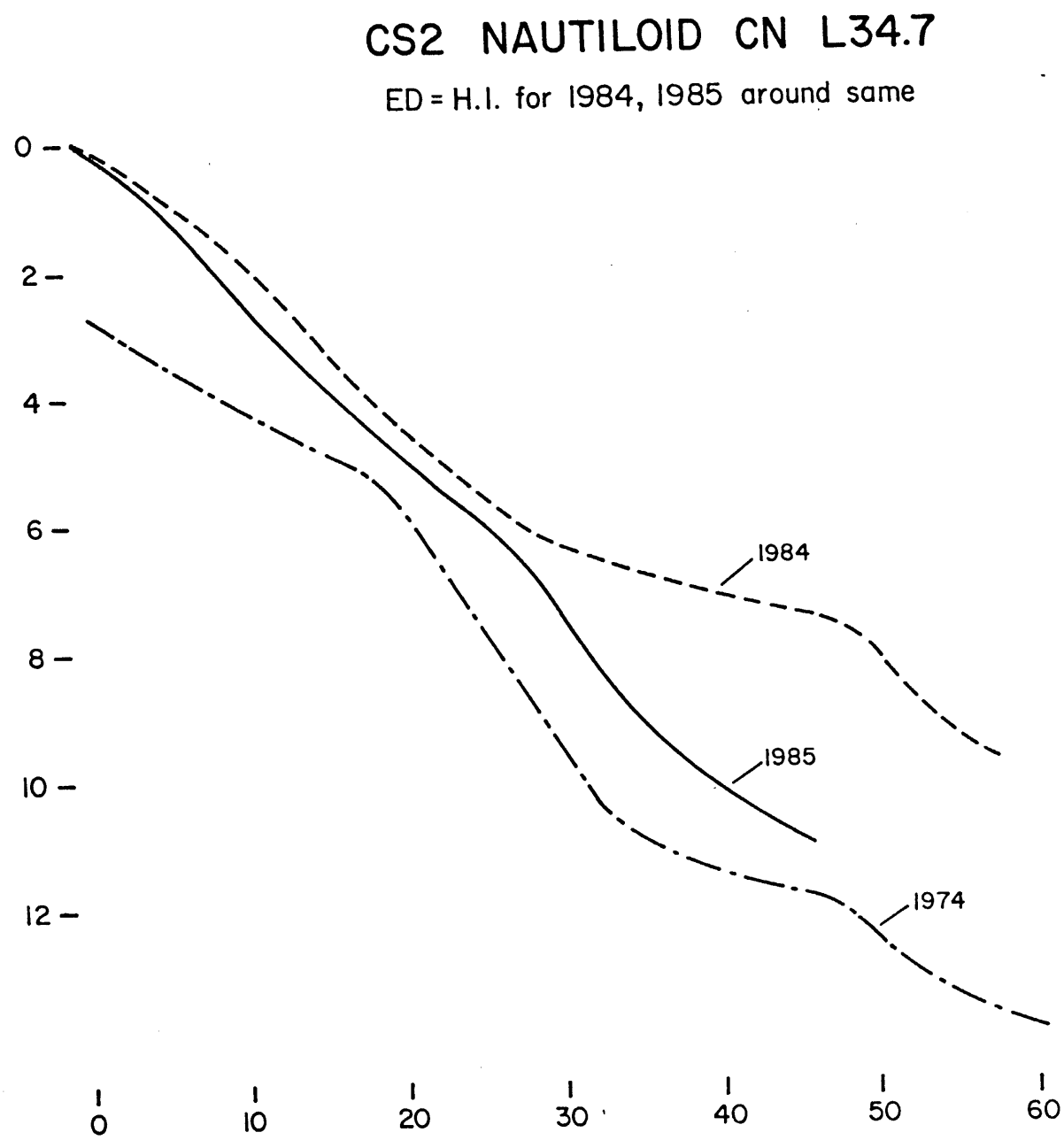
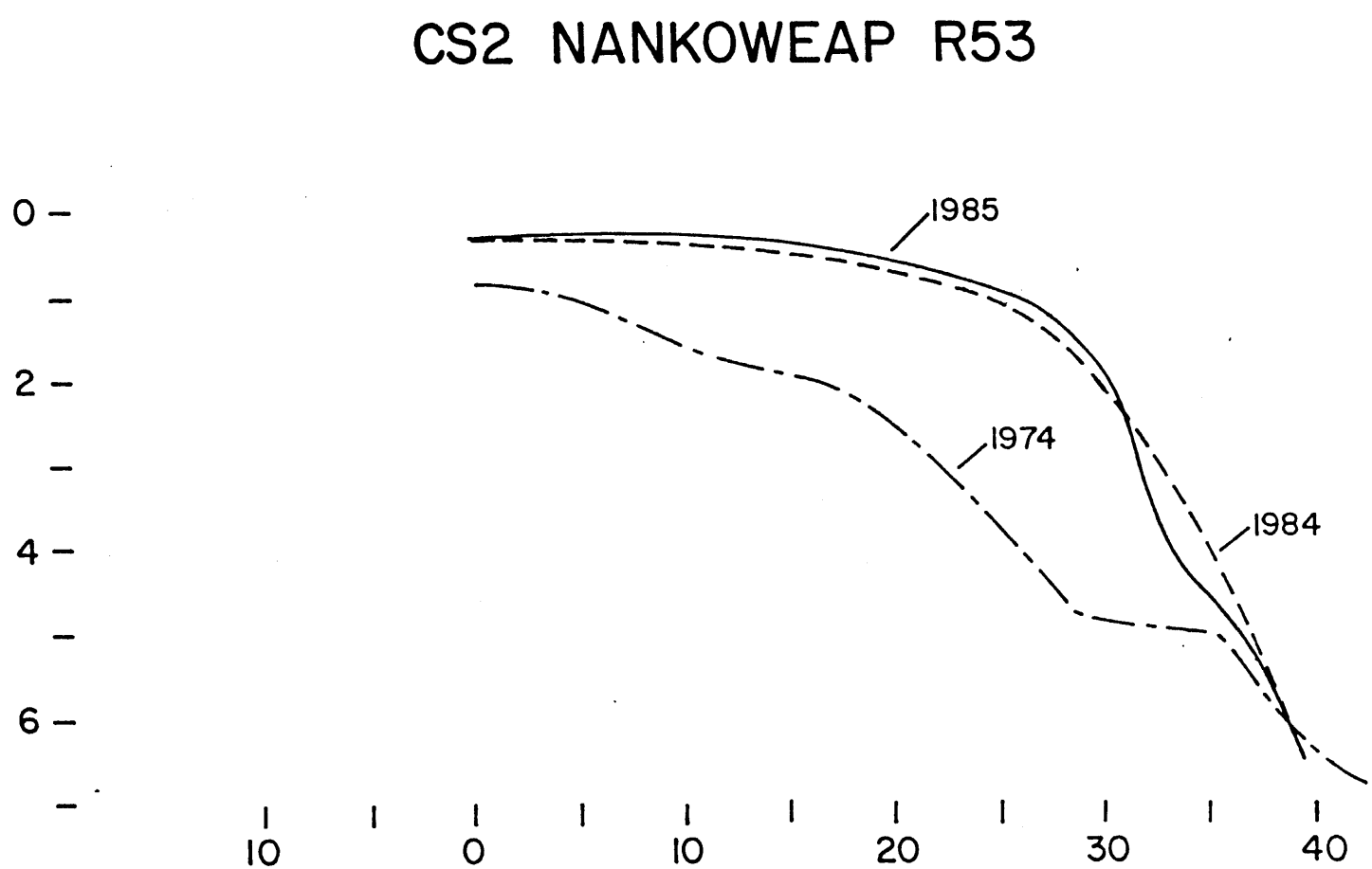

CS2 NAUTILOID CN L34.7
ED = H.I. for 1984, 1985 around same
0
2
4
6
8
10
12
1984
1985
1974
0
10
20
30
40
50
60

Figure II-8



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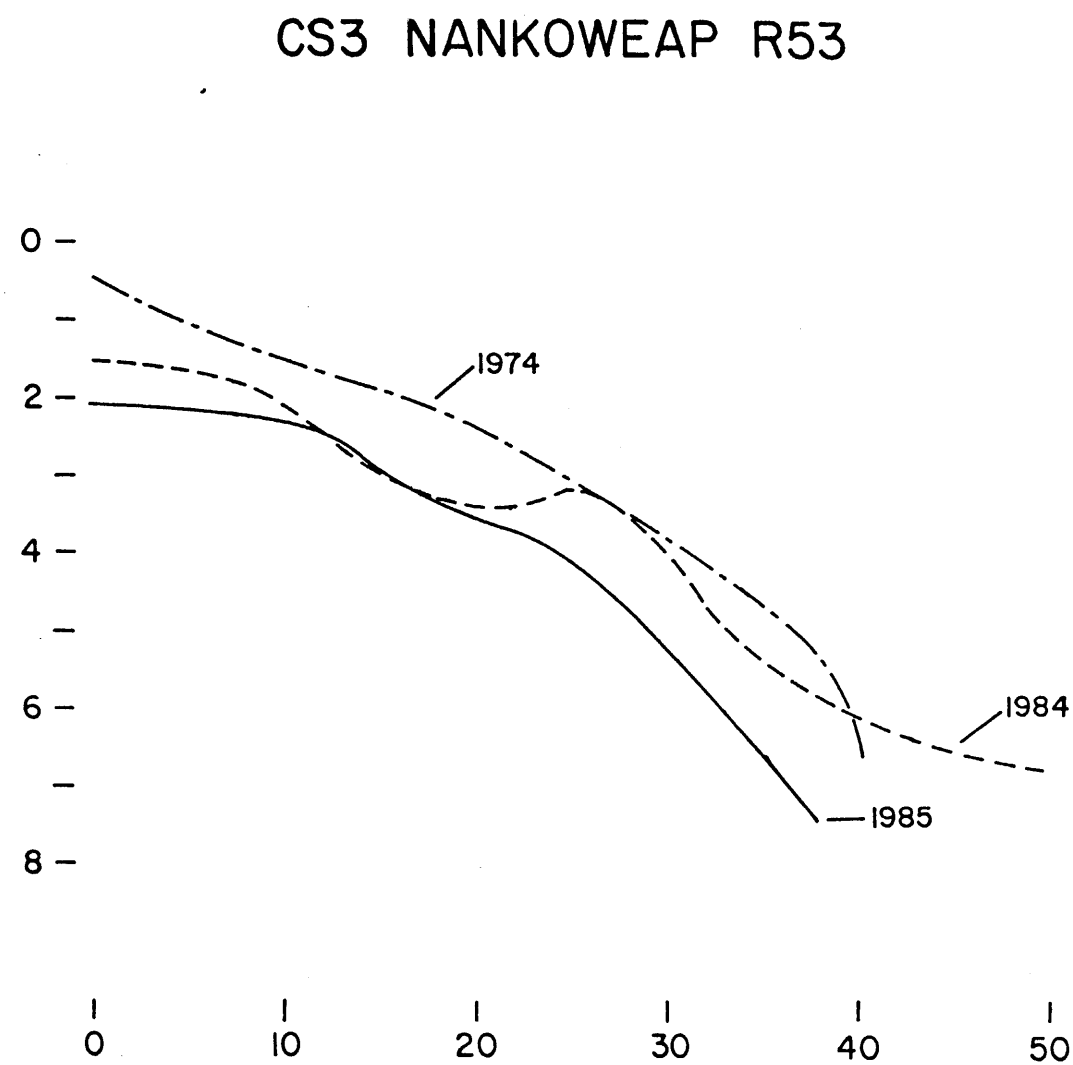

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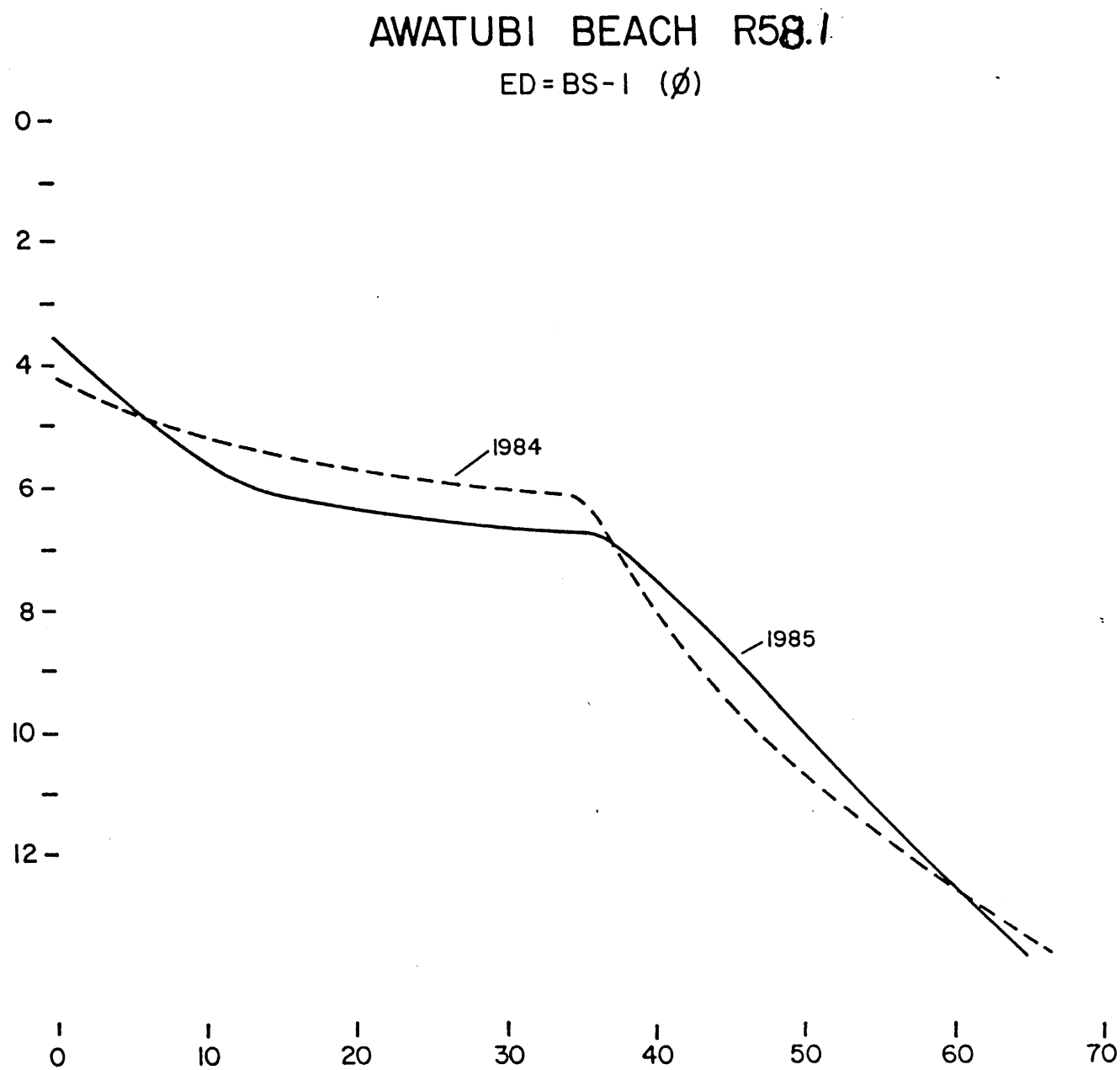

AWATUBI BEACH R58.1
ED = BS-1 (Ø)
0
2
4
6
8
10
12
1984
1985
0
10
20
30
40
50
60
70

Figure II-11

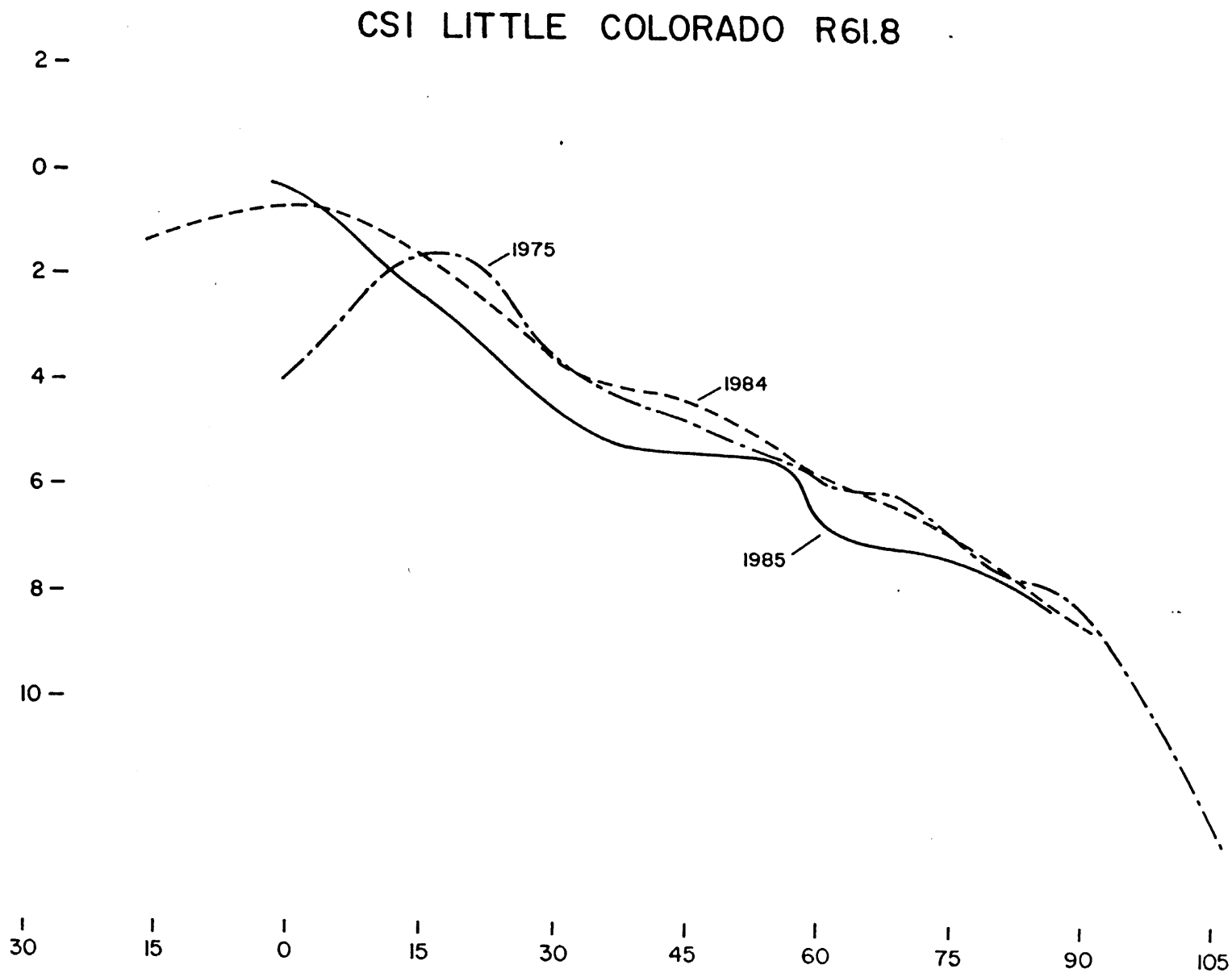
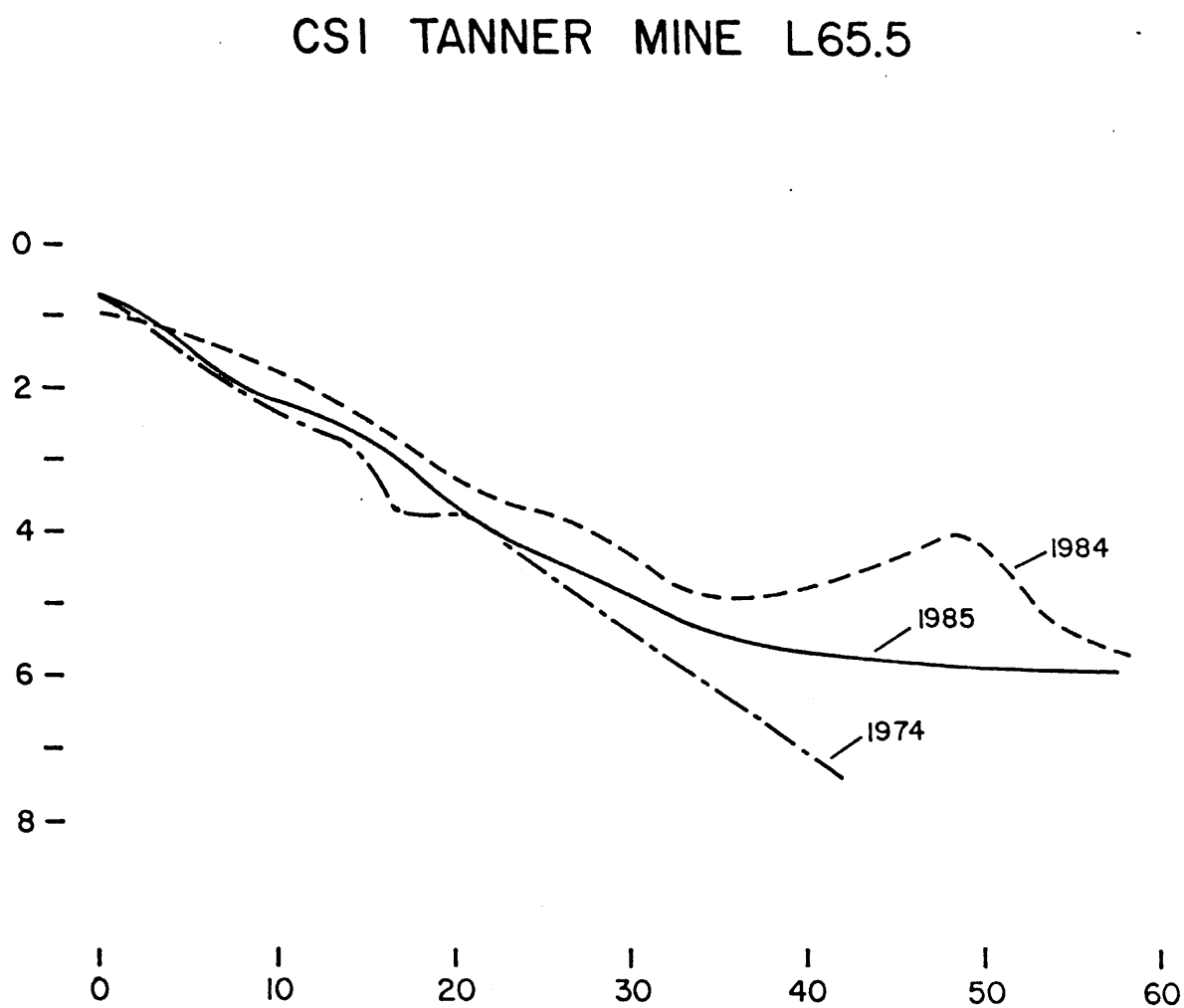

CSI LITTLE COLORADO R61.8
2
0
2
4
6
8
10
1975
1984
1985
30
15
0
15
30
45
60
75
90
105

Figure II-12



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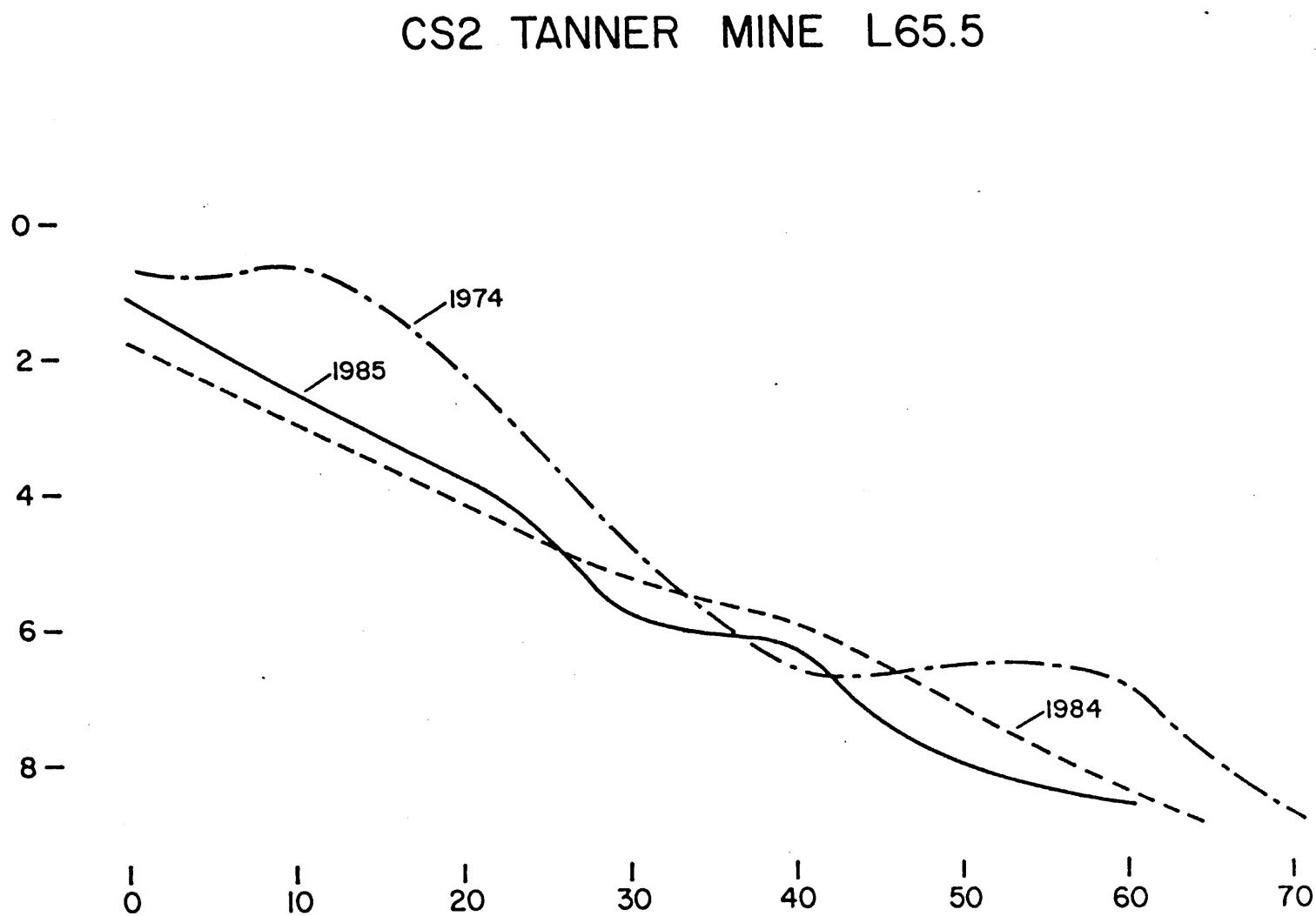

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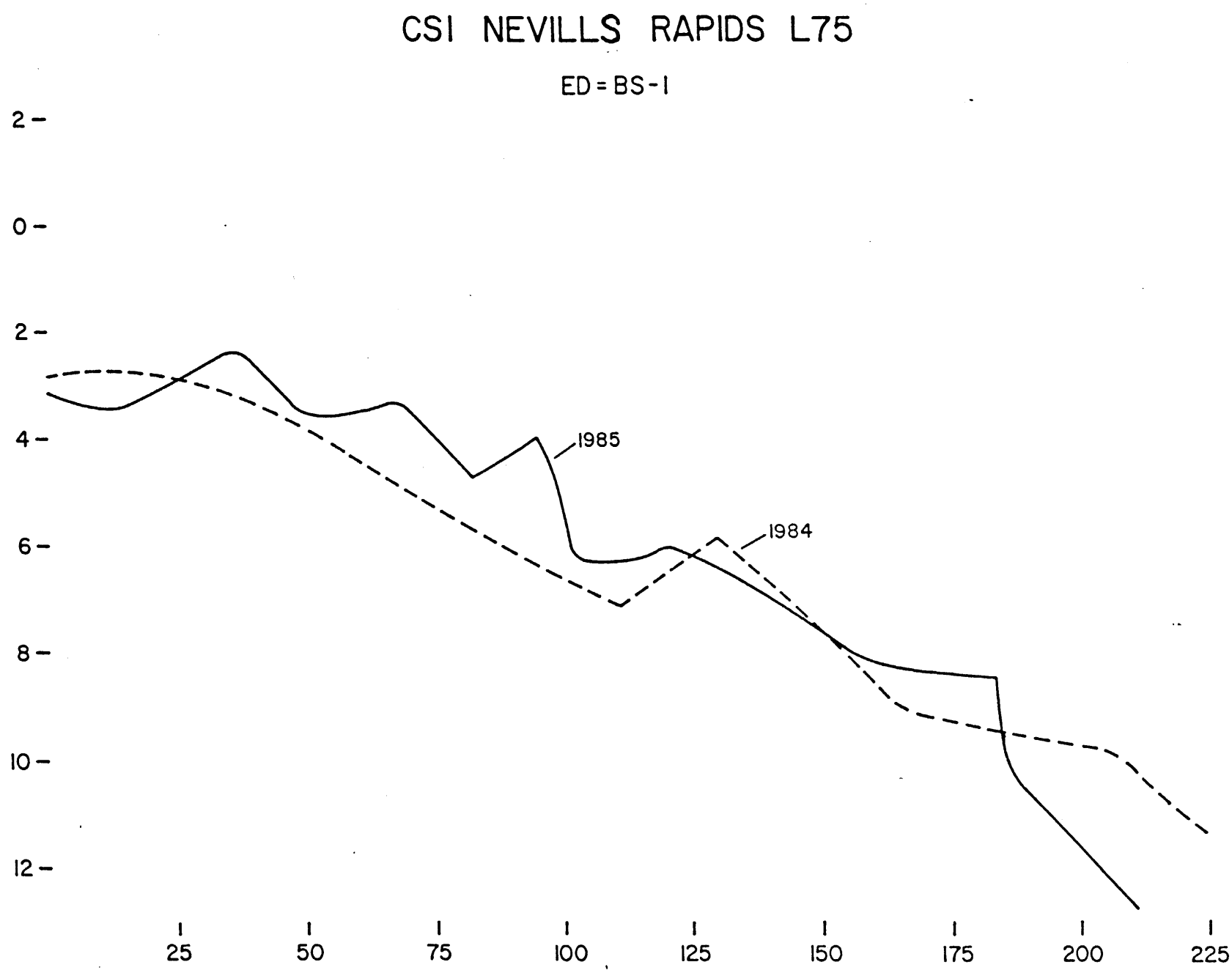

CSI NEVILLS RAPIDS L75
ED = BS-1
2
0
2
4
6
8
10
12
1985
1984
25
50
75
100
125
150
175
200
225

Figure II-15

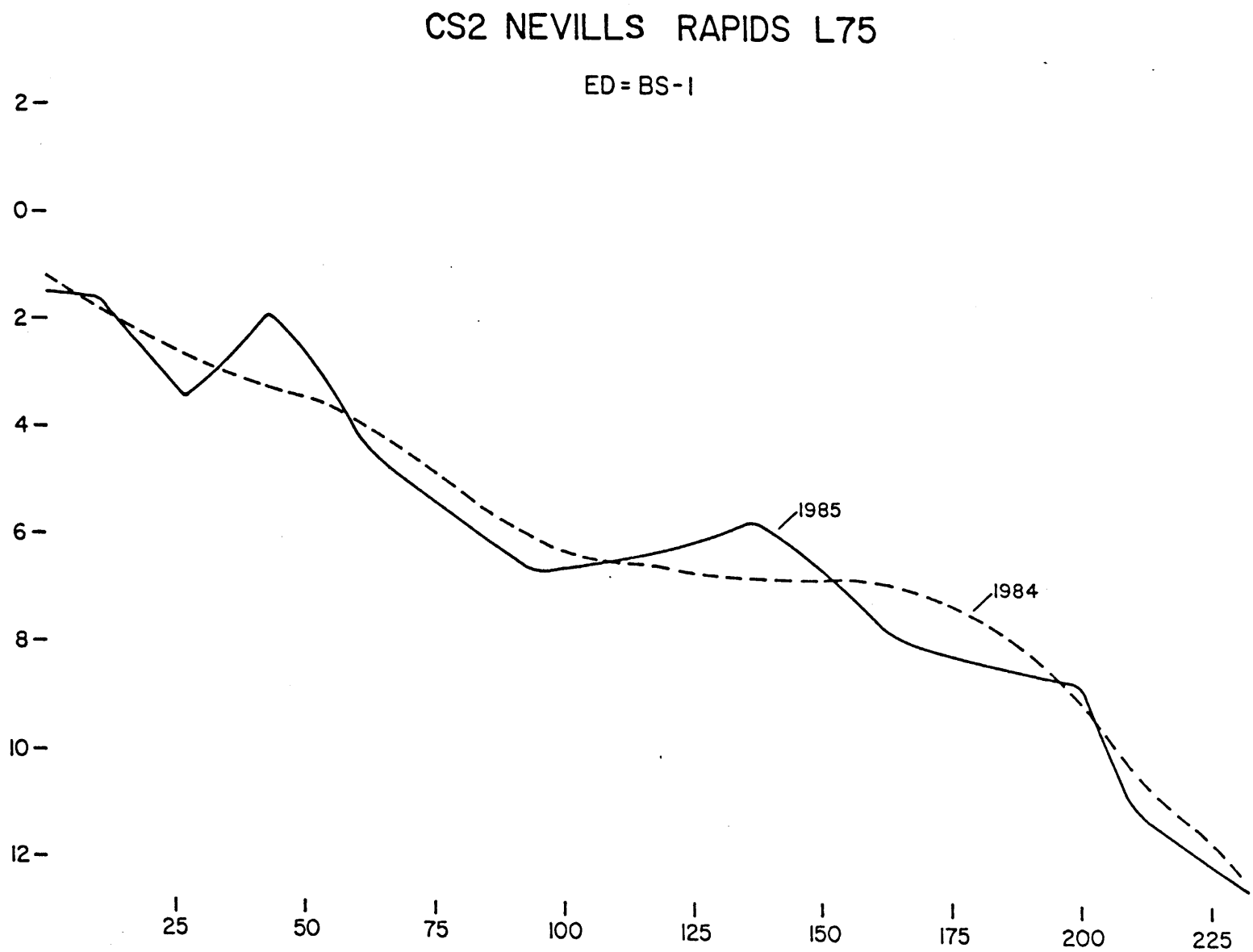

CS2 NEVILLS RAPIDS L75
ED = BS-1
2
0
2
4
6
8
10
12
1985
1984
25
50
75
100
125
150
175
200
225

Figure II-16

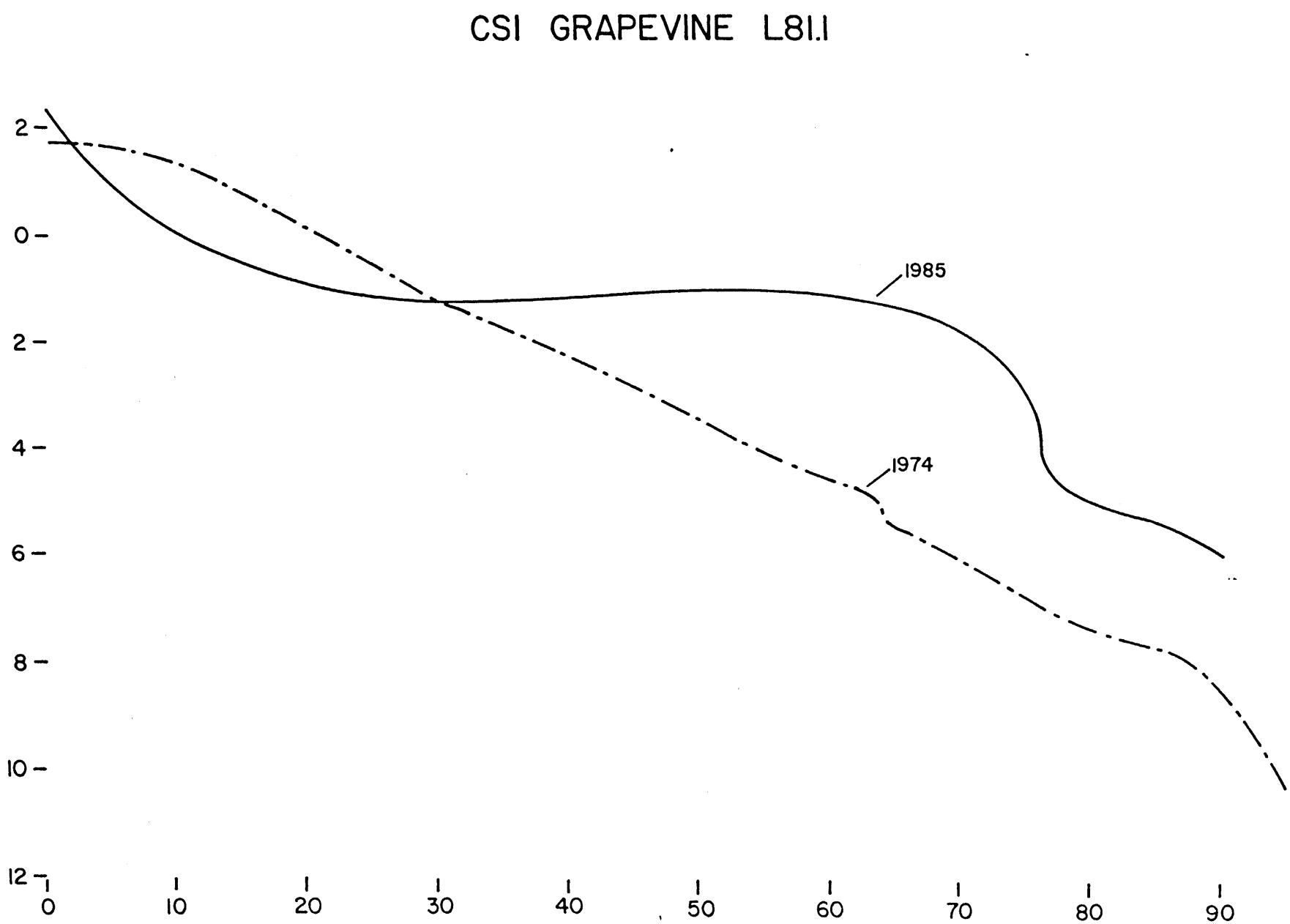

CSI GRAPEVINE L81.1
2
0
2
4
6
8
10
12
0
10
20
30
40
50
60
70
80
90
1985
1974

Figure II-17

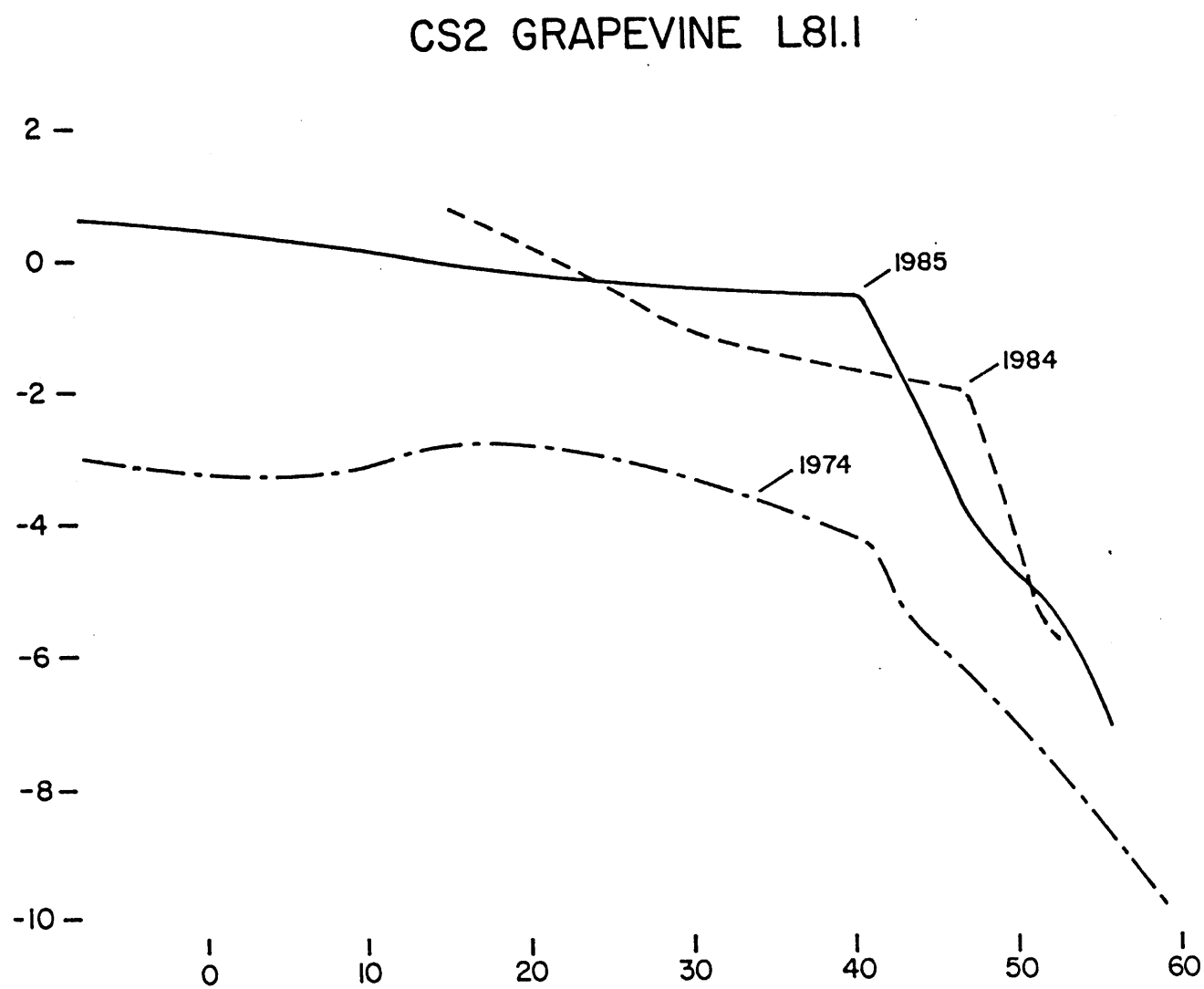


Figure II-18

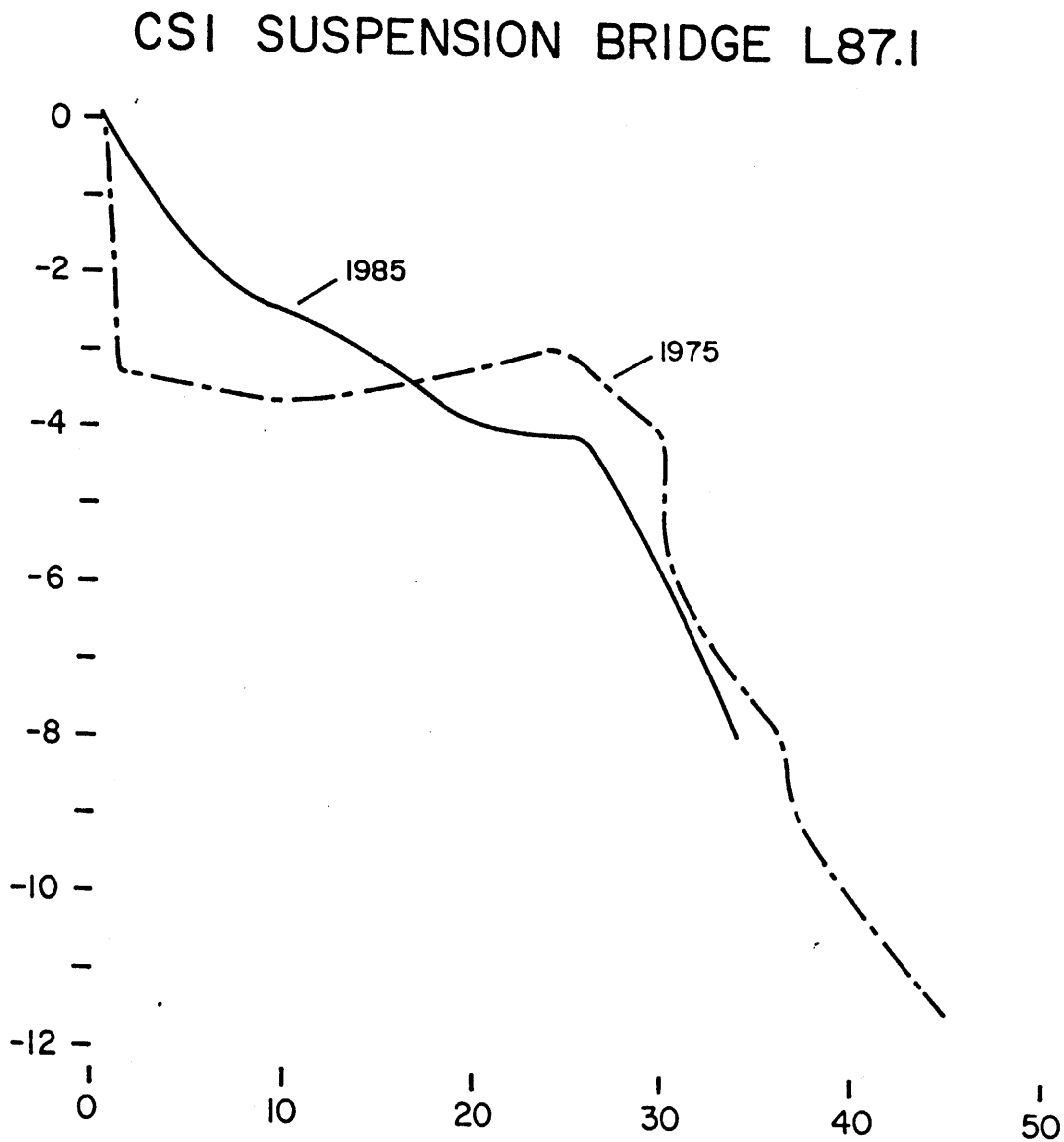

CSI SUSPENSION BRIDGE L87.1
0
-2
-4
-6
-8
-10
-12
0
10
20
30
40
50
1985
1975

Figure II-19

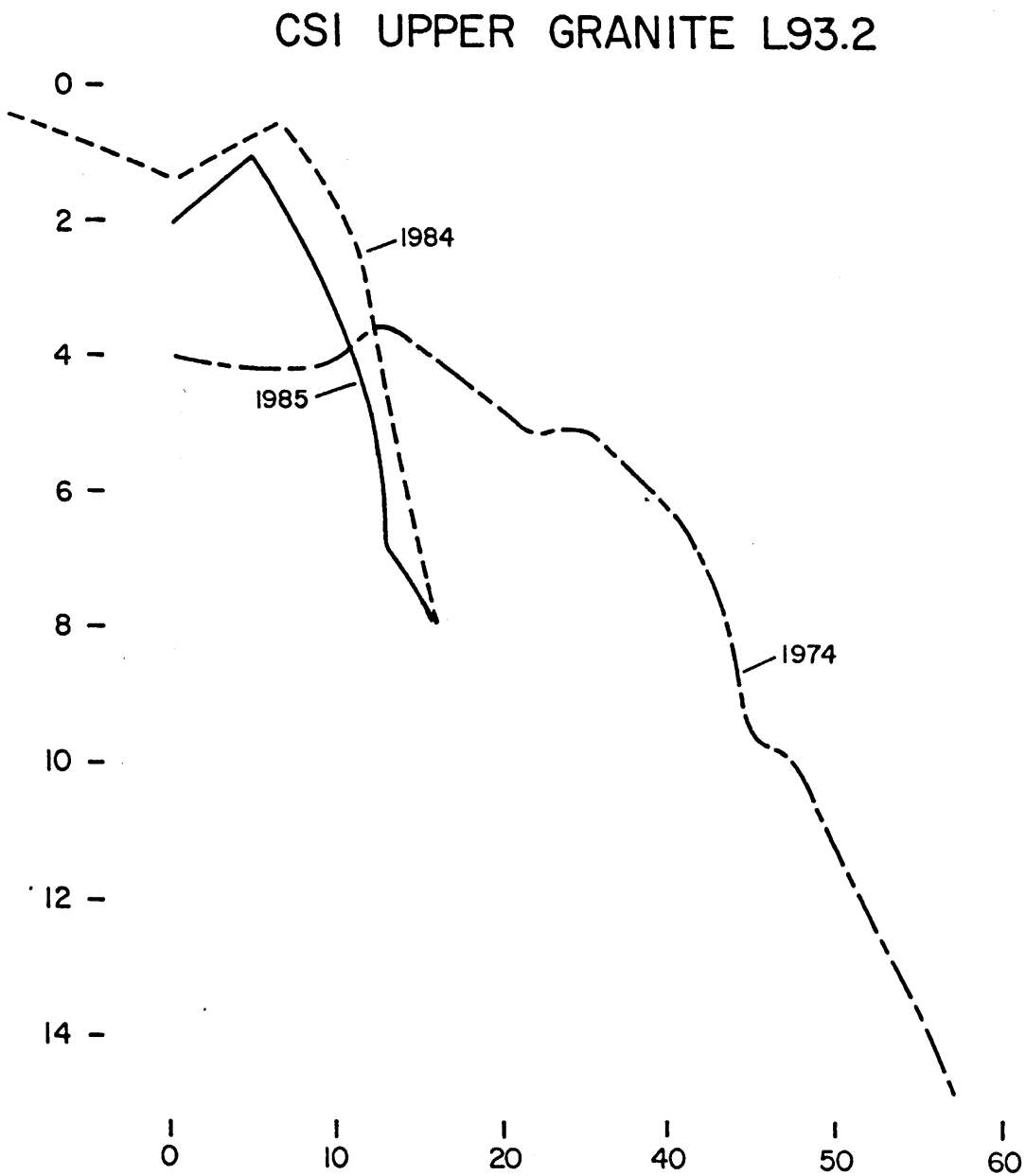

CSI UPPER GRANITE L93.2
0
2
4
6
8
10
12
14
1984
1985
1974
0
10
20
40
50
60

Figure II-20

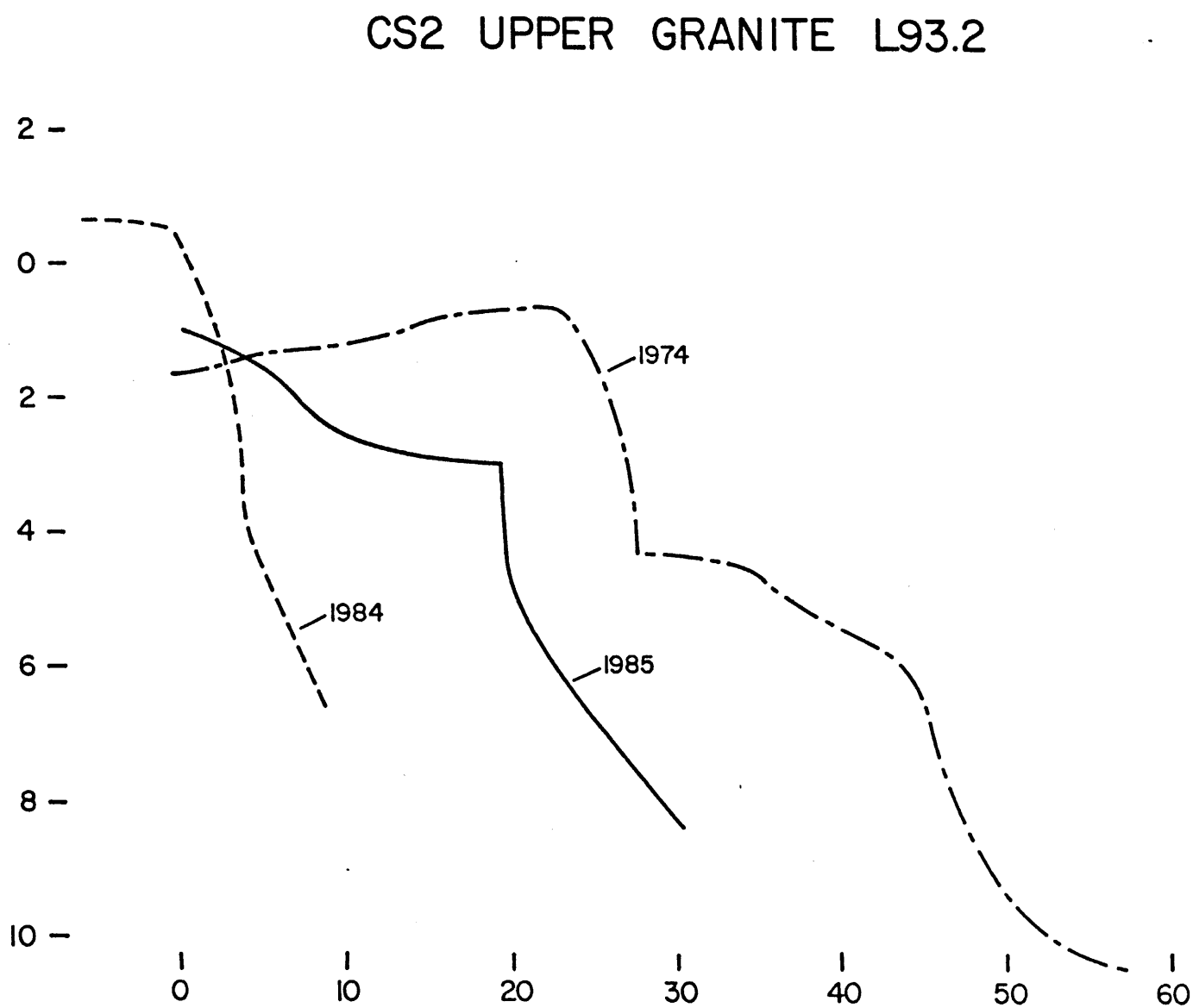

CS2 UPPER GRANITE L93.2
2
0
2
4
6
8
10
0
10
20
30
40
50
60
1974
1984
1985

Figure II-21

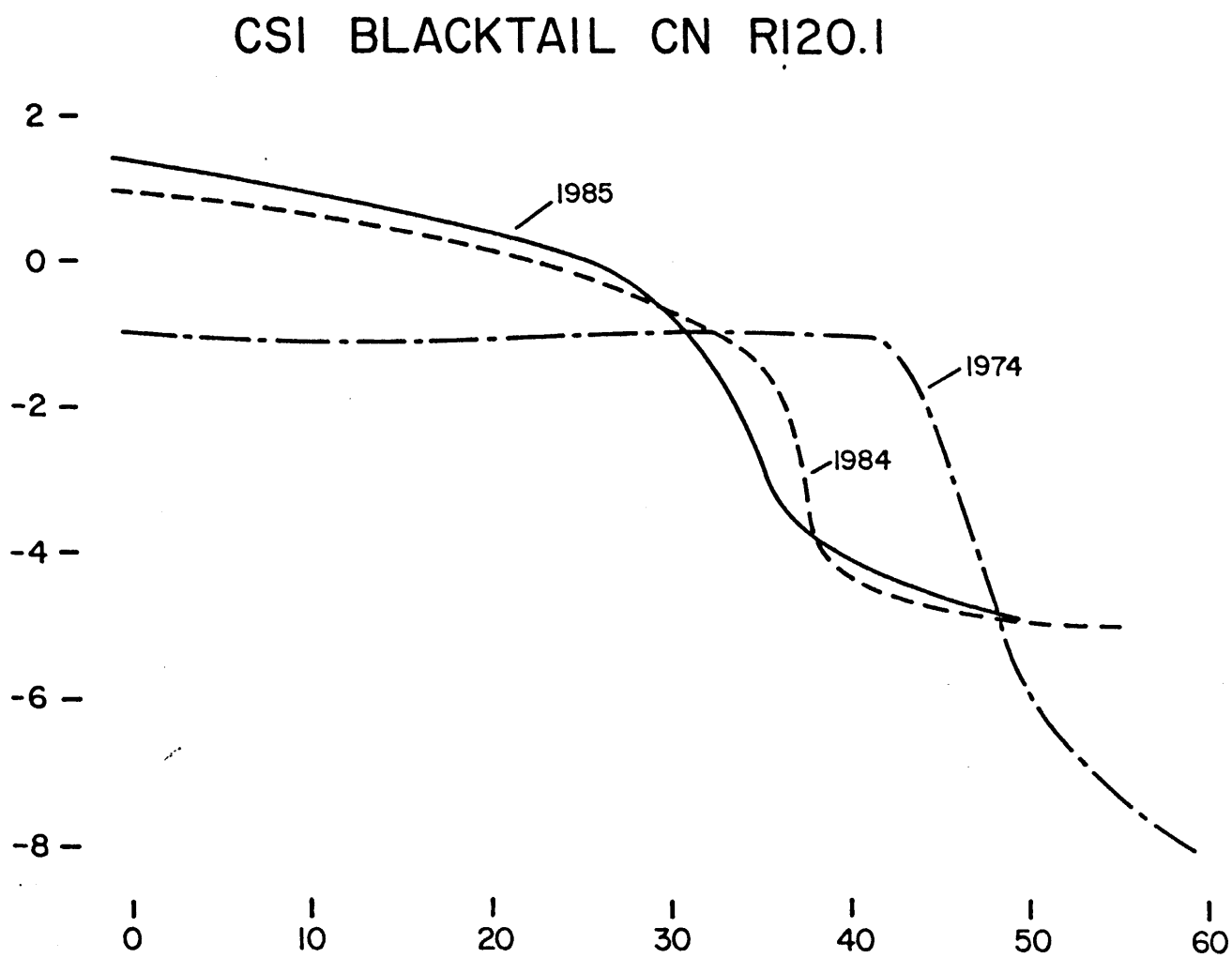
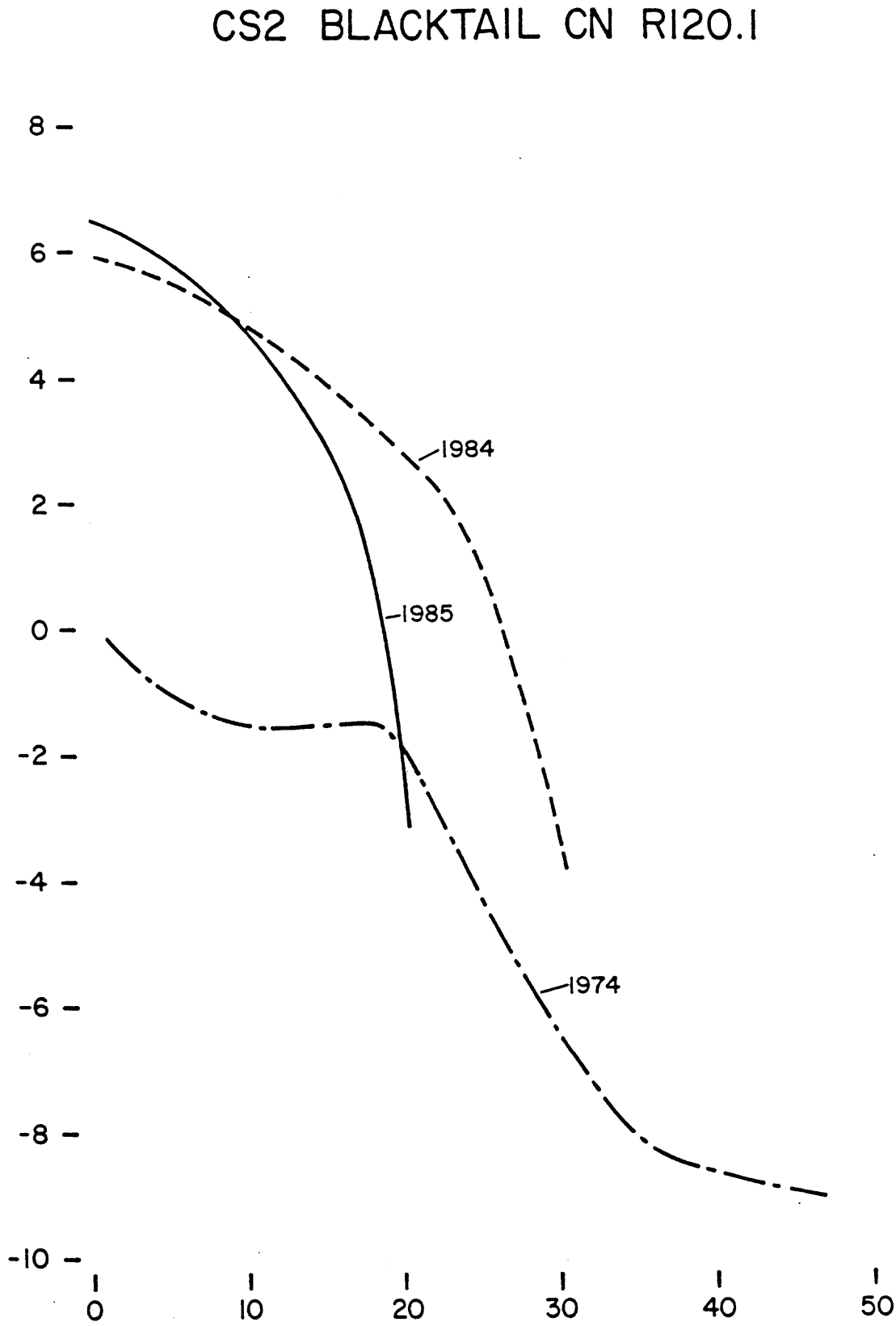

CSI BLACKTAIL CN R120.1
2
0
-2
-4
-6
-8
0
10
20
30
40
50
60
1985
1974
1984

Figure II-22

Figure II-23


CS2 BLACKTAIL CN R120.1
8
6
4
2
0
-2
-4
-6
-8
-10
0
10
20
30
40
50
1984
1985
1974

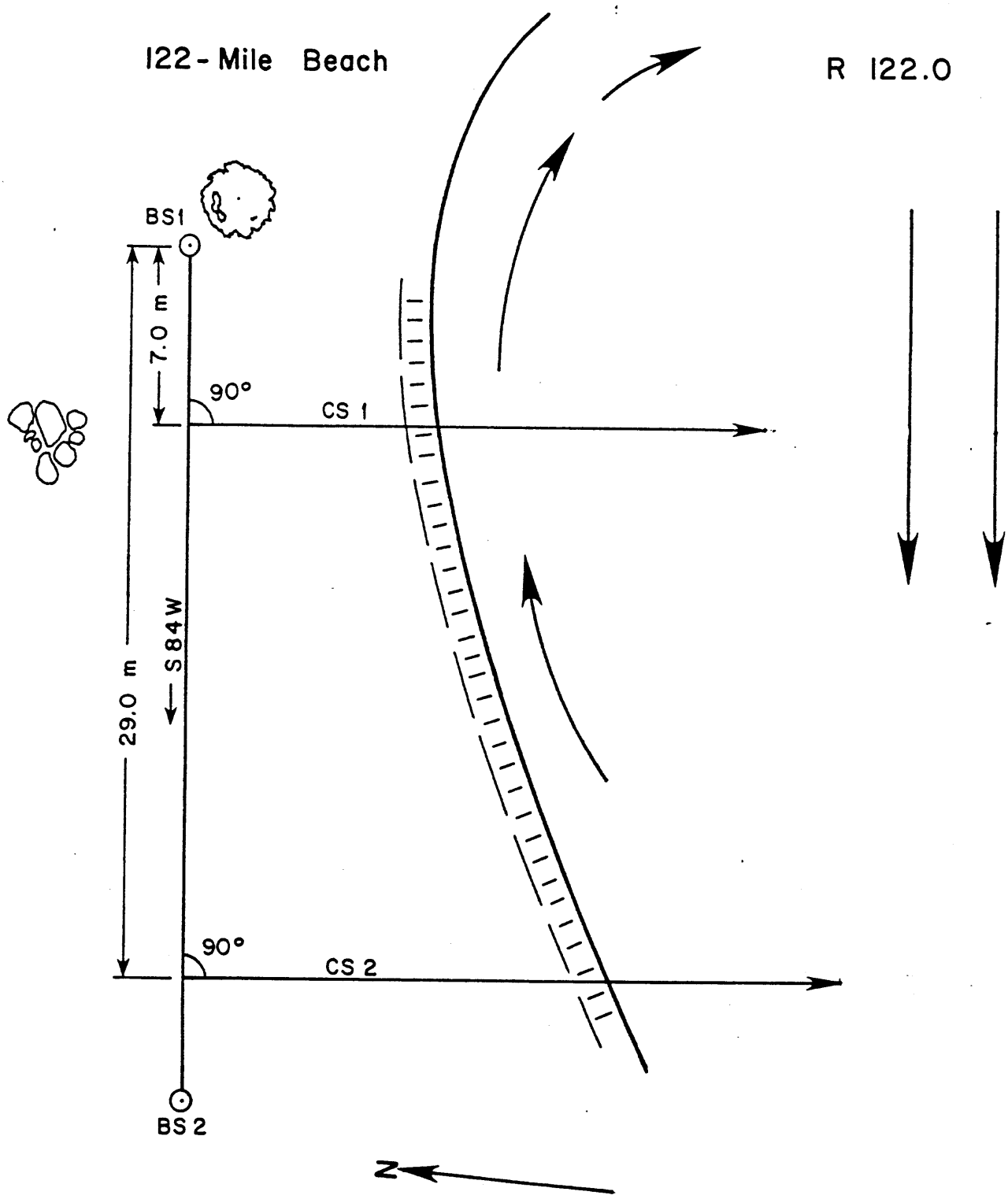


Figure II-24

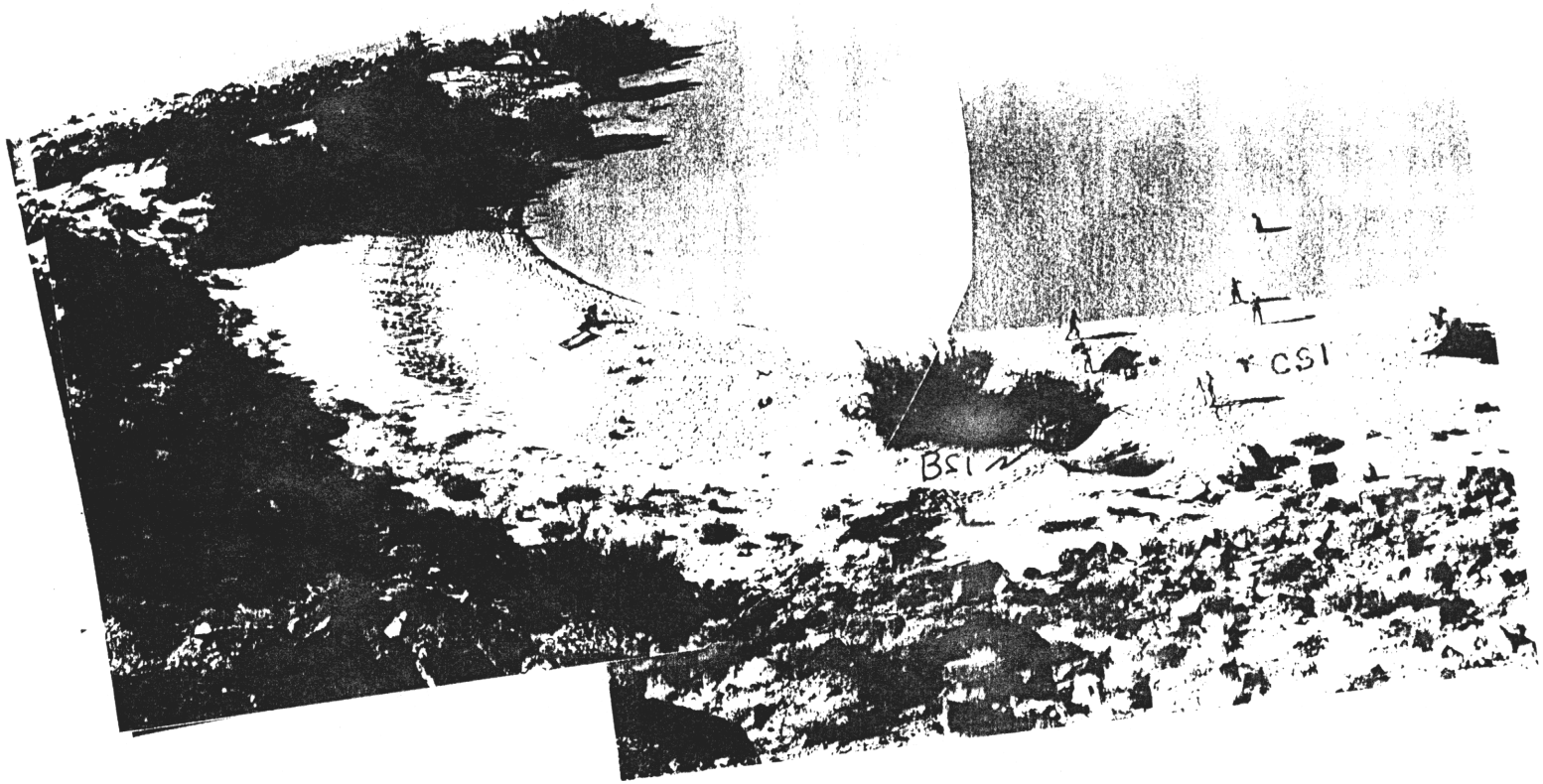


Figure II-25

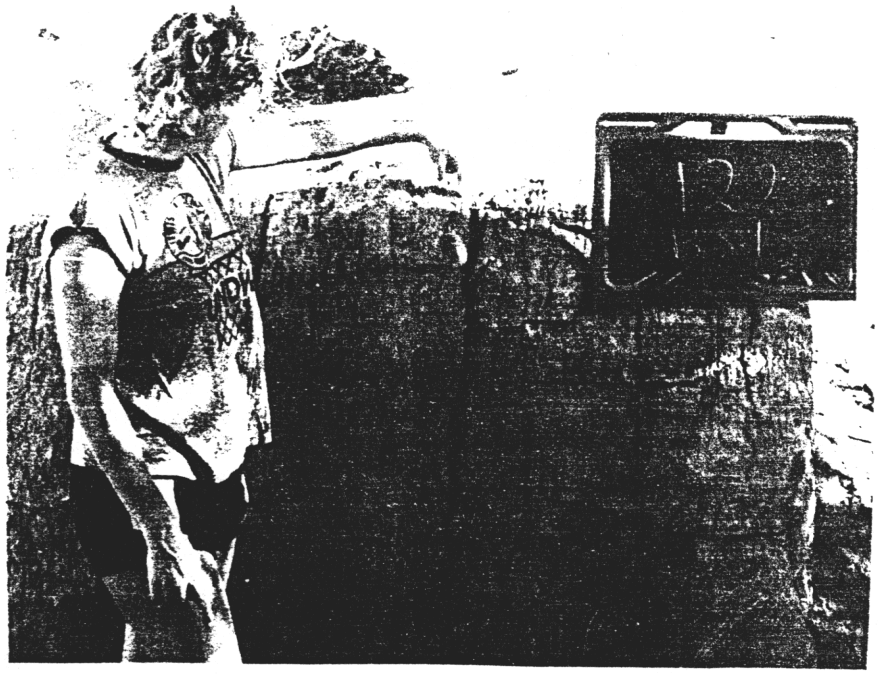


Figure II-26

BEACH PROFILE LOCATION SHEET R 122

Date established 6 August 1985

Base station #1 Large boulder blue gray LS. bedding vertical — Photo ✓ Perm. mark Nail

Base station #2 Light brn LS boulder vertical bedding — Photo ✓ Perm. mark Nail

Base Station #3 _____ — Photo _____ Perm. mark _____

Elevation datum BS 1 Photo # ✓

Length of base line #1 33.9 m from BS1 to BS2
Base line orientation S 84 W from BS1 to BS2

Length of base line # 2 _____ from _____
Base line orientation _____ from _____

Length of base line #3 _____ from _____
Base line orientation _____ from _____

Cross section #1: 7.0 m from BS1
at an angle of 90° (counter) clockwise from direction of BS1 to BS2

Cross section #2: 29.0 m from BS1 ~~to BS2~~
at an angle of 90° (counter) clockwise from direction of BS1 to BS2

Cross section #3: _____ from _____
at an angle of _____ (counter) clockwise from direction of _____

Comments Mostly new beach sand deposited in 1983-84 "spills"

New 175

CROSS-SECTION DATA SHEET

MILE: R 122 CAMPGROUND NAME: 122 - mile

CROSS-SECTION NO. CS1 SURVEY DATE: 6 Aug 85 8:05 AM

ORIGINAL SURVEY? ✓ RESURVEY NO.

FROM	TO	ROD READING (feet)	DISTANCE (ft/in)	ANGLE (deg.)	COMMENTS
CS1	B-2	2.95	—	—	
CS1	CS1 (H.I.)	4.88	0	—	
"	1	4.62	10'-9"	—	
	2	3.84	28'6"		Tag @ cut bank
	3	6.10	32'		Water edge
	4	7.85	41'4"		
	5	8.40	58'11"		
	6	8.39	76'2"		
CS1	B51	3.22	7.0 m		E.D.
		ED			

COMMENTS: Sand thickness > 3½' everywhere

~ 29 000 cfs

Hw. 1215

CROSS-SECTION DATA SHEET

MILE: R 122 CAMPGROUND NAME: 122-mile

CROSS-SECTION NO. 2 SURVEY DATE: 6 Aug 85 7:50 A.m.

ORIGINAL SURVEY? 1 RESURVEY NO.

FROM	TO	ROD READING (feet)	DISTANCE (ft/in)	ANGLE (deg.)	COMMENTS
CS 2	BS 2	2.83			
CS 2	CS2	4.74	HI		
	1	4.98	25'4"		
	2	3.75	50'10"		top cut bank
		6.14	55'2"		Water: edge
		7.80	87'2"		
CS2	BS1 (ED)	3.11	2a m		

COMMENTS:

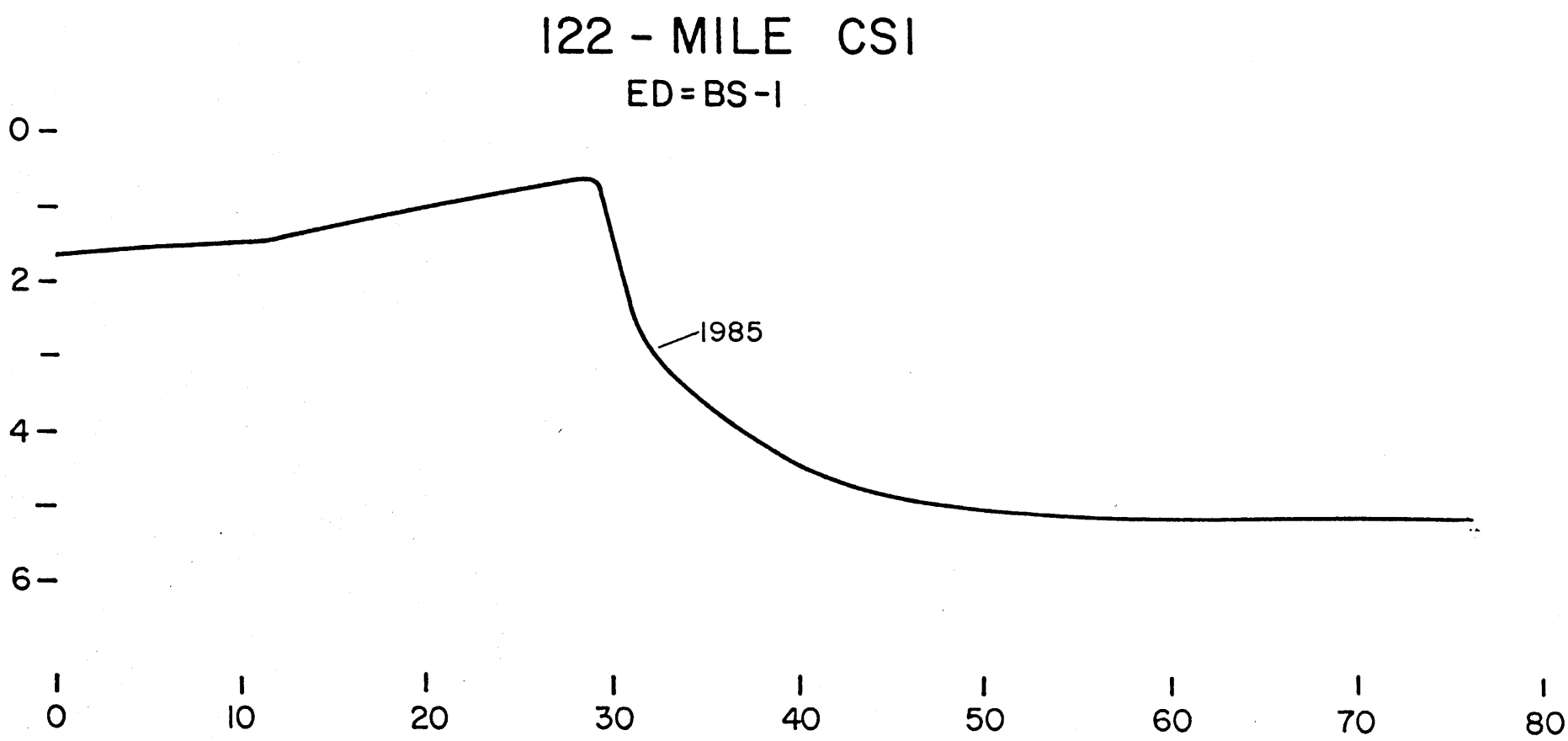


Figure II-27

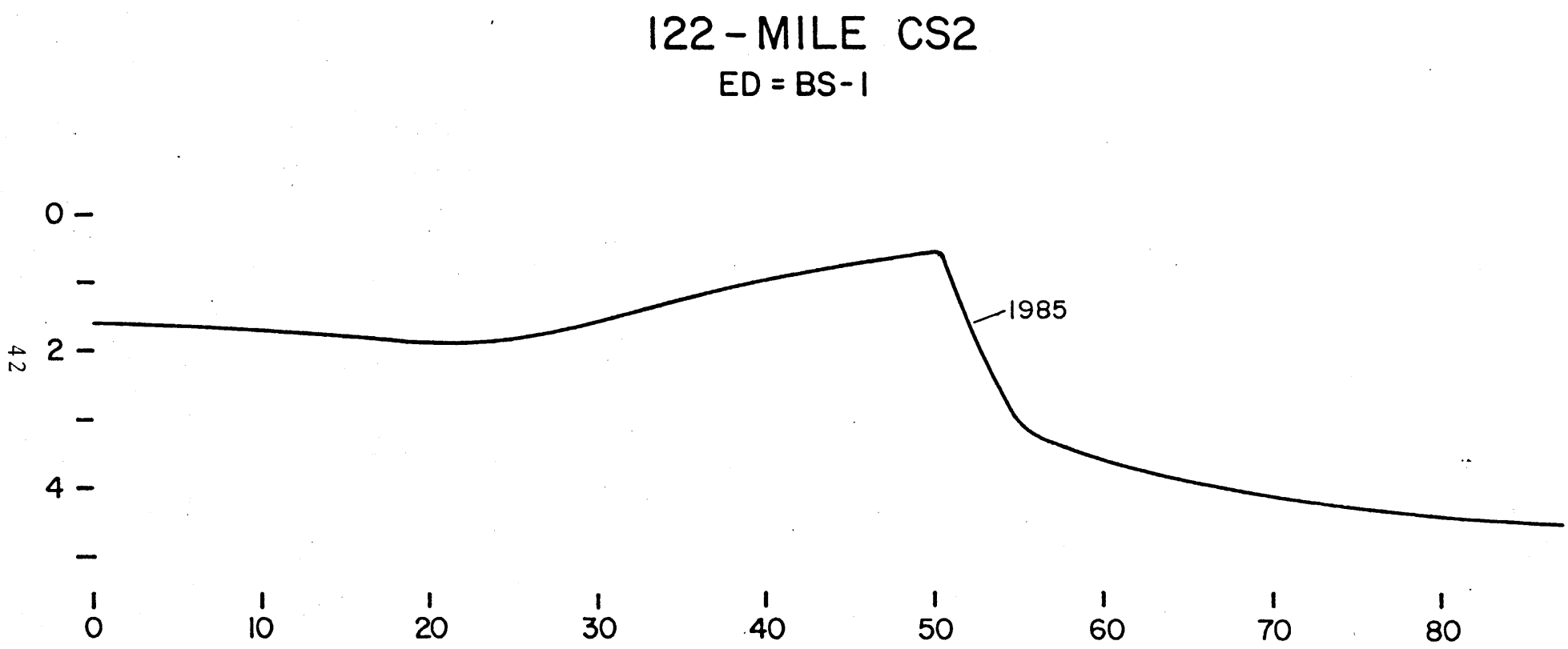


Figure II-28

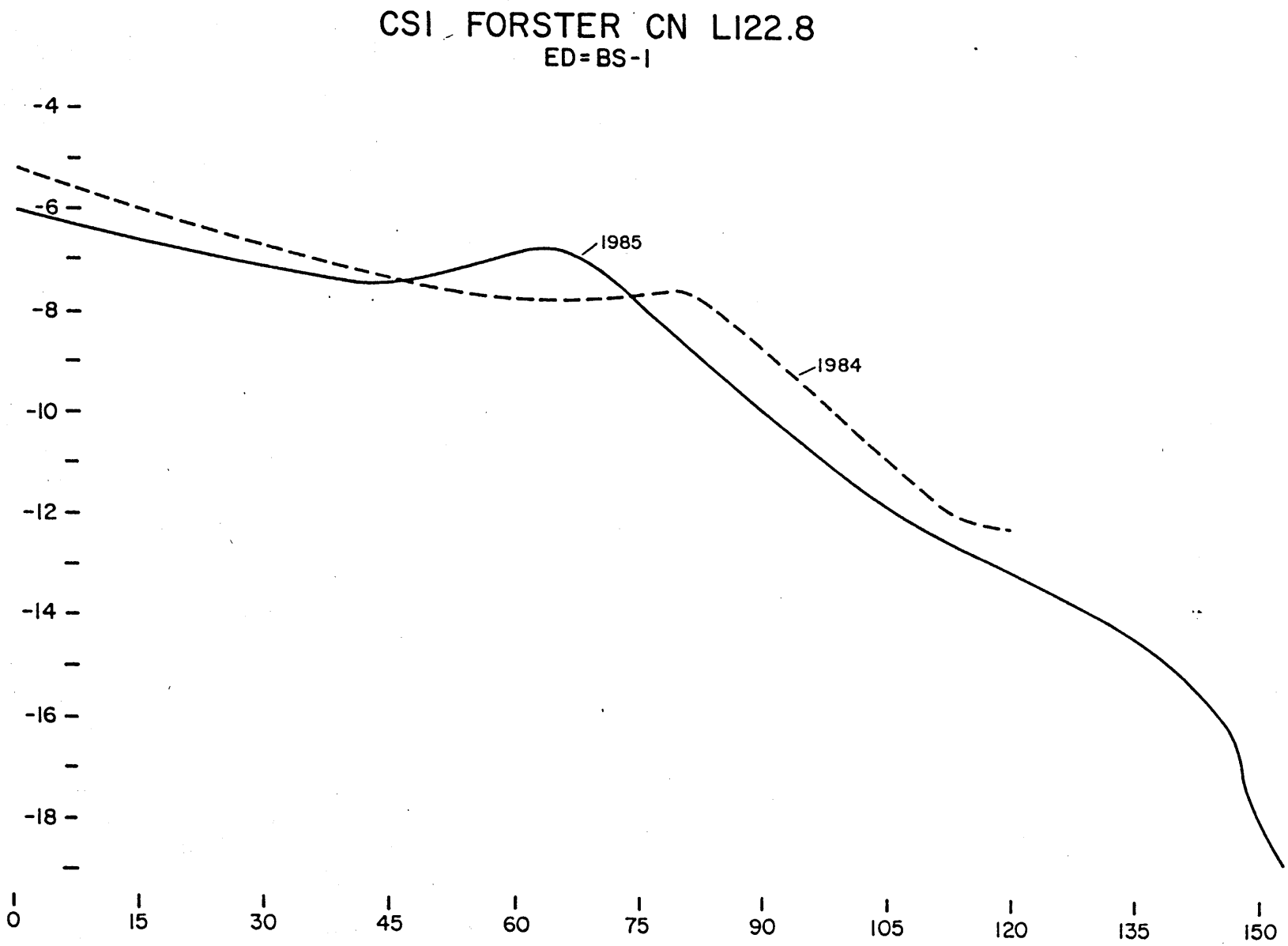

CSI FORSTER CN L122.8
ED=BS-1
-4
-6
-8
-10
-12
-14
-16
-18
0
15
30
45
60
75
90
105
120
135
150
1985
1984

Figure II-29

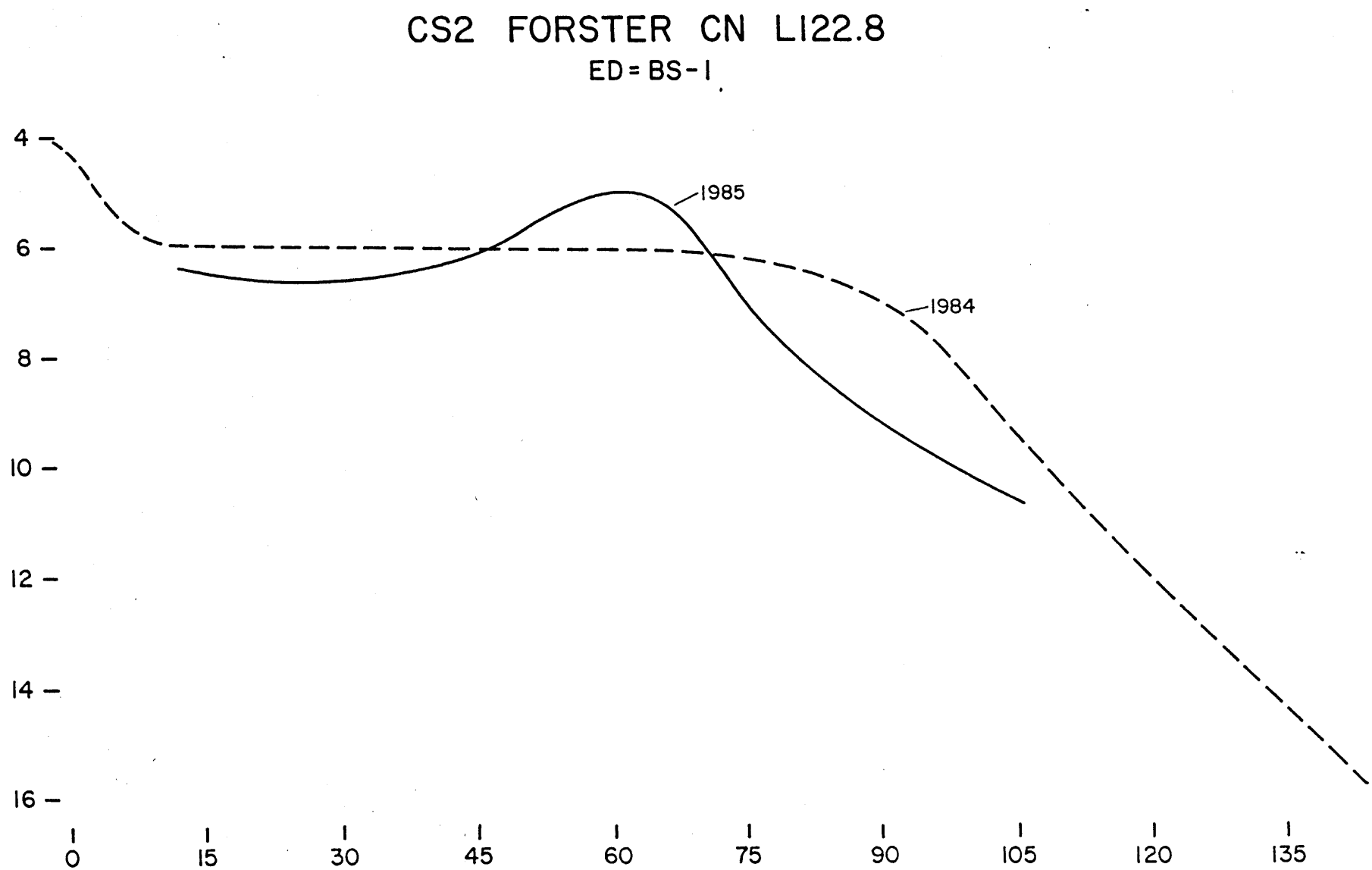

CS2 FORSTER CN L122.8
ED = BS-1
4
6
8
10
12
14
16
0
15
30
45
60
75
90
105
120
135
1985
1984

Figure II-30

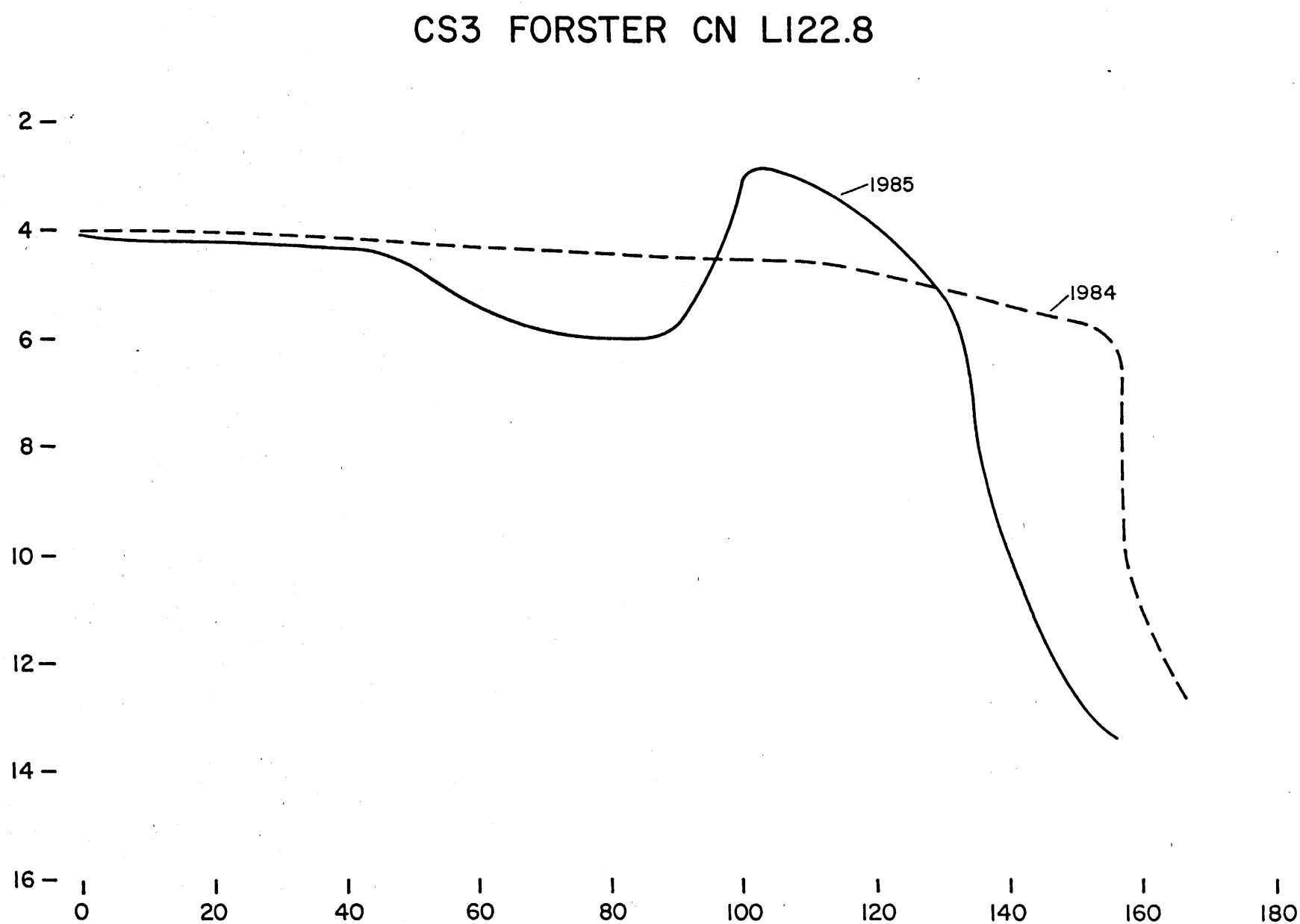

CS3 FORSTER CN L122.8
2
4
6
8
10
12
14
16
0
20
40
60
80
100
120
140
160
180
1985
1984

Figure II-31

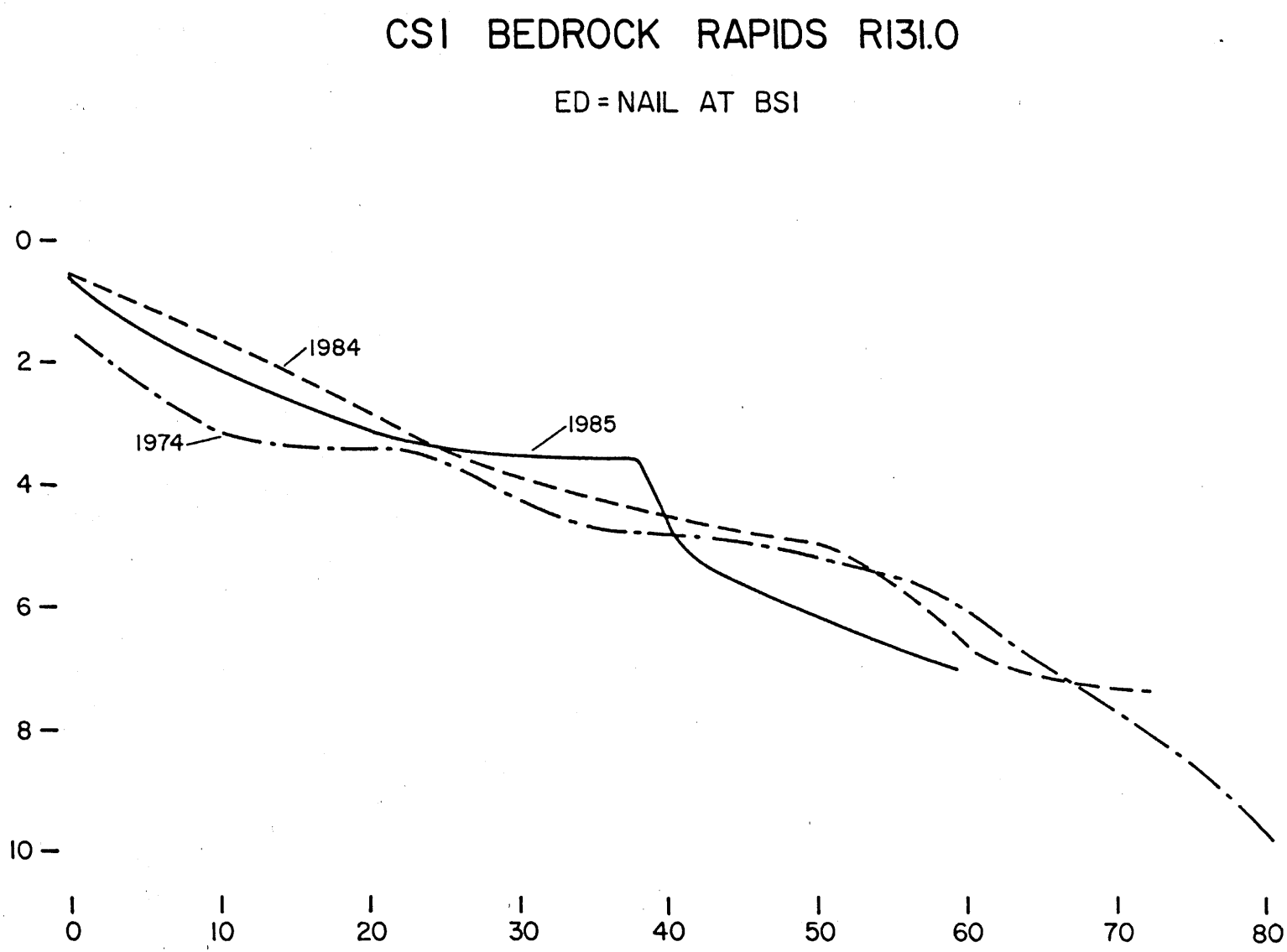

CS1 BEDROCK RAPIDS R131.0
ED = NAIL AT BS1
0
2
4
6
8
10
0
10
20
30
40
50
60
70
80
1984
1985
1974

Figure II-32

CS2 BEDROCK RAPIDS R131.0

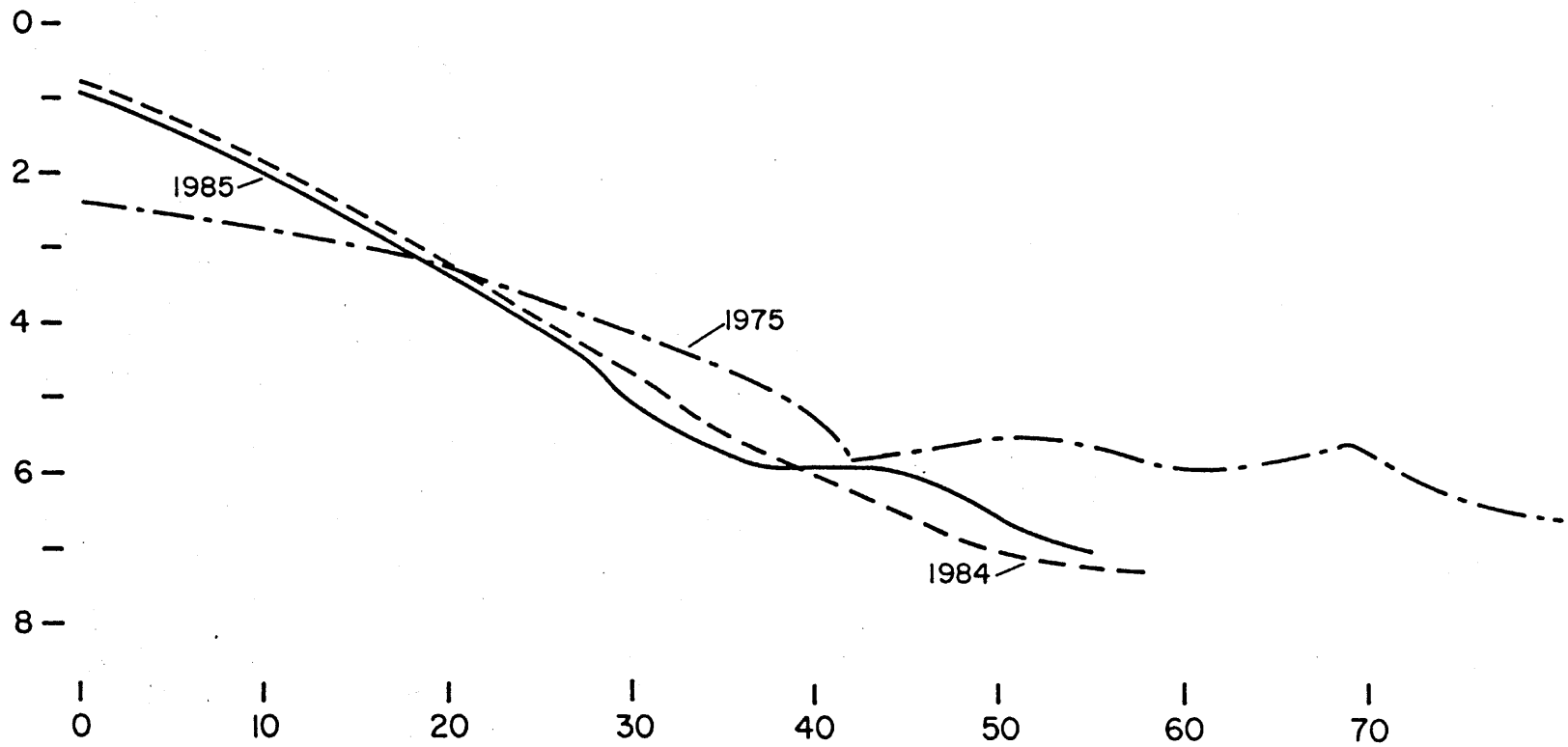


Figure II-33

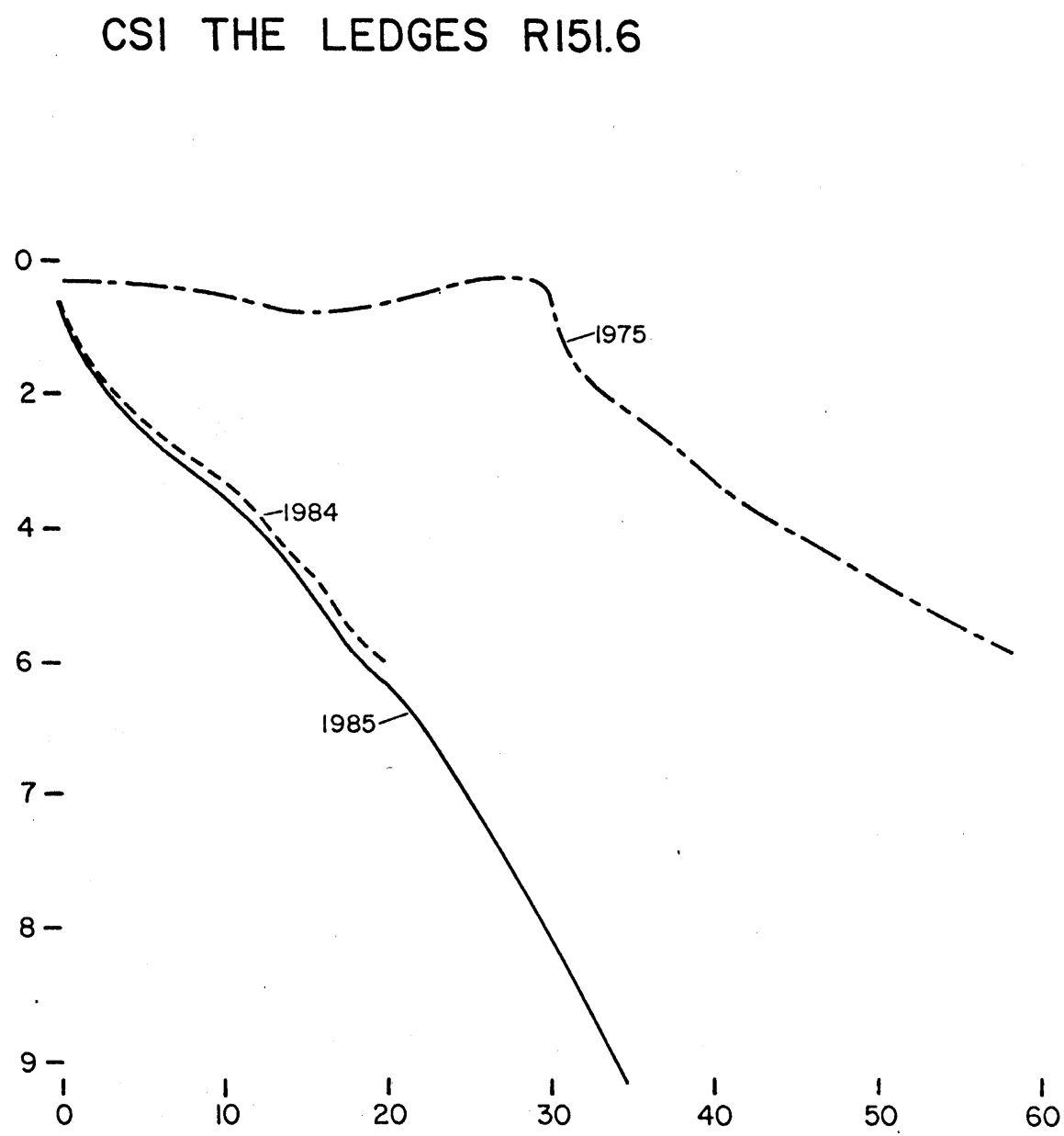


Figure II-34

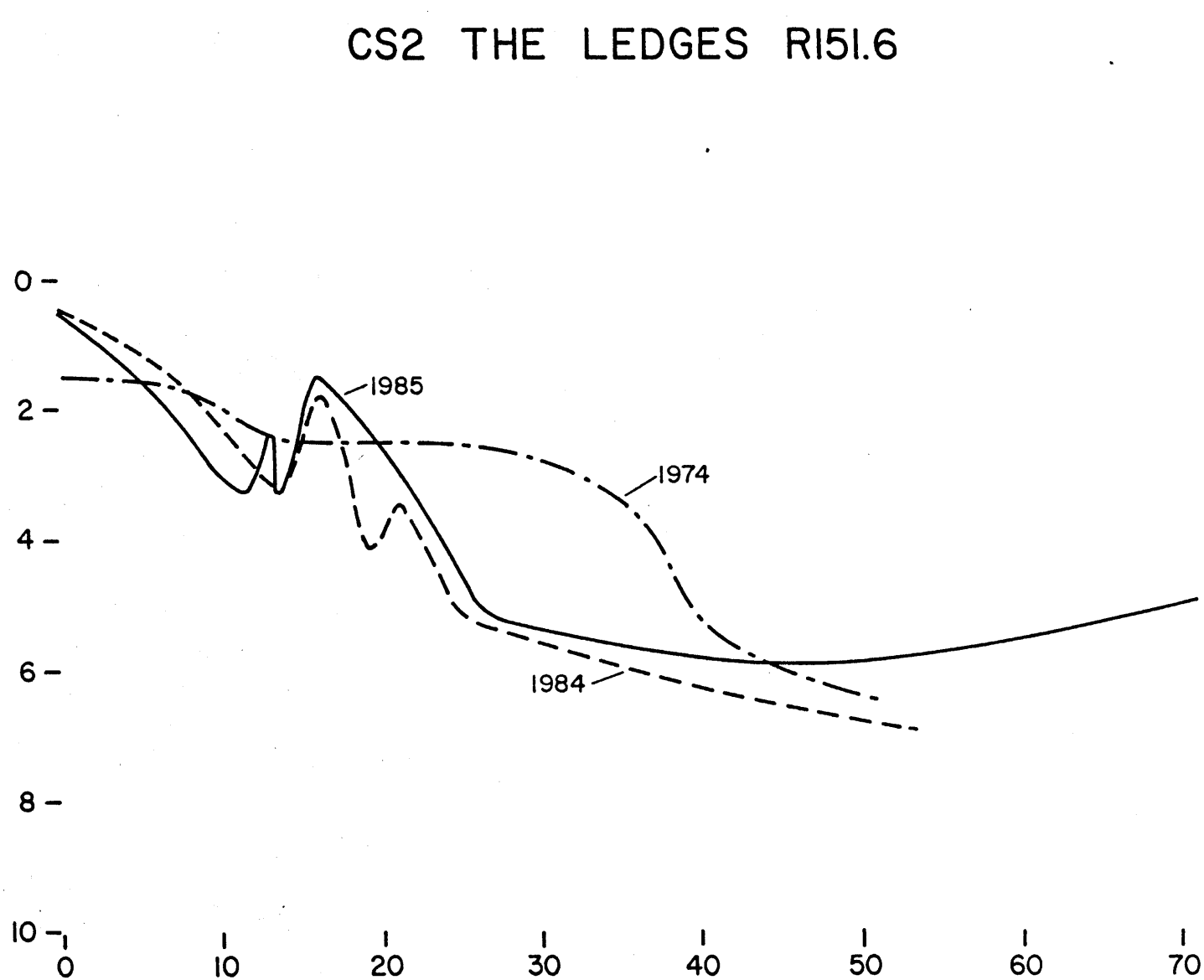

CS2 THE LEDGES R151.6
0
2
4
6
8
10
0
10
20
30
40
50
60
70
1985
1974
1984

Figure II-35

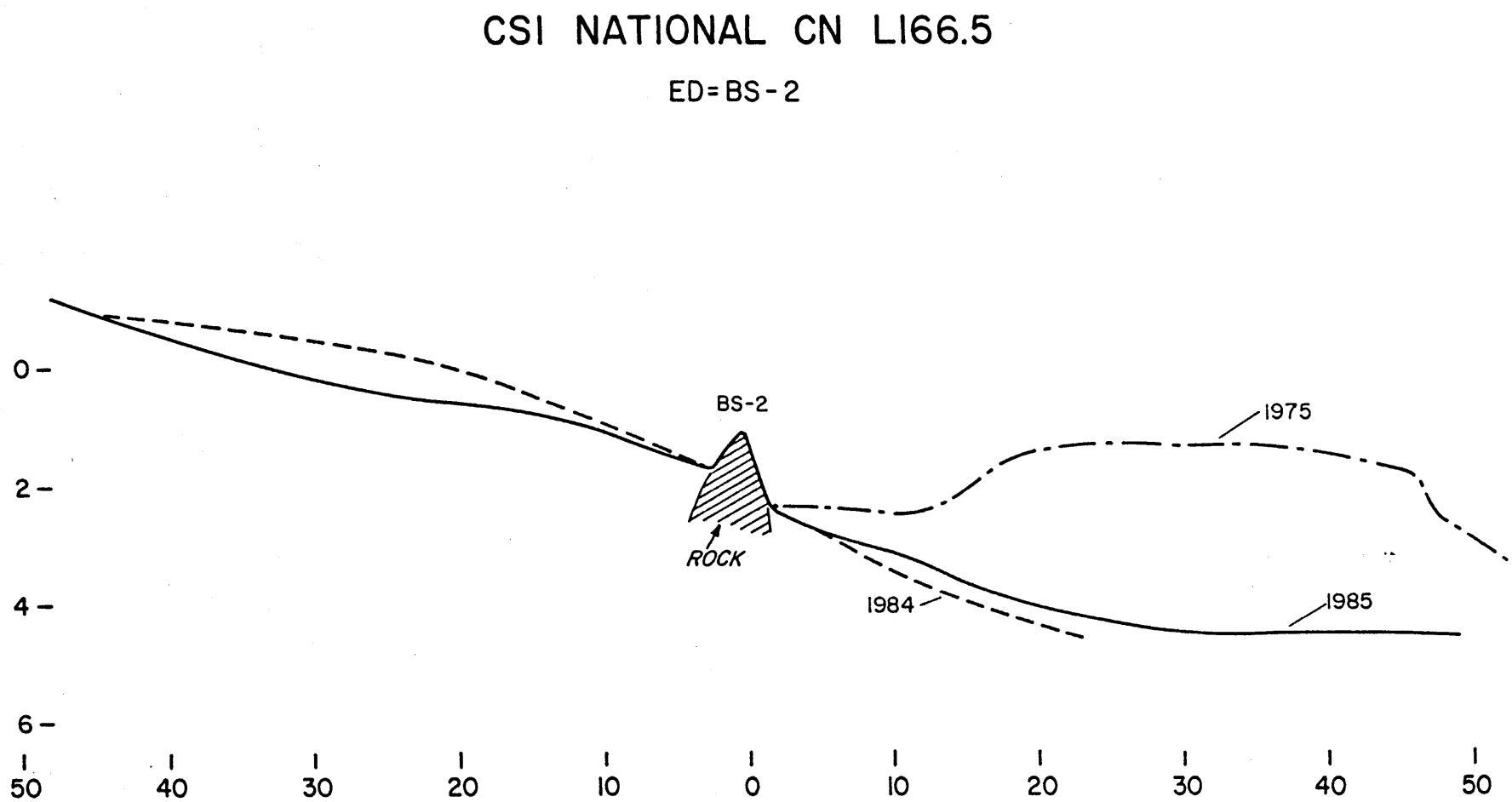

CSI NATIONAL CN L166.5
ED=BS-2
BS-2
ROCK
1975
1984
1985
0
2
4
6
50
40
30
20
10
0
10
20
30
40
50

Figure II-36

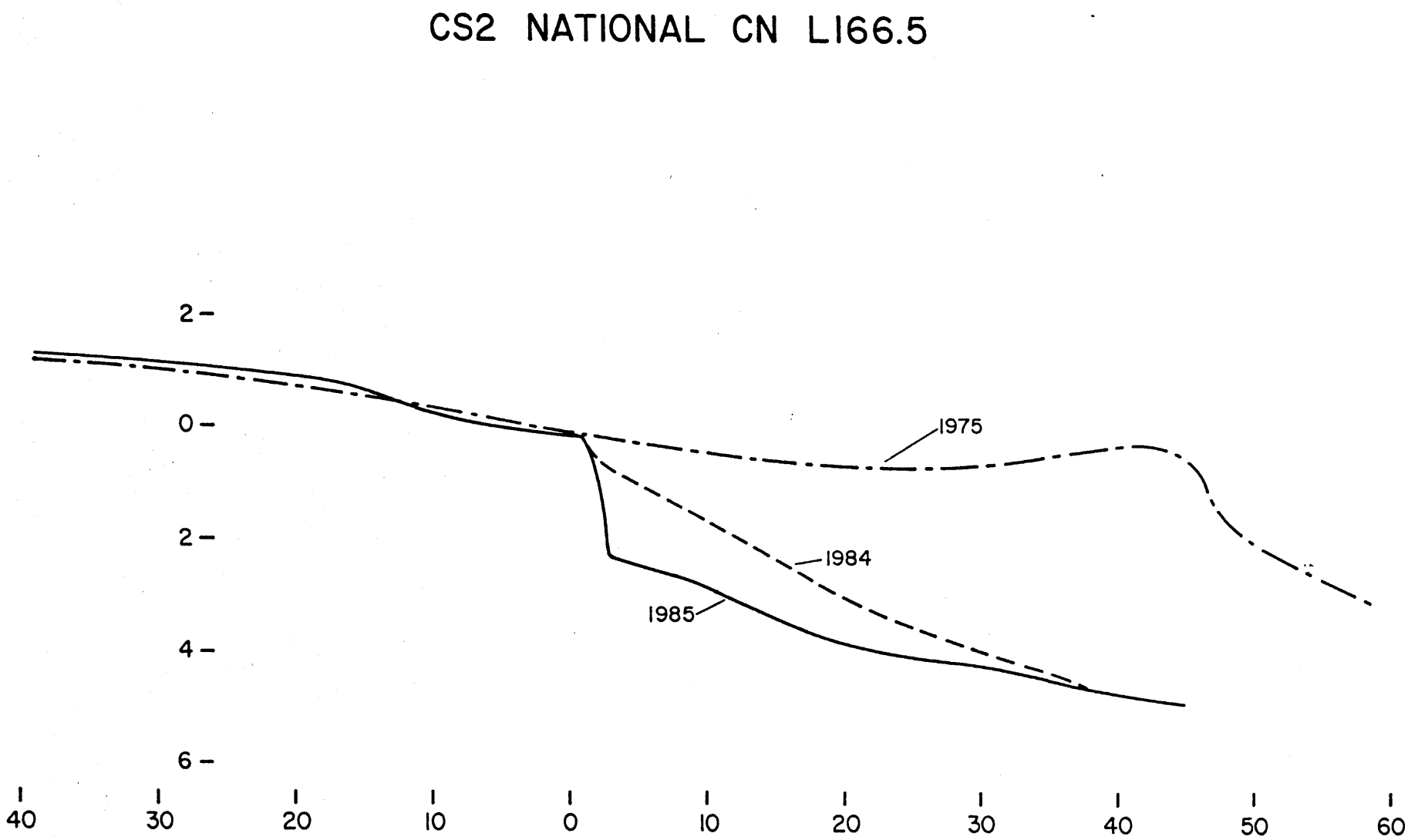

CS2 NATIONAL CN L166.5
2
0
2
4
6
40
30
20
10
0
10
20
30
40
50
60
1975
1984
1985

Figure II-37

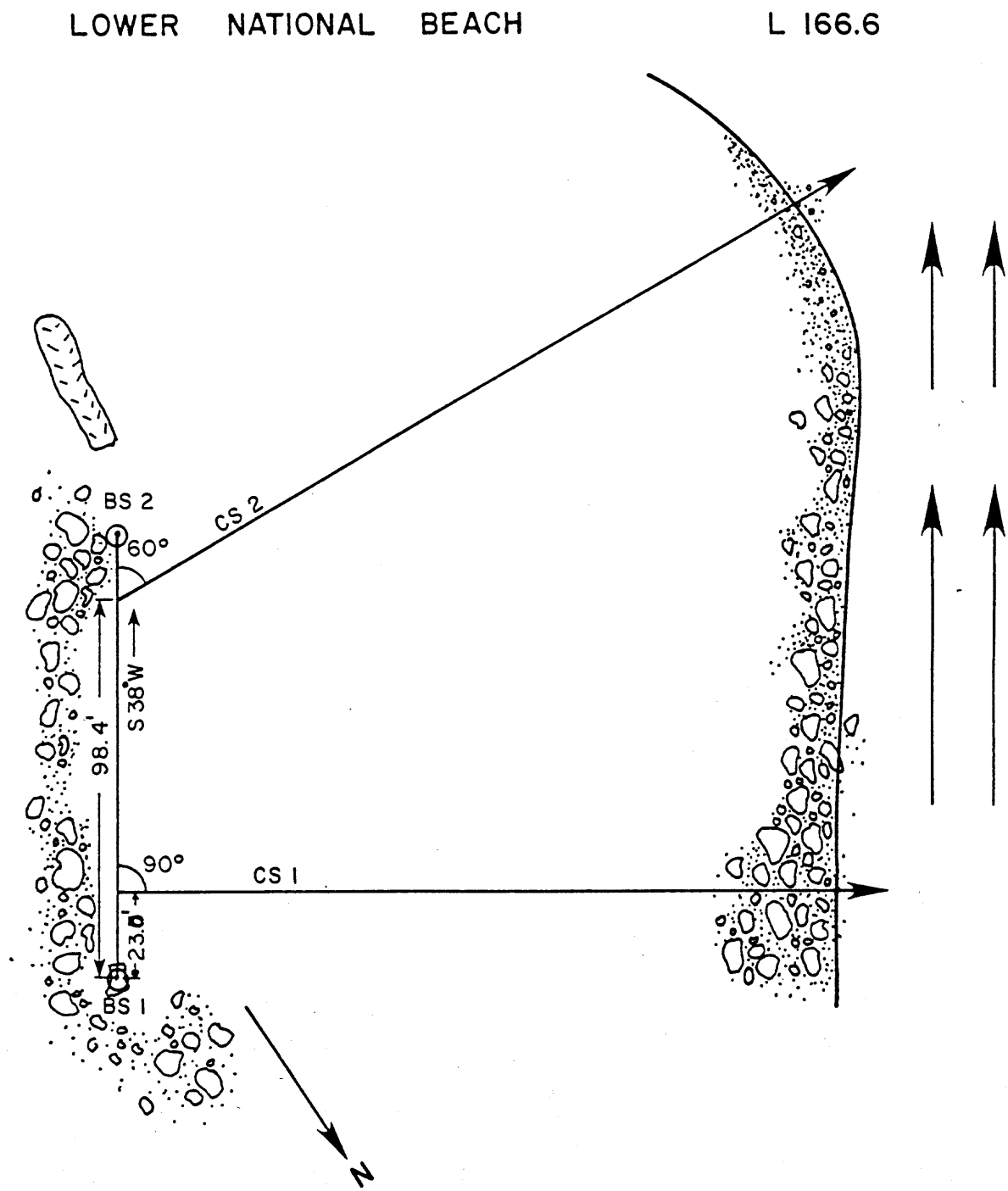

LOWER NATIONAL BEACH
L 166.6
BS 2
CS 2
60°
S 38°W
98.4'
90°
CS 1
23.0'
BS 1
N

Figure II-38

Figure II-39

L 166.6

BEACH PROFILE LOCATION SHEET Lower National CN

Date established 8 Aug 1985 A.m.

Base station #1 Steeply tilted gray L.S. boulder Photo ✓
Perm. mark Nail

Base station #2 Gently tilted L.S. boulder Photo ✓
Perm. mark Nail in crack near top

Base Station #3 _____ Photo _____
Perm. mark _____

Elevation datum BS1, BS2 Photo # _____

Length of base line #1 35.38 m from BS1 to BS2
Base line orientation S 38 W from BS1 to BS2

Length of base line # 2 _____ from _____
Base line orientation _____ from _____

Length of base line #3 _____ from _____
Base line orientation _____ from _____

Cross section #1: 7.0 m from BS1 → BS2
at an angle of 90° (~~counter~~) clockwise from direction ~~to~~ BS2

Cross section #2: 30.0 m from BS1 → BS2
at an angle of 60° (~~counter~~) clockwise from direction ~~to~~ BS2

Cross section #3: _____ from _____
at an angle of _____ (counter) clockwise from direction of _____

Comments Extreme South end of National Canyon Beach

CROSS-SECTION DATA SHEET

MILE: L 166.6 CAMPGROUND NAME: Lower National

CROSS-SECTION NO. 1 SURVEY DATE: 8 Aug 85

ORIGINAL SURVEY? yes ✓ RESURVEY NO. No

FROM	TO	ROD READING (feet)	DISTANCE (ft/in)	ANGLE (deg.)	COMMENTS
	ED = BS 2				
CS 1	" 2	6.39 (ED)			
S1	CS1	4.73 1.66	HI		
	1	6.80 .11	13' 10"		sand
	2	9.47 3.08	33' 4"		sand
	3	13.85 7.46	65' 3"		bottom of sand slope
	4	13.75 7.36	76' 5"		
	5	14.70 8.31	90' 5"		
	6	14.81 8.42	100' 0"		
	7	16.26 9.87	135' 7"		
	8	15.73 9.34	159' 4"		begin boulders
	9	16.06	176' 4"		boulders
	10	18.00	189' 4"	-0° 04' down	boulders (w/e)
	10	18.2	189' 4"	— calculated	
CS 1	BS1	0.90	7.0 m		

COMMENTS:

ED = BS 2

CROSS-SECTION DATA SHEET:

MILE: L 166.6 CAMPGROUND NAME: Lower National

CROSS-SECTION NO. 2 SURVEY DATE: 8 Aug 85

ORIGINAL SURVEY? yes ✓ ~~RESURVEY NO.~~

FROM	TO	ROD READING (feet)	DISTANCE (ft/in)	ANGLE (deg.)	COMMENTS
CS2	BS1	0.00	30.0 m	+2° 54'	Rod on nail
	BS2	3.12			Rod on nail
CS 2	CS2	4.75	HI		Sand
	1	5.01	18' 4"		
	2	5.80	35' 8"		
	3	7.73	51' 4"		
	4	10.96	90' 2"		
	5	10.80	100' 0"		
	6	10.66	132' 5"		
	7	12.50	160' 0"		Sand
	8	11.95	176' 6"		Top of slope
	9	14.45	195' 11"		gravel near water
	10	14.79	205' 2"		w/edge - gravel
	11	16.20	219' 10"		Sand

COMMENTS:

ED = BS 2

53° 52' 09'

~~142° 09'~~

143° 09'

53° 09'

~~45° 09'~~

113° 09'

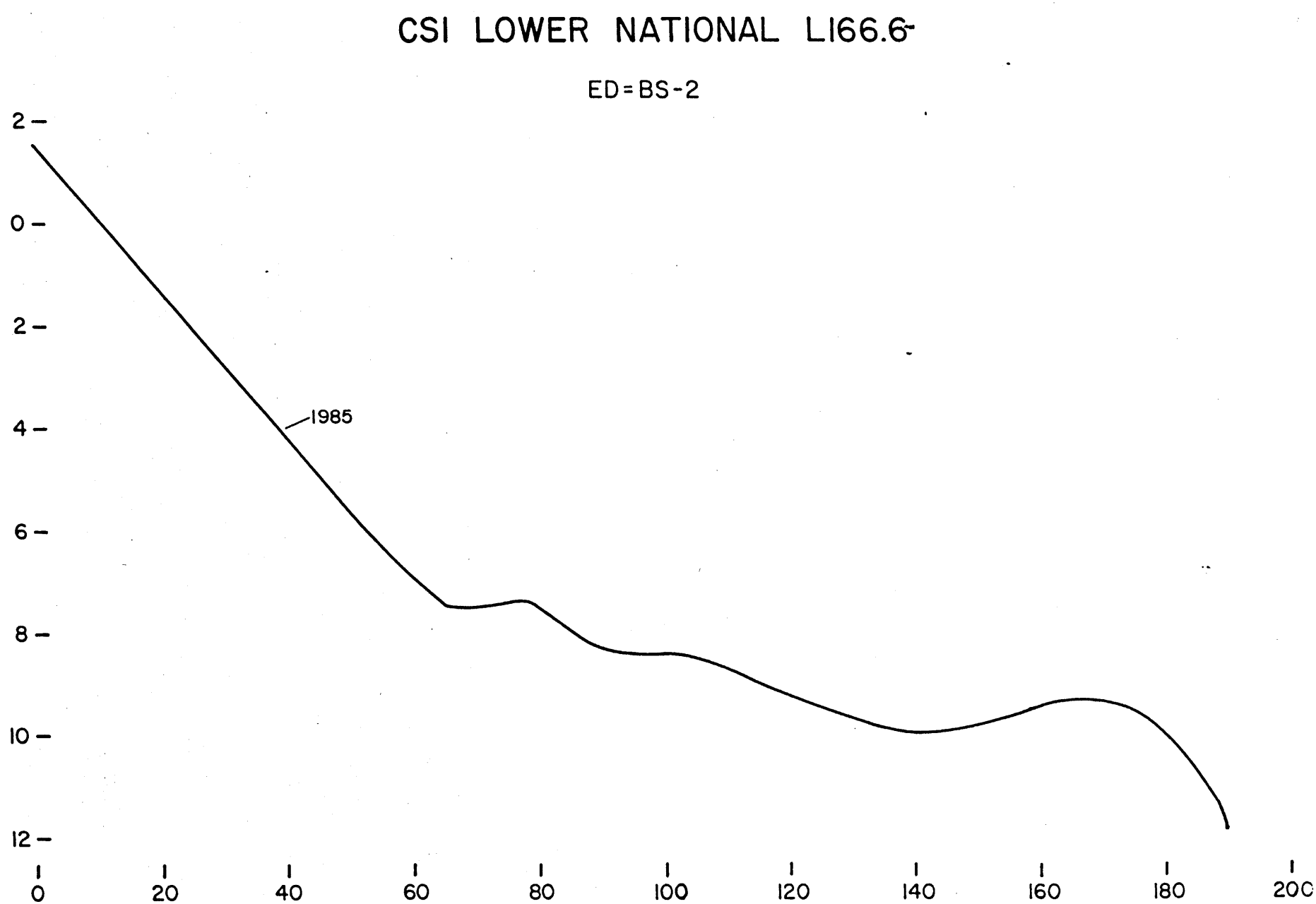

CSI LOWER NATIONAL L166.6
ED=BS-2
2
0
2
4
6
8
10
12
1985
0
20
40
60
80
100
120
140
160
180
200

Figure II-40

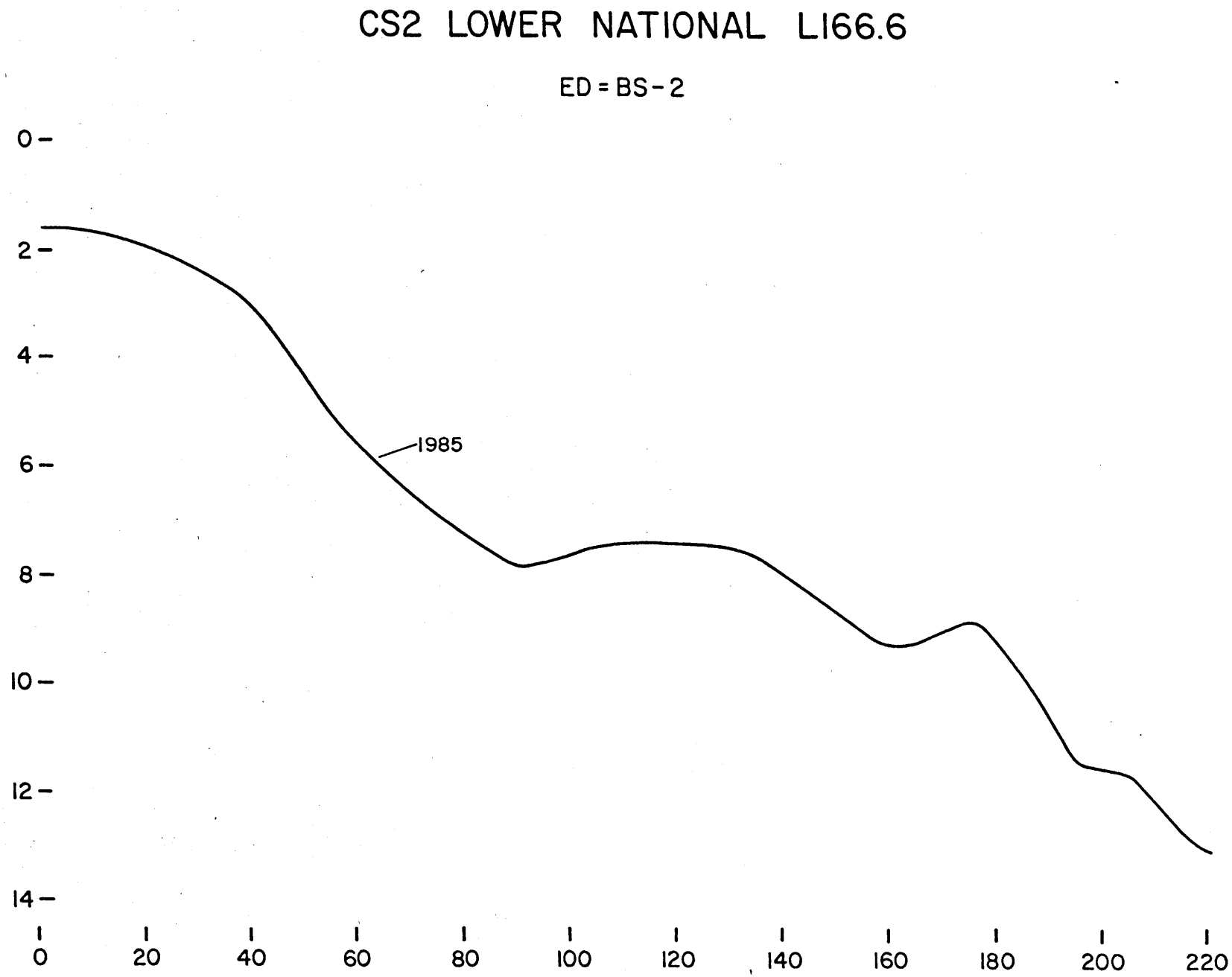

CS2 LOWER NATIONAL L166.6
ED = BS-2
0
2
4
6
8
10
12
14
1985
0
20
40
60
80
100
120
140
160
180
200
220

Figure II-41

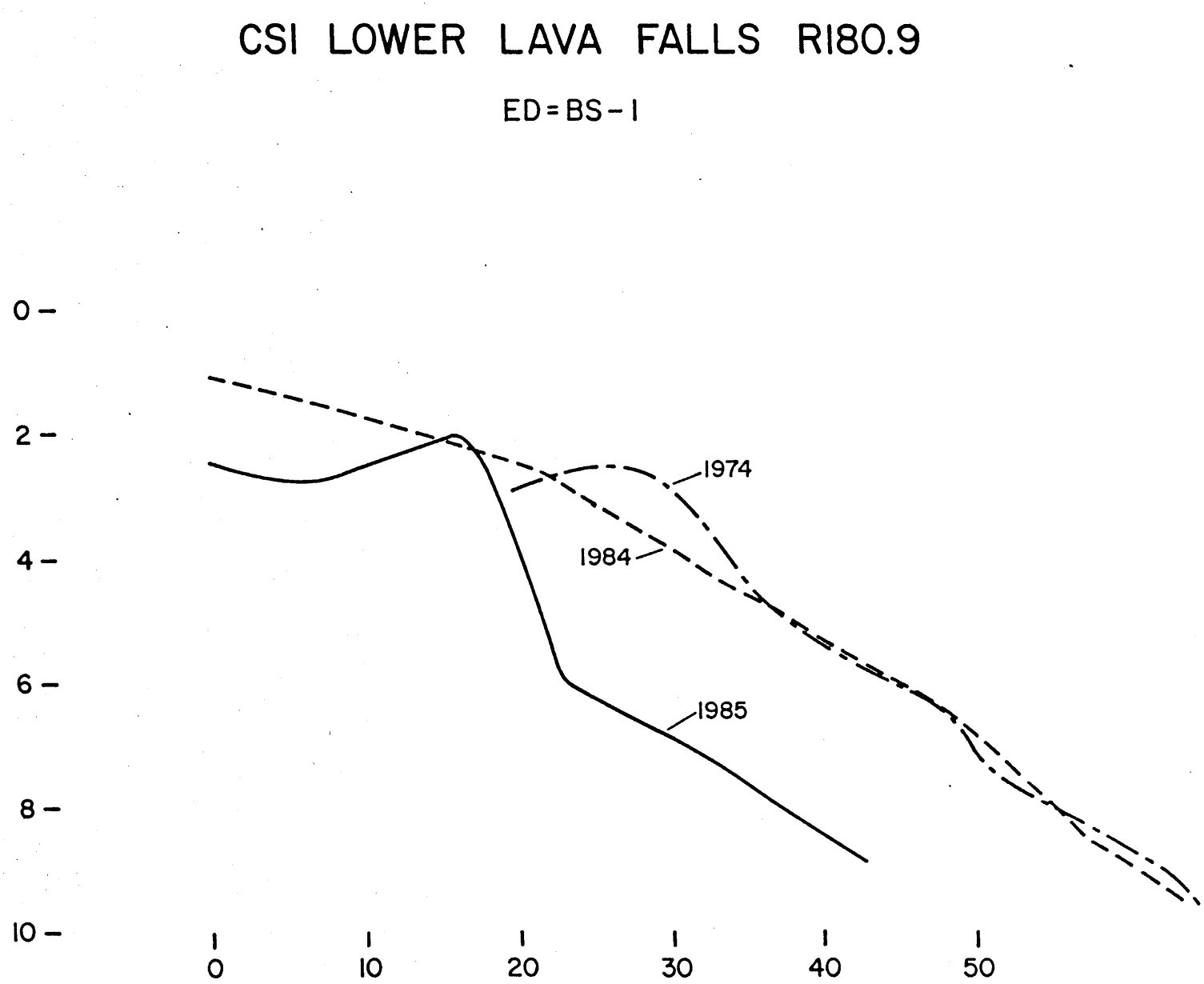

CSI LOWER LAVA FALLS R180.9
ED=BS-1
0
2
4
6
8
10
0
10
20
30
40
50
1974
1984
1985

Figure II-42

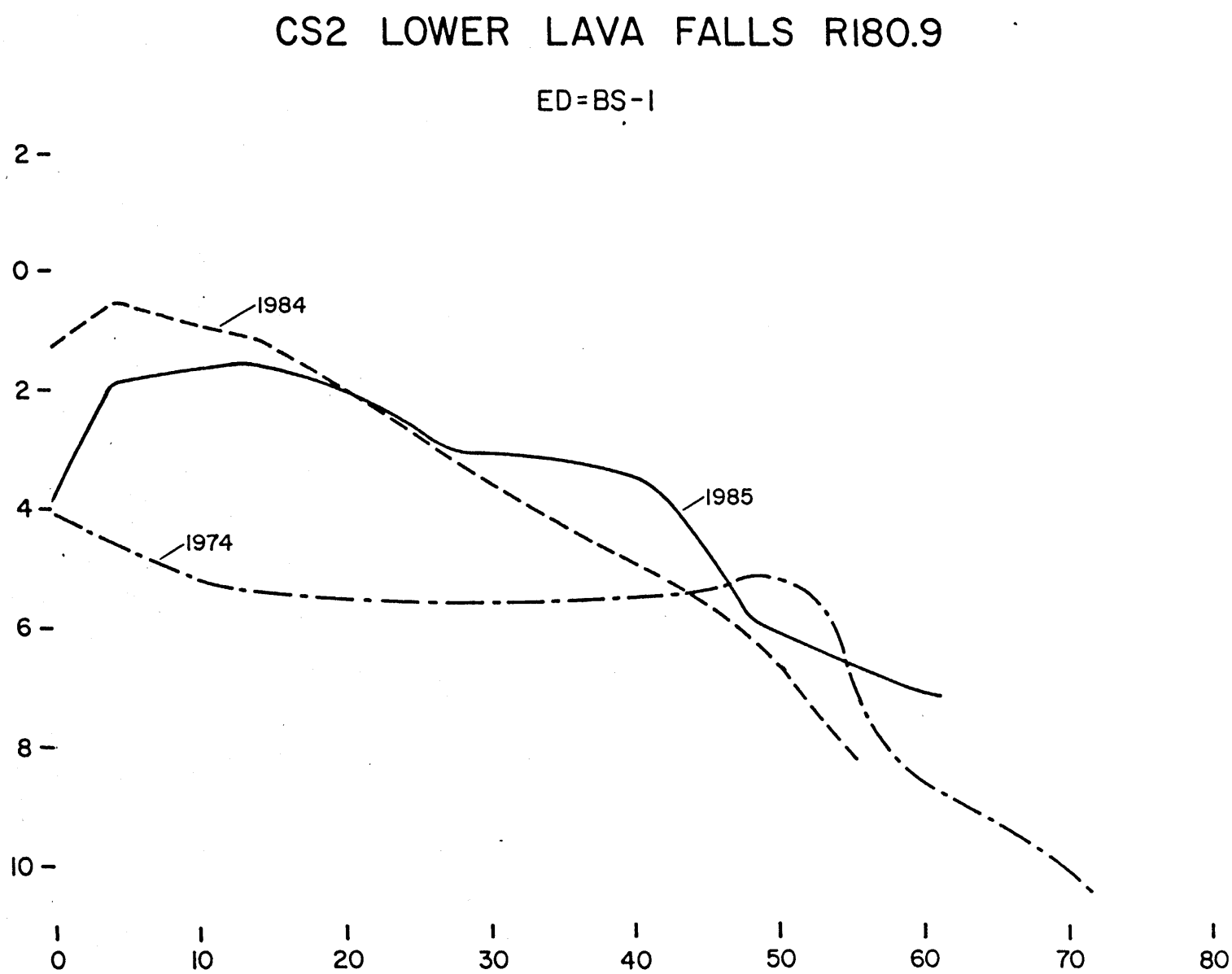

CS2 LOWER LAVA FALLS R180.9
ED=BS-1
2
0
2
4
6
8
10
1984
1985
1974
0
10
20
30
40
50
60
70
80

Figure II-43

CSI 190 MILE BEACH L190.2

ED = BS - 2

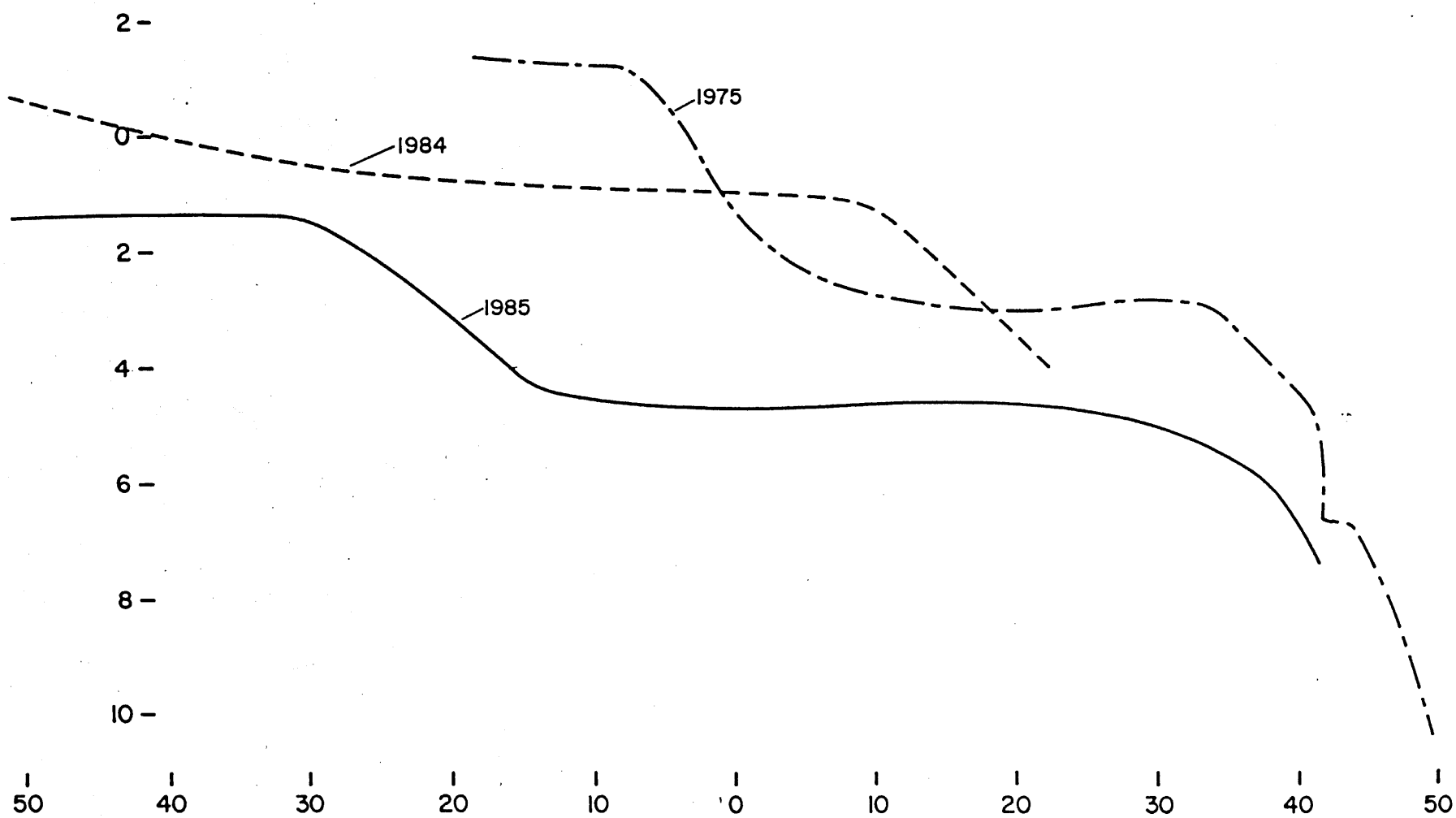


Figure II-44

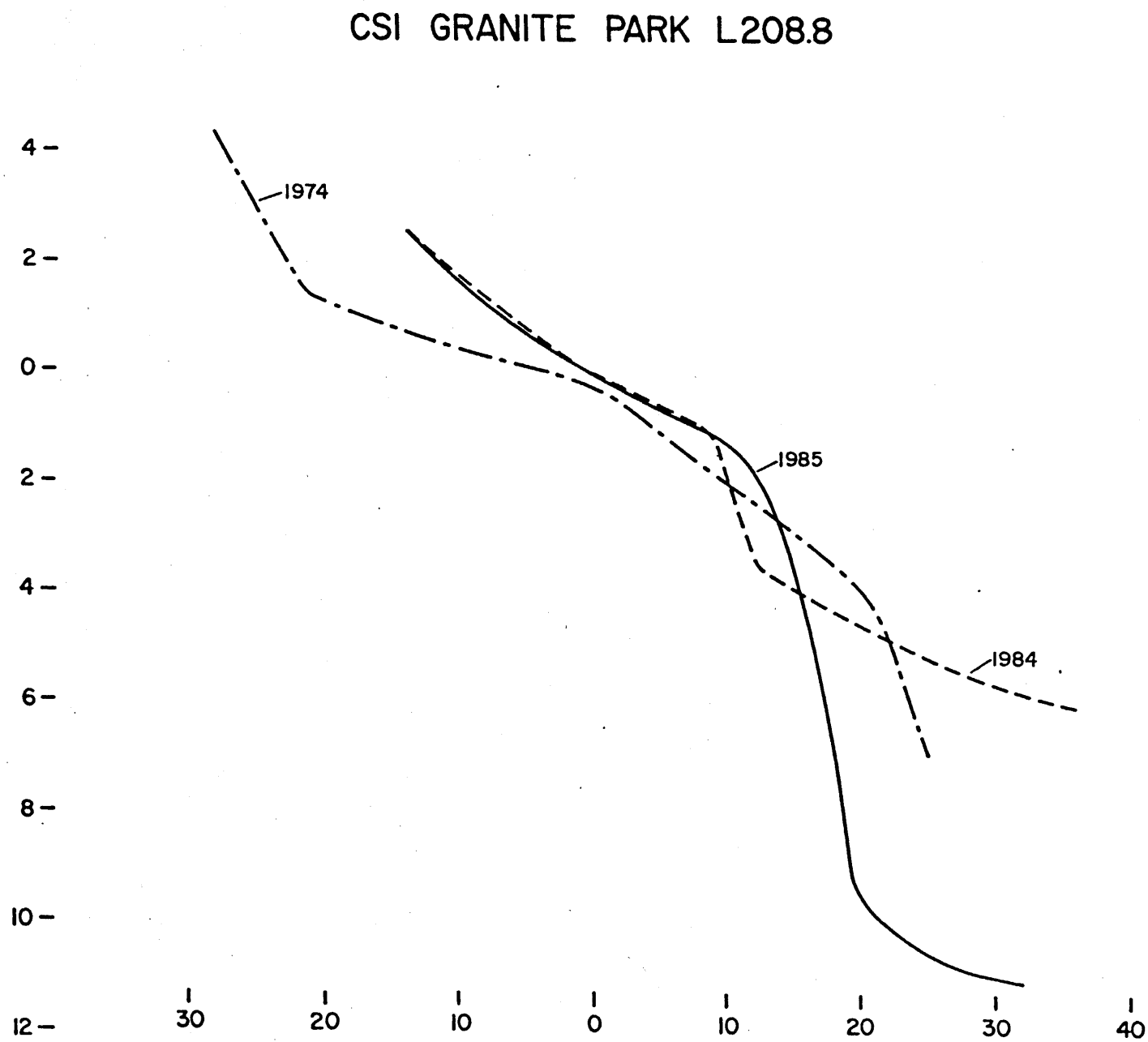

CSI GRANITE PARK L208.8
4
2
0
2
4
6
8
10
12
30
20
10
0
10
20
30
40
1974
1985
1984

Figure II-45

CS2 GRANITE PARK L208.8

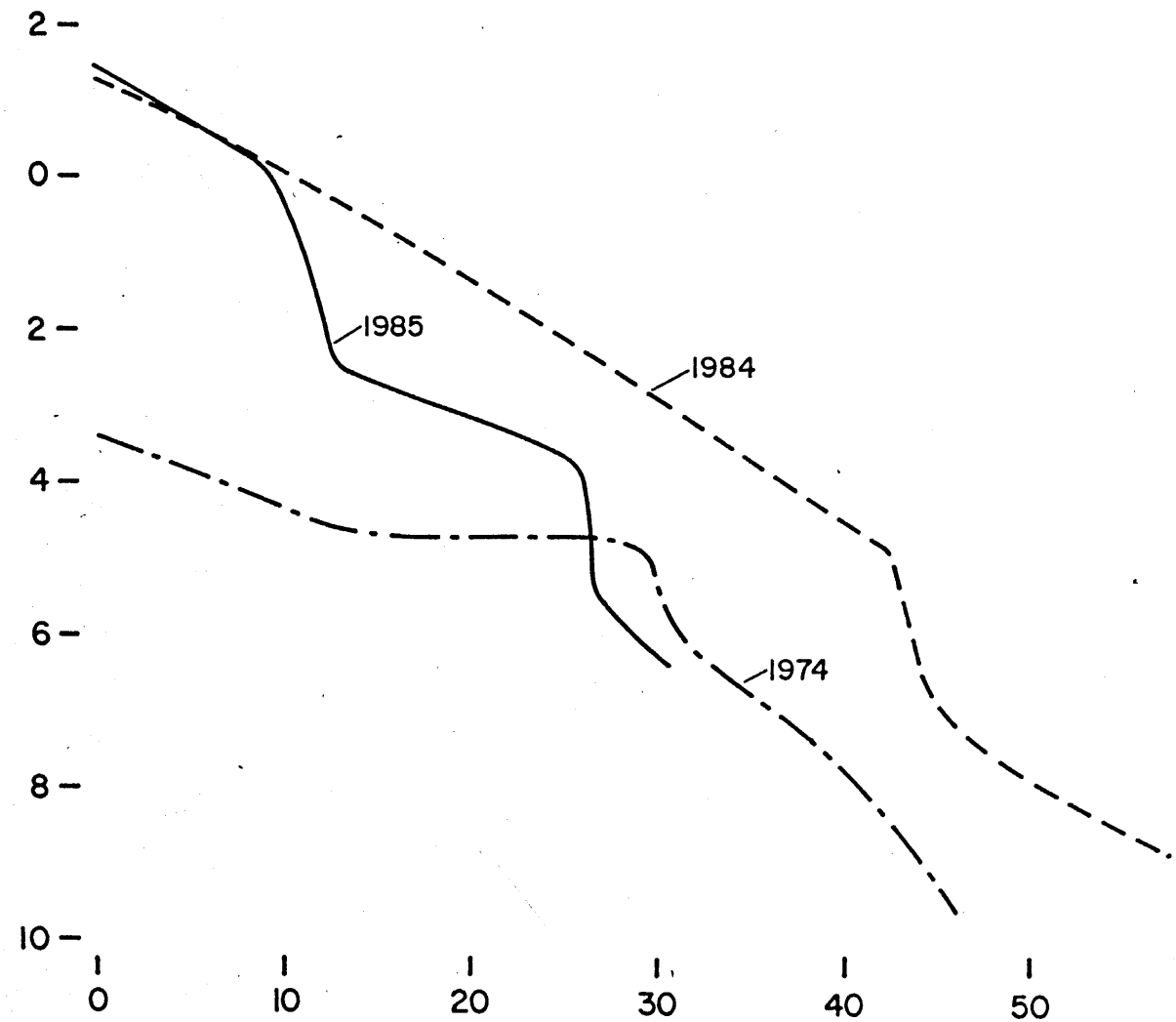


Figure II-46

LOWER 220- MILE BEACH R 220

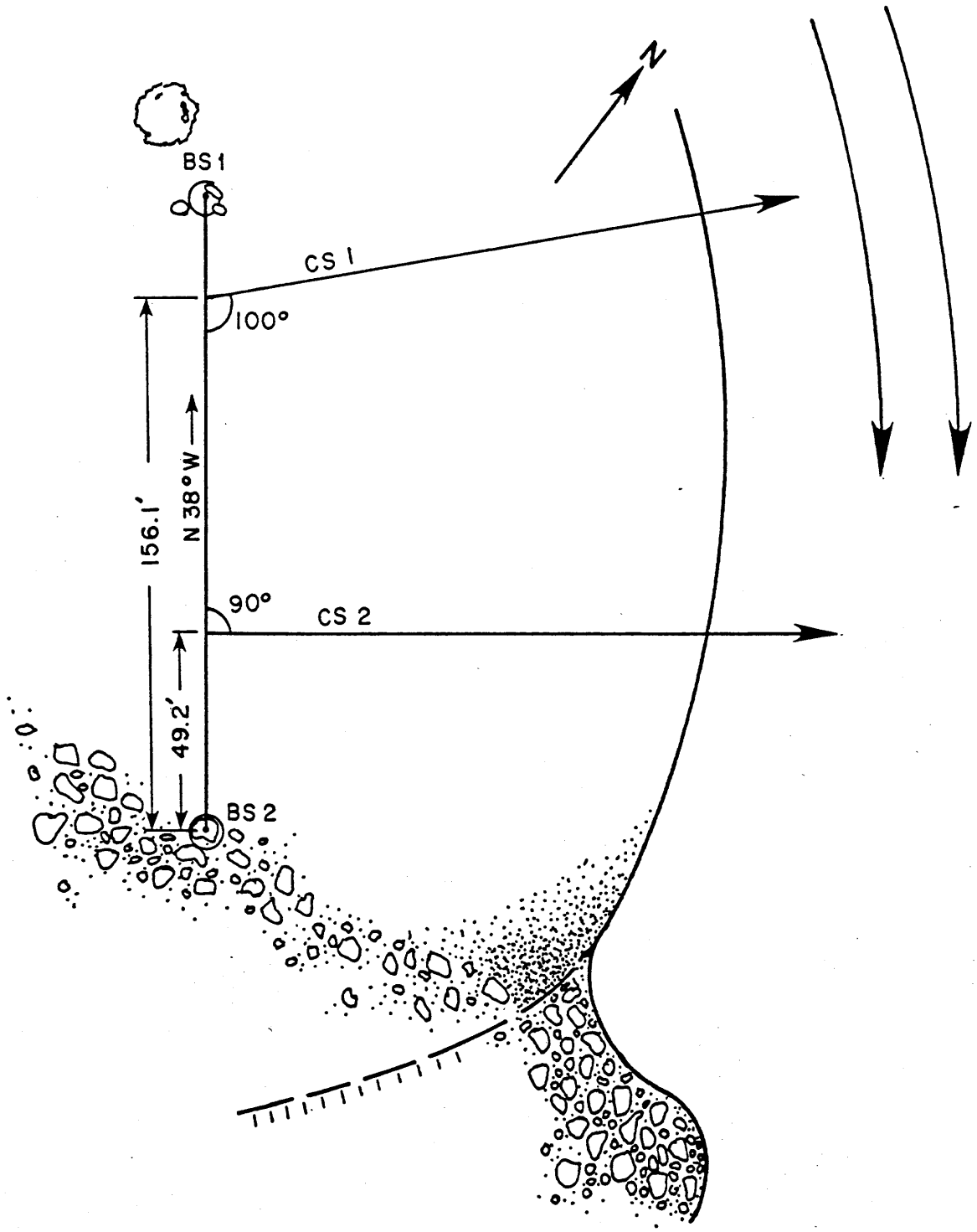


Figure II-47

BS 2

BS 1

Figure II-48

BEACH PROFILE LOCATION SHEET R 220-mile

Date established 10 August 85 Rm.

Base station #1 Top gray L.S. boulder — Photo ✓ Perm. mark X cut on top of boulder

Base station #2 Top white L.S. boulder — Photo ✓ Perm. mark X cut on top of boulder

Base Station #3 _____ — Photo _____ Perm. mark _____

Elevation datum BS1, BS2 Photo # _____

Length of base line #1 47.6 m from BS1 - BS2
Base line orientation N 38 W from BS2 → BS1

Length of base line # 2 _____ from _____
Base line orientation _____ from _____

Length of base line #3 _____ from _____
Base line orientation _____ from _____

Cross section #1: 40 m from BS2 toward BS1
at an angle of 100° (counter) clockwise from direction of BS1 to BS2

Cross section #2: 15.0 from BS2
at an angle of 90° (counter) clockwise from direction of BS2 → BS1

Cross section #3: _____ from _____
at an angle of _____ (counter) clockwise from direction of _____

Comments X on BS2 already in place by some other Survey team

CROSS-SECTION DATA SHEET

MILE: R 220 CAMPGROUND NAME: 220 mile

CROSS-SECTION NO. 2 SURVEY DATE: 10 Aug 85

ORIGINAL SURVEY? yes RESURVEY NO.

FROM	TO	ROD READING (feet)	DISTANCE (ft/in)	ANGLE (deg.)	COMMENTS
CS 2	BS1	3.05	ED		N 38° W
CS 2	BS2	2.49	15.0 m		
CS 2	CS 2	4.70	HI		
	1	6.50	26", 3'		
	2	7.52	42' 7"		Sand
	3	8.07	64' 8"		
	4	8.33	79' 5"		
	5	9.18	93' 0"		
	6	10.30	101' 0"		
	7	12.38	111' 2"		
	8	13.00	123' 0"		W/edge
	9	14.76	129' 2"		CR

COMMENTS: BS 2 is "ED"

120° 44'
210° 44'

CROSS-SECTION DATA SHEET

MILE: R 220 CAMPGROUND NAME: mile 220

CROSS-SECTION NO. 1 SURVEY DATE: 10 Aug 85

ORIGINAL SURVEY? yes RESURVEY NO.

FROM	TO	ROD READING (feet)	DISTANCE (ft/in)	ANGLE (deg.)	COMMENTS
CS1	BS2	3.15	← → BS 2	is "ED"	
CS1	CS1	4.98	HI		16" sand
	1	7.68	23' 11"		22" sand
	2	8.84	43' 0"		18" sand
	3	9.42	69' 6"		4'+ "
	4	10.49	84' 2"		top of slope
	5	12.14	92' 2"		46" Sand
	6	12.76	100' 0"		
	7	13.54	125' 0"		w/edge 4'+
	8	15.40	133'		in water
CS1	BS1	3.71			Top of rock

COMMENTS:

264° 50'
364° 50'

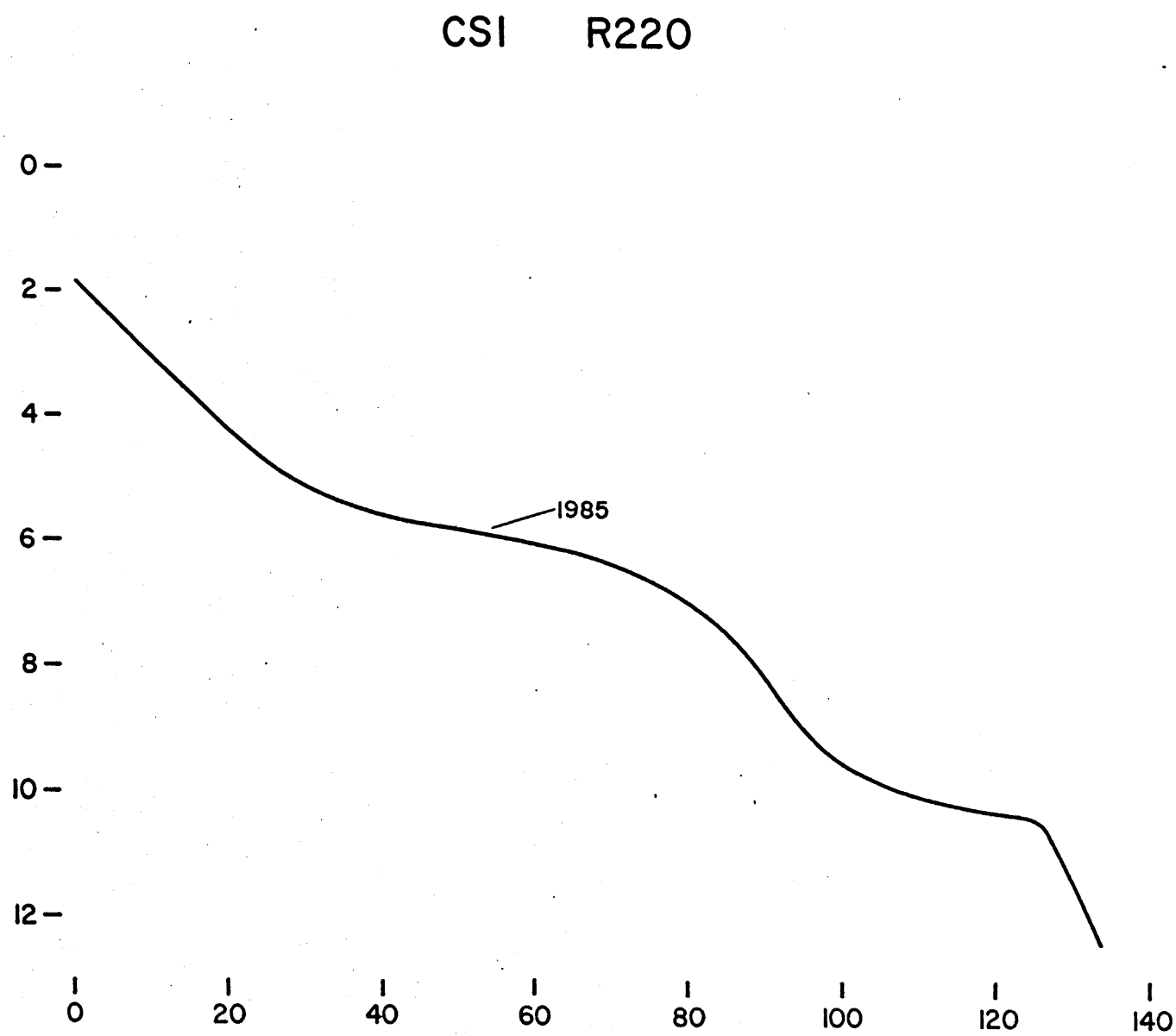


Figure II-49

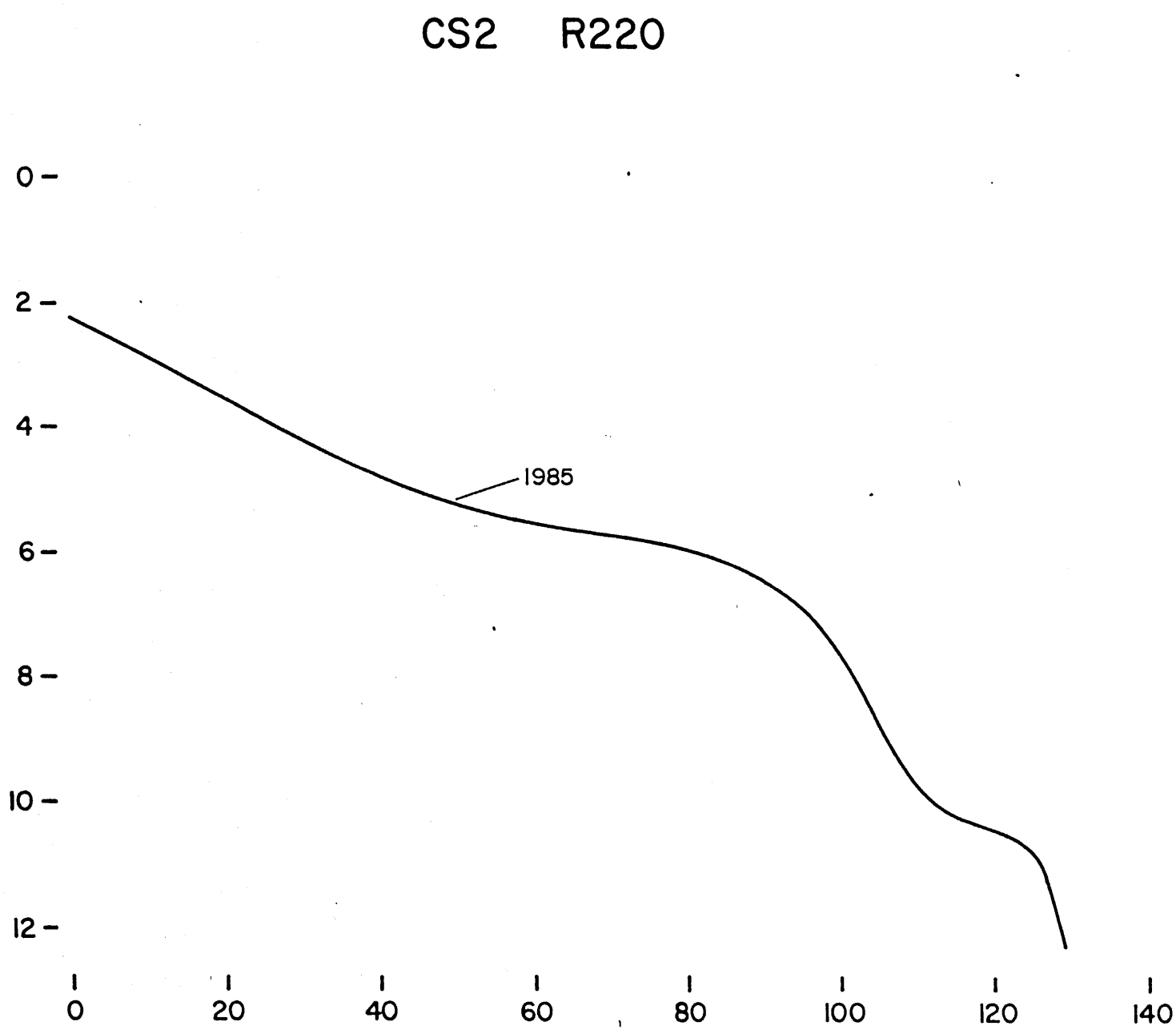


Figure II-50

CHAPTER III

PHOTOGRAPHIC COMPARISON OF BEACHES IN THE GRAND CANYON 1982-1985

Kenneth Harkey

INTRODUCTION

One of the methods effectively used in recent years to document changes in the environment of a given location is a process called repeat photography. Visible changes that take place over time can be identified by comparing photographs of the site taken at different times from exactly the same spot.

Repeat photography is here used to document changes over time on Colorado River beaches in the Grand Canyon. This is particularly valuable now because unusually high river flows in 1983 extensively altered beach configurations in the Canyon. By taking photographs of the beaches now, after the flood waters have subsided, and comparing them to photographs of the same beaches taken before the flood, the investigator can objectively determine what changes have occurred in that time, presumably, to a large extent, as a result of the high water. Fortunately, as a result of human impact studies performed in 1982, a body of pre-flood photographs exists for 35 beaches along the river in Glen and Grand Canyons.

OBJECTIVES

The purpose of this project was to rephotograph 28 beaches in the Grand Canyon that had been initially photographed in 1982, and to compare those photographs to identify changes that have taken place in the intervening period in beach size and shape, in vegetation, and in the occurrence of boulders and driftwood.

METHODS

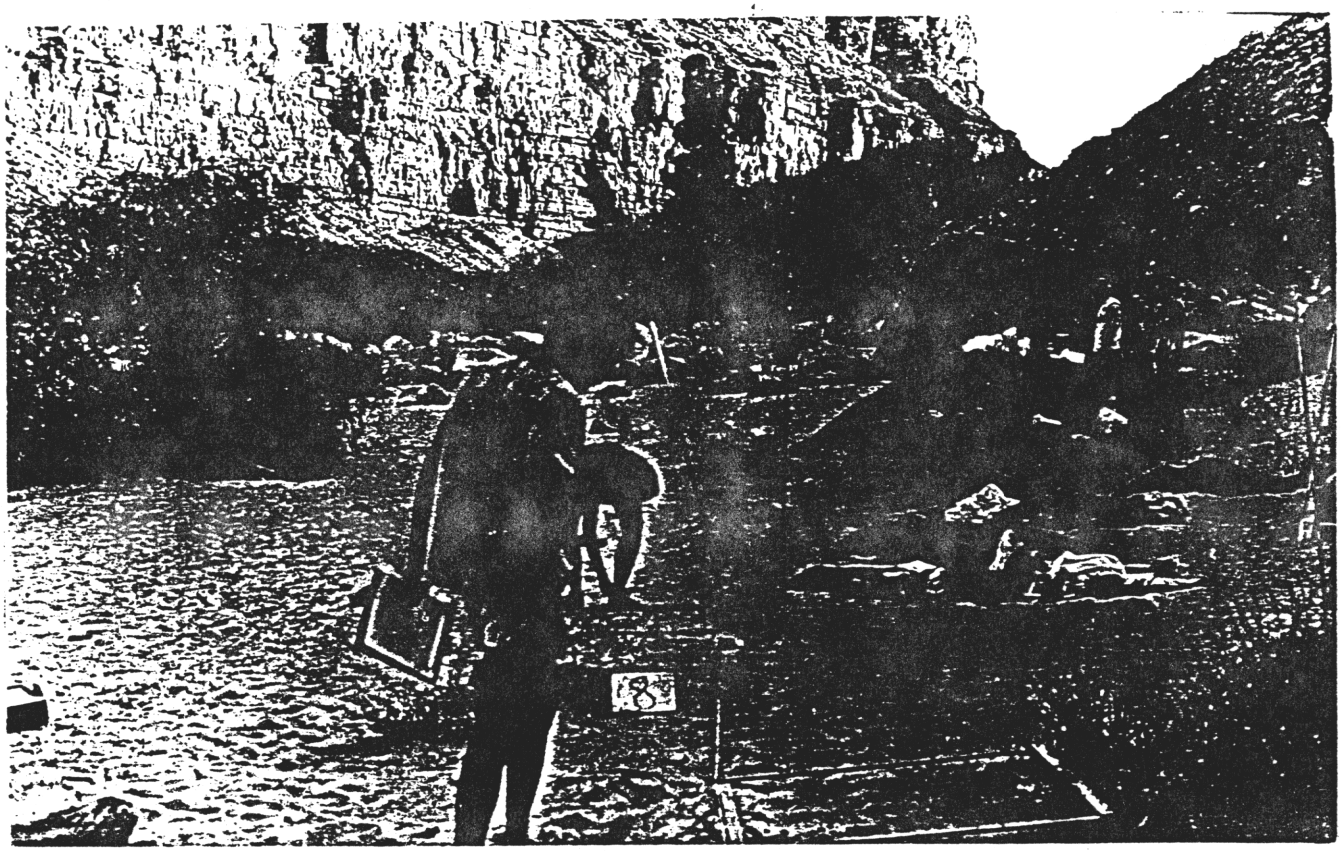
As in 1982, the photographs this year were taken in conjunction with a study of human impact on camping beaches in the Grand Canyon (see Carothers and others in this volume). The original photographs had been taken along transect lines laid out for the impact study, and from sites above the beaches looking toward the river. This year, the exact location of each photograph had to be found for each beach and a new photograph taken. The new photographs were then compared with the old ones.

RESULTS

Comparison photographs from five beaches are presented here: Badger Rapid (river mile (RM) 8), 20 Mile (RM 20), Nevills Rapid (RM 75.5), Hance Rapid (RM 76.5) and Trail Canyon (RM 219). In each case, a brief description of the beach is followed by the comparison photographs. The 1982 photograph is shown at the top of the page, and the 1985 photograph is shown at the bottom.

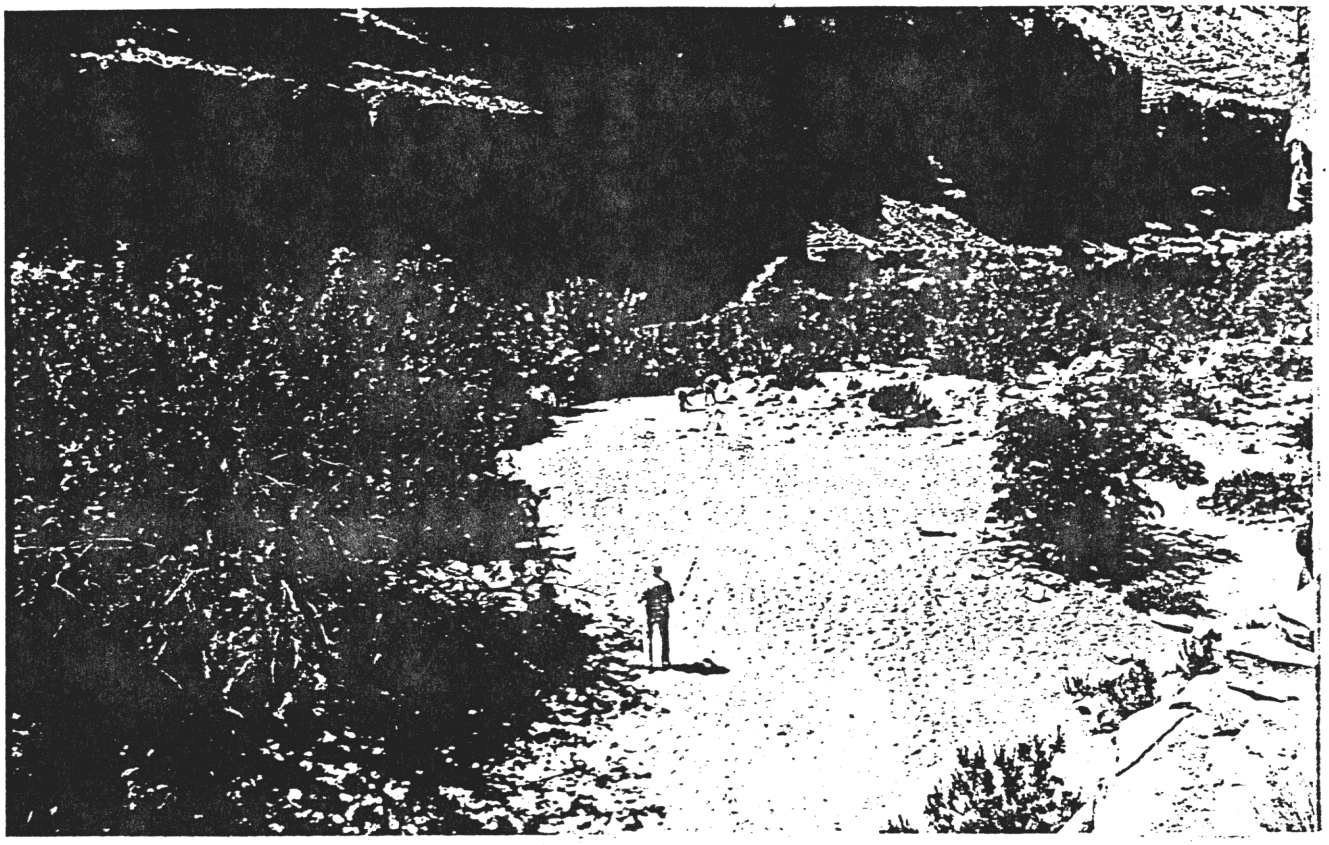
Badger Rapid (RM 8)

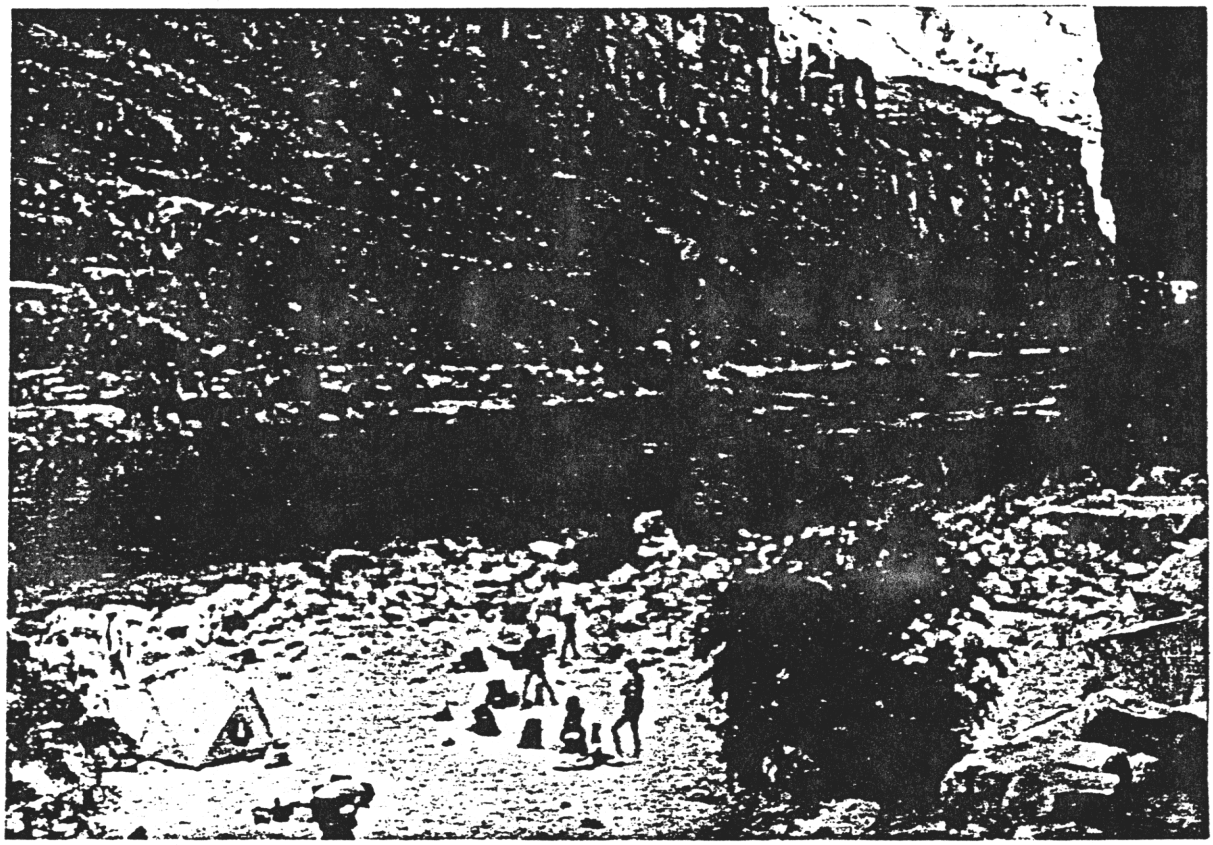
Badger Rapid campsite, pictured on the following page, is located eight miles below Lees Ferry. The two most striking differences shown in the two photographs are the deposition of at least three feet of new sand to the upper part of the beach and the near total removal of vegetation. The beach has also been cut back significantly.


18

20 Mile (RM 20)

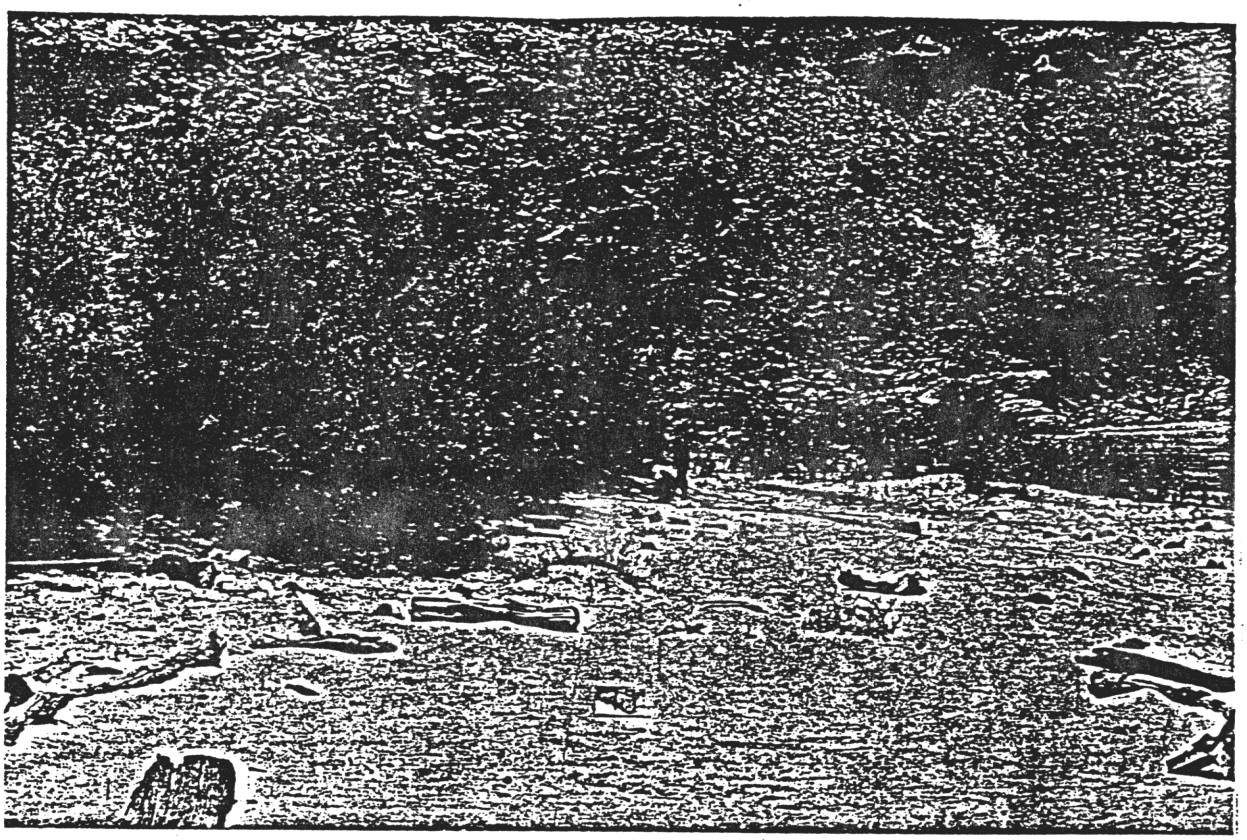
Three major changes have occurred at 20 Mile beach since 1982. The two most obvious have been the removal of most of the vegetation near the beach line and the removal of sand from the beach itself. The third change has been the substantial increase in vegetation along the old high water line, reflecting rapid growth, probably as a result of flood waters reaching that normally dry area.

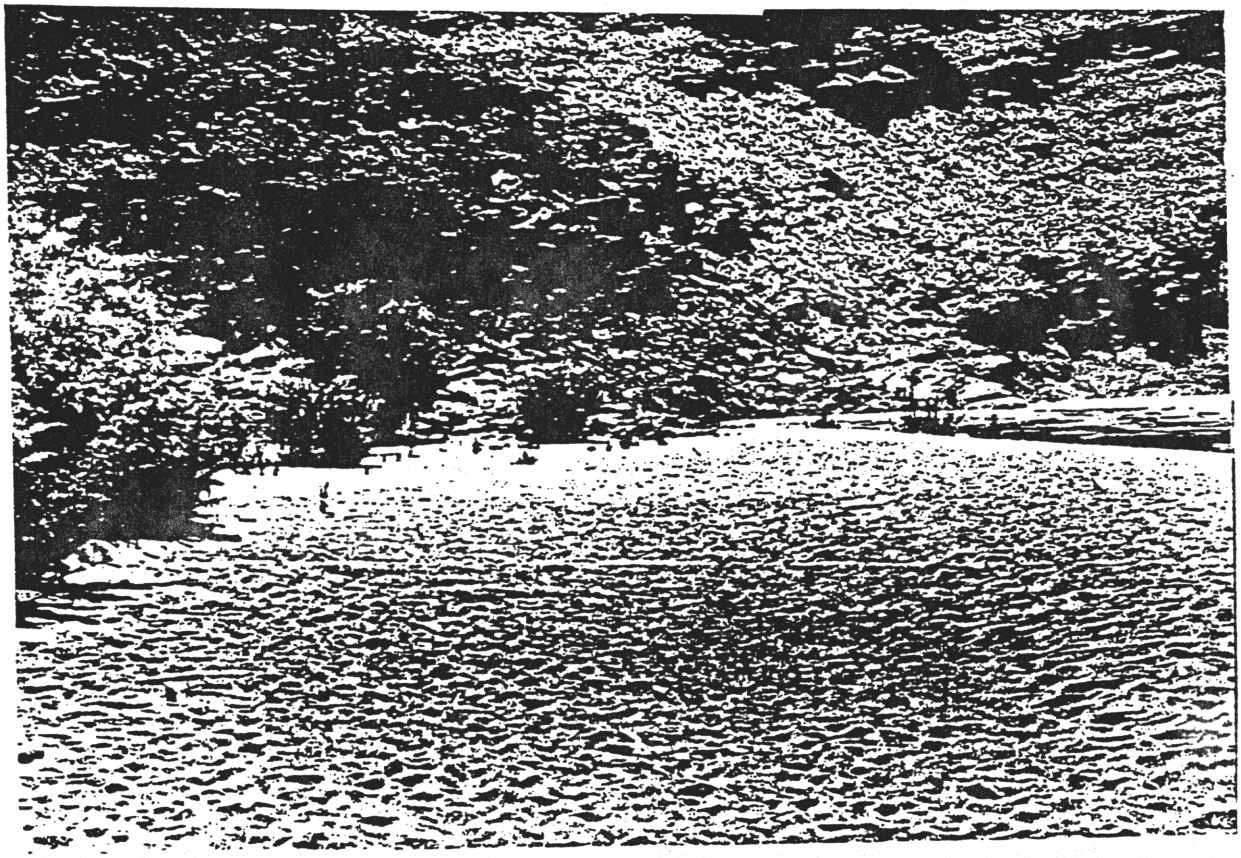




Nevills Rapid (RM 75.5)

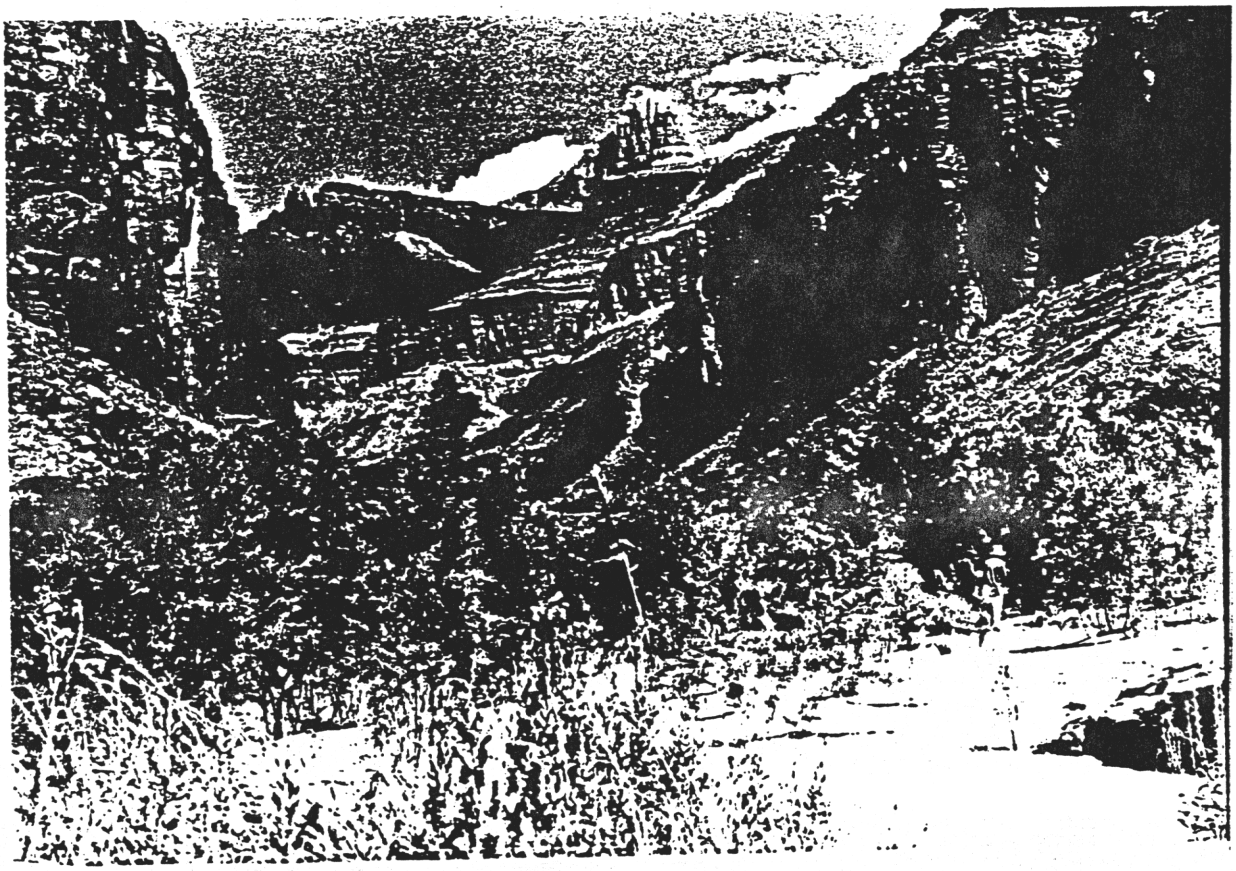
The most significant change at Nevills beach has been the removal of all driftwood that had accumulated on the beach. There has also been an increase in the depth of sand and a removal of most vegetation.





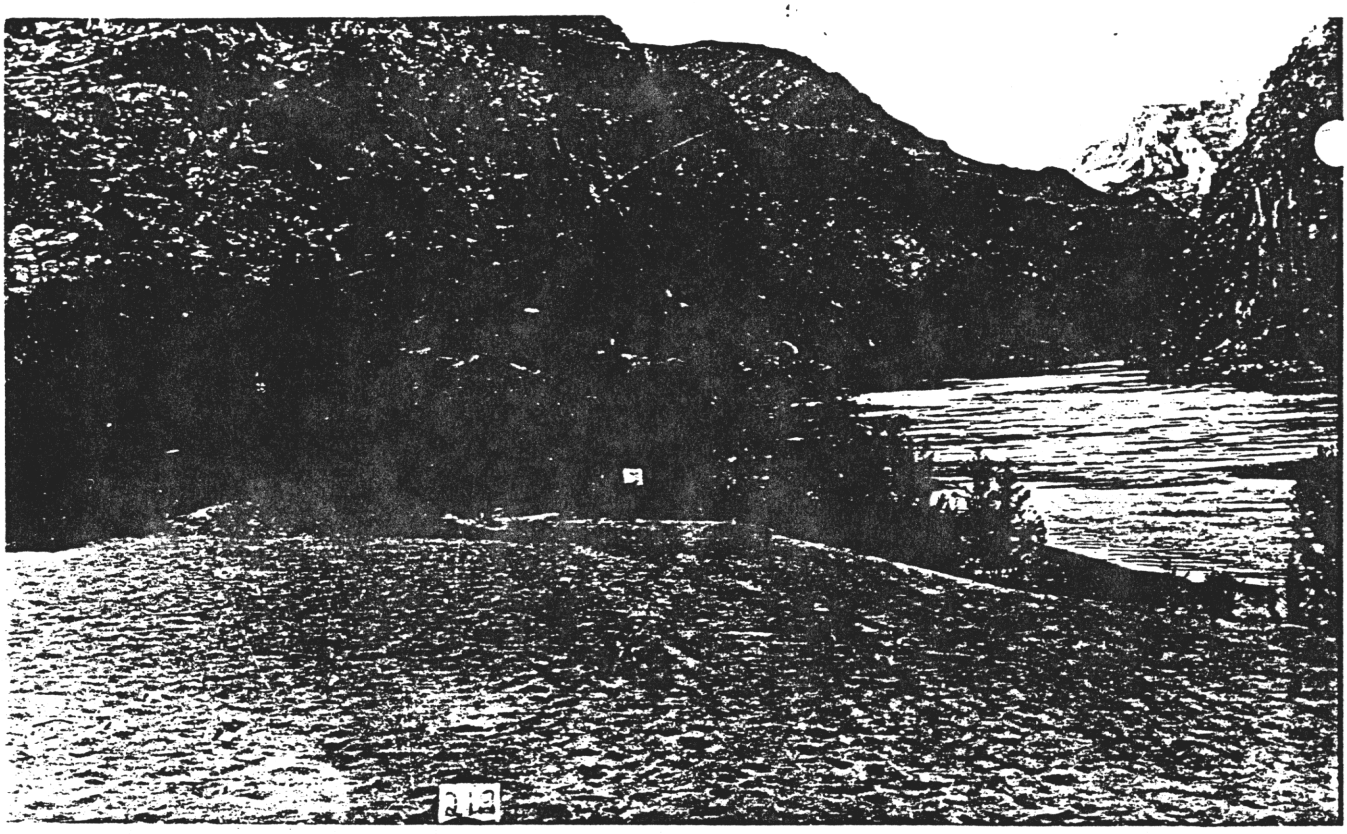
Hance Rapid (RM 76.5)

Hance Rapid beach has remained much the same except for the deposition of a small amount of sand near the talus slope and a large increase in vegetation on the beach itself.



219 Mile (RM 219)

The beach at 219 Mile has undergone two major changes: the removal of most of the vegetation next to the water line and a decrease in the size of the beach.



CONCLUSIONS

After viewing the before and after photographs in this project, it is evident that the flood of 1983 resulted in extensive changes in the beach environments. The flood cleared out much of the vegetation that had lined the beach fronts, although some vegetation is growing back. Some of the beaches lost sand from the water's edge, but are thicker in the interior portions, suggesting a redistribution of sand. At some of the beaches, vegetation some distance from the river has grown very rapidly, apparently as a result of the flood waters. The flood also acted as a cleansing agent, sweeping the beaches nearly free of human debris and driftwood.

While only a small number of comparison photographs are presented here, it should be sufficient to confirm the usefulness of repeat photography to document environmental changes within the Grand Canyon.

RECOMMENDATIONS

When taking the initial photographs for a repeat photography project, try to include at least one easily recognizable landmark that is unlikely to change. If at all possible, use the same type of camera for subsequent photographs so that the size of the field remains the same.

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CHAPTER IV

TOPOGRAPHIC MAPPING OF BEACHES ALONG THE COLORADO RIVER IN GRAND CANYON

Sean Sherlock

INTRODUCTION

The beaches along the Colorado River in Grand Canyon have undergone changes as a result of the completion of Glen Canyon Dam in 1963. The dam has altered the character of the river by drastically reducing its sediment load and changing the periodicity of its flow from highly variable seasonal fluctuations to a fairly steady year-round flow with daily fluctuations tied to hydroelectric production. Sediment load dropped from 140 million tons per year before the dam to 20-30 million tons per year after, with most of this coming from downstream tributaries. Before the dam, the flow ranged from an average of 700-4,000 cubic feet per second (cfs) in winter to 86,000 cfs in summer. Since the dam, flow has been fairly steady at 30-32,000 cfs year-round, with small daily fluctuations that at times drop the rate to as low as 12,000 cfs. There have been only a few unusually high or low flows in the last 20 years. The highest was a flood in the spring of 1983 that reached 96,000 cfs.

Beach profiles that have been measured (Beus and others 1985) suggest a trend of erosion from the time the dam closed

until the 1983 flood. The flood resulted in pronounced and unexpected changes in beach configuration. In general, sand was added to the upstream end of the beaches and eroded from the downstream end. Some beaches gained sand and some lost, with an apparent net gain in the beaches as a whole. This was probably due to the reworking of sediments that had previously been deposited on the river bed. Some beaches were removed completely, and some new beaches were formed. Since that time, the long-term trend of erosion has apparently resumed.

In order to better understand the complex system within the Canyon of beach erosion and deposition --- a system profoundly effected by dam releases, and which potentially can be managed to a degree by regulated dam releases --- A. D. Howard measured profiles and established bench marks on several beaches in 1974 (Howard 1975). This work has been continued and expanded by S. S. Beus (Beus and others 1982, 1983, and 1984) and others.

OBJECTIVES

As a further expansion of this research, this project undertook plane table topographic mapping of two frequently used camping beaches along the Colorado River in Grand Canyon. The resulting maps can be compared to future maps as a means of determining changes to the beaches over time. Such comparison is very limited now because topographic maps of individual beaches do not exist. However, aerial photographs do, and a comparative analysis of one study beach was conducted as part of this project.

METHODS

Awatubi, a new beach formed at river mile R 58.1 by the 1983 flood, was surveyed on 3 August 1985. Lower National, a long-used campsite beach at river mile L166.6, was surveyed on 8 August 1985. The mapping was done using an alidade and plane table. The sand depth at the two mapped beaches, as well as others, was sampled at various locations with a soil auger. The river was flowing at 29,000 cfs at the time the beaches were mapped.

After the maps were completed, the map of Lower National was compared to an aerial photograph taken during an unusually low flow of 5,000 cfs in October 1983.

RESULTS

A flash flood had occurred in National Canyon shortly before the photograph was taken, and the stream channel at the north end of the beach was several feet deeper than it is now. Investigation showed that it is being filled in by wind-blown sand. Sand deposited at the lower end of the beach by the river is being transported toward the upper end of the beach by the prevailing wind which blows up-canyon. This location should be checked again next year to determine if there has been much dune migration, and, if so, how far the sand has been moved up the beach.

Results of sand depth sampling with the soil auger suggests that topography of the beaches is generally controlled by underlying rocks. However, some ridges are dunes of wind-blown sand, and there are some thick terraces of sand deposited by the river during periods of high flow. The best conditions for beach

deposition are in large eddies which form down-river from large obstructions such as debris fans at the mouths of side canyons. Sand is transported by the river during high flows, and the lower velocity of water in the eddies allows the sand to settle out and form deposits that become beaches at lower water levels.

CONCLUSIONS

The topographic maps produced in this project, which are on file with S. Beus in the Geology Department of Northern Arizona University, can be compared to others made in the future in order to monitor changes in the beaches. With observations over time, investigators should learn enough about how beaches change with changing water flows to make reasoned recommendations regarding controlled water releases from Glen Canyon Dam.

ACKNOWLEDGMENTS

Thanks are due to Dr. Beus for guidance of the project; to Alan Doty, John Coffin and Paula Messina for their help with the surveying; to the people at Humphrey Summit for running the river trip; and to Dorothy House, the editor.

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Beus, S. S. and others. 1984. Changes in beach profiles along the Colorado River in Grand Canyon, 1974-1983. In Beus, S. S. and Carothers, S. W. (eds.), Colorado River Investigations II, July-August, 1983. Northern Arizona University/Museum of Northern Arizona manuscript report submitted to Grand Canyon National Park, p.58-105.

Beus, S. S. and others. 1985. Topographic changes in the fluvial terrace deposits used as campsite beaches along the Colorado River in Grand Canyon. In House, D. (ed.) Colorado River Investigations III, July-August 1984. Northern Arizona University/Museum of Northern Arizona manuscript report submitted to Grand Canyon National Park, p.23-84.

Howard, A. D. 1975. Establishment of benchmark study sites along the Colorado River in Grand Canyon National Park for monitoring beach erosion caused by natural forces and human impact. University of Virginia Grand Canyon Study, Technical report no. 1.

CHAPTER V

SEDIMENTARY STRUCTURES IN COLORADO RIVER BARS IN THE GRAND CANYON

Diane M. Farrenkopf

INTRODUCTION

Sedimentary structures preserved in rock have been studied by scientists for over a hundred years. Despite this, the environments and conditions under which these structures are formed are still not fully understood. Studies undertaken in recent years to gain a better understanding of the dynamics of different structures have taken many directions -- from laboratory simulations to field study and observation of recently formed layers of sediments in different depositional environments.

The difficulty in interpreting these structures arises from the number of factors that influence their formation. "Bed form or bed roughness is a function of the following variables (and possibly others): depth, slope, particle size and shape, particle sorting, specific gravity of grains, density and viscosity of the water-sediment mixture, and cross-sectional shape and alignment of the channel" (Harms and Fahnestock 1965, p.87). Direction of stream flow is also known to be an important factor in the formation of sedimentary structures.

Despite the uncertain state of knowledge about them, sedimentary structures can be studied to learn something about the conditions that produced the sand bars and beaches in which they are found. This should prove to be a useful tool for the investigation of the complex geomorphology of the Colorado River in the Grand Canyon.

OBJECTIVES

The purpose of this project was two-fold. The first objective was to test two methods of collecting small-scale peels or cross-sections of sand bars or beaches in the Grand Canyon for later study in the laboratory. The second objective was to analyze peels from selected locations to determine stream flow patterns at the time of bar formation.

METHODS

To obtain small-scale peels or cross-sections of beaches or bars, two methods were used.

Method 1

Materials:	shovel	pins or toothpicks
	trowel	paint brush
	clear acrylic spray	Elmer's glue
	cheese cloth	1'x1' styrofoam sheet
	scissors	brunton compass

1. A site near a cut-bank or on either end of the bar or beach was selected for the test. It was found that it was best to make two peels at each location.

2. A trench was dug and one side smoothed with the trowel.

3. The acrylic spray was applied evenly on the smooth trench wall to a depth of at least 1cm. It was important to apply at least this amount in order to get a good peel.

4. A 1.5 foot length of cheesecloth was cut and carefully pinned over the acrylic-coated section, placing pins around the outer edges.

5. The cheesecloth was then sprayed with another coat of acrylic to make it more stable and prevent it from stretching.

6. Elmer's glue was spread in a layer about 2mm thick on the styrofoam sheet.

7. The sheet was then placed against the cheesecloth with firm, even pressure on the back to hold it in position.

8. The compass orientation of the peel was recorded on the back.

9. After drying in place for 1 to 1.5 hours, the peel was removed by slicing through the sand just behind it with the trowel.

10. The peel was allowed to dry thoroughly, then the excess sand was brushed away with the paint brush.

<u>Method 2</u>

Materials:	shovel	pins or toothpicks
	trowel	paint brush
	hair spray (spray pump)	laytex glue & small can
	cheese cloth	1'x1' styrofoam sheet
	scissors	brunton compass

1. The peel site was chosen and prepared as in steps 1-4 of method 1.

2. The mounted cheesecloth was thoroughly saturated with hair spray applied with a spray pump.

3. A layer of laytex glue was then applied to the entire surface of the cheesecloth. It was allowed to dry 15-20 minutes, then two to four more coats were applied in the same manner.

4. The compass orientation was written on the back of the peel.

5. The peel was allowed to dry, then removed as in method 1.

RESULTS

During the eleven day river trip, 13 peels were taken at five locations.

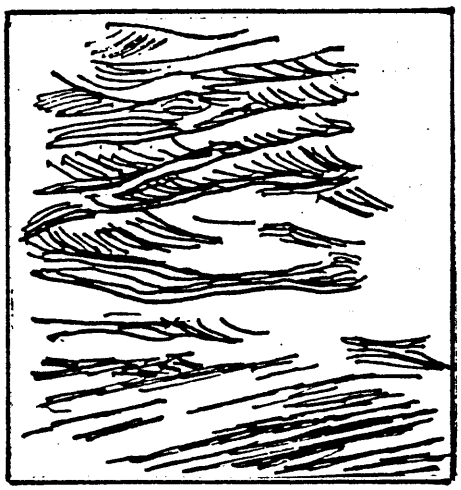
Table 1. Results of sand bar peel collecting trip, August 1985.

Location	River Mile	Clear Peels	Unclear Peels
Lower Nankoweap	53	0	1
Awatubi	58.1	3	1
Blacktail Canyon	120.1	1	1
National Canyon	166.6	0	*4
Lower Lava Falls	180.9	2	0

* Three of the peels from National Canyon showed some cross-bedding, but it was too faint to interpret.

Data from the successful peels at Awatubi, Blacktail Canyon, and Lower Lava Falls were analyzed to determine stream flow patterns at the time of deposition.

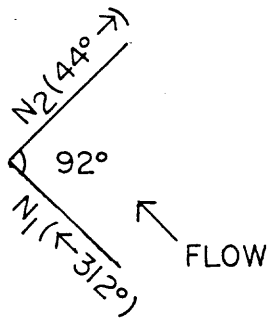
AWATUBI (RM 58.1)

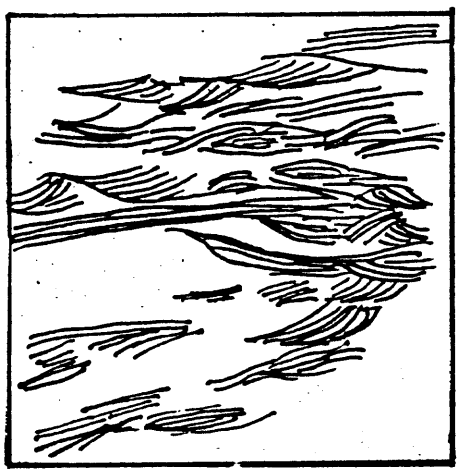


N1

312°

The upper part of this peel shows bounding surfaces oriented generally in a north westerly (NW) direction. When lined up with the trough cross-beds in N2, they indicate that the flow in this area was in a NW direction.

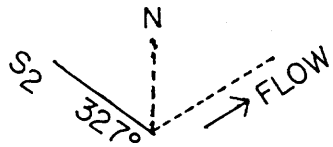




N2

44°

This matches the observed flow along the northern part of the bar (Fig. V-4).



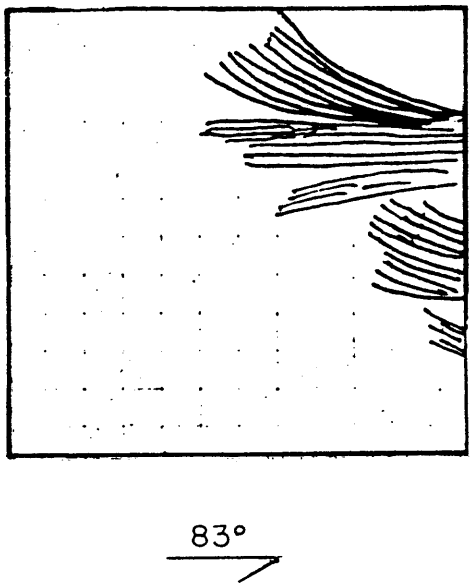
S2

327°

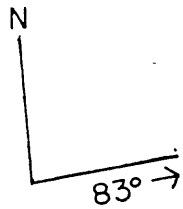
The orientation of the troughs in the upper part of this peel indicates that the flow would have been in a direction close to perpendicular to the orientation of the peel. Since the peel was 327o NW, the flow was probably NE. This corresponds to the observed flow (Fig. V-4).

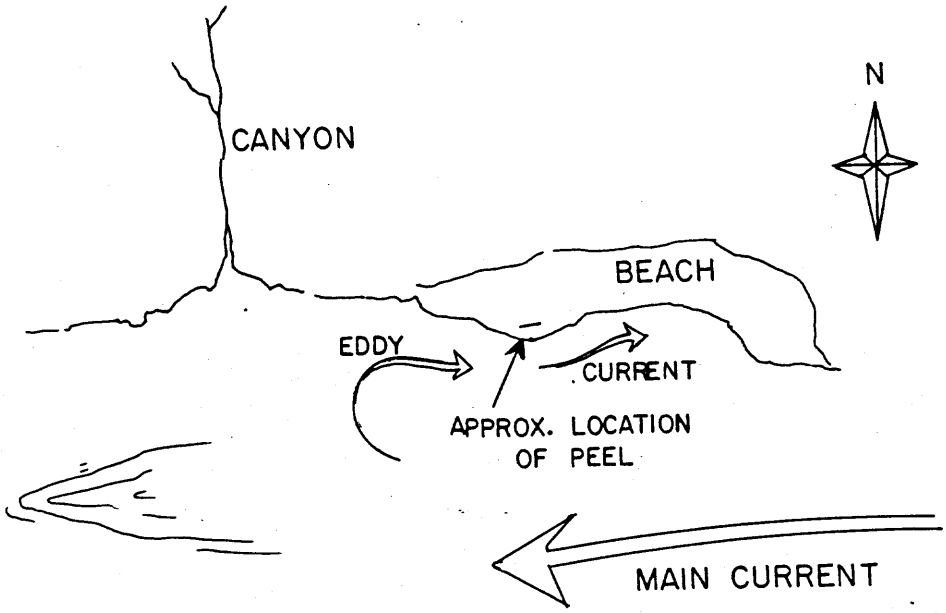
* Rough sketches which do not represent actual angles or size.

BLACKTAIL CANYON (RM 120.1)

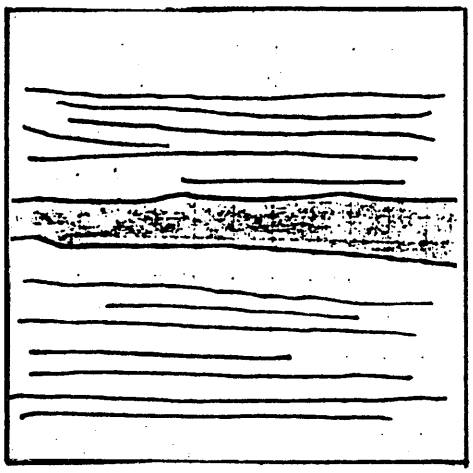


Here the cross-beds show dipping generally in the same orientation of the peel (almost due E). This would agree with the observed pattern of flow. Refer to Fig. V-2 for comparison.



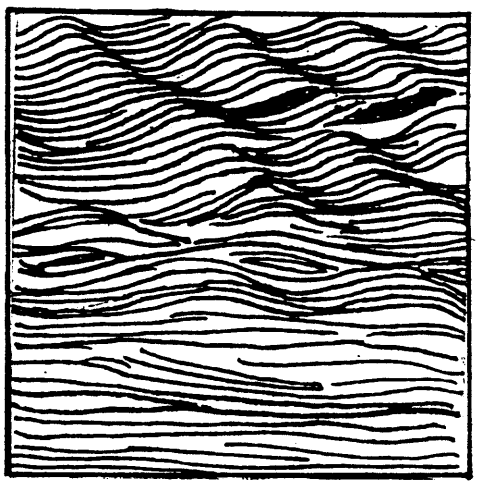


LOWER LAVA FALLS (RM 180.9)



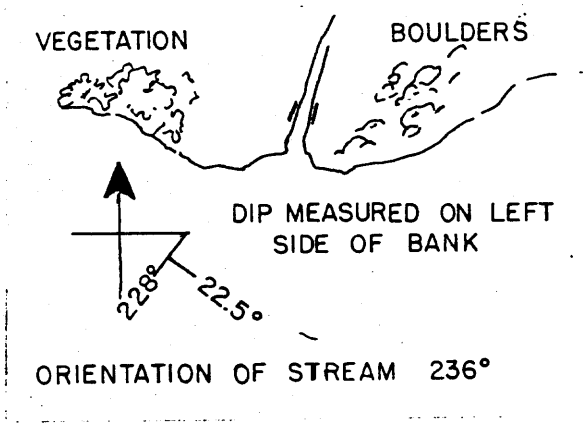
341°

Most distinctive in this peel is a red layer of fine, silty clay about 1 - 1.5 inch thick. This indicates that at the time of deposition, the water must have been fairly quiet, possibly in a standing pool. Parallel stratification above and below this layer indicates a low flow (slow moving water)-- probably near an area of faster moving water which would provide sediment.



332°

The structure in this peel changes (from bottom to top) from a parallel bed to ripples in phase to climbing ripples. This shows an increase in the velocity of flow during deposition. "The change from ripples in phase to those out of phase (climbing ripples) indicates a slight, but progressive increase in current velocity with a decrease in depth" (McKee 1965, p.78). Also, according to McKee, there needs to be an excess of sediment being added to the system if "ripple marks are built upward in overlapping series rather than merely migrate in a forward direction" (p.74). A possible source for this amount of sediment may be flood waters. The dip sloping in a SE direction indicates that this flood might have been from a side canyon. See Fig. V-3.



CONCLUSION

Sedimentary structures in small-scale peels of beach or bar sands can be studied and some general conclusions drawn as to possible depositional conditions.

The methods employed in this experiment were not consistently successful. The following observations and suggestions may result in an improved success rate in future experiments.

1. The spray pump was more effective than the aerosol for applying the sand fixative. It allowed greater saturation of the sand and resulted in a more stable peel.

2. Cheesecloth was difficult to work with and did not provide a firm backing. Fiber glass mesh might produce a more stable peel.

3. Laytex glue worked better than Elmer's glue, but neither was entirely satisfactory and other adhesives should be tried.

A simpler method employing materials that are easier to work with would speed the process and make it possible to take peels at more beaches.

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McKee, E. D. 1965. Experiments on ripple lamination. In Primary sedimentary structures and their hydrodynamic interpretation. Society of Economic Paleontologists and Mineralogists Special Publication, no. 12, p.66-83.

Pettijohn, F. J. and P. E. Poter. 1964. Atlas and glossary of primary sedimentary structures. Springer-verlag, New York.

Figure V-1. Cross-bedding of variable direction in modern Sand Dunes. Great Sand Dunes National Monument, Colorado, U.S.A. (Photograph by G.P. Merk).

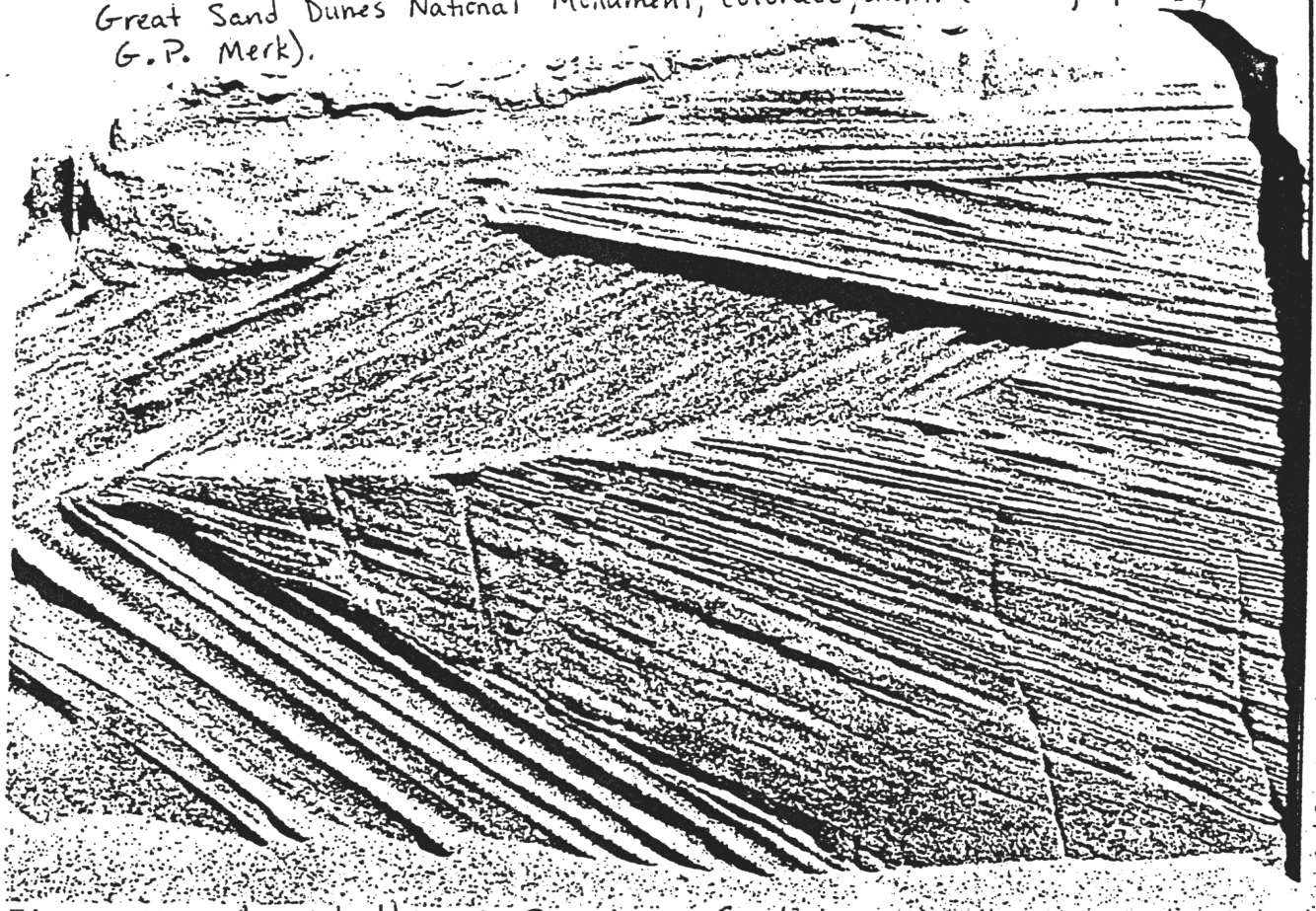


Figure V-2. Cross-bedding in Purslane Sandstone, Pocono Group (Mississippian). Note Tangential foresets. Current from right to left. Approx. 6 miles west of Hancock on U.S Highway 40 at Sidelong Hill, Washington County, Maryland, U.S.A.

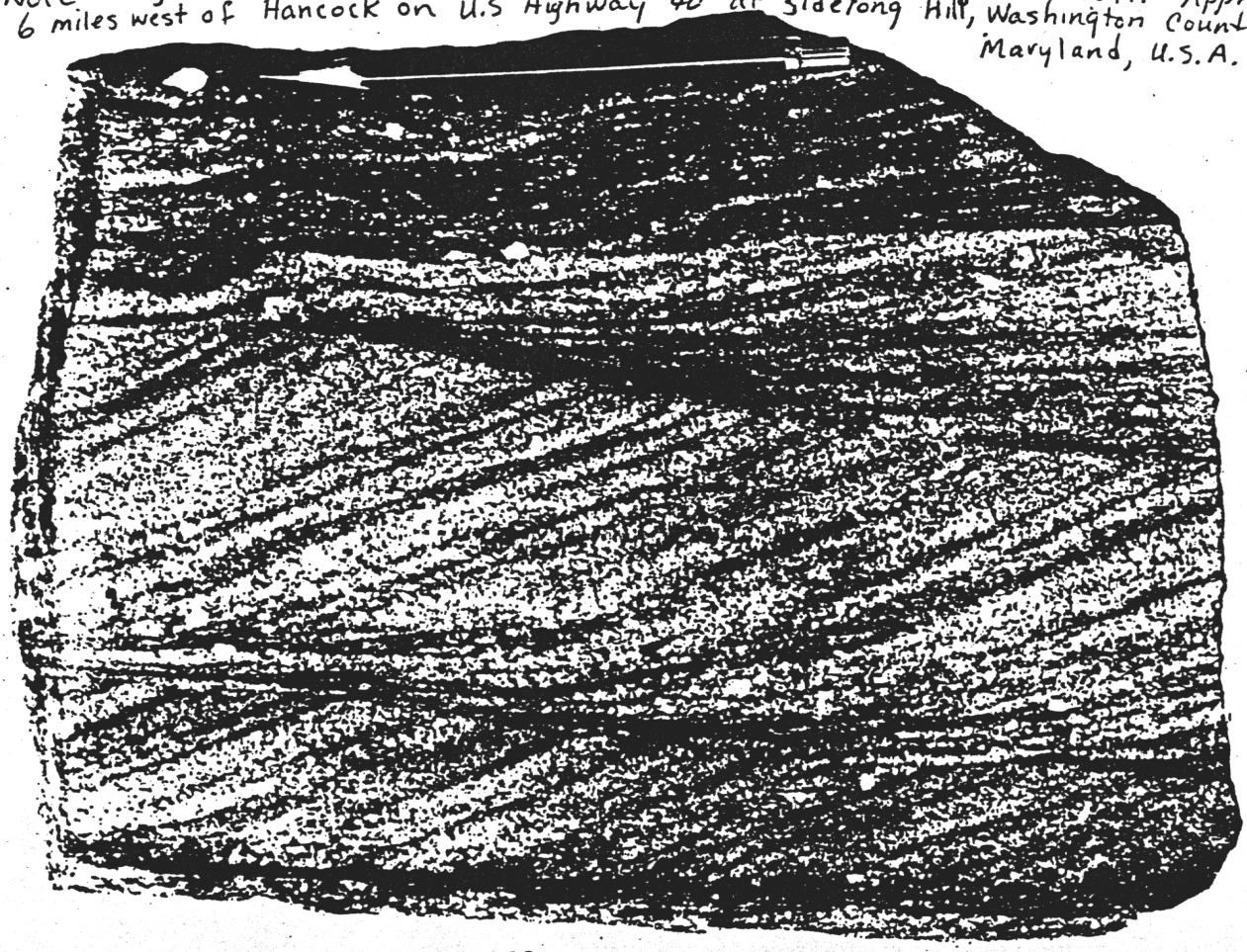


Figure V-3. Ripple cross-lamination in river alluvium. Ripple laminae rhythmically superimposed with development of pseudobedding in upper half of picture, 123.5 mile canyon, Colorado River, Arizona, U.S.A. (McKee, 1938, Fig. 4-D).

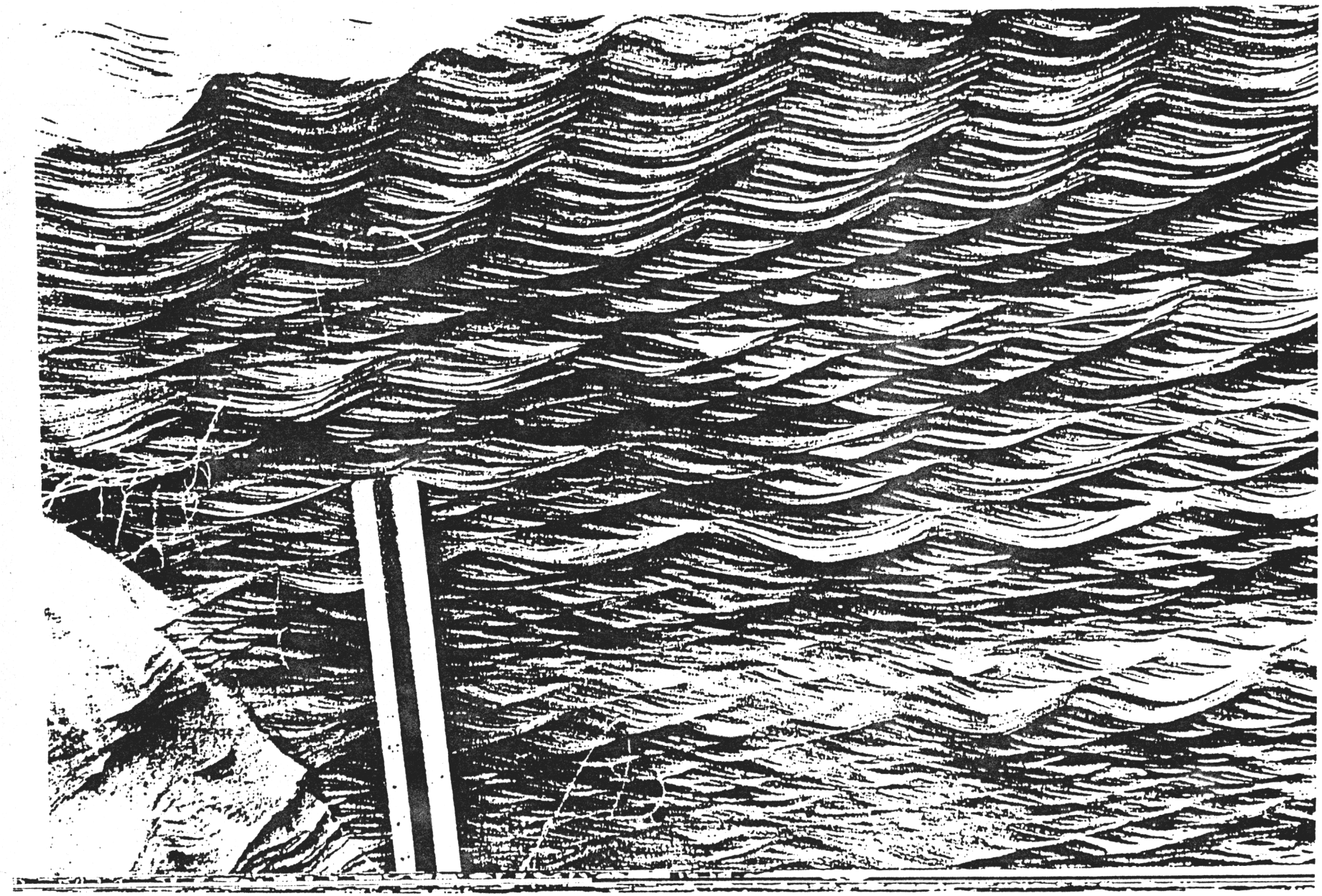


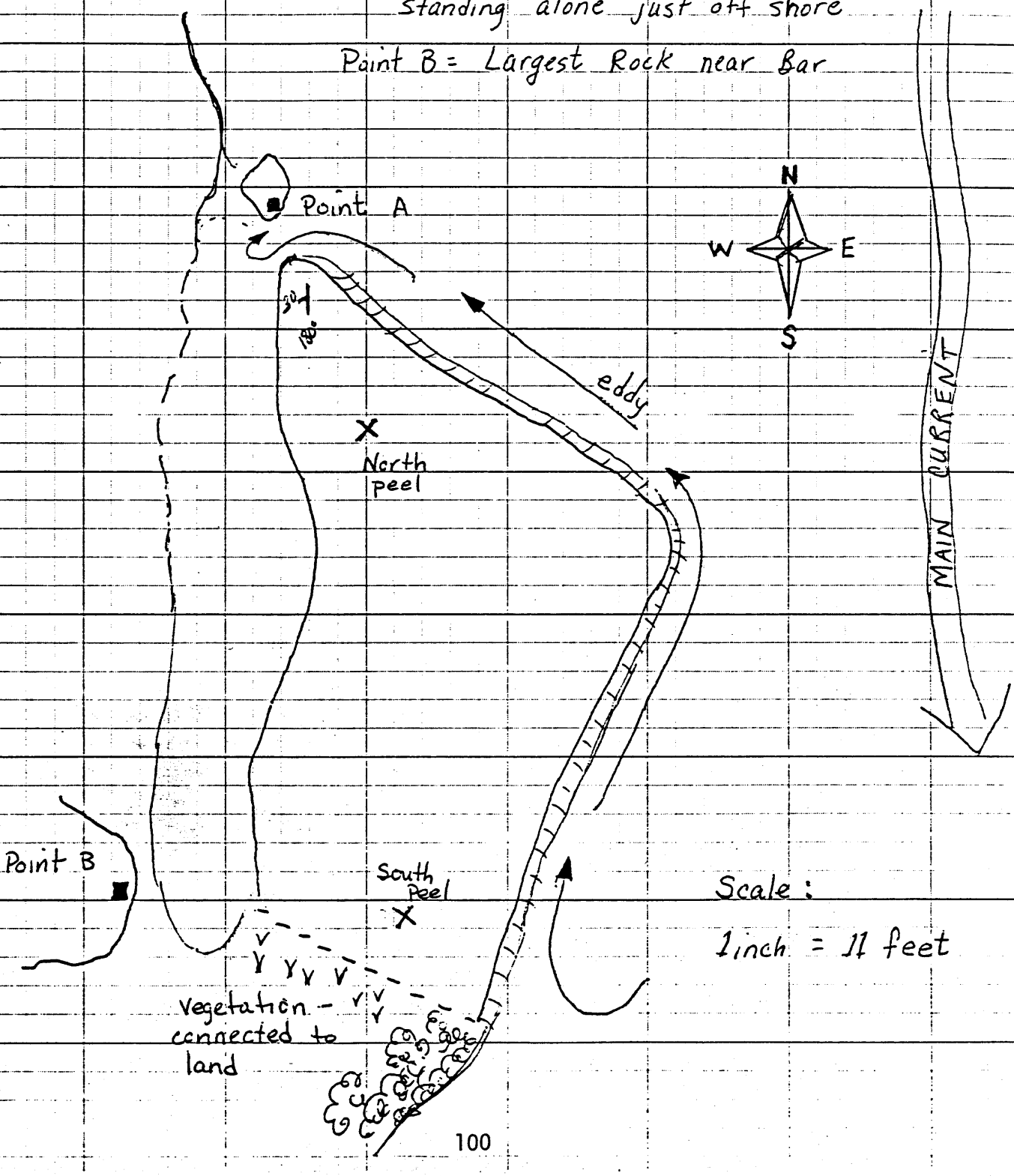
Figure V-4.

Bar South of Awatubi (Mile 58.1)

Point A to North Peel = 154° 47 feet
Point A to South Peel = 129° 110 feet
Point B to North Peel = 355° 74 feet
Point B to South Peel = 59° 41 feet

Point A = Large Rock of pitted limestone standing alone just off shore

Point B = Largest Rock near Bar



CHAPTER VI

BEACH SAND GRAIN SIZE ON THE COLORADO RIVER IN THE GRAND CANYON

Frank B. Lojko

The results of the 1985 study will be combined with those obtained in 1986 and will be reported next year.

CHAPTER VII

TEMPERATURE GRADIENTS OF SELECTED BEACHES ALONG THE COLORADO RIVER BETWEEN LEES FERRY AND DIAMOND CREEK AUGUST 1985

Mark Smith

INTRODUCTION

Beach temperatures are an important factor in the ecological system along the Colorado River in the Grand Canyon. Plant distribution and some animal movements, particularly reptilian, are regulated in part by air and surface temperatures. It is therefore of interest to gain an understanding of the thermal characteristics of Grand Canyon beaches.

Cold air drainage should have an effect on temperature variations and gradients. Consequently, degree of slope of a given beach would be expected to be a contributing factor to temperature variation on that beach. The proximity of the river with its very cold water surface temperature should be a factor as well.

There have been no previous study of beach temperature gradients in the Grand Canyon. Station readings from Lees Ferry and other locations along the river are available (Green 1964) and were used to establish temperature probabilities for those locations.

OBJECTIVES

The purpose of this study was, first, to test the hypothesis that noticeable variations in temperature do occur over the width of a beach between the water's edge and the talus slope along a line perpendicular to the direction of the river's flow; and, second, to determine if a relationship exists between the slope of a beach and the difference in temperature.

An additional purpose was to gather temperature, relative humidity, and dew point profiles for selected beaches at different times of day. River water temperatures were measured as well.

METHODS

Maximum and minimum temperatures were taken over ten consecutive days on eight beaches used by the Northern Arizona University Grand Canyon natural history class for overnight stops (Table VII-1) on a research trip conducted in August, 1985.

Maximum-minimum were placed on the slope of each study beach in a line perpendicular to the river's edge. The thermometers were mounted on wooden stakes 1.2 meters (4 feet) above the beach surface. The stakes were placed at 10 meter intervals beginning at the river's edge until they reached the talus slope.

Placement of the thermometers was done in the evening no later than 8:00 P.M. Thermometers were read and removed at approximately 8:00 A.M. On two occasions, the thermometers were left in place for a 36 hour period.

Eye-height measurements were taken with a Brunton Compass to determine the degree of slope of the beach.

Fifteen (15) relative humidity and dew point readings on nine beaches were made: ten in the morning, three in the evening, and two at midday. To gather these data, wet and dry bulb readings with a sling psychrometer were taken at the water's edge and at the edge of the talus slope.

A hydrolab operated by the Arizona Game and Fish Department was used to measure water temperatures in the main channel at seven locations along the length of the river from Lees Ferry to Diamond Creek.

RESULTS

Beach temperature variations were determined using only the minimum temperatures (Table VII-2), because maximum temperatures appeared to be inaccurate (Table VII-3).

All ten sets of data show a variation in temperature across the test beaches. The least difference was 1 ^{o}F at 20 Mile Beach; and the greatest difference was 12 ^{o}F recorded at two beaches: Granite Rapid and Pancho's Kitchen. The average temperature difference for all beaches 6.5 ^{o}F.

The pattern of temperature difference was the same for each beach, with the lowest readings at or near the river's edge and the highest at or near the talus slope.

The lowest minimum was 60 ^{o}F at Awatubi, and the highest minimum was 81 ^{o}F at 220 Mile Beach.

Beach slope ranged from 2 ^{o} at Granite Rapid to 9 ^{o} at Pancho's Kitchen (Table VII-2).

Morning relative humidity readings near the water averaged

47% with a dew point of 17. Along the talus slope, they averaged 44% with a dew point of 19 (Table VII-4). On six of the ten mornings the riverside area was more humid than the talus slope area. On four mornings, the opposite was true. The two morning readings at National Canyon reversed themselves. On 8/9/85, the riverside reading (43%) was lower than the talus reading (59%); on 8/10/85, the riverside reading (62%) was higher than the talus reading (57%). Both talus readings were above average.

Evening relative humidity readings near the water averaged 24%; along the talus they averaged 23%. A similar pattern was evident at midday: riverside readings averaged 22.5%; talus readings averaged 20.5%.

Dew points were quite stable. The range was from 13 to 23, with an average of 19. The average difference between riverside and talus dew point readings was 2.

Water temperatures of the main channel (Table VII-5) show a gradual warming as the river moves through the Canyon. The temperature of the water at Glen Canyon dam on 8/1/85 was 10 ^{o}C, or 50 ^{o}F. At river mile 195, a reading of 14.5 ^{o}C, or 58 ^{o}F, was taken. This amounts to a 4.5 ^{o}C, or 8 ^{o}F, increase in the water's temperature over that distance.

CONCLUSIONS

As expected, there were variations in temperature at all beaches, with the lowest temperatures being at the water's edge and the highest being at the edge of the talus slope. Variations in temperature were established over a distance as short as 10 meters, with a temperature difference of as much as 12 ^{o} recorded

over a distance of 60 meters. This probably reflects cold air drainage, although the influence of cold water temperatures may be a factor as well.

There was no correlation between degree of slope and degree of temperature difference. In, fact the beach with the second largest slope (7°) exhibited the least temperature difference (1° F), and the beach with the smallest slope (2°) exhibited the greatest difference (12° F). This directly contradicts the expected results.

There appears to be a greater correlation between temperature variation and beach width (distance away from the water), than between temperature variation and beach slope. If the data from Pancho's Kitchen are deleted (the 20 meter reading was recorded near a large boulder which may have resulted in an abnormally high reading), the remaining data suggest that such a correlation is high.

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Table VII-1. Temperature measurement locations, August 1985.

River Mile	Beach	Date
20	20 Mile	8-1
58.1	Awatubi	8-2
58.1	Awatubi	8-3
93.2	Granite Rapid	8-4
122	122 Mile	8-5
137	Pancho's Kitchen	8-6
166.6	National Canyon	8-7
166.6	National Canyon	8-8
194	194 Mile	8-9
220	220 Mile	8-10

Table VII-2. Minimum temperatures from selected beaches between Lees Ferry and Diamond Creek, August 1985.

Beach	Degree of Slope	Thermometer Location	Minimum Temp. (oF)
20 Mile	7	St. #1 Meter 0	72
		St. #2 Meter 8	70
		St. #3 Meter 20	72
		St. #4 Meter 38	73
Awatubi	5	St. #1 Meter 0	62
		St. #2 Meter 10	63
		St. #3 Meter 20	64
		St. #4 Meter 30	64
		St. #5 Meter 40	66
		St. #6 Meter 50	66
		St. #7 Meter 60	68
Awatubi	5	St. #1 Meter 0	60
		St. #2 Meter 10	62
		St. #3 Meter 20	63
		St. #4 Meter 30	62
		St. #5 Meter 40	63
		St. #6 Meter 50	64
		St. #7 Meter 60	66
Granite Rapid	2	St. #1 Meter 0	64
		St. #2 Meter 10	62
		St. #3 Meter 20	68
		St. #4 Meter 30	74
		St. #5 Meter 40	73
		St. #6 Meter 50	75
		St. #7 Meter 60	76
122 Mile	5	St. #1 Meter 0	64
		St. #2 Meter 10	66
		St. #3 Meter 20	68
Pancho's Kitchen	9	St. #1 Meter 0	63
		St. #2 Meter 10	62
		*St. #3 Meter 20	75
National Canyon	4	St. #1 Meter 0	73
		St. #2 Meter 10	75
		St. #3 Meter 20	75
		St. #4 Meter 30	79
		St. #5 Meter 40	79
National Canyon	4	St. #1 Meter 0	70
		**St. #2 Meter 10	63
		**St. #3 Meter 20	60
		St. #4 Meter 30	75
		St. #5 Meter 40	77

Table VII-2. Cont.

Beach	Degree of Slope	Thermometer Location	Minimum Temp. (oF)
194 Mile	6	St. #1 Meter 0	68
		St. #2 Meter 10	70
		St. #3 Meter 20	70
		St. #4 Meter 30	75
		St. #5 Meter 40	72
		St. #6 Meter 50	73
220 Mile	5	St. #1 Meter 0	75
		St. #2 Meter 10	78
		St. #3 Meter 20	76
		St. #4 Meter 30	79
		St. #5 Meter 40	81

* - St. #3 was near large boulder
** - St. #2 and St. #3 fell during second night

Table VII-3. Cont.

Beach	Degree of Slope	Thermometer Location	Minimum Temp. (oF)
220 Mile	5	St. #1 Meter 0	98
		St. #2 Meter 10	100
		St. #3 Meter 20	101
		St. #4 Meter 30	99
		St. #5 Meter 40	86

* - St. #3 was near large boulder
** - St. #2 and St. #3 fell during second night

Table VII-3. Maximum temperatures from selected beaches between Lees Ferry and Diamond Creek, August 1985.

Beach	Degree of Slope	Thermometer Location	Maximum Temp. (oF)
20 Mile	7	St. #1 Meter 0	87
		St. #2 Meter 8	98
		St. #3 Meter 20	89
		St. #4 Meter 38	92
Awatubi	5	St. #1 Meter 0	108
		St. #2 Meter 10	104
		St. #3 Meter 20	117
		St. #4 Meter 30	105
		St. #5 Meter 40	91
		St. #6 Meter 50	106
		St. #7 Meter 60	119
Granite Rapid	2	St. #1 Meter 0	92
		St. #2 Meter 10	94
		St. #3 Meter 20	95
		St. #4 Meter 30	93
		St. #5 Meter 40	90
		St. #6 Meter 50	95
		St. #7 Meter 60	100
122 Mile	5	St. #1 Meter 0	104
		St. #2 Meter 10	102
		St. #3 Meter 20	105
Pancho's Kitchen	9	St. #1 Meter 0	94
		St. #2 Meter 10	98
		*St. #3 Meter 20	97
National Canyon	4	St. #1 Meter 0	98
		St. #2 Meter 10	100
		St. #3 Meter 20	102
		St. #4 Meter 30	102
		St. #5 Meter 40	84
National Canyon	4	St. #1 Meter 0	104
		**St. #2 Meter 10	113
		**St. #3 Meter 20	115
		St. #4 Meter 30	106
		St. #5 Meter 40	81
194 Mile	6	St. #1 Meter 0	100
		St. #2 Meter 10	100
		St. #3 Meter 20	102
		St. #4 Meter 30	99
		St. #5 Meter 40	80
		St. #6 Meter 50	99

Table VII-4. Relative humidity and Dew Point from selected locations along the Colorado River between Lees Ferry and Diamond Creek, August 1985.

Location		Time/Date	Relative Humidity (%)	Dew Point
20 Mile	W	8PM / 8-1	24	19
	T		31	22
	W	8AM / 8-2	54	17
	T		43	17
Awatubi	W	8PM / 8-2	21	19
	T		18	19
	W	8AM / 8-3	20	17
	T		26	20
	W	2PM / 8-3	20	22
	T		17	22
	W	8PM / 8-3	27	18
	T		21	19
	W	8AM / 8-4	81	13
	T		64	14
Nevills	W	Noon 8-4	25	20
	T		24	23
Granite Rapid	W	8AM / 8-5	42	16
	T		34	17
122 Mile	W	8AM / 8-6	29	18
	T		21	19
Pancho's Kitchen	W	8AM / 8-7	72	14
	T		52	21
National Canyon	W	8AM / 8-8	43	17
	T		58	22
	W	8AM / 8-9	62	20
	T		57	20
194 Mile	W	8AM / 8-10	32	19
	T		42	21
220 Mile	W	7AM / 8-11	36	18
	T		43	17

W = Water's edge
T = Talus slope edge

Table VII-5. Water temperatures of the main channel of the Colorado River in the Grand Canyon, August 1985.

Location	Date	Temperature in Celcius
Glen Canyon Dam	8-1	10.00
20 Mile	8-1	11.01
60.5 Mile	8-3	10.26
93.2 Mile	8-5	11.70
138.5 Mile	8-6	12.30
166.6Mile	8-8	13.58
194 Mile	8-9	14.51

CHAPTER VIII

SECCHI DISC READINGS ALONG THE COLORADO RIVER IN THE GRAND CANYON

Mark Smith

INTRODUCTION

In the pre-Glen Canyon Dam era, the Colorado River was a river "of color", usually red. This was caused by a heavy load of suspended sediment, an average of 140 million tons a year. Since the dam's construction, the upstream sediment has been trapped behind the dam in Lake Powell, and the river that enters Grand Canyon National Park at Lees Ferry runs clear and cold. The only sediment of significance now contributed to the river in Grand Canyon comes from tibutaries below the dam. The river can be seen at times to change color as these tributaries input waters of varying sediment load. A tributary in flood (usually resulting from summer rains or spring snowmelt at higher elevations), can contribute a considerable amount of sediment. At other times, the same tributary may add only negligible amounts of suspended sediments.

Limnological studies conducted in 1975 (Cole 1976) included Secchi disc readings to determine the opacity of the river at different points. The disc readings were incorporated into a formula that rendered the depth of the euphotic zone. The

opacity (or conversely, the clarity) of the river is critical for the growth, reproduction and survival of many aquatic species of plants and animals. For biologists, knowledge of the relative opacity of the river along its length over time is important for an understanding of the its biotic systems. For geologists, knowledge of sediment sources is essential for an understanding of the river's geomorphology.

OBJECTIVES

The Secchi disc readings in this study were taken in order to establish the varying clarity of the Colorado River between Lees Ferry and Diamond Creek. A graphing of disc readings should show a relation between decreasing water clarity and tributary inflow.

METHODS

A Secchi disc on a calibrated rope was lowered into the water during the middle of the day at predetermined points along the course of the river. The test points bracketed major tributaries. The disc was lowered in a straight line toward the bottom until it was no longer visible (or until it hit bottom -- whichever came first). The depth of descent was read from the marked rope. The observer tried to maintain an equal eye level at approximately one meter above the water surface for all readings (Welch 1948).

RESULTS

Readings were taken from Lees Ferry to river mile (RM) 220. At Lees Ferry the disc was still visible at the bottom of

the river at a level of 4.2m (Table VIII-1). It could not seen among boulders and algae. At RM 5 below the Paria River confluence, the reading was .9m. The readings decreased at RM 16 to .75m. Clarity increased at RM 19.8 to 1.2m. The readings leveled off at Nautiloid and Nankoweap to 1.2m.

Above the Little Colorado River (LCR) near RM 65, disc readings increased to 1.8m, but dropped radically at Grapevine (RM 81) to a reading of .05m. It decreased to .02m at RM131 and remained at that level until Diamond Creek.

CONCLUSIONS

The readings show a decrease of clarity below the confluences of the Paria and Little Colorado Rivers. Both were very muddy in appearance, obviously carrying a heavy sediment load. An increase in clarity occurred below Vasey's Paradise where a large, clear spring discharges into the river. This apparently diluted the silting caused by the Paria upstream. The discoloration from the LCR, however, was never improved by tributaries downstream. Tapeats, Deer, and Havasu Creeks appeared to have significant flows of clear water, but they had no effect on the disc readings downstream.

Both the Paria and the Little Colorado Rivers are influenced by summer rains, and the amount of sedimentation they contribute to the main river in August would not be constant year round, yet both tributaries are sure to be major contributors to the sediment load of the Colorado River in the Grand Canyon.

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Welch, P. S. 1948. Limnological methods. McGraw Hill, New York.

Table VIII-1. Secchi disc readings along the Colorado River in the Grand Canyon, August 1985.

River Mile	Depth in meters
0	4.20
5	.90
18	.75
19.8	1.30
35	1.20
52	1.20
65	1.80
81	.05
131	.02
194	.02
220	.02

CHAPTER IX

DISTRIBUTION AND ABUNDANCE OF NATIVE AND EXOTIC FISH SPECIES IN THE COLORADO RIVER, GRAND CANYON AUGUST 1984 AND 1985

Veronica M. Yurcik

INTRODUCTION

The uniqueness of the Colorado River and its isolation from other drainage systems have contributed to the development of an endemic fish population unlike that of any other region in the United States (Miller, Valentine and Archer 1982). However the "rugged terrain" of the Grand Canyon and the "low economic and sport value" placed on the native species of the Colorado River within the Canyon have until only recently limited any extensive icthylogical research (Holden and Stalnaker 1973 and 1975). Intensive studies have been initiated in the last few years as a result of the suspected impact of large numbers of park visitors, growing interest in wildlife (Suttkus and Clemmer 1976), and, more critically, to changes caused by Glen Canyon Dam that have precipitated river conditions that seem more beneficial to exotic than to native fish species (Miller, Valentine and Archer 1982). Specifically, the operation of Glen Canyon Dam has altered the natural regime of the Colorado River in three areas: sedimentation, water temperature and periodicity. Clear, cold water of fluctuating flows has replaced the silt-laden river controlled by seasonal temperature and flow patterns. A decline

of endemic species has been attributed to changes in water quality and quantity and to the introduction of stocked exotic species (McAda, Seethaler and Wydoski 1976). "With the continued proliferation of exotic species, the question remains as to how well the natives will be able to tolerate the new dam-created environment" (Yurcik 1984).

Presently three of the endemic species are considered to be extirpated in the Grand Canyon: the Colorado squawfish (Ptychocheilus lucius), the bonytail chub (Gila elegans), and the roundtail chub (Gila robusta). The razorback sucker (Xyrauchen texanus) is considered extant based on one capture in 1978 (Carothers and Minckley 1981) and one in the spring of 1984 (Arizona Game and Fish Department, personal communication). The humpback chub (Gila cypha) exists predominately in close proximity to the Little Colorado River. The speckled dace (Rhinichthys osculus) is populus in the tributaries, and the flannelmouth sucker (Catostomus latipinnis) and the bluehead sucker (Catostomus discobolus) appear throughout the river (Carothers and Minckley 1981).

Assessment of post-dam changes is difficult as historical documentation of environmental factors is limited (Joseph and Sinning 1977). Moreover, Seethaler, McAda and Wydowski (1976) point out that "streamflow requirements for the endemic fish in the Colorado River are not known." Thus present investigations are being conducted to determine the effects of fluctuating flows on growth, food habits, reproduction potential, habitat types, stocked fish, movement, abundance, and distribution. This

information is essential in assessing possible trends. As part of this ongoing research, fisheries investigations were conducted on the Colorado River, Grand Canyon from July 30 to August 11, 1985 in a cooperative effort by the Arizona of Game and Fish Department and Northern Arizona University (NAU).

OBJECTIVES

The objective of this report is to analyze the data from those investigations in terms of abundance and distribution of both native and exotic species. Comparisons will be made to the 1984 NAU report "Distribution and Abundance of Native and Exotic Fish Species in the Colorado River, Grand Canyon, Arizona" (Yurcik 1984).

METHODS

Fish captures were made by electrofishing and by seine and trammel netting in the mainstream Colorado River. This report will examine only those species caught by electrofishing.

The electrofishing vessel was a rubber snout raft with a custom designed rig. A gas-fueled generator powered a Coffelt Variable Voltage Pulsator, Electroshocker Model VVP-15, which supplied both 220 AC and 220 DC pulsed voltage output. The majority of fish were released after being weighed, measured and tagged. Some samples were taken by Arizona Game and Fish, preserved in a 10% formalin solution or (ETOH) ethanol alcohol for analysis of age, food habits and determination of stocked fish. Northern Arizona University took samples for filleting to determine effects of electroshocking.

For the purpose of more indepth study, fish were analyzed in divisions of 50mm. In the graphs shown in Figures IX-1.1-1.7 and 4.1-4.9, all fish falling into any one range appear over the last mm of the increment, e.g. the graphed number (bar) appearing over the 100mm coordinate includes all fish within the 51-100mm increment.

K-factors, a measure of the condition of the fish, were determined for each specimen by using the following formula:

$$K = \frac{\text{weight in grams} \times 100{,}000}{\text{length in millimeters}}$$

Any fish not having a recorded weight was assigned a K-factor of zero. These fish were not included in the K-factor averages.

All data were analyzed in terms of river Reaches as defined in Appendix 2.

RESULTS

A total of 997 fish were captured by electrofishing in river Reaches 10-50. All raw data are summarized by Reach listing species and individual fish lengths in ascending order in Tables IX-1.1-1.5. Total composition and catch per effort for each Reach are summarized in Table IX-2. Percentage compositions of rainbow trout and carp by Reach are shown in Tables IX-3 and IX-4 respectively. K-factors by length increments for rainbow trout are shown in Table IX-5 and for carp in Table IX-6. Mean length and standard deviations for all fishes are listed in Table IX-7. Length frequency distributions for rainbow trout appear in Figures IX-1.1-1.9 and for carp in Figures IX-3.3-3.8.

Distribution percentages of rainbow trout by Reach appear in Figures IX-2.1-2.5. K-factor graphs for rainbow trout and carp appear in Figures IX-4.1-4.9 and IX-5.1-5.8 respectively. Mean, median and standard deviation graphs for rainbow trout are in Figures IX-6.1 and IX-6.2 and for carp in Figures IX-7.1 and IX-7.2.

The following data are broken down by Reach. There are no comparable 1984 data for Reach 10 as Northern Arizona University did not sample it in that year.

REACH 10

The most common fish captured in this Reach was rainbow trout (95.6%), with sizes ranging from 65-580mm* ($\bar{x}$=302.67±108.04). The 237 adults comprised 58.4% of all fishes, and 151 juveniles, 37.2%. Of the rainbow trout catch alone, 61% were adults and 39% were juveniles. Length frequency distribution indicates a decrease in numbers as fish increase in size to 250mm; thereupon numbers increase from 250-350mm and then decline from 350mm and up (Figures IX-1.1, 2.1). K-factors were more consistent throughout all length increments than in any other Reach. The highest average K-factor was 1.18 for fish within 51-100mm and the lowest average was .97 for fish 551-600mm (Figure IX-4.1, Table IX-5).

The second most common species was flannelmouth sucker

* This range excludes 102 rainbow trout young of the year that were captured, counted only and released. These 102 fish were included in total percentage but are not represented in any graphs.

(2.7%), with 11 adult captures ranging in size from 448-527mm ($\bar{x}$=486.55±24.13). The K-factor for the one fish in the 401-450mm range was 1.03. The six fish in the 451-500mm range had an average of 1.00, and the four fish in the 501-550mm range had an average of 1.00. However, individual analysis reveals K-factors ranging from .84-1.19 with no apparent trend (Table IX-1.1).

The next most common species was brook trout (.7%), with three adult captures of 326, 349 and 375mm ($\bar{x}$=348.67±18.37). K-factors were 1.46, 1.03 and 1.12 respectively.

One adult and one juvenile largemouth bass were .5% of the catch, with sizes of 122 and 241mm ($\bar{x}$=181.50±59.50). The 122mm fish had a K-factor of 1.05, and the 241mm fish a K-factor of 1.51.

One adult bluehead sucker and one adult cutthroat trout each comprised .2% of the catch. The bluehead sucker was 353mm with a K-factor of 1.00. The cutthroat trout was 596mm with a K-factor of .86.

REACH 20

In both 1984 and 1985, the most common species captured in Reach 20 was rainbow trout. In 1985, rainbow trout was 96% of the catch, with sizes ranging from 72-548mm ($\bar{x}$=316.53±114.49). The 151 adults comprised 76.3% of all fishes, and 39 juveniles, 19.7%. In 1984, rainbow trout was 80% of the catch, with sizes ranging from 77-600mm ($\bar{x}$=339.89±105.34). The 64 adults comprised 71.1% of all fishes, and eight juveniles, 8.9%. The relative frequency of adults to juveniles was higher than for any other Reach, with 89% being adults and 11% juveniles. The 1985 data

show an increase in percentage of juveniles, with 79% being adults and 21 juveniles.

Distribution of fish in 1984 parallels 1985 with a decline in numbers as fish increase in size above 300mm (Figures IX-1.2, 1.3, 2.2). In all but one comparable length increment, 1984 K-factors were higher than in 1985 (Figures IX-4.1, 4.2, Table IX-5).

The second most common species was carp (1.5%). The three captures were adults with sizes of 391, 471 and 496mm ($\bar{x}$=452.67±44.78). K-factor averages were 1.59 and 1.73 (Figure IX-5.1, Table IX-6). In 1984, three adult carp with sizes of 407, 473 and 521mm ($\bar{x}$=471.33±50.78) comprised 3.3% of the catch. K-factors were 1.57, 1.47 and 1.30 respectively (Figures IX-5.1, 5.2, Table IX-6). Length frequency distributions reveal the same number of fish caught and similar ranges for both years ((Figures IX-3.1, 3.2).

One juvenile humpback chub, 186mm with a K-factor of .99, was .5% of the catch. In 1984, humpback chub was the second most common species captured in Reach 20 comprising 11.1% of the catch, with sizes ranging from 121-360mm ($\bar{x}$=211±79.09). Two adults comprised 2% of all fishes, and eight juveniles, 9%. Of the humpback chub catch alone, 20% were adults and 80% juveniles. Although K-factor averages appear to rise as length increases (.81, .80, .96, .98 for fish 101-350mm), looking at the individual K-factors reveals a less definitive upward pattern (Table IX-1.2).

One adult speckled dace and one adult bluehead sucker each

were .5% of the catch. The speckled dace was 108mm with a K-factor of 1.11. The bluehead sucker was 330mm with a K-factor of 1.65. Neither of these species were captured in Reach 20 in 1984. No brooktrout were caught in 1985; however, in 1984 two adult brooktrout comprised 2.2% of the catch, with sizes of 410 and 444mm and respective K-factors of 1.81 and .76.

REACH 30

In both 1984 and 1985, the most common species in Reach 30 was rainbow trout. In 1985, rainbow trout was 68.3% of the catch, with sizes ranging from 104-508mm ($\bar{x}$=318.07±67.10). The 41 adults comprised 66.7% of all fishes, and one juvenile, 1.7%. The relative frequency of adults to juveniles was higher than for any other Reach: 98% were adults and 2% juveniles. In 1984, rainbow trout was 33.3% of the catch, with sizes ranging from 87-444mm ($\bar{x}$=262±126). Eight adults comprised 19% of all fishes, and six juveniles, 14.3%. Of the rainbow trout catch alone, 57% were adults and 43% were juveniles. Length frequency distributions for both years show numbers of fish in Reach 30 to be low (Figures IX-1.4, 1.5, 2.3). In 1984, only 7.4% of the total rainbow trout catch was taken in Reach 30, compared to 8.4% in 1985 (Table IX-3). There were only three comparable length increments for 1984-85, and in all of them (301-450mm) K-factors rose as size increased. However, the small numbers of fish caught in both years and the lack of recorded weights for fish below 301mm in 1984 make definitive analyses difficult (Figures IX-4.4, 4.5, Table IX-5).

The second most common species was brook trout (16.7%). The

ten captures were adults, with sizes ranging from 222-377mm ($\bar{x}$=293.30±49.66). K-factors for length increments 351-400mm were

Humpback chub and carp each comprised 6.7% of the catch. Four juvenile humpback chub ranged in size from 164-193mm ($\bar{x}$=182±12.19), with an average K-factor of 1.12. In 1984 humpback chub comprised 21.5% of the catch, with sizes ranging 46-345mm ($\bar{x}$=125±93). One adult was 2.4% of all fishes, and eight juveniles, 19%. Of the humpback chub catch alone, 11% were adults and 89% were juveniles. Only three of this catch had recorded weights. A fish of 147mm had a K-factor of .63, a fish of 152mm had a K-factor of 1.14, and a fish of 345mm had a K-factor of 1.00.

Carp (6.7%) ranged in size from 198-493mm, with two adults and two juveniles each comprising 3.33% of the catch. Length frequency ditributions reveal a decrease in carp captures (Figures IX-3.3, 3.4). In 1984, 18.3% of all carp collected were in Reach 30, as opposed to 6.6% in 1985 (Table IX-4). K-factors were somewhat higher in 1984 (Figures IX-5.3, 5.4, Table IX-6).

One adult browntrout of 390mm with a K-factor of 1.18 was 1.7% of the catch. In 1984, one adult brown trout of 479mm with a K-factor of 1.05 was 2.4% of the catch.

Two species that did not appear in 1985 but did in 1984 were flannelmouth sucker and fathead minnow. In 1984, one adult flannelmouth sucker of 482mm with a K-factor of .67 was 2.4% of the catch, and six adult fathead minnows 45-67mm comprised 14.3% of the catch. There were no recorded weights for the fathead minnows.

REACH 40

The most common species in Reach 40 was rainbow trout (82%), with sizes ranging from 78-415mm ($\bar{x}$=249.62±55.59). The 229 adults comprised 76.3% of all fishes, and 17 juveniles, 5.7%. Of rainbow trout alone, 93% were adults and 7% were juveniles. In 1984, rainbow trout was 73.1% of the catch, with sizes ranging from 81-410mm ($\bar{x}$=235±109). The 43 adults comprised 39.8% of all fishes, and 36 juveniles, 33.3%. Of rainbow trout alone, 54.4% were adults and 45.6% were juveniles. Length frequency distributions for 1984 and 1985 show dissimilar profiles for fish 51-200mm and similar profiles for fish between 251-450mm. Most notable is the disparity within the 201-250mm range where no fish appear in 1984 in contrast to 150 fish in 1985 (Figures IX-2.4, 4.6, 4.7). 1984 K-factors were higher than 1985 factors in comparable length increments of 251-450mm (Figures IX-4.6, 4.7, Table IX-5).

The next most common species was carp (14%), with sizes ranging from 91-545mm ($\bar{x}$=432.38±80.40). The 40 adults were 13.3% of all fishes, and two juveniles, 7%. The relative frequency of appearance of adults to juveniles was higher than for any other Reach, with 95% of the catch being adults and 5% juveniles. Carp was also the second most common species in 1984 (22.3%), with sizes ranging from 172-561mm ($\bar{x}$=429.83±86.48). The 22 adults comprised 10% of all fishes, and two juveniles, .9%. Of carp alone, 92% were adults and 8% juveniles. Length frequencies show similar profiles; however, in 1985, an increase is noted in the

401-500mm range (Figures IX-3.5, 3.6). Both years showed falling K-factors from 301-500mm and a subsequent rise in the 501-550mm range. 1984 K-factors were consistently higher (Figures IX-5.5, 5.6, Table IX-6).

Bluehead sucker was 1.7% of the catch, with sizes ranging from 142-241mm ($\bar{x}$=188±34.79). Four adults comprised 1.33% of all fishes, and one juvenile, .33%. Of bluehead sucker alone, 80% were adults and 20% juveniles. The juvenile had a K-factor of 1.47, the two adults within the 151-200mm range had an average of

Only one bluehead sucker was caught in 1984 (.5%). It was 166mm and had a K-factor of .87.

Four adult speckled dace were 1.7% of the catch, with sizes ranging from 57-105mm ($\bar{x}$=89.5±19.0). Only one weight was recorded and that was for a speckled dace of 95mm. The K-factor was 1.17. No speckled dace were taken in Reach 40 in 1984.

Two adult browntrout were .7% of the catch with sizes of 217 and 316mm ($\bar{x}$=266.5±49.50) and K-factors of 1.00 and .72 respectively. Three adult browntrout were 2.8% of the catch in 1984, with lengths of 288, 306 and 316mm ($\bar{x}$=303.33±11.59) and K-factors of .84, .92 and 1.01 respectively.

One adult flannelmouth sucker, 350mm with K-factor of 1.10 was .3% of the catch. No flannelmouth suckers were captured in 1984.

REACH 50

The most common species captured in Reach 50 was rainbow trout (42.4%), with sizes ranging from 102-334mm

($\bar{x}$=263.50±73.39). The 12 adults comprised 36.4% of all fishes, and two juveniles, 6.1%. Of rainbow trout alone, 86% were adults and 14% juveniles. In 1984, rainbow trout was 44.7% of the catch. Ten adults comprised 17.7% of all fishes, and 15 juveniles, 26.8%. Of rainbow trout alone, 40% were adults and 60% juveniles. The small number of captures in both years makes it difficult to assess any trend in length frequency profiles (Figures IX-1.8, 1.9). In 1984, 13.2% of all the rainbow trout catch was taken in Reach 50, as compared to 2.9% of the total catch in 1985 (Table IX-3). 1984 K-factors were higher than those of 1985 (Figures IX-4.8, 4.9).

The second most common species was carp (36.4%), with sizes ranging from 86-529mm ($\bar{x}$=398.08±141.40). Ten adults comprised 30.3% of all fishes, and two juveniles, 6.1%. Of carp alone, 83% were adults and 17% juveniles. In 1984, carp was also the second most common species (39.3%), with 22 adults ranging in size from 422-482mm ($\bar{x}$=401.09±54.46). Length frequency distributions reveal a percentage decrease in numbers and a wider distribution in 1985 (Figures IX-3.7, 3.8, Table IX-4). K-factors were comparable for only those fish from 351-500mm and showed 1985 factors to be equal to or higher than those for 1984 (Figures IX-5.7, 5.8, Table IX-6).

Five bluehead suckers were 15.2% of the catch, with sizes ranging from 228-303mm ($\bar{x}$=252.80±30.86). K-factors averaged .86 for three fish within 201-250mm and .72 for a fish of 275mm and 1.06 for a fish of 303mm. In 1984, one bluehead sucker of 305mm with a K-factor of .97 was 1.8% of the catch.

Two adult speckled dace were 6.1% of the catch. A fish of

91mm had a K-factor of .80, and a fish of 108mm had a K-factor of .79. In 1984, three adult speckled dace (77, 81 and 103mm) comprised 5.8% of the catch. There were no recorded weights.

In 1984, one 301mm humpback chub with a 1.00 K-factor, one 373mm flannelmouth sucker with a 1.41 K-factor, one 50mm fathead minnow (no recorded weight), and two channel catfish, 200mm and 295mm with K-factors of 1.00 and .82 respectively were captured. None of these species appeared in Reach 50 in 1985.

SUMMARY

Rainbow trout was the most common species taken in all Reaches in both years. Data show an increase in total numbers from 64.2% of the total catch in 1984 to 83.08% in 1985 (88.16% including Reach 10)*. Carothers and Minckley (1981) stated that adult rainbow trout comprised 14.6% of the 1978 summer mainstream catch**. In 1984, adult rainbow trout comprised 57.6% of the total catch and in 1985, 67.1%. These figures reveal a trend toward increasing abundance. Length frequencies show similar patterns. Overall population and numbers of adults decreased downstream with the exception of Reach 40 in both years. Comparison of 1984 and 1985 indicates that in 1985 abundance of juveniles generally decreased downstream, the greatest decrease being in Reach 40. However, Reach 40 exhibited high numbers of fish in the 201-250 mm range. Overall mean sizes were higher in

* In order to compare 1984 and 1985 data, total percentages for 1985 were computed for Reaches 20-50. Total percentages for Reaches 10-50 in 1985 appear in parentheses.

** The 1978 catch includes specimens taken by electrofishing and trammel nets.

1985 and decreased downstream, but not in a consistent pattern as in 1984. 1985 K-factors indicate increasing variation downstream and lower factors than 1984. Reach 10 had the most consistently high K-factors in 1985, perhaps attributable to less competition and a more abundant food supply in the clearer, colder waters.

Carp was the second most common species collected in both years showing a decline from 20.3% of the total catch in 1984 to 10.32% in 1985 (6% including Reach 10). Carothers and Minckley stated that adult carp comprised 56.1% of the 1978 total summer mainstream catch. In 1984 adult carp comprised 26.9% of the total catch and in 1985, 7.1%. These figures reveal a trend toward decreasing abundance in contrast to increases in rainbow trout. Reach 40 was the only Reach in 1985 to show an increase in abundance. Most obvious was the increased catch for fish 401-500mm in length. The 1985 decline in abundance was most notable in Reaches 30 and 50. Generally, abundance increased downstream in both years with the greatest concentration occurring in Reach 40. Mean size of carp in 1985 was lower than in 1984 and did not show the consistent decreasing pattern of 1984. In the two comparable length ranges, K-factors were lower in 1985.

The total percentage of humpback chub showed a decline from 7.1% of the total catch in 1984 to .9% in 1985 (.5% including Reach 10). This decline may be more attributable to method of collection than an actual decrease in abundance. Carothers and Minckley (1981) have noted that electrofishing was often unsuccessful in collecting humpback chub. The catch for both years was concentrated in the vicinity of the Little Colorado

River, fish being taken at river miles 61, 62 and 73 in 1984 and at river miles 59 and 74 in 1985. However, August 1985 larval seining data (courtesy of Arizona Game and Fish) indicates a wider distribution with 28 fish from 42-143mm captured in connected backwaters in Reaches 40 and 50. This is in contrast to previous studies that stated that reproduction seemed to be limited to upstream locations (Carothers and Minckley 1981). If spawning downstream can be verified, it will effect decisions regarding flows to insure the continued creation of such backwaters.

Bluehead suckers comprised 1.7% of the total 1984 catch and 1.86% of the 1985 catch (1.2% including Reach 10). The 1984 catch was taken in Reach 40 and 50 and the 1985 catch in all Reaches except Reach 30.

Brown trout comprised 1.4% of the total 1984 catch and .5% in 1985 (.3% including Reach 10). Distribution for both years was limited to Reach 30 and 40. Previous studies have indicated that brown trout is limited in its mainstream distribution (Carothers and Minckley 1981).

Brooktrout comprised .7% of the total 1984 catch as compared to 1.7% in 1985 (1.3% including Reach 10). The 1984 catch was collected in Reach 20 and the 1985 catch in Reaches 20 and 30.

Speckled dace comprised 1% of the total catch in 1984 and 1.2% in 1985 (.7% including Reach 10). The small size of this species makes collection by electrofishing difficult and thus mainstream collections do not represent actual mainstream population (Carothers and Minckley 1981).

Flannelmouth suckers comprised 1.7% of the total catch in

1984 and .5% in 1985 (1.4% including Reach 10). August 1985 seining data indicate a population of adults and juveniles in connected backwaters. Methods other than electrofishing will probably reveal greater distribution and abundance of this species.

Fathead minnows comprised 2.4% of the total 1984 catch. None were captured by electrofishing in 1985. Larval seining data, however, show abundance throughout the river (personal communication with Arizona Game and Fish).

Channel catfish comprised .7% of the 1984 catch. None were collected in 1985.

Cutthroat trout and largemouth bass comprised .1% and .2% respectively of the total 1985 catch. These species were not collected in 1984.

CONCLUSIONS

An increase in abundance of rainbow trout and a decrease in abundance of carp are noted. All Reaches with the exception of Reach 40 show similar patterns in both years. Rainbow trout and carp increases in 1985 suggest that changes appear to be occurring in Reach 40 that will warrant further investigation. The lower K-factors in 1985 may be attributable to increased competition. Electrofishing results indicate a decline in the native species: humpback chub and flannelmouth sucker; however, seining data show an abundance and distribution that are different. Thus any definitive statement cannot be made without data from all methods of collection. The lack of pre-dam

baseline data continues to make the assessment of trends in distribution and abundance difficult.

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Table IX-2. Summary of total collection by electrofishing, August 1985: effort and composition. Catch per effort (c/f) computed for a 100 minute effort.

Species	Reach 10			Reach 20			Reach 30			Reach 40			Reach 50			All Reaches	
	#	c/f	%	#	c/f	%	#	c/f	%	#	c/f	%	#	c/f	%	#	%
RBT A	237	127.4	58.4	151	100.7	76.3	40	59.7	66.7	229	84.2	76.3	12	13.8	36.4	669	67.1
J	151	81.2	37.2	39	26.0	19.7	1	1.5	1.7	17	6.3	5.7	2	2.3	6.1	210	21.1
Total	388	208.6	95.6	190	126.7	96.0	41	61.2	68.3	246	90.4	82.0	14	16.1	42.4	879	88.16
CRP A				3	2.0	1.5	2	3.0	3.3	40	14.7	13.3	10	11.5	30.3	55	5.5
J							2	3.0	3.3	2	.7	.7	2	2.3	6.1	6	.6
Total				3	2.0	1.5	4	6.0	6.7	42	15.4	14	12	13.8	36.4	61	6.0
FMS A	11	5.9	2.7	2	1.3	1.0				1	.4	.3				14	1.4
J																	
Total	11	5.9	2.7	2	1.3	1.0				1	.4	.3				14	1.4
BKT A	3	1.6	.7				10	15.0	16.7							13	1.3
J																	
Total	3	1.6	.7				10	15.0	16.7							13	1.3
BHS A	1	.5	.2	1	.7	.5				4	1.5	1.3	5	5.7	15.2	11	1.1
J										1	.4	.3				1	.1
Total	1	.5	.2	1	.7	.5				5	1.8	1.6	5	5.7	15.2	12	1.2
SD A				1	.7					4	1.5	1.3	2	2.3	6.1	7	.7
J																	
Total				1	.7	.5				4	1.5	1.3	2	2.3	6.1	7	.7
HBC A																	
J				1	.5	.7	4	6.0	6.7							5	.5
Total				1	.5	.7	4	6.0	6.7							5	.5
BRT A							1	1.5	1.7	2	.7	.7				3	.3
J																	
Total							1	1.5	1.7	2	.7	.7				3	.3
LMB A	1	.5	.2													1	.1
J	1	.5	.2													1	.1
Total	2	1.1	.5													2	.2
CTT A	1	.5	.2													1	.1
J																	
Total	1	.5	.2													1	.1

Table 1.1

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Species	Length	Weight	Reach	Effort	Condition (K)Factor
RBT	65	6	10	54	2.18
RBT	65	4	10	7	1.46
RBT	69	4	10	7	1.22
RBT	74	5	10	7	1.23
RBT	74	4	10	7	0.99
RBT	76	5	10	7	1.14
RBT	81	6	10	7	1.13
RBT	81	6	10	7	1.13
RBT	85	6	10	7	0.98
RBT	86	6	10	41	0.94
RBT	87	8	10	7	1.21
RBT	88	7	10	7	1.03
RBT	89	8	10	7	1.13
RBT	90	9	10	54	1.23
RBT	90	9	10	41	1.23
RBT	92	10	10	54	1.20
RBT	92	9	10	7	1.16
RBT	93	11	10	54	1.37
RBT	93	9	10	18	1.12
RBT	93	9	10	7	1.12
RBT	94	9	10	7	1.08
RBT	96	8	10	7	0.90
RBT	97	10	10	7	1.10
RBT	98	10	10	7	1.06
RBT	99	13	10	41	1.34
RBT	100	10	10	7	1.00
RBT	102	13	10	41	1.23
RBT	103	11	10	7	1.01
RBT	103	10	10	18	0.92
RBT	104	13	10	7	1.16
RBT	110	15	10	54	1.13
RBT	115	15	10	54	0.99
RBT	116	21	10	41	1.35
RBT	116	15	10	54	0.96
RBT	122	22	10	41	1.21
RBT	125	18	10	18	0.92
RBT	128	21	10	54	1.00
RBT	133	28	10	41	1.19
RBT	136	28	10	66	1.11
RBT	138	30	10	41	1.14
RBT	146	32	10	54	1.03
RBT	147	34	10	66	1.13
RBT	148	37	10	66	1.14
RBT	152	30	10	18	0.85
RBT	163	53	10	54	1.22
RBT	163	50	10	18	1.15
RBT	178	57	10	41	1.01
RBT	192	71	10	41	1.00
RBT	199	92	10	54	1.17
RBT	232	132	10	41	1.06
RBT	243	174	10	41	1.21
RBT	245	158	10	41	1.07
RBT	251	155	10	41	0.98

Species	Length	Weight	Reach	Effort	Condition (K)Factor
RBT	252	187	10	41	1.17
RBT	252	178	10	41	1.11
RBT	254	270	10	66	1.65
RBT	256	246	10	54	1.47
RBT	258	166	10	41	0.97
RBT	262	177	10	41	0.98
RBT	266	195	10	54	1.04
RBT	267	269	10	41	1.41
RBT	267	210	10	41	1.10
RBT	267	201	10	54	1.06
RBT	271	546	10	66	2.74
RBT	271	224	10	41	1.13
RBT	272	216	10	41	1.07
RBT	272	201	10	41	1.00
RBT	273	253	10	41	1.24
RBT	273	233	10	41	1.15
RBT	273	230	10	41	1.13
RBT	273	220	10	18	1.08
RBT	273	203	10	41	1.00
RBT	273	201	10	41	0.99
RBT	275	230	10	41	1.11
RBT	277	253	10	41	1.19
RBT	277	232	10	54	1.09
RBT	278	240	10	41	1.12
RBT	278	239	10	41	1.11
RBT	279	219	10	41	1.01
RBT	280	258	10	41	1.18
RBT	280	245	10	41	1.12
RBT	281	250	10	41	1.13
RBT	282	243	10	41	1.08
RBT	282	242	10	41	1.08
RBT	283	267	10	41	1.18
RBT	283	227	10	41	1.00
RBT	284	264	10	54	1.15
RBT	284	251	10	41	1.10
RBT	284	250	10	41	1.09
RBT	284	237	10	41	1.03
RBT	285	268	10	41	1.16
RBT	285	234	10	41	1.01
RBT	286	264	10	41	1.14
RBT	286	258	10	66	1.10
RBT	286	252	10	41	1.08
RBT	286	241	10	66	1.03
RBT	286	232	10	41	0.99
RBT	287	251	10	41	1.06
RBT	287	226	10	41	0.96
RBT	288	248	10	54	1.04
RBT	288	240	10	54	1.00
RBT	289	272	10	41	1.13
RBT	289	263	10	41	1.09
RBT	289	117	10	41	0.48
RBT	290	273	10	54	1.12
RBT	290	254	10	54	1.04

Table 1.1

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Species	Length	Weight	Reach	Effort	Condition (K)Factor
RBT	292	263	10	41	1.06
RBT	293	310	10	66	1.23
RBT	294	278	10	41	1.09
RBT	294	256	10	41	1.01
RBT	295	296	10	54	1.15
RBT	295	274	10	54	1.07
RBT	295	263	10	66	1.02
RBT	295	237	10	41	0.92
RBT	296	238	10	41	0.92
RBT	297	320	10	41	1.22
RBT	297	289	10	54	1.10
RBT	299	314	10	41	1.17
RBT	299	293	10	66	1.10
RBT	300	303	10	54	1.12
RBT	300	275	10	54	1.02
RBT	301	304	10	54	1.11
RBT	301	289	10	41	1.06
RBT	301	284	10	41	1.04
RBT	301	242	10	41	0.89
RBT	303	317	10	54	1.14
RBT	303	267	10	66	0.96
RBT	304	372	10	18	1.32
RBT	304	301	10	54	1.07
RBT	304	297	10	54	1.06
RBT	306	321	10	54	1.12
RBT	306	309	10	66	1.08
RBT	306	309	10	18	1.08
RBT	306	295	10	66	1.03
RBT	307	320	10	66	1.11
RBT	307	292	10	66	1.01
RBT	307	290	10	66	1.00
RBT	308	335	10	54	1.15
RBT	308	313	10	41	1.07
RBT	308	302	10	54	1.03
RBT	309	300	10	41	1.02
RBT	310	332	10	66	1.11
RBT	310	320	10	66	1.07
RBT	311	246	10	41	0.82
RBT	312	382	10	66	1.26
RBT	312	359	10	66	1.18
RBT	313	371	10	54	1.21
RBT	313	330	10	54	1.08
RBT	314	376	10	66	1.21
RBT	314	337	10	54	1.09
RBT	315	347	10	54	1.11
RBT	316	343	10	66	1.09
RBT	316	338	10	66	1.07
RBT	316	308	10	54	0.98
RBT	316	299	10	54	0.95
RBT	317	344	10	54	1.08
RBT	318	345	10	41	1.07
RBT	318	316	10	54	0.98
RBT	318	300	10	66	0.93
RBT	318	288	10	41	0.90
RBT	320	336	10	66	1.03
RBT	320	285	10	54	0.87
RBT	321	358	10	66	1.08
RBT	321	307	10	66	0.93
RBT	322	337	10	66	1.01
RBT	322	336	10	41	1.01
RBT	322	328	10	66	0.98
RBT	323	326	10	66	0.97
RBT	324	358	10	66	1.05
RBT	324	334	10	54	0.98
RBT	326	393	10	66	1.13
RBT	326	385	10	66	1.11
RBT	326	364	10	66	1.05
RBT	327	390	10	66	1.12
RBT	327	380	10	66	1.09
RBT	327	377	10	66	1.08
RBT	327	314	10	54	0.90
RBT	328	437	10	66	1.26
RBT	328	391	10	66	1.11
RBT	328	369	10	41	1.05
RBT	329	335	10	54	0.94
RBT	330	403	10	54	1.12
RBT	331	400	10	66	1.10
RBT	332	402	10	66	1.10
RBT	334	386	10	66	1.04
RBT	334	363	10	54	0.97
RBT	336	432	10	66	1.14
RBT	336	420	10	66	1.11
RBT	336	412	10	66	1.09
RBT	336	346	10	41	0.91
RBT	337	402	10	66	1.05
RBT	338	382	10	41	0.99
RBT	339	464	10	66	1.19
RBT	340	935	10	66	2.38
RBT	340	443	10	66	1.13
RBT	340	395	10	66	1.00
RBT	341	464	10	66	1.17
RBT	342	401	10	66	1.00
RBT	343	422	10	66	1.05
RBT	343	419	10	66	1.04
RBT	346	477	10	66	1.15
RBT	346	471	10	66	1.14
RBT	346	421	10	66	1.02
RBT	348	485	10	66	1.15
RBT	348	438	10	66	1.04
RBT	349	457	10	54	1.08
RBT	350	512	10	66	1.19
RBT	350	476	10	54	1.11
RBT	350	463	10	66	1.08
RBT	351	529	10	18	1.22
RBT	352	477	10	66	1.09
RBT	352	452	10	66	1.04

Table 1.1

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Species	Length	Weight	Reach	Effort	Condition (K)Factor
RBT	352	450	10	66	1.03
RBT	353	476	10	66	1.08
RBT	353	457	10	66	1.04
RBT	353	445	10	66	1.01
RBT	356	433	10	66	0.96
RBT	357	442	10	54	0.97
RBT	358	527	10	66	1.15
RBT	359	554	10	66	1.20
RBT	364	564	10	54	1.17
RBT	365	474	10	66	0.97
RBT	366	582	10	41	1.19
RBT	368	588	10	66	1.18
RBT	375	547	10	66	1.04
RBT	377	554	10	41	1.03
RBT	378	547	10	66	1.01
RBT	379	569	10	66	1.05
RBT	382	578	10	66	1.04
RBT	382	560	10	66	1.00
RBT	385	1100	10	66	2.08
RBT	385	593	10	66	1.04
RBT	391	702	10	41	1.17
RBT	391	653	10	66	1.09
RBT	392	650	10	66	1.08
RBT	393	675	10	66	1.11
RBT	394	546	10	41	0.89
RBT	396	737	10	66	1.19
RBT	396	701	10	66	1.13
RBT	397	624	10	66	1.00
RBT	398	712	10	18	1.13
RBT	400	712	10	41	1.11
RBT	404	805	10	41	1.22
RBT	411	731	10	54	1.05
RBT	411	717	10	41	1.03
RBT	412	793	10	66	1.13
RBT	416	723	10	66	1.00
RBT	416	723	10	66	1.00
RBT	416	627	10	18	0.87
RBT	421	845	10	41	1.13
RBT	423	765	10	66	1.01
RBT	423	715	10	18	0.94
RBT	424	869	10	18	1.14
RBT	424	868	10	54	1.14
RBT	433	848	10	66	1.04
RBT	434	880	10	54	1.09
RBT	441	846	10	54	0.99
RBT	442	826	10	18	0.96
RBT	442	813	10	66	0.94
RBT	444	1036	10	54	1.18
RBT	445	965	10	66	1.10
RBT	445	721	10	66	0.82
RBT	450	910	10	54	1.00
RBT	451	778	10	66	0.85
RBT	460	1012	10	54	1.04
RBT	463	1007	10	54	1.01
RBT	465	853	10	66	0.85
RBT	468	1099	10	54	1.07
RBT	469	1125	10	54	1.09
RBT	471	1135	10	66	1.09
RBT	471	905	10	54	0.87
RBT	473	1176	10	54	1.11
RBT	473	1059	10	66	1.00
RBT	474	1226	10	66	1.15
RBT	476	1168	10	66	1.08
RBT	489	1383	10	66	1.18
RBT	490	1278	10	66	1.09
RBT	493	1451	10	66	1.21
RBT	496	1466	10	18	1.20
RBT	497	1272	10	54	1.04
RBT	502	1214	10	41	0.96
RBT	503	1381	10	54	1.09
RBT	543	1828	10	66	1.14
RBT	549	1464	10	66	0.88
RBT	553	1743	10	54	1.03
RBT	580	1772	10	66	0.91
LNG	122	19	10	18	1.05
LNG	241	211	10	66	1.51
FMS	448	925	10	41	1.03
FMS	463	1002	10	41	1.01
FMS	463	989	10	41	1.00
FMS	471	1244	10	41	1.19
FMS	472	984	10	54	0.94
FMS	482	1131	10	54	1.01
FMS	494	1047	10	54	0.87
FMS	510	1476	10	66	1.11
FMS	512	1363	10	66	1.02
FMS	514	1147	10	66	0.84
FMS	523	1458	10	41	1.02
CTT	596	1827	10	66	0.86
BKT	326	505	10	41	1.46
BKT	349	436	10	54	1.03
BKT	371	573	10	41	1.12
BHS	353	441	10	54	1.00

RBT
MEAN
302.67
STANDARD DEV.
100.04

LNG
MEAN
181.50
STANDARD DEV.
59.50

FMS
MEAN
486.55
STANDARD DEV.
24.13

CTT
MEAN
596.00
STANDARD DEV.
0.00

BKT
MEAN
348.67
STANDARD DEV.
18.37

BHS
MEAN
353.00
STANDARD DEV.
0.00

Table 1.2

GRAND CANYON - AUGUST 1985

Species	Length	Weight	Reach	Effort		Condition (K)Factor
SD	108	14	20	24	SD	1.11
RBT	72	5	20	37	MEAN	1.34
RBT	76	6	20	37	108.00	1.37
RBT	89	13	20	37	STANDARD DEV.	1.84
RBT	91	10	20	37	0.00	1.33
RBT	91	10	20	37		1.33
RBT	103	16	20	37		1.46
RBT	103	13	20	37		1.19
RBT	104	14	20	37		1.24
RBT	104	13	20	24		1.16
RBT	105	17	20	37		1.47
RBT	105	16	20	37		1.38
RBT	105	9	20	9		0.78
RBT	106	17	20	37		1.43
RBT	107	11	20	24		0.90
RBT	110	19	20	37		1.43
RBT	111	13	20	24		0.95
RBT	112	15	20	24		1.07
RBT	116	19	20	24		1.22
RBT	116	17	20	24		1.09
RBT	117	13	20	9		0.81
RBT	119	16	20	9		0.95
RBT	122	19	20	24		1.05
RBT	123	19	20	24		1.02
RBT	124	13	20	9		0.68
RBT	125	21	20	24		1.08
RBT	127	21	20	33		1.03
RBT	130	26	20	24		1.18
RBT	131	24	20	24		1.07
RBT	132	31	20	24		1.35
RBT	133	29	20	37		1.23
RBT	134	30	20	37		1.25
RBT	141	27	20	9		0.96
RBT	142	32	20	24		1.12
RBT	145	43	20	24		1.41
RBT	148	41	20	24		1.26
RBT	148	39	20	24		1.20
RBT	149	31	20	24		0.94
RBT	157	49	20	33		1.27
RBT	157	39	20	29		1.01
RBT	270	202	20	37		1.03
RBT	279	246	20	37		1.13
RBT	282	233	20	29		1.04
RBT	283	200	20	37		0.88
RBT	286	252	20	37		1.08
RBT	291	269	20	37		1.09
RBT	292	260	20	37		1.04
RBT	295	244	20	37		0.95
RBT	296	262	20	29		1.01
RBT	297	292	20	33		1.11
RBT	297	259	20	29		0.99
RBT	298	212	20	37		0.80

Table 1.2

GRAND CANYON - AUGUST 1985

Species	Length	Weight	Reach	Effort	Condition (K)Factor
RBT	299	281	20	37	1.05
RBT	301	273	20	37	1.00
RBT	302	329	20	37	1.19
RBT	302	320	20	24	1.16
RBT	302	265	20	29	0.96
RBT	305	280	20	37	0.99
RBT	305	276	20	37	0.97
RBT	306	368	20	37	1.28
RBT	306	310	20	29	1.08
RBT	307	293	20	29	1.01
RBT	309	325	20	37	1.10
RBT	310	262	20	37	0.88
RBT	312	381	20	37	1.25
RBT	312	320	20	37	1.05
RBT	312	320	20	29	1.05
RBT	312	317	20	37	1.04
RBT	313	314	20	37	1.02
RBT	314	309	20	37	1.00
RBT	315	329	20	37	1.05
RBT	316	333	20	37	1.06
RBT	318	302	20	18	0.94
RBT	318	353	20	37	1.10
RBT	318	346	20	37	1.08
RBT	320	318	20	29	0.97
RBT	323	347	20	24	1.03
RBT	323	324	20	37	0.96
RBT	324	348	20	29	1.02
RBT	324	326	20	9	0.96
RBT	325	319	20	33	0.93
RBT	327	417	20	29	1.19
RBT	329	346	20	29	0.97
RBT	329	331	20	37	0.93
RBT	329	333	20	18	0.94
RBT	330	366	20	37	1.02
RBT	330	357	20	29	0.99
RBT	331	362	20	37	1.00
RBT	331	355	20	29	0.98
RBT	332	398	20	37	1.09
RBT	333	446	20	37	1.21
RBT	333	416	20	37	1.13
RBT	333	361	20	9	0.98
RBT	333	347	20	37	0.94
RBT	334	427	20	37	1.15
RBT	335	362	20	18	0.96
RBT	335	373	20	18	0.99
RBT	335	395	20	18	1.05
RBT	336	403	20	37	1.06
RBT	336	320	20	24	0.84
RBT	337	362	20	29	0.95
RBT	338	482	20	37	1.25
RBT	338	387	20	18	1.00
RBT	338	377	20	37	0.98

Table 1.2

GRAND CANYON - AUGUST 1985

Species	Length	Weight	Reach	Effort	Condition (K)Factor
RBT	338	418	20	18	1.08
RBT	339	377	20	37	0.97
RBT	341	407	20	37	1.03
RBT	341	384	20	37	0.97
RBT	342	421	20	37	1.05
RBT	343	392	20	37	0.97
RBT	344	492	20	37	1.21
RBT	345	510	20	37	1.24
RBT	346	445	20	37	1.07
RBT	348	413	20	33	0.98
RBT	349	413	20	24	0.97
RBT	349	380	20	33	0.89
RBT	352	478	20	37	1.10
RBT	352	433	20	37	0.99
RBT	352	421	20	37	0.97
RBT	353	445	20	37	1.01
RBT	356	430	20	18	0.95
RBT	357	465	20	24	1.02
RBT	359	482	20	37	1.04
RBT	359	452	20	33	0.98
RBT	360	412	20	18	0.88
RBT	361	468	20	37	0.99
RBT	361	435	20	24	0.92
RBT	363	526	20	37	1.10
RBT	366	408	20	37	0.83
RBT	367	510	20	18	1.03
RBT	370	545	20	33	1.08
RBT	372	500	20	29	0.97
RBT	373	542	20	33	1.04
RBT	375	494	20	33	0.94
RBT	376	542	20	29	1.02
RBT	377	510	20	29	0.95
RBT	378	610	20	37	1.13
RBT	378	500	20	37	0.93
RBT	381	587	20	18	1.06
RBT	383	572	20	29	1.02
RBT	386	563	20	18	0.98
RBT	386	510	20	29	0.89
RBT	386	599	20	18	1.04
RBT	388	597	20	29	1.02
RBT	393	570	20	18	0.94
RBT	393	589	20	18	0.97
RBT	393	684	20	33	1.13
RBT	398	597	20	33	0.95
RBT	400	608	20	29	0.95
RBT	401	635	20	33	0.98
RBT	407	685	20	18	1.02
RBT	407	703	20	33	1.04
RBT	408	707	20	37	1.04
RBT	412	747	20	37	1.07
RBT	412	711	20	29	1.02
RBT	413	682	20	29	0.97

Table 1.2

Species	Length	Weight	Reach	Effort		Condition (K) Factor
RBT	414	689	20	24		0.97
RBT	415	674	20	33		0.94
RBT	416	743	20	29		1.03
RBT	418	755	20	29		1.03
RBT	419	689	20	33		0.94
RBT	420	765	20	33		1.03
RBT	420	680	20	37		0.92
RBT	424	844	20	29		1.11
RBT	432	756	20	29		0.94
RBT	433	788	20	29		0.97
RBT	433	776	20	29		0.96
RBT	436	801	20	37		0.97
RBT	436	573	20	29		0.69
RBT	438	830	20	37		0.99
RBT	443	905	20	18		1.04
RBT	444	1038	20	37		1.19
RBT	446	907	20	33		1.02
RBT	448	962	20	37	RBT	1.07
RBT	449	965	20	37	MEAN	1.07
RBT	453	922	20	29	316.53	0.99
RBT	455	955	20	37	STANDARD DEV.	1.01
RBT	458	961	20	29	114.49	1.00
RBT	466	1191	20	37		1.18
RBT	466	957	20	29	HBC	0.95
RBT	476	1196	20	33	MEAN	1.11
RBT	480	643	20	29	186.00	0.58
RBT	488	1077	20	37	STANDARD DEV.	0.93
RBT	497	1306	20	9	0.00	1.06
RBT	503	1485	20	18		1.17
RBT	506	1187	20	18		0.92
RBT	509	1019	20	29		0.77
RBT	510	665	20	18		0.50
RBT	520	1193	20	18	FMS	0.85
RBT	521	1048	20	24	MEAN	0.74
RBT	548		20	18		0.00
HBC	186	64	20	33	437.50	0.99
FMS	392	545	20	33	STANDARD DEV.	0.90
FMS	483	1093	20	29	45.50	0.97
CRP	391	950	20	9		1.59
CRP	471	1956	20	29	CRP	1.87
CRP	496	1913	20	29	MEAN	1.57
BHS	330	594	20	29	452.67	1.65
					STANDARD DEV.	
					44.78	
					BHS	
					MEAN	
					330.00	
					STANDARD DEV.	
					0.00	

Table 1.[redacted]

Species	Length	Weight	Reach	Effort			Condition (K) Factor
RBT	365		20	2			0.00
RBT	366	504	20	51.28			1.03
RBT	369	585	20	51.28			1.16
RBT	371	532	20	51.28			1.04
RBT	372	570	20	47.57			1.11
RBT	378	564	20	51.28			1.04
RBT	384	597	20	47.57			1.05
RBT	388	696	20	47.57			1.19
RBT	415	779	20	47.57			1.09
RBT	418	820	20	47.57			1.12
RBT	421	924	20	47.57			1.24
RBT	452	990	20	47.57			1.07
RBT	466	1104	20	47.57			1.09
RBT	468	1410	20	47.57			1.38
RBT	492		20	2			0.00
RBT	499	1420	20	47.57			1.14
RBT	533	1690	20	47.57			1.12
RBT	540	1560	20	47.57			0.99
RBT	545	1700	20	51.28			1.05
RBT	600	1340	20	47.57	RBT MEAN	339.89	0.62
HBC	121	14	20	1.5	SD	105.34	0.79
HBC	134	20	20	4.05			0.83
HBC	135	20	20	4.05			0.81
HBC	180	50	20	4.05			0.86
HBC	196	78	20	4.05			1.04
HBC	203	86	20	4.05			1.03
HBC	206	70	20	4.05			0.80
HBC	226	120	20	4.05			1.04
HBC	349	416	20	1.5			0.98
HBC	360		20	4.05	HBC MEAN	211	0.00
FMS	425	729	20	1.5	SD	79.09	0.95
FMS	444	1008	20	47.57	FMS MEAN	446	1.15
FMS	469	1110	20	47.57	SD	19.02	1.08
CRP	407	1060	20	1.5			1.57
CRP	476	1610	20	1.5	CRP MEAN	471.33	1.49
CRP	531	1940	20	1.5	SD	56.73	1.30
BKT	436	1500	20	47.57	BKT MEAN	440	1.81
BKT	444	662	20	47.57	SD	4	0.76

lable 1.5

Species	Length	Weight	Reach	Effort			Condition (K)Factor
RBT	164	16	30	26			1.42
RBT	230	123	30	26			0.91
RBT	243	152	30	41			1.06
RBT	252	165	30	26			1.03
RBT	255	146	30	26			0.88
RBT	258	168	30	26			0.98
RBT	264	186	30	26			1.01
RBT	265	188	30	41			1.01
RBT	270	200	30	41			1.02
RBT	271	213	30	41			1.07
RBT	275	199	30	26			0.96
RBT	276	213	30	41			1.01
RBT	277	223	30	41			1.05
RBT	278	205	30	26			0.95
RBT	279	235	30	41			1.08
RBT	283	231	30	41			1.02
RBT	290	227	30	26			0.86
RBT	304	285	30	41			1.01
RBT	309	273	30	41			0.93
RBT	309	260	30	26			0.88
RBT	313	292	30	26			0.95
RBT	317	322	30	41			1.01
RBT	319	292	30	26			0.90
RBT	334	314	30	26			0.84
RBT	337	407	30	26			1.06
RBT	342	349	30	26			0.87
RBT	344	317	30	26			0.78
RBT	348	402	30	26			0.95
RBT	354	453	30	26			1.02
RBT	354	419	30	41			0.94
RBT	357	415	30	26			0.91
RBT	357	370	30	26			0.81
RBT	359	402	30	26			0.87
RBT	374	539	30	41			1.03
RBT	381	505	30	26	RBT		0.91
RBT	385	645	30	41	MEAN		1.13
RBT	391	669	30	41		318.07	1.12
RBT	415	692	30	41	STANDARD DEV.		0.97
RBT	419	1060	30	41		67.10	1.98
RBT	425	757	30	41			0.99
RBT	500	1049	30	41	NDC		0.88
NDC	164	49	30	41	MEAN		1.11
NDC	183	69	30	41		182.75	1.13
NDC	186	68	30	41	STANDARD DEV.		1.06
NDC	198	90	30	41		12.19	1.16
CRP	198	143	30	41			1.84
CRP	199	143	30	41	CRP		1.81
CRP	419	1191	30	41	MEAN		1.62
CRP	493	1763	30	41		327.25	1.47
BKT	222	102	30	26	STANDARD DEV.		0.93
BKT	222	98	30	26		131.38	0.90
BKT	236	131	30	26			1.00
BKT	267	176	30	26			0.92
BKT	277	179	30	26			0.88
BKT	275	190	30	26	BKT		0.87
BKT	286	182	30	26	MEAN		0.78
BKT	314	245	30	26		283.30	0.79
BKT	353	389	30	26	STANDARD DEV.		0.88
BKT	377	454	30	26		89.66	0.85
NBT	390	698	30	41			1.18
					BRT		
					MEAN		

Table 1.2A

Species	Length	Weight	Reach	Effort	Condition (K) Factor
RBT	77		20	47.57	0.00
RBT	80		20	51.28	0.00
RBT	84		20	51.28	0.00
RBT	93		20	47.57	0.00
RBT	106		20	47.57	0.00
RBT	110		20	51.28	0.00
RBT	110		20	51.28	0.00
RBT	119		20	47.57	0.00
RBT	277	296	20	51.28	1.39
RBT	297	349	20	47.57	1.33
RBT	308	344	20	47.57	1.18
RBT	309	336	20	51.28	1.14
RBT	311	349	20	47.57	1.16
RBT	314	380	20	51.28	1.23
RBT	315	396	20	51.28	1.27
RBT	315	307	20	47.57	0.98
RBT	316	352	20	47.57	1.12
RBT	319	356	20	51.28	1.10
RBT	323	364	20	51.28	1.08
RBT	324	388	20	51.28	1.14
RBT	324	366	20	51.28	1.08
RBT	327	370	20	47.57	1.06
RBT	329	360	20	51.28	1.01
RBT	332	418	20	47.57	1.14
RBT	332	406	20	47.57	1.11
RBT	333	398	20	47.57	1.08
RBT	336	398	20	51.28	1.05
RBT	340	436	20	51.28	1.11
RBT	340	423	20	47.57	1.08
RBT	343	478	20	51.28	1.18
RBT	344	479	20	47.57	1.18
RBT	345	494	20	51.28	1.20
RBT	345	454	20	47.57	1.11
RBT	345	448	20	51.28	1.09
RBT	347	500	20	51.28	1.20
RBT	347	424	20	51.28	1.01
RBT	349	496	20	47.57	1.17
RBT	352	508	20	51.28	1.16
RBT	352	452	20	47.57	1.04
RBT	353	502	20	47.57	1.14
RBT	353	500	20	47.57	1.14
RBT	353	436	20	51.28	0.99
RBT	355	448	20	47.57	1.00
RBT	356	484	20	47.57	1.07
RBT	357	547	20	47.57	1.20
RBT	359	490	20	51.28	1.06
RBT	360	448	20	51.28	0.96
RBT	362	524	20	51.28	1.10
RBT	362	462	20	47.57	0.97
RBT	363	548	20	51.28	1.15
RBT	363	443	20	47.57	0.93
RBT	365	524	20	51.28	1.08

Table 1.3 A

Species	Length	Weight	Reach	Effort		Condition (K) Factor
RBT	87		30	48.77		0.00
RBT	91		30	48.77		0.00
RBT	114		30	48.77		0.00
RBT	118		30	48.77		0.00
RBT	157		30	48.77		0.00
RBT	165		30	48.77		0.00
RBT	314	338	30	9.96		1.09
RBT	341	368	30	11.4		0.93
RBT	348	400	30	2.28		0.95
RBT	356	410	30	48.77		0.91
RBT	365	500	30	48.77		1.03
RBT	374	560	30	48.77		1.07
RBT	389	615	30	2.28		1.04
RBT	444	925	30	2.28	RBT MEAN 261.64	1.06
HBC	46		30	48.77	SD 125.50	0.00
HBC	55		30	48.77	HBC MEAN 124.78	0.00
HBC	60		30	48.77	SD 92.90	0.00
HBC	61		30	11.4		0.00
HBC	63		30	48.77		0.00
HBC	147	20	30	48.77		0.63
HBC	152	40	30	48.77		1.14
HBC	194		30	9.96		0.00
HBC	345	410	30	6.16		1.00
FMS	482	750	30	48.77	FMS MEAN 482	0.67
FHM	45		30	48.77	SD 0	0.00
FHM	46		30	48.77		0.00
FHM	50		30	48.77		0.00
FHM	53		30	48.77		0.00
FHM	54		30	48.77		0.00
FHM	67		30	48.77		0.00
CRP	151		30	48.77	FHM MEAN 52.5	0.00
CRP	346	520	30	6.16	SD 7.27	1.26
CRP	359	1100	30	48.77		2.38
CRP	380	1000	30	48.77		1.82
CRP	441	1400	30	48.77		1.63
CRP	470	1680	30	48.77		1.62
CRP	479	1500	30	48.77		1.36
CRP	490	2100	30	48.77		1.78
CRP	530	2290	30	2.28		1.54
CRP	545	3040	30	48.77		1.88
CRP	580	2820	30	6.16	CRP MEAN 433.73	1.45
BRT	479	1150	30	9.96	SD 115.10	1.05
					BRT MEAN 479	
					SD 0	

Table 1.4

GRAND CANYON - AUGUST 1985

Species	Length	Weight	Reach	Effort			Condition (K)Factor
SB	57		40	50	SB		0.00
SB	95	10	40	51	MEAN		1.17
SB	101		40	50		89.5	0.00
SB	105	13	40	51	STANDARD DEV.		1.12
RBT	78		40	50		19.10	0.00
RBT	85	5	40	51			0.81
RBT	102		40	6			0.00
RBT	115		40	50			0.00
RBT	117		40	50			0.00
RBT	120	18	40	51			1.04
RBT	123		40	50			0.00
RBT	142	32	40	42			1.12
RBT	155	34	40	45			0.91
RBT	157	40	40	51			1.03
RBT	171	49	40	45			0.98
RBT	188	78	40	31			1.17
RBT	189	60	40	50			0.89
RBT	192	80	40	50			1.13
RBT	193	75	40	50			1.04
RBT	198	80	40	50			1.03
RBT	200	88	40	31			1.10
RBT	202	90	40	50			1.09
RBT	202	80	40	50			0.97
RBT	202	80	40	50			0.97
RBT	203	38	40	50			0.45
RBT	205	84	40	45			1.00
RBT	205	80	40	29			0.93
RBT	205	80	40	31			0.93
RBT	205		40	29			0.00
RBT	206	92	40	31			1.05
RBT	207	90	40	45			1.01
RBT	207	90	40	50			1.01
RBT	208	100	40	50			1.11
RBT	208	84	40	45			0.93
RBT	209	94	40	31			1.03
RBT	209	84	40	31			0.92
RBT	210	90	40	29			0.97
RBT	211	98	40	45			1.04
RBT	212	112	40	31			1.18
RBT	212	100	40	50			1.05
RBT	212	75	40	50			0.79
RBT	213	88	40	45			0.91
RBT	213	55	40	50			0.57
RBT	214	106	40	31			1.08
RBT	214	100	40	50			1.02
RBT	214	96	40	45			0.98
RBT	214	90	40	50			0.92
RBT	216	110	40	29			1.09
RBT	216	102	40	31			1.01
RBT	216	100	40	50			0.99
RBT	216	98	40	45			0.97
RBT	216	96	40	29			0.95

Species	Length	Weight	Reach	Effort	Condition (K)Factor
RBT	216	96	40	29	0.95
RBT	216	88	40	45	0.87
RBT	216	84	40	29	0.83
RBT	217	100	40	50	0.98
RBT	217	100	40	50	0.98
RBT	217	85	40	50	0.83
RBT	217	35	40	50	0.34
RBT	218	106	40	31	1.02
RBT	218	100	40	31	0.97
RBT	218	98	40	31	0.95
RBT	218	96	40	29	0.93
RBT	219	98	40	29	0.93
RBT	219	90	40	50	0.86
RBT	219	86	40	29	0.82
RBT	220	102	40	29	0.96
RBT	220	55	40	50	0.52
RBT	221	110	40	50	1.02
RBT	221	110	40	50	1.02
RBT	221	106	40	29	0.98
RBT	221	106	40	31	0.98
RBT	222	115	40	50	1.05
RBT	222	110	40	50	1.01
RBT	222	110	40	50	1.01
RBT	222	110	40	42	1.01
RBT	222	106	40	45	0.97
RBT	222	100	40	50	0.91
RBT	222	100	40	29	0.91
RBT	222	98	40	31	0.90
RBT	222	75	40	50	0.69
RBT	223	112	40	31	1.01
RBT	223	110	40	31	0.99
RBT	223	110	40	50	0.99
RBT	223	110	40	50	0.99
RBT	223	106	40	45	0.96
RBT	223	100	40	50	0.90
RBT	223	88	40	45	0.79
RBT	223	42	40	50	0.38
RBT	224	100	40	31	0.89
RBT	224	98	40	45	0.87
RBT	224	98	40	29	0.87
RBT	224	75	40	50	0.67
RBT	224	65	40	50	0.58
RBT	225	110	40	50	0.97
RBT	225	108	40	31	0.95
RBT	225	108	40	29	0.95
RBT	225	108	40	31	0.95
RBT	225	104	40	29	0.91
RBT	225	102	40	45	0.90
RBT	225	100	40	29	0.88
RBT	225	92	40	29	0.81
RBT	226	124	40	29	1.07
RBT	226	120	40	50	1.04

Table 1.4

GRAND CANYON - AUGUST 1985

Species	Length	Weight	Reach	Effort	Condition (K)Factor
RBT	226	100	40	50	0.87
RBT	226	100	40	50	0.87
RBT	226	65	40	50	0.56
RBT	227	110	40	29	1.01
RBT	227	96	40	29	0.82
RBT	228	120	40	50	1.01
RBT	228	112	40	31	0.94
RBT	228	112	40	29	0.94
RBT	228	112	40	31	0.94
RBT	228	108	40	45	0.91
RBT	228	100	40	45	0.84
RBT	229	132	40	29	1.10
RBT	229	112	40	29	0.93
RBT	229	102	40	29	0.85
RBT	229		40	29	0.00
RBT	230	124	40	29	1.02
RBT	230	112	40	31	0.92
RBT	230	110	40	29	0.90
RBT	230	106	40	31	0.87
RBT	230	104	40	29	0.85
RBT	231	114	40	31	0.92
RBT	231	112	40	45	0.91
RBT	231	110	40	50	0.89
RBT	231	108	40	45	0.88
RBT	231	106	40	45	0.86
RBT	231	100	40	50	0.81
RBT	232	120	40	6	0.96
RBT	232	112	40	29	0.90
RBT	232	80	40	50	0.64
RBT	232		40	29	0.00
RBT	233	140	40	50	1.11
RBT	233	114	40	45	0.90
RBT	234	142	40	31	1.11
RBT	234	124	40	45	0.97
RBT	234	118	40	45	0.92
RBT	234	110	40	42	0.86
RBT	235	126	40	29	0.97
RBT	235	57	40	50	0.44
RBT	236	150	40	29	1.14
RBT	236	142	40	29	1.08
RBT	236	136	40	31	1.03
RBT	236	122	40	29	0.93
RBT	236	122	40	42	0.93
RBT	236	120	40	50	0.91
RBT	236	88	40	29	0.67
RBT	237	140	40	50	1.05
RBT	237	118	40	29	0.89
RBT	237	116	40	29	0.87
RBT	238	124	40	29	0.92
RBT	239	116	40	29	0.85
RBT	239		40	29	0.00

Species	Length	Weight	Reach	Effort	(K)Factor
RBT	241	145	40	6	1.04
RBT	241	130	40	42	0.93
RBT	241	120	40	42	0.86
RBT	242	140	40	6	0.99
RBT	242	138	40	42	0.97
RBT	242	130	40	29	0.92
RBT	243	116	40	51	0.81
RBT	244	136	40	42	0.94
RBT	245	155	40	6	1.05
RBT	246	177	40	45	0.85
RBT	247	130	40	45	0.86
RBT	248	138	40	45	0.90
RBT	249	144	40	51	0.93
RBT	249	140	40	50	0.91
RBT	250	162	40	51	1.04
RBT	253	164	40	45	1.01
RBT	257	168	40	18	0.99
RBT	260	178	40	29	1.01
RBT	264	168	40	42	0.91
RBT	265	158	40	42	0.85
RBT	268	174	40	42	0.90
RBT	269	185	40	6	0.95
RBT	270	170	40	42	0.86
RBT	271	162	40	42	0.81
RBT	274	166	40	42	0.81
RBT	276	162	40	51	0.77
RBT	277	210	40	50	0.99
RBT	285	160	40	51	0.69
RBT	291	210	40	42	0.85
RBT	292	240	40	50	0.96
RBT	293	218	40	45	0.85
RBT	295	210	40	50	0.82
RBT	296	300	40	50	1.16
RBT	296	245	40	6	0.94
RBT	296	210	40	50	0.81
RBT	297	240	40	51	0.92
RBT	299	246	40	31	0.92
RBT	301	220	40	42	0.84
RBT	302	220	40	29	0.83
RBT	303	264	40	42	0.95
RBT	304	272	40	42	0.97
RBT	307	300	40	51	1.06
RBT	308	260	40	45	0.92
RBT	308	178	40	29	0.61
RBT	308	174	40	29	0.60
RBT	310	240	40	31	0.81
RBT	311	206	40	29	0.68
RBT	312	274	40	42	0.90
RBT	312	256	40	42	0.84
RBT	313	246	40	45	0.80
RBT	314	316	40	18	1.02
RBT	314	244	40	31	0.79

Table 1.4

GRAND CANYON - AUGUST 1985

Species	Length	Weight	Reach	Effort		Condition (K)Factor
RBT	317	200	40	50		0.63
RBT	319	400	40	6		1.23
RBT	319	280	40	42		0.89
RBT	319	286	40	42		0.88
RBT	320	254	40	45		0.78
RBT	320	222	40	45		0.68
RBT	322	301	40	18		0.90
RBT	322	280	40	29		0.84
RBT	324	312	40	45		0.92
RBT	327	282	40	42		0.81
RBT	327	230	40	45		0.66
RBT	328	274	40	29		0.78
RBT	328	260	40	29		0.74
RBT	330	184	40	29		0.51
RBT	330	122	40	45		0.34
RBT	331	262	40	45		0.72
RBT	332	375	40	42		1.02
RBT	332	306	40	50		0.84
RBT	335	302	40	42		0.80
RBT	336	328	40	42		0.86
RBT	336	280	40	50		0.74
RBT	338	260	40	45		0.67
RBT	339	128	40	45		0.33
RBT	340	324	40	51		0.82
RBT	341	316	40	42		0.80
RBT	342	390	40	42		0.97
RBT	343	322	40	29		0.80
RBT	344	280	40	29		0.69
RBT	345	244	40	29		0.59
RBT	346	416	40	45		1.00
RBT	346	356	40	29		0.86
RBT	347	134	40	42		0.32
RBT	348	326	40	29		0.77
RBT	348	285	40	45		0.68
RBT	348	166	40	29		0.39
RBT	355	250	40	45		0.56
RBT	365	409	40	18		0.84
RBT	367	348	40	42	RBT	0.70
RBT	377	330	40	45	MEAN	0.62
RBT	394	478	40	42	249.62	0.78
RBT	399	414	40	29	STANDARD DEV.	0.65
RBT	415	532	40	42	55.59	0.74
FMS	350	470	40	31		1.10
CRP	91	13	40	51	FMS	1.73
CRP	155	58	40	42	MEAN	1.56
CRP	335	606	40	18	350.00	1.61
CRP	355	468	40	51	STANDARD DEV.	1.05
CRP	375	615	40	42	0.00	1.17
CRP	396	1004	40	42		1.62
CRP	405	810	40	45		1.22
CRP	408	902	40	42		1.33
CRP	413	825	40	42		1.17
CRP	415	920	40	45		1.29
CRP	422	940	40	51		1.25
CRP	427	905	40	42		1.20

Species	Length	Weight	Reach	Effort		Condition (K)Factor
CRP	429	1006	40	42		1.32
CRP	430	768	40	51		0.97
CRP	435	1100	40	45		1.34
CRP	437	1140	40	18		1.37
CRP	441	900	40	45		1.14
CRP	445	1352	40	18		1.53
CRP	445	1130	40	42		1.28
CRP	447	1243	40	18		1.39
CRP	450	1442	40	18		1.58
CRP	450	1010	40	42		1.11
CRP	450	950	40	50		1.04
CRP	453	1280	40	50		1.38
CRP	456	1287	40	18		1.36
CRP	460	1296	40	18		1.33
CRP	461	1307	40	42		1.33
CRP	461	1274	40	18		1.30
CRP	463	1205	40	42		1.21
CRP	464	1100	40	51		1.10
CRP	468	1130	40	45		1.10
CRP	471	1204	40	42		1.15
CRP	473	1250	40	45		1.18
CRP	475	1060	40	42	CRP	0.99
CRP	478	1290	40	51	MEAN	1.18
CRP	479	1150	40	51	432.38	1.05
CRP	480		40	50	STANDARD DEV.	0.00
CRP	490	1303	40	42	80.40	1.11
CRP	492	1604	40	18		1.35
CRP	514	1600	40	51	BRT	1.18
CRP	531	2245	40	18	MEAN	1.50
CRP	545	2284	40	18	266.5	1.41
BRT	217	102	40	18	STANDARD DEV.	1.00
BRT	316	226	40	45	49.50	0.72
BHS	142	42	40	6	BHS	1.47
BHS	163	40	40	31	MEAN	0.92
BHS	184	46	40	31	188.00	0.74
BHS	210	90	40	50	STANDARD DEV.	0.97
BHS	241	122	40	31	34.79	0.87

Table 1.4A

Species	Length	Weight	Reach	Effort	Condition (K) Factor
RBT	81		40	44.86	0.00
RBT	84		40	60.13	0.00
RBT	89		40	44.86	0.00
RBT	90		40	60.13	0.00
RBT	92		40	60.13	0.00
RBT	94		40	60.13	0.00
RBT	95		40	44.86	0.00
RBT	100		40	60.13	0.00
RBT	101		40	44.86	0.00
RBT	104		40	60.13	0.00
RBT	105		40	60.13	0.00
RBT	107		40	60.13	0.00
RBT	109		40	60.13	0.00
RBT	110		40	44.86	0.00
RBT	111		40	10.28	0.00
RBT	113		40	60.13	0.00
RBT	117		40	10.28	0.00
RBT	117		40	44.86	0.00
RBT	117		40	10.28	0.00
RBT	119		40	60.13	0.00
RBT	120		40	60.13	0.00
RBT	124		40	44.86	0.00
RBT	125		40	60.13	0.00
RBT	126		40	60.13	0.00
RBT	127		40	44.86	0.00
RBT	127		40	44.86	0.00
RBT	134		40	60.13	0.00
RBT	136		40	60.13	0.00
RBT	140		40	16.16	0.00
RBT	146		40	10.28	0.00
RBT	148		40	10.28	0.00
RBT	150		40	60.13	0.00
RBT	151		40	10.28	0.00
RBT	168		40	10.28	0.00
RBT	170		40	16.16	0.00
RBT	195		40	10.28	0.00
RBT	280	202	40	60.13	0.92
RBT	284	245	40	60.13	1.07
RBT	286	264	40	44.86	1.13
RBT	288	272	40	44.86	1.14
RBT	290	258	40	60.13	1.06
RBT	290	235	40	60.13	0.96
RBT	296	266	40	60.13	1.03
RBT	298	277	40	44.86	1.05
RBT	302	261	40	44.86	0.95
RBT	308	290	40	16.16	0.99
RBT	310	306	40	60.13	1.03
RBT	310	270	40	60.13	0.91
RBT	311	292	40	60.13	0.97
RBT	316	326	40	10.28	1.03
RBT	319	288	40	60.13	0.89
RBT	320	370	40	10.28	1.13

Table 1.4A

Species	Length	Weight	Reach	Effort			Condition (K) Factor
RBT	321	305	40	60.13			0.92
RBT	323	350	40	60.13			1.04
RBT	325	364	40	44.86			1.06
RBT	327	392	40	44.86			1.12
RBT	331	362	40	60.13			1.00
RBT	332	379	40	44.86			1.04
RBT	333	390	40	60.13			1.06
RBT	334	372	40	44.86			1.00
RBT	336	389	40	44.86			1.03
RBT	336	386	40	44.86			1.02
RBT	340	396	40	60.13			1.01
RBT	343	378	40	60.13			0.94
RBT	345	410	40	60.13			1.00
RBT	345	402	40	60.13			0.98
RBT	347	400	40	60.13			0.96
RBT	348	481	40	44.86			1.14
RBT	349	384	40	60.13			0.90
RBT	357	460	40	60.13			1.01
RBT	357	458	40	44.86			1.01
RBT	360	422	40	60.13			0.90
RBT	361	394	40	60.13			0.84
RBT	363	456	40	60.13			0.95
RBT	373	500	40	60.13			0.96
RBT	373	484	40	60.13			0.93
RBT	376	442	40	60.13			0.83
RBT	408	642	40	60.13			0.95
RBT	410	540	40	60.13	RBT MEAN	235.48	0.78
HBC			40	60.13	SD	108.91	ERR
CRP	172	98	40	10.28			1.93
CRP	200	130	40	10.28			1.63
CRP	344	805	40	44.86			1.98
CRP	382	820	40	10.28			1.47
CRP	404	750	40	10.28			1.14
CRP	405	985	40	60.13			1.48
CRP	411	910	40	10.28			1.31
CRP	423		40	44.86			0.00
CRP	445	1180	40	60.13			1.34
CRP	446	1220	40	60.13			1.38
CRP	449	1220	40	60.13			1.35
CRP	451	1230	40	16.16			1.34
CRP	456	1120	40	60.13			1.18
CRP	458	1000	40	16.16			1.04
CRP	468	1510	40	60.13			1.47
CRP	474	1460	40	60.13			1.37
CRP	483	1640	40	60.13			1.46
CRP	488	1380	40	16.16			1.19
CRP	498	1420	40	44.86			1.15
CRP	501	1760	40	60.13			1.40
CRP	502	1430	40	10.28			1.13
CRP	503	2040	40	60.13			1.60
CRP	523	2160	40	60.13			1.51
CRP	561	2460	40	16.16	CRP MEAN	429.83	1.39
BRT	288	200	40	60.13	SD	86.48	0.84
BRT	306	264	40	44.86			0.92
BRT	316	320	40	60.13	BRT MEAN	316	1.01
BHS	166	40	40	16.16	SD	0	0.87
[illegible]	—	—	NO	60.13	BHS MEAN	166	
					SD	0	

Table 1.5

GRAND CANYON - AUGUST 1985

Species	Length	Weight	Reach	Effort		Condition (K)Factor
SD	91	6	50	49	SD	0.80
SD	108	10	50	49	MEAN	0.79
RBT	102	11	50	38	99.50	1.04
RBT	117	12	50	38	STANDARD DEV.	0.75
RBT	227	114	50	49	8.50	0.97
RBT	236	112	50	49		0.85
RBT	239	136	50	38		1.00
RBT	249	142	50	49		0.92
RBT	261	162	50	49		0.91
RBT	310	276	50	49		0.93
RBT	314	284	50	49		0.92
RBT	316	272	50	49	RBT	0.86
RBT	325	222	50	49	MEAN	0.65
RBT	326	275	50	49	263.50	0.79
RBT	333	324	50	49	STANDARD DEV.	0.88
RBT	334	340	50	38	73.39	0.91
CRP	86	5	50	38		0.79
CRP	109	20	50	38		1.54
CRP	371	580	50	38		1.14
CRP	378	900	50	38		1.67
CRP	384	850	50	38		1.50
CRP	412	940	50	38		1.34
CRP	421	955	50	38		1.28
CRP	469	1220	50	38	CRP	1.18
CRP	481	1380	50	38	MEAN	1.24
CRP	485	1440	50	38	389.08	1.26
CRP	529	2010	50	38	STANDARD DEV.	1.36
CRP	544	2010	50	38	141.40	1.25
BHS	228	118	50	49		1.00
BHS	228	100	50	49		0.84
BHS	230	90	50	49		0.74
BHS	275	150	50	49	BHS	0.72
BHS	303	294	50	49	MEAN	1.06
					252.80	
					STANDARD DEV.	
					30.86	

Table 1.5A

Species	Length	Weight	Reach	Effort		Condition (K) Factor
SD	77		50	36.12		0.00
SD	81		50	25.75		0.00
SD	103	123	50	36.12	SD MEAN 87	11.26
RBT	66		50	54.38	SD 11.43	0.00
RBT	90		50	54.38		0.00
RBT	104		50	54.38		0.00
RBT	108		50	54.38		0.00
RBT	115		50	54.38		0.00
RBT	115		50	54.38		0.00
RBT	123		50	36.12		0.00
RBT	132		50	54.38		0.00
RBT	139		50	54.38		0.00
RBT	142		50	54.38		0.00
RBT	145	36	50	54.38		1.18
RBT	151		50	54.38		0.00
RBT	160		50	54.38		0.00
RBT	181	48	50	36.12		0.81
RBT	184	60	50	54.38		0.96
RBT	224	108	50	36.12		0.96
RBT	284	216	50	54.38		0.94
RBT	285	190	50	36.12		0.82
RBT	292	230	50	54.38		0.92
RBT	303	228	50	54.38		0.82
RBT	303	236	50	36.12		0.88
RBT	320	310	50	54.38		0.95
RBT	325	320	50	36.12		0.93
RBT	335	362	50	54.38		0.96
RBT	337	392	50	54.38	RBT MEAN 198.52	1.02
HBC	311	300	50	25.75	SD 89.21	1.00
FMS	373	730	50	25.75	FMS MEAN 373	1.41
FHM	50		50	36.12	SD 0	0.80
CRP	307	374	50	36.12	FHM MEAN 50	1.29
CRP	315	404	50	36.12	SD 0	1.29
CRP	317	382	50	36.12		1.20
CRP	337	600	50	36.12		1.57
CRP	357	550	50	36.12		1.21
CRP	358	818	50	25.75		1.78
CRP	365	578	50	36.12		1.19
CRP	376	774	50	25.75		1.46
CRP	379	828	50	25.75		1.52
CRP	383	940	50	25.75		1.67
CRP	397	730	50	36.12		1.17
CRP	400	740	50	36.12		1.16
CRP	422	862	50	25.75		1.15
CRP	430	996	50	36.12		1.25
CRP	431	1000	50	36.12		1.25
CRP	446	1050	50	36.12		1.18
CRP	449	1020	50	36.12		1.13
CRP	461	1220	50	25.75		1.25
CRP	463	1350	50	25.75	CRP MEAN 401.09	1.36
CRP	472	1490	50	25.75	54.46	1.42
CRP	482	1200	50	25.75		1.07
CC	200	80	50	54.38		1.00
CC	295	210	50	36.12	CC MEAN 247.5	0.82
BHS	305	276	50	25.75	SD 47.5	0.97

TABLE 3: TOTAL PERCENTAGE OF RAINBOW TROUT BY REACH 1984, 1985*

	REACH 20		REACH 30		REACH 40		REACH 50		TOTAL	TOTAL
	#	%	#	%	#	%	#	%	#	%
1984	72	37.9%	14	7.4%	79	41.6%	25	13.2%	190	100
1985	190	38.7%	41	8.4%	246	50.1%	14	2.9%	491	100

*1985 R10 data was not included to make comparison to 1984 data possible

TABLE 4: TOTAL PERCENTAGE OF CARP BY REACH 1984, 1985

	REACH 20		REACH 30		REACH 40		REACH 50		TOTAL	TOTAL
	#	%	#	%	#	%	#	%	#	%
1984	3	5.0%	11	18.3%	~~22~~ 24	40.0%	22	36.7%	~~58~~ 60	100
1985	3	4.9%	4	6.6%	42	68.9%	12	19.7%	61	100

Table 5. K-Factors by Length Increment for Rainbow Trout 1984-1985 Reaches 10-50 Colorado River, Grand Canyon

	1984 RBT K-Factor	#	%	1985 RBT K-Factor	#	%
50						
0-50		0			0	
51-100		2			0	
101-150	1.18	9	36.00%	0.90	2	14.29%
151-200	0.89	4	16.00%		0	
201-250	0.96	1	4.00%	0.94	4	28.57%
251-300	0.91	3	12.00%	0.91	1	7.14%
301-350	0.92	6	24.00%	0.85	7	50.00%
351-400		0			0	
401-450		0			0	
451-500		0			0	
501-550		0			0	
551-600		0			0	
		25			14	
40						
0-50		0			0	
51-100		8	10.13%	0.81	2	0.81%
101-150		24	30.38%	1.08	6	2.44%
151-200		4	5.06%	1.03	9	3.66%
201-250		0		1.05	150	60.98%
251-300	1.04	8	10.13%	0.90	22	8.94%
301-350	1.00	25	31.65%	0.78	50	20.33%
351-400	0.93	8	10.13%	0.69	6	2.44%
401-450	0.87	2	2.53%	0.74	1	0.41%
451-500		0			0	-
501-550		0			0	
551-600		0			0	
		79			246	
30						
0-50		0			0	
51-100		2	14.29%		0	
101-150		2	14.29%	1.42	1	2.44%
151-200		2	14.29%		0	
201-250		0		0.99	2	4.88%
251-300		0		1.00	14	34.15%
301-350	0.99	3	21.43%	0.93	11	26.83%
351-400	1.01	4	28.57%	0.97	9	21.95%
401-450	1.06	1	7.14%	1.31	3	7.32%
451-500		0			0	
501-550		0		0.80	1	2.44%
551-600		0			0	
		14			41	
20						
0-50		0			0	
51-100		4	5.56%	1.44	5	2.63%
101-150		4		1.14	32	16.84%
151-200		0	5.56%	1.14	2	1.05%
201-250		0	1.39%		0	
251-300	1.36	2	1.39%	1.02	13	6.84%
301-350	1.12	27	37.50%	1.02	63	33.16%
351-400	1.07	23	31.94%	1.06	33	17.37%
401-450	1.15	3	4.17%	1.64	26	13.68%
451-500	1.17	5	6.94%	0.98	9	4.74%
501-550	1.05	3	4.17%	0.83	7	3.68%
551-600	0.62	1	1.39%		0	
		72			190	
10						
0-50					0	
51-100				1.18	26	9.09%
101-150				1.09	17	5.94%
151-200				1.07	6	2.10%
201-250				1.11	3	1.05%
251-300				1.11	69	24.13%
301-350				1.08	88	30.77%
351-400				1.11	33	11.54%
401-450				1.04	21	7.34%
451-500				1.05	17	5.94%
501-550				1.02	4	1.40%
551-600				0.97	2	0.70%
					286	

Table 6. K-Factors by Length Increment For Carp, 1984 And 1985 Reaches 20-50 Colorado River, Grand Canyon.

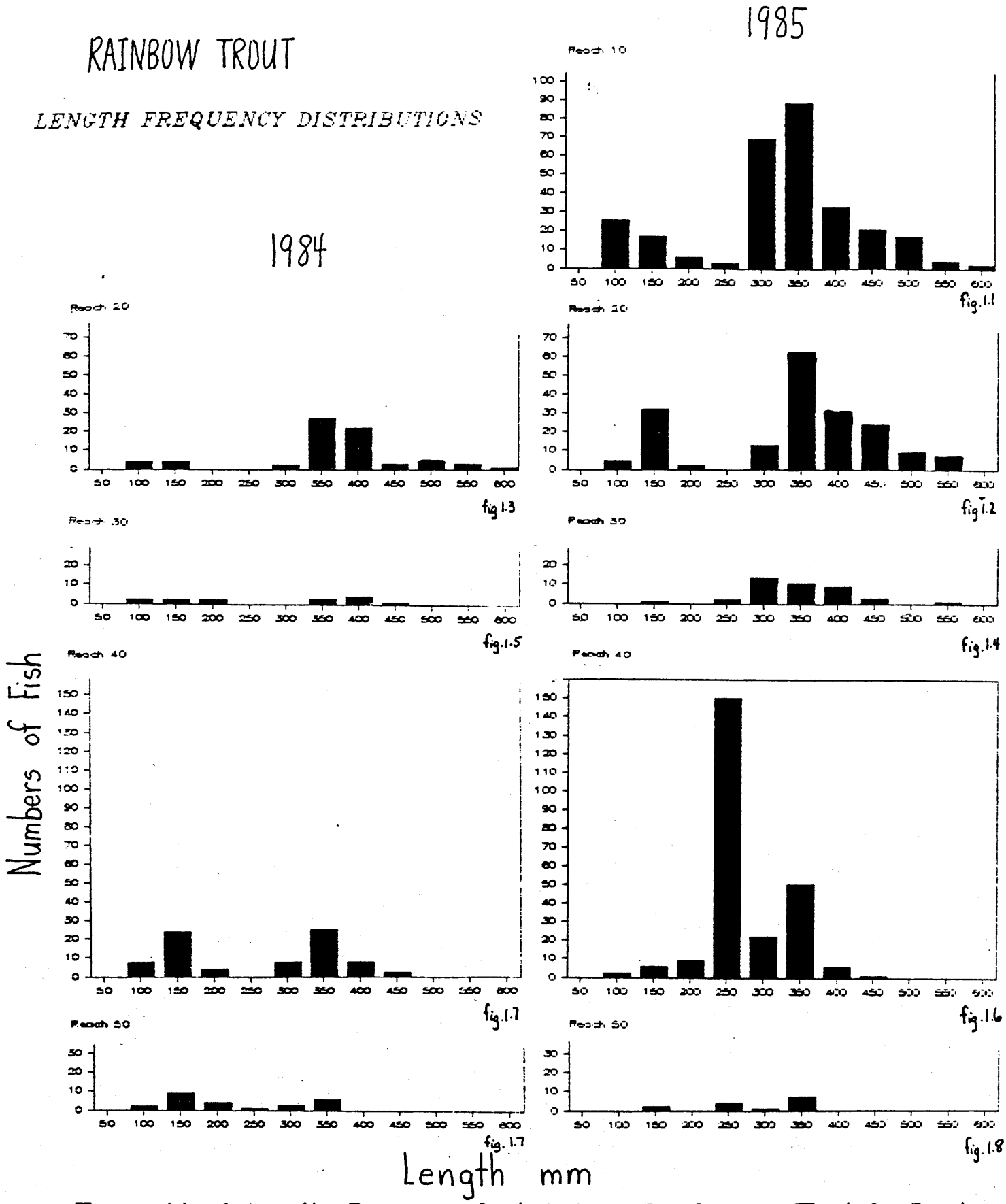
	1984 CRP K-Factor	#	%	1985 CRP K-Factor	#	%
R 50						
0-50		0			0	
51-100		0		0.79	1	8.33%
101-150		0		1.54	1	8.33%
151-200		0			0	
201-250		0			0	
251-300		0			0	
301-350	1.34	4	18.18%		0	
351-400	1.40	8	36.36%	1.44	3	25.00%
401-450	1.19	5	22.73%	1.31	2	16.67%
451-500	1.24	5	22.73%	1.23	3	25.00%
501-550		0		1.31	2	16.67%
551-600		0			0	
		22			12	
R 40						
0-50		0			0	
51-100		0		1.73	1	2.38%
101-150		0	4.17%		0	
151-200	1.78	2	4.17%	1.56	1	2.38%
201-250		0			0	
251-300		0			0	
301-350	1.98	1	4.17%	1.61	1	2.38%
351-400	1.47	1	4.17%	1.28	3	7.14%
401-450	1.33	7	29.17%	1.27	17	40.48%
451-500	1.28	8	33.33%	1.21	16	38.10%
501-550	1.41	4	16.67%	1.36	3	7.14%
551-600	1.39	1	4.17%		0	
		24			42	
R 30						
0-50		0			0	
51-100		0			0	
101-150		0			0	
151-200		1	9.09%	1.83	2	50.00%
201-250		0			0	
251-300		0			0	
301-350	1.26	1	9.09%		0	
351-400	2.10	2	18.18%		0	
401-450	1.63	1	9.09%	1.62	1	25.00%
451-500	1.54	3	27.27%	1.47	1	25.00%
501-550	1.66	2	18.18%		0	
551-600	1.45	1	9.09%		0	
		11			4	
R 20						
0-50		0			0	
51-100		0			0	
101-150		0			0	
151-200		0			0	
201-250		0			0	
251-300		0			0	
301-350		0			0	
351-400		0		1.59	1	33.33%
401-450	1.57	1	33.33%		0	
451-500	1.49	1	33.33%	1.72	2	66.67%
501-550	1.30	1	33.33%		0	
551-600		0			0	
		3			3	

TABLE 7. Mean And Standard Deviation For All Electrofishing Captures, 1984 And 1985. Colorado River, Grand Canyon.

	1985 Reach	1984 Reach	1985 Reach	1984 Reach	1985 Reach	1984 Reach	1985 Reach	1984 Reach	1985 Reach
	10	20	20	30	30	40	40	50	50
rbt MEAN	302.67	339.89	316.53	261.64	318.07	235.48	249.62	198.52	263.50
STANDARD DEV.	108.04	105.34	114.49	125.51	67.10	108.91	55.59	89.21	73.39
crp MEAN		471.33	452.67	433.73	327.25	429.83	432.38	401.09	389.08
STANDARD DEV.		50.73	44.78	115.10	131.38	86.48	80.40	54.46	141.40
fms MEAN	486.55	446.00	431.6	482.00			350	373.00	
STANDARD DEV.	24.13	18.02	45.5	0.00			0	0.00	
bhs MEAN	353		330			166.00	188.00	305.00	252.80
STANDARD DEV.	0		0			0.00	34.79	0.00	30.86
hbc MEAN		211.00	186	124.78	182.75			311.00	
STANDARD DEV.		79.09	0	92.90	12.19			0.00	
sd MEAN			108				89.5	87.00	99.5
STANDARD DEV.			0				19.1	11.43	8.50
brt MEAN				479.00	390	303.33	266.5		
STANDARD DEV.				0.00	0	11.59	49.5		
bkt MEAN	348.67	440.00			283.3				
STANDARD DEV.	18.37	4.00			49.66				
lmb MEAN	181.5								
STANDARD DEV.	59.5								
ctt MEAN	396								
STANDARD DEV.	0								
cc MEAN								247.50	
STANDARD DEV.								47.57	
fhm MEAN				52.5				50.00	
STANDARD DEV.				7.27				0	

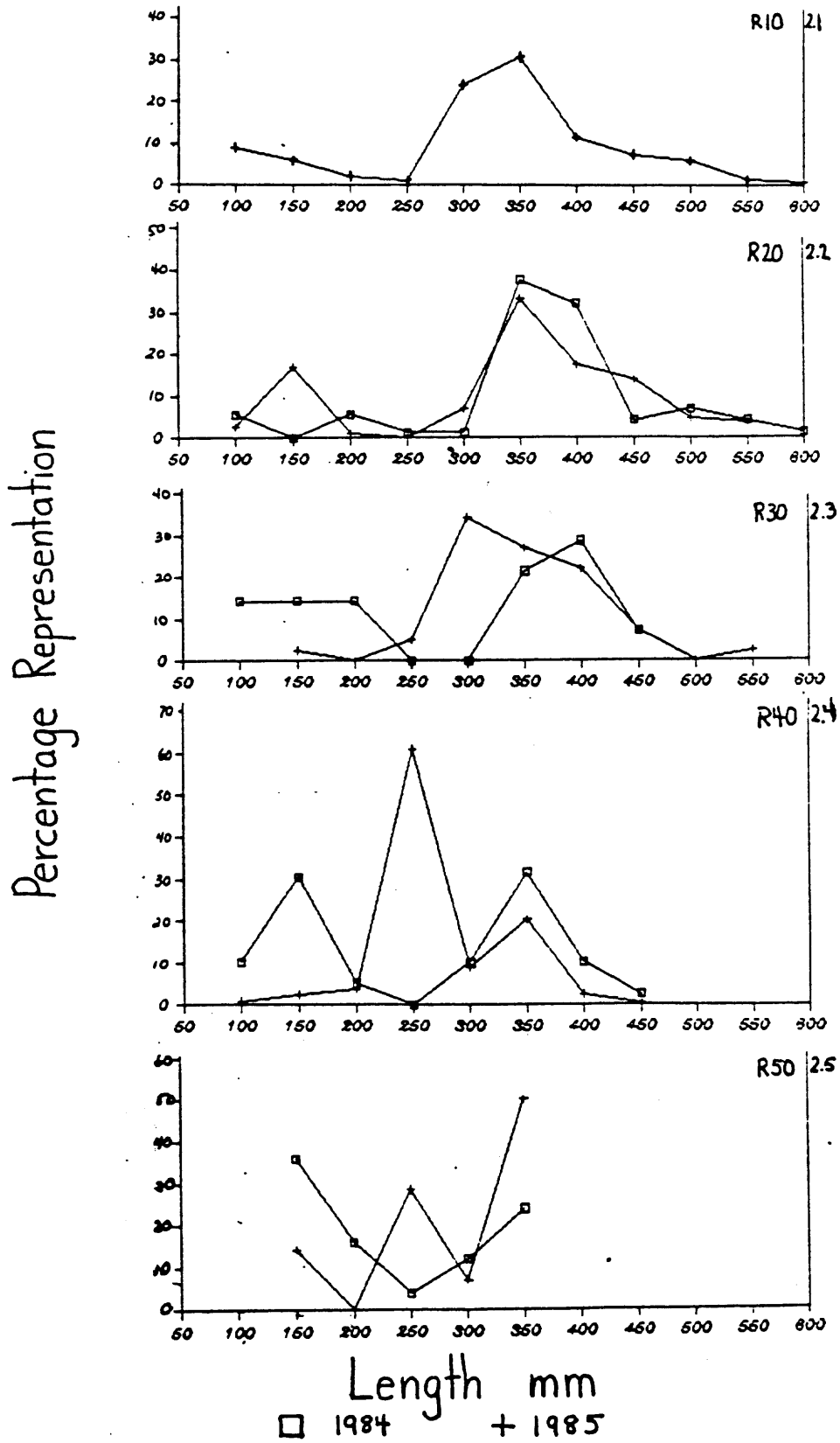
RAINBOW TROUT

LENGTH FREQUENCY DISTRIBUTIONS



Figures 1.1-1.9 Length Frequency Distributions For Rainbow Trout By Reach, Colorado River, Grand Canyon 1984-1985.

RAINBOW TROUT

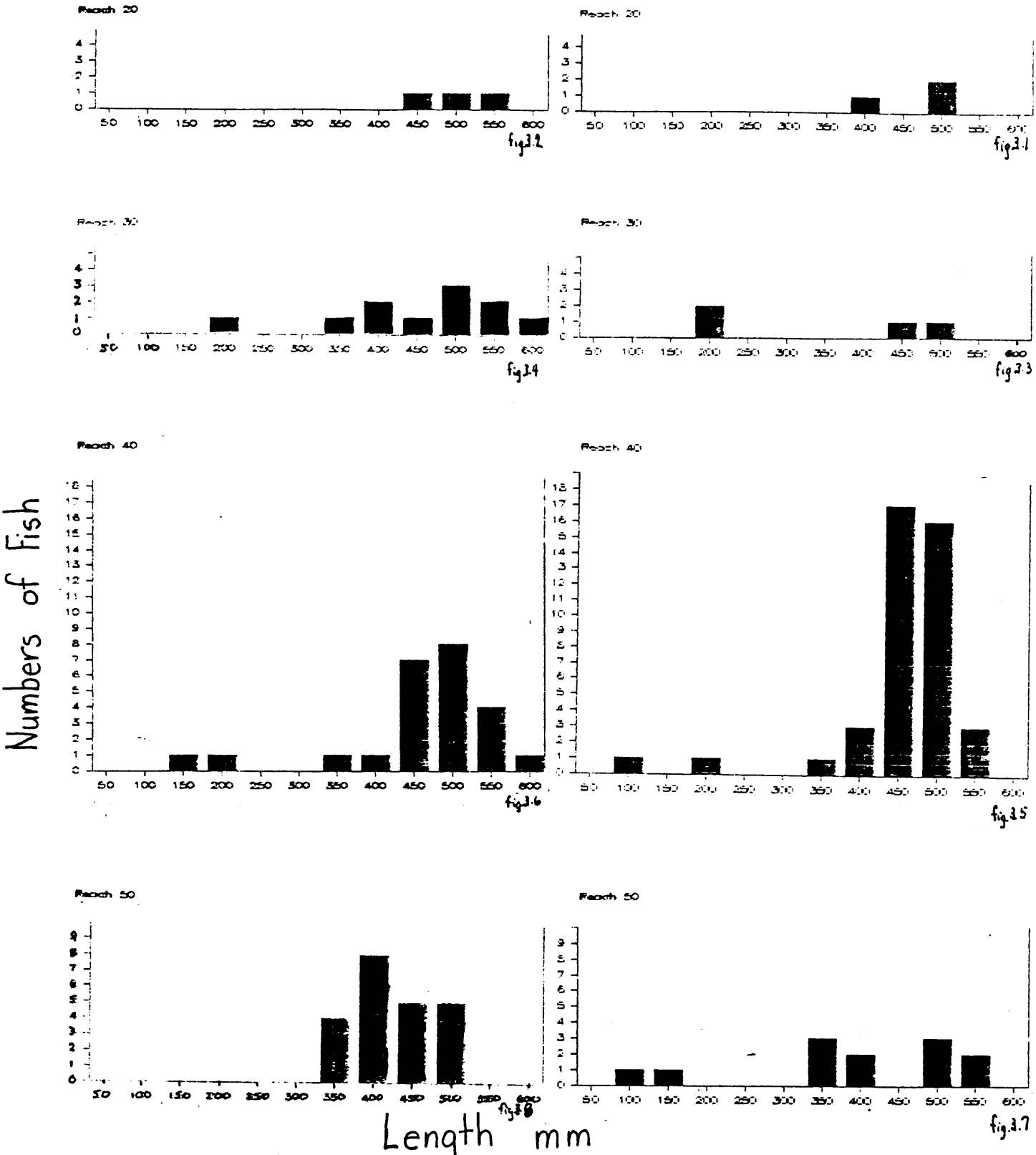


Figures 2.1-2.5 Distribution Percentages for Rainbow Trout by Reach, 1984 vs. 1985 Colorado River, Grand Canyon.

CARP

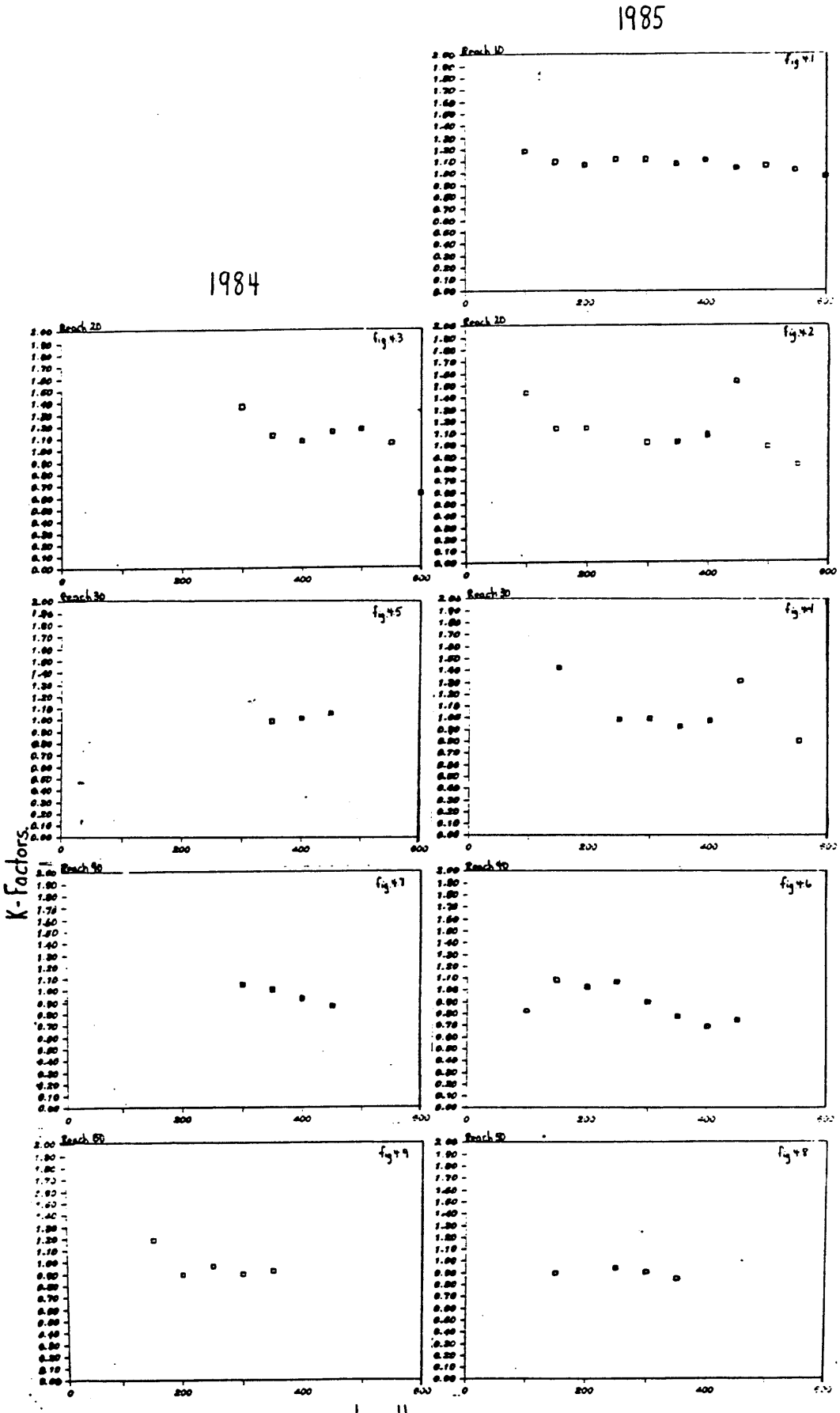
LENGTH FREQUENCY DISTRIBUTIONS

1984 1985



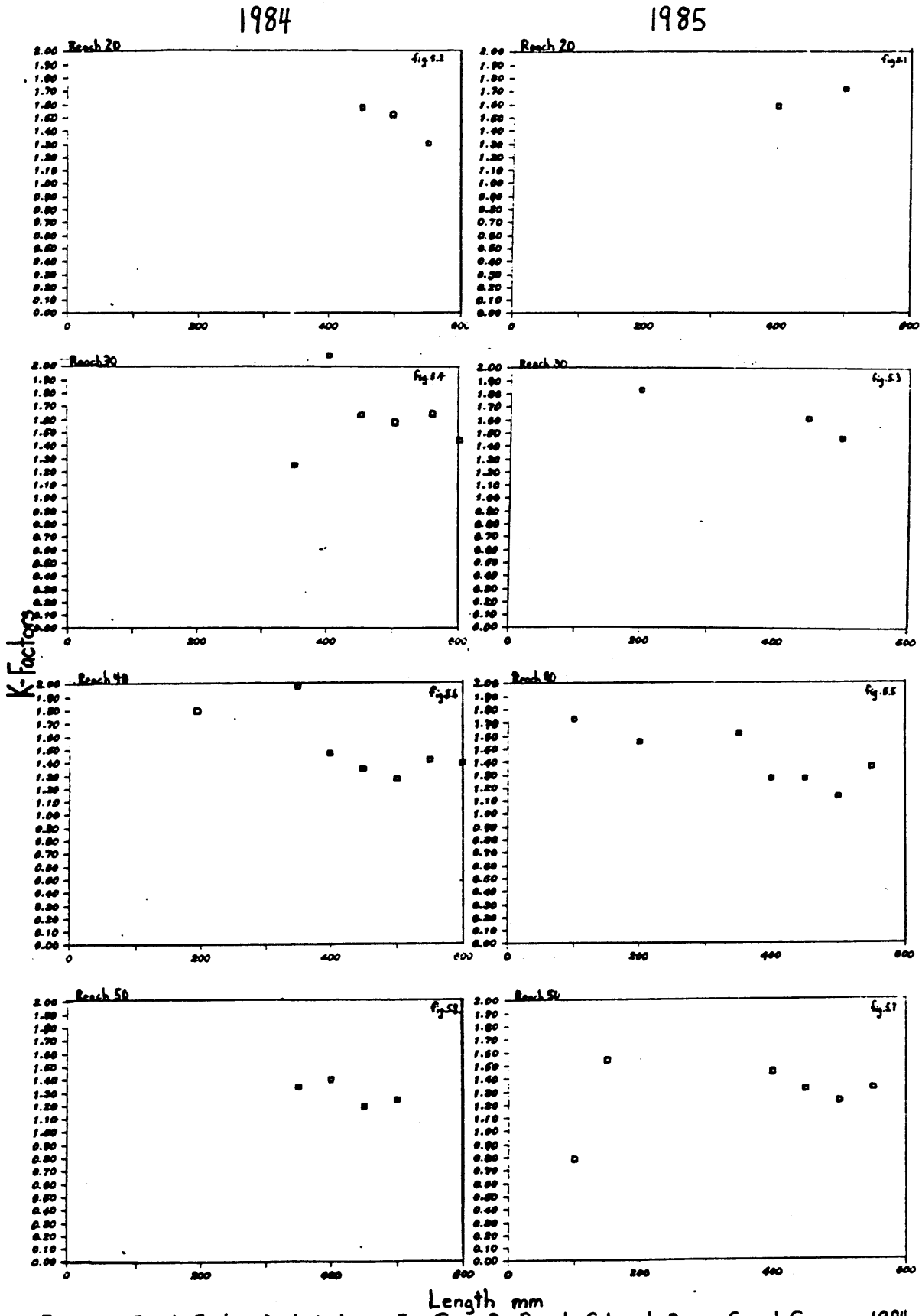
Figures 3.1-3.8 Length Frequency Distributions For Carp By Reach. Colorado River, Grand Canyon 1984-1985.

K-Factor Distributions For Rainbow Trout



Figures 4.1-4.9 K-factor Distributions for Rainbow Trout By Reach, Colorado River, Grand Canyon 1984-1985.

K-Factor Distributions For Carp



Figures 5.1-5.9 K-Factor Distributions For Carp By Reach, Colorado River, Grand Canyon 1984-1985.

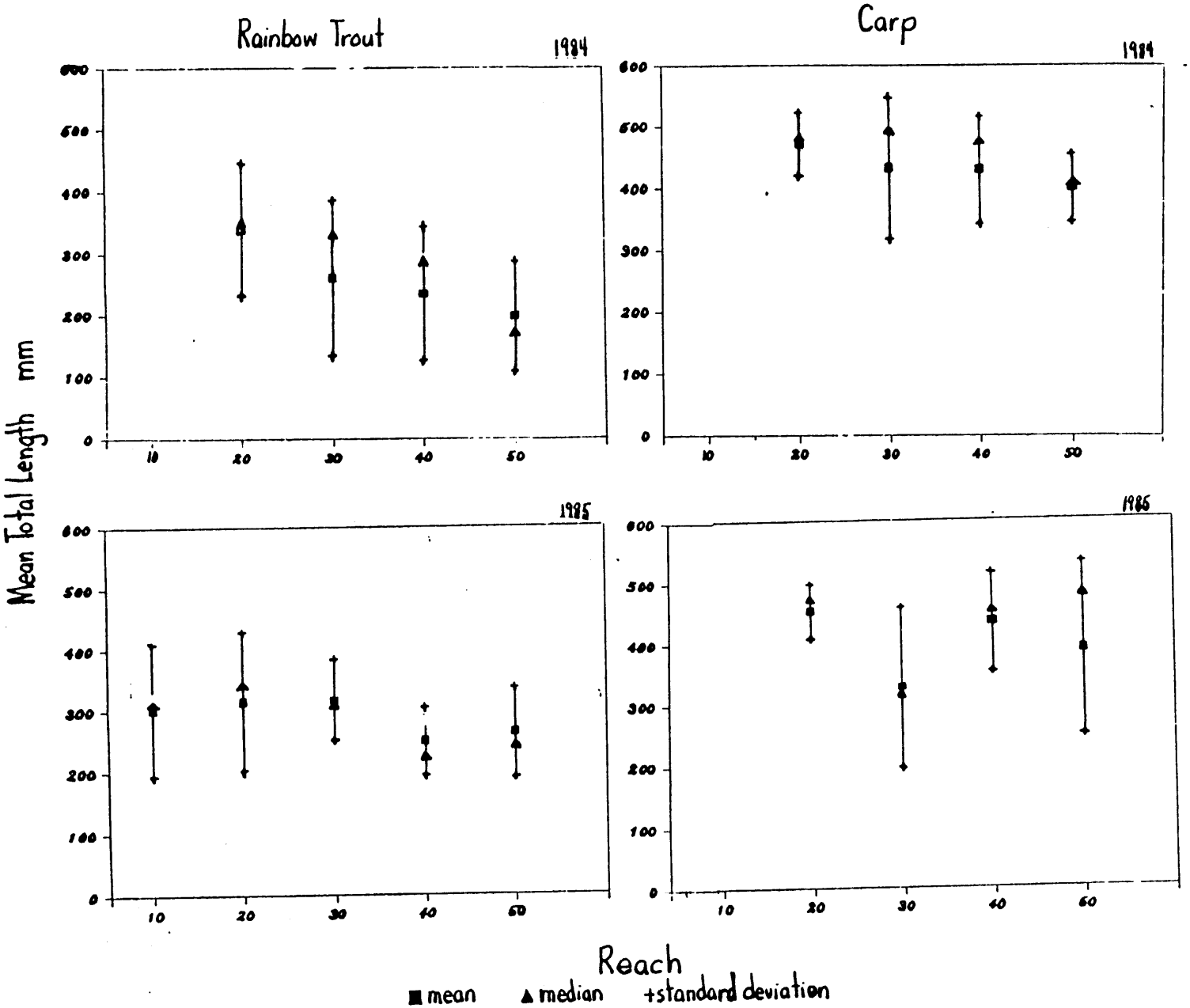


Fig. 6.1-6.2 & 7.1-7.2 Mean, Median And Standard Deviation of Rainbow Trout And Carp By Reach, Colorado River, Grand Canyon 1984-1985.

APPENDICES

Appendix 1. Species Abbreviations

RBT	rainbow trout	BKT	brook trout
CRP	carp	BRT	brown trout
HBC	humpback chub	CTT	cutthroat trout
FMS	flannelmouth sucker	LMB	largemouth bass
BHS	bluehead sucker	SD	speckled dace

Appendix 2. Reach Designations

Reach 10	Dam to Lee's Ferry
Reach 20	Lee's Ferry to the Little Colorado River
Reach 30	Little Colorado River to Bright Angel
Reach 40	Bright Angel to National
Reach 50	National to Separation

CHAPTER X

AN EVALUATION OF BONE AND MUSCLE DAMAGE IN FISHES EXPOSED TO ELECTRICAL CURRENT IN THE COLORADO RIVER IN GRAND CANYON NATIONAL PARK

Norman Sharber, Tina Allen and Jack Sande

INTRODUCTION

The Arizona Game and Fish Department has been utilizing electrofishing to gather a sample population of fish from the Colorado River as part of an investigation of the long term effects of Glen Canyon Dam on the indigenous and exotic fishes of the Grand Canyon. Their objective is to collect data on the distribution and abundance of fish in the Canyon in order to gain an understanding of the effect of fluctuating flow on fish growth, food habits, and reproductive potential.

The electrofisher is a 22-foot, rubber snout catamaran rigged with a generator-powered Coffelt Variable Voltage Pulsator, Electroshocker Model VVP-15. The electroshocker, utilizing pulsed direct current, attracts fish toward an anode near the surface of the water where they are netted. After being measured, weighed, and tagged, the fish are released. Two types of pulses are used: 1/4 wave sinusoidal pulses "S" and square wave pulses "B" (Fig. X-1). Both pulses have a peak value of 260 volts, width of four milliseconds, and a frequency of 60 cps.

Researchers want to capture and release the fish without

injuring them, yet little is known about the condition of the fish after being shocked.

OBJECTIVES

This study was undertaken to evaluate the effects of this mode of electrofishing on fish (predominantly rainbow trout) shocked in the Colorado River of the Grand Canyon. It was hypothesized that, 1. large fish (over 300mm in length) subjected to electroshocking with "S" and "B" pulse types will sustain significant muscle and bone damage, and 2. the incidence of damage will vary with the type of pulse used.

Previous research has established that larger (i.e. longer) fish are substantially more susceptible to severe injury from electroshocking than are smaller fish, therefore the primary objective of this study is to determine the rate of the most severe form of injury, spinal fracture, in fish (rainbow trout) of over 300 mm. For purposes of comparison, data were also gathered on lesser injuries, such as bleeding and bruising, and on injury to smaller specimens.

METHODS

The study team accompanied the Arizona Game and Fish electrofishing researchers on a ten day data collecting trip in August, 1985. During that period, pulse types "S" and "B" were used on alternating days. Each day the electrofishers decapitated (the heads being used for another investigation) and set aside for the study team a portion of the day's catch. It was found that tissue injury was more apparent to the observer if

the fish had been dead for a period of time before examination.

In order to determine the existence and extent of damage, the following procedure was followed:

1. A well-sharpened knife or electric knife was used to make a ventral incision along the body of the fish cutting the flesh away from the spinal column.

2. Both sides of each fish were treated in this manner to facilitate examination of the spinal column.

3. A spoon or similar implement was used to scrape any remaining flesh away from the spinal column to expose the vertebrae.

4. The fish was then visually inspected for bleeding or bruising. The vertebrae were closely examined for evidence of fracture. This was accomplished by running a fingernail along the column to identify small fractures not visually evident.

5. A scale of one to four was used to measure the extent of damage visible to the eye and touch of the examiner:

   1 - No visible injury to either tissue or vertebrae.

   2 - Minor bleeding.

   3 - Major bleeding or tissue injury.

   4 - Broken vertebrae.

6. The location of any injury was recorded using the following key:

   1 - Anterior end of the fish, before the dorsal fin.

2 - Mid-section.

3 - Posterior end of the fish, after the dorsal fin.

7. The weight in grams and length in millimeters of each specimen, and the pulse used to capture the specimen, were recorded from Arizona Game and Fish data sheets.

8. Ten fish were flown out of the Canyon at the Little Colorado River, then X-rayed for possible spinal damage by professional radiologists. The specimens were subsequently dissected and examined according to the above procedure. The results of the visual examination were then compared to the X-ray results in order to test the accuracy of the field method.

RESULTS

Eighty-two (82) rainbow trout were examined on-site during the study. Of these, 45 were over 300 mm in length, and 37 were under 300 mm.

Of the 45 longer fish, those of primary interest in this study, 23 had been shocked with the "S" pulse, and 22 with the "B" pulse.

Sixteen of the 45, or 36%, showed evidence of spinal fracture. Another 11, or 24%, showed evidence of bleeding or bruising, but no fractures. Consequently, 60% of the sample exhibited some degree of injury.

For this size class (over 300mm), there was little difference between the injury rates for pulse "S" and pulse "B". Thirty-nine percent (39%) of those specimens shocked with pulse

"S" showed evidence of spinal fracture, as compared to 32% of those shocked with pulse "B". Twenty-two percent (22%) of those shocked with pulse "S" showed evidence of bleeding or bruising, as compared to 27% of those shocked with pulse "B". A total of 61% of those shocked with pulse "S" exhibited some degree of injury, as compared to 59% of those shocked with pulse "B" (see Table X-1).

Of the 37 shorter fish, those under 300mm in length, 28 had been shocked with the "S" pulse, and nine with the "B" pulse.

Six of the 37, or 16%, showed evidence of spinal fracture, and another 12, or 32%, showed evidence of bleeding or bruising. Consequently, a total of 48% exhibited some degree of injury.

Unlike the data for the larger fish, there was a significant difference between injury rates for pulse "S" and pulse "B" among the smaller fish. Twenty-one percent (21%) of those shocked with pulse "S" showed evidence of spinal fracture, as compared to 0% of those shocked with pulse "B". Eighteen percent (18%) of those shocked with pulse "S" showed evidence of bleeding or bruising, as compared to 78% of those shocked with pulse "B". A total of 39% of those shocked with pulse "S" exhibited some degree of injury, versus 78% of those shocked with pulse "B" (see Table X-2).

Although it was not of central importance to the study, record was kept of the location of spinal fractures in the fish. Twenty-two fish appeared to have fractured vertebrae. One fish showed breaks in two locations, so there was a total of 23 fractures. Over half, or 52%, of the breaks occurred in the

midsection of the fish, 22% occurred in the anterior end, and 26% occurred in the posterior end. All of the posterior breaks appeared in fish over 300 mm, and amounted to 35% of the fractures in that size category.

The ten fish that were X-rayed showed an 80% rate of severe injury (compression fractures of the vertebrae). Most damage occurred in the posterior one-third of the fish. Radiologists found one break that had not been detected in the visual examination.

CONCLUSIONS

Although the sample was small, over one-third, or 36%, of all fish over 300 mm in length examined in the field had suffered spinal fracture. Another 24% exhibited less severe injury. Eighty percent (80%) of the fish X-rayed showed spinal fracture. Findings do support the hypothesis that electrofishing, as practiced in the study, does cause a significant amount of tissue and bone damage to the fish shocked.

Data also indicate that there is a difference in the damage caused by "S" and "B" pulses, but only among smaller fish, and that difference may be attributable to the small sample size (nine specimens) of fish under 300 mm shocked with "B" pulse. Since the purpose of this study is to investigate the effect of electroshocking on larger fish, the apparent difference between pulse types is not of significance.

Although it is peripheral to this study, the findings strongly support previous observations that the incidence of damage increases with the size of fish. Specimens over 300 mm in

length were subject to a significantly higher rate of spinal fracture than were fish under 300 mm.

The radiographic evaluation revealed a 10% error in the visual examination. This would indicate that the field examinations are fairly reliable, but that some spinal injuries are probably missed. Spinal fractures might be on the order of 10% higher than reported.

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Table X-1. Degree of damage in fish over 300mm in length.

Pulse Type	Number	*Damage rating (No. of fish) 1	2-3	4	Damage rating (% of fish) 1	2-3	4
S	23	9	5	9	39%	22%	39%
B	22	9	6	7	41%	27%	32%
S & B	45	18	11	16	40%	24%	36%

* 1 No apparent injury
2-3 Bruising or bleeding
4 Fractured vertebrae

Table X-2. Degree of damage in fish under 300mm in length.

Pulse Type	Number	*Damage rating (No. of fish) 1	2-3	4	Damage rating (% of fish) 1	2-3	4
S	28	17	5	6	61%	18%	21%
B	9	2	7	0	22%	78%	0%
S & B	37	19	12	6	51%	32%	16%

* 1 No apparent injury
2-3 Bruising or bleeding
4 Fractured vertebrae

CHAPTER XI

ABUNDANCE AND DISTRIBUTION OF NATIVE AND DOMESTIC PLANTS ON THE COLORADO RIVER FROM LEES FERRY TO DIAMOND CREEK

Cheryl Wilke

INTRODUCTION

It was the purpose of this investigation to survey a selected group of plants along the beaches of the Colorado River from Lees Ferry to Diamond Creek. A decline in elevation of approximately 1,700 feet over this distance should result in a specific change in vegetation types. Great Basin Desert plant types invade the Canyon from the Lees Ferry end, and Sonoran and Mojave Desert plant types invade the lower reaches. All three deserts come together at the lower end of the Canyon in the Lake Mead area.

In addition to the decline in elevation from approximately 3,100 feet to approximately 1,325 feet, other factors influence the abundance and distribution of plants within the Canyon. These include the amount of moisture and available light (some plants were found on one side of the river at a particular mileage, but were absent on the other side); and the effects of air currents, temperature differences, and soil types.

Glen Canyon Dam has had a very direct effect on vegetation abundance and distribution by eliminating the seasonal high flows

that formerly scoured out riverside vegetation and brought moisture to the terrace plants. The altered flow regime has favored the proliferation of some exotic species by changing the habitats that native species had become highly adapted to.

The plants selected for the survey are representative of different desert types, and should appear at different elevations. None should occur throughout the full 225 mile length of the study area. These plants are:

Apache Plume (*Fallugia paradoxa*)

Brittlebush (*Encelia farinosa*)

Creosote (*Larrea tridentata*)

Ocotillo (*Fouquieria splendens*)

Rabbitbrush (*Chrysothamnus*)

Barrel Cactus (*Ferocactus*)

Shadscale (*Atriplex confertifolia*)

Acacia (*Acacia greggii*)

White Bursage (*Franseria dumosa*)

Grizzly Bear Cactus (*Opuntia erinacea*)

Banana Yucca (*Yucca baccata*)

Narrowleaf Yucca (*Yucca angustissima*)

Trailing Four O'Clock (*Allionia incarnata*)

Redbud (*Cercis occidentalis*)

Camelthorn (*Alhagi camelorum*)

Mesquite (*Prosopis glandulosa*)

Hackberry (*Celtis reticulata*)

Previous studies have indicated that several of these plants (Apache Plume, Brittlebush, Rabbitbrush, Redbud, Camelthorn,

Mesquite, and Hackberry) occur in various distributions in the Canyon, but not continuously. The river miles where most of the plants would be expected to be found were known before the survey began.

OBJECTIVES

The goal of the study was to compile a distribution record along the Colorado River in the Grand Canyon for each of the plants listed above.

METHODS

Twenty-three beaches, beginning at river mile 18.5 and ending at river mile 219, were surveyed for the indicated species. The recorder walked along the length of each beach parallel to the river to the end of the beach, then climbed the talus slope to the terrace above the beach and walked back along the terrace parallel to the river to the far end of the terrace, then descended to the beach at river level and walked back to the point of origin, thus completing a loop that traversed both beach and terrace environments. The recorder identified each of the plant species on the list and counted the number of individuals present.

Abundance for each beach was then calculated on a percentage basis. The percentage reported for each species is the abundance of that plant relative to the abundance of other plants being surveyed.

For convenience of reporting, a number rating was assigned to a range of percentages. They are as follows:

+ = present but very few

1 = 1%-5%

2 = 5%-25%

3 = 25%-50%

4 = 50%-75%

5 = 75%-95%

6 = 95%-100%

Two plants, shadscale and white bursage, were never found.

RESULTS

The results are reported in figures XI-1 through XI-15.

CONCLUSIONS

In general, the plants chosen for sampling were found in the areas in which they were expected to be found. The higher elevation plants were found generally at the beginning of the Canyon, some in the dry wash areas, and the lower elevation desert plants were found lower in the Canyon. A few of the plants (barrel cactus, grizzly bear cactus, camelthorn and trailing four-o'clock) were more widespread.

It was interesting to note that in some cases a particular plant would be found growing only on a certain section or area of the beach. Also interesting was the fact that some plants would be found at a particular mile, be missing for a mile or so, then reappear.

It was found that, in general, a particular species would be found at a definite distance from the water and was rarely found at a closer or further distance, regardless of the beach.

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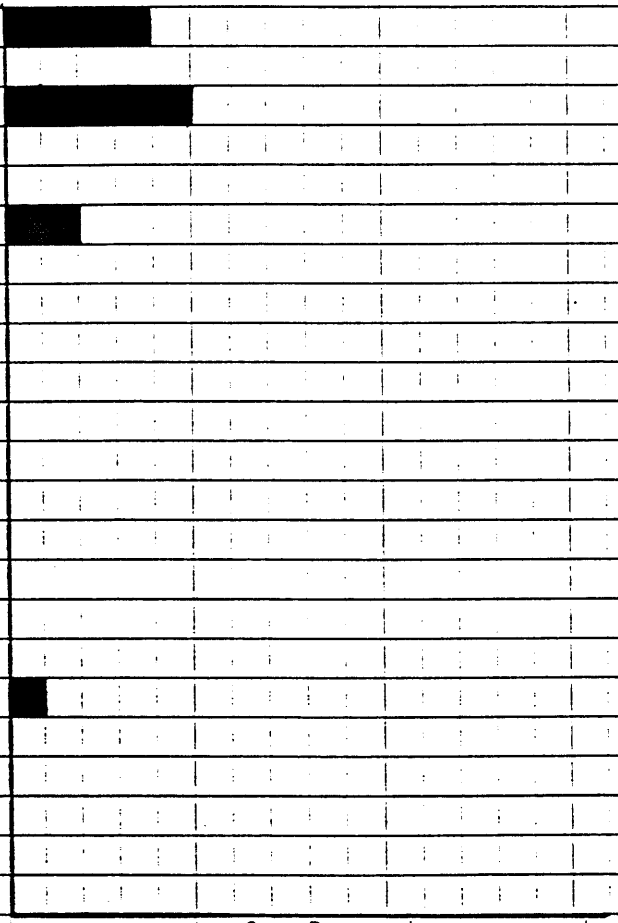
Figure XI- 1. Apache plume.

Expected elevation: higher

Expected mileage: Lees Ferry to Deer Creek

#	River Mile
12	18.2L
0	19 L
30	20 L
0	34.7L
0	53 L
10	58.1R
0	65.5L
0	75.5L
0	81.1L
0	87.5L
0	98.2R
0	108.5L
0	120.1L
0	122 L
0	136 L
0	151.6R
0	166.6L
1	180.9R
0	190.2R
0	194 R
0	198.5R
0	208.8L
0	219 R



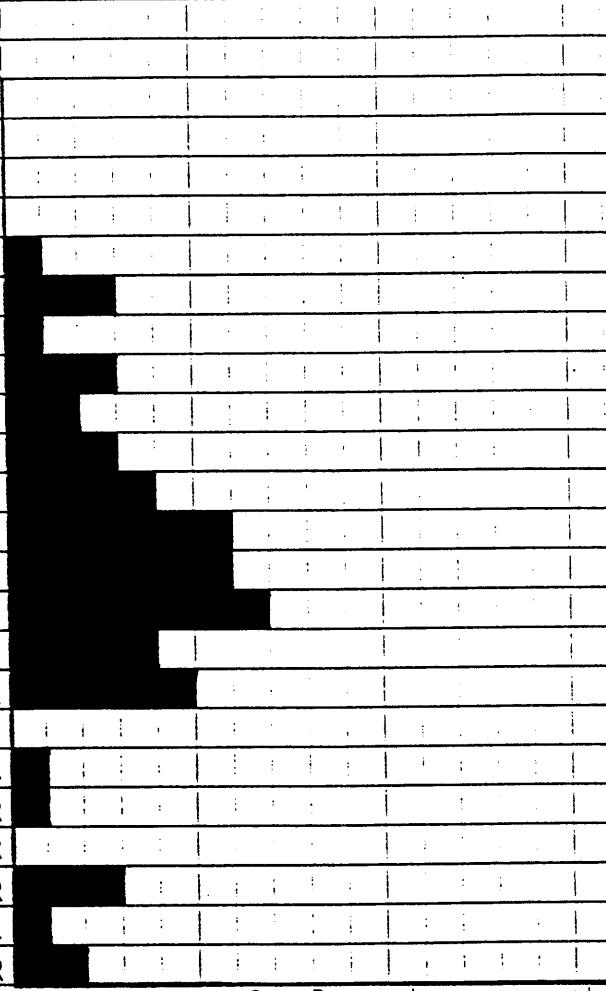
Comments: Apache plume was generally found high on the beach with the exception of one found at mile 180.9 which was very near the water (approx. 20')

Figure XI- 2. Brittlebush.

Expected elevation: 1,000-3,000

Expected mileage: 40 - 207.6

#	River Mile
0	18.2L
0	19 L
0	20 L
0	34.7L
6	53 L
30	58.1R
10	65.5L
50	75.5L
9	81.1L
8	87.5L
46	98.2R
150	108.5L
100	120.1L
300	122 L
20	136 L
100	151.6R
0	166.6L
6	180.9R
4	190.2R
0	194 R
60	198.5R
12	208.8L
12	219 R



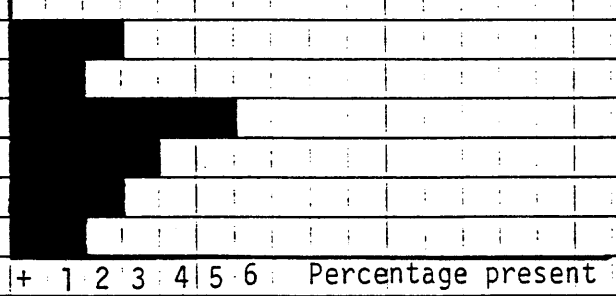
Comments: Brittlebush seemed to grow both high on the talus slopes and nearer to the beach. The plants closer to the beach seemed to be healthier.

Figure XI-3. Creosote.

Expected elevation: 1,000 - 2,500

Expected mileage: 167 on

#	River Mile
0	18.2L
0	19 L
0	20 L
0	34.7L
0	53 L
0	58.1R
0	65.5L
0	75.5L
0	81.1L
0	87.5L
0	98.2R
0	108.5L
0	120.1L
0	122 L
0	136 L
0	151.6R
0	166.6L
100	180.9R
6	190.2R
100	194 R
100	198.5R
100	208.8L
6	219 R



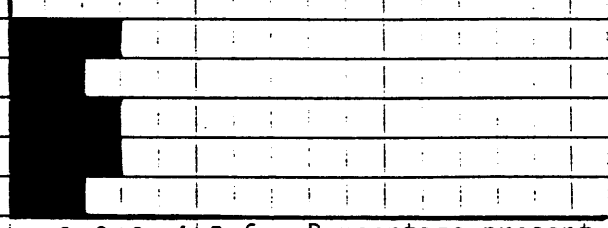
Comments: Grows relatively far from the water high up on the talus slopes.

Figure XI- 4. Ocotillo.

Expected elevation: 1,000 - 2,500

Expected mileage: 154 on

#	River Mile
0	18.2L
0	19 L
0	20 L
0	34.7L
0	53 L
0	58.1R
0	65.5L
0	75.5L
0	81.1L
0	87.5L
0	98.2R
0	108.5L
0	120.1L
0	122 L
0	136 L
0	151.6R
0	166.6L
0	180.9R
12	190.2R
10	194 R
60	198.5R
100	208.8L
6	219 R



Comments: Viewed at 180.4. Generally high on talus slope.

Figure XI- 5. Rabbitbush.

Expected elevation: higher up

Expected mileage: Lees Ferry to mile 45

#	River Mile	
22	18.2L	
24	19 L	
0	20 L	
0	34.7L	
0	53 L	
0	58.1R	
0	65.5L	
0	75.5L	
0	81.1L	
0	87.5L	
0	98.2R	
0	108.5L	
0	120.1L	
0	122 L	
0	136 L	
0	151.6R	
0	166.6L	
0	180.9R	
0	190.2R	
0	194 R	
0	198.5R	
0	208.8L	
0	219 R	

+ 1 2 3 4 5 6 Percentage present

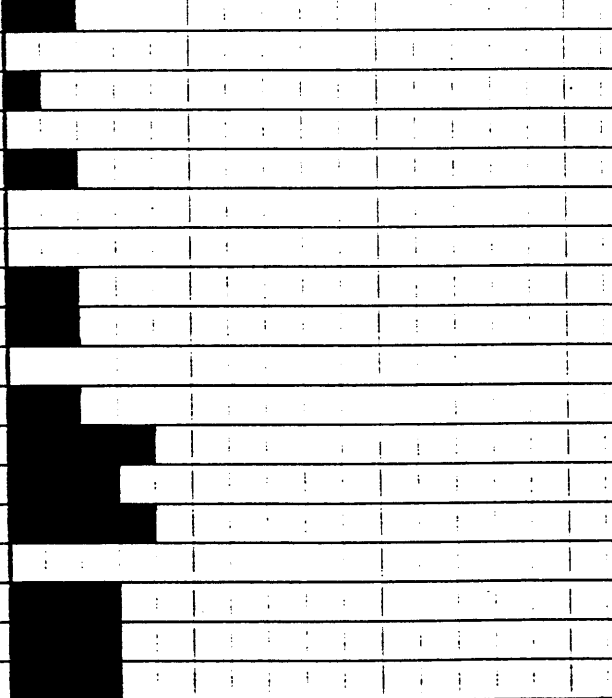
Comments: Found high on beach terraces.

Figure XI- 6. Barrel cactus.

Expected elevation: 1,000+2,500

Expected mileage: 111 to 207.6

#	River Mile
0	18.2L
0	19 L
0	20 L
0	34.7L
0	53 L
8	58.1R
0	65.5L
2	75.5L
0	81.1L
2	87.5L
0	98.2R
0	108.5L
15	120.1L
40	122 L
0	136 L
50	151.6R
20	166.6L
30	180.9R
30	190.2R
0	194 R
40	198.5R
50	208.8L
20	219 R



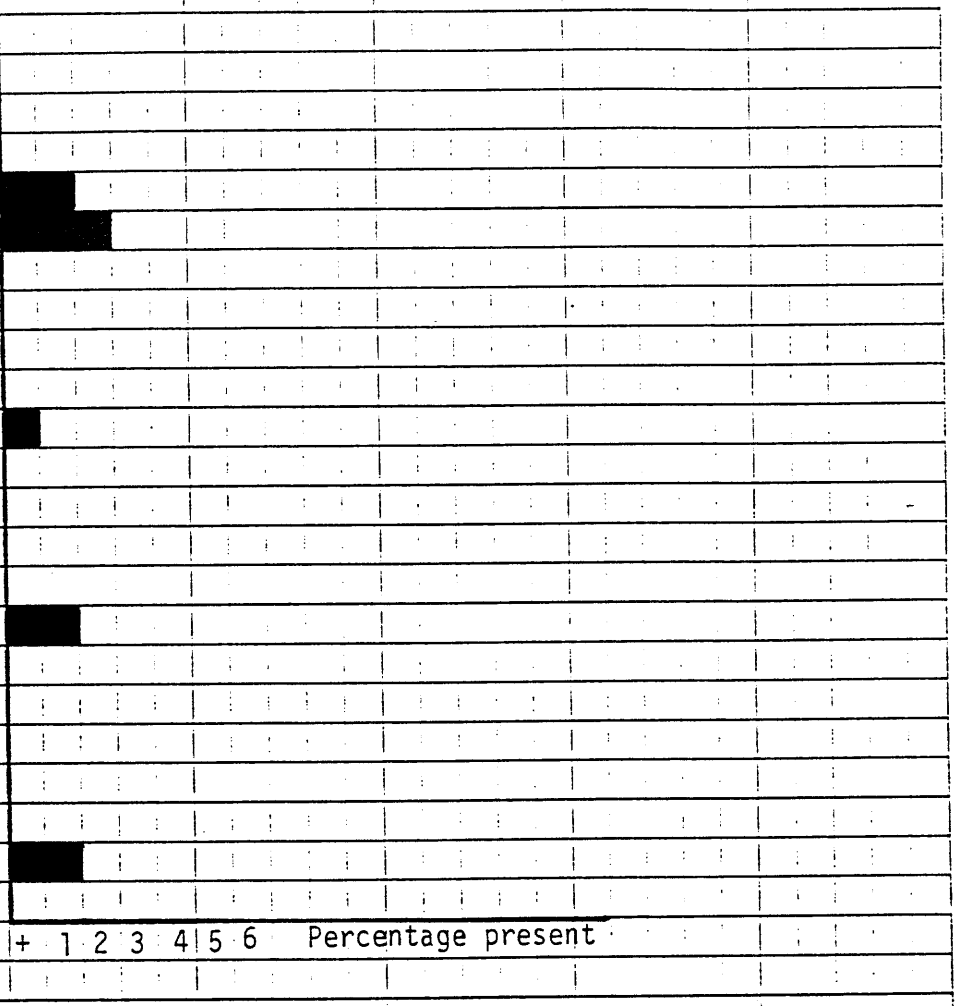
Comments: At mile 180.9, the barrel cactus were almost exclusively growing on one large granite rock, on the left side of the beach. At mile 209, they were growing in close relationship to the ocotillo.

Figure XI-7. Grizzly Bear Cactus.

Expected elevation: 2,500-4,500

Expected mileage: not available

#	River Mile
0	18.2L
0	19 L
0	20 L
0	34.7L
54	53 L
10	58.1R
0	65.5L
0	75.5L
0	81.1L
0	87.5L
1	98.2R
0	108.5L
0	120.1L
0	122 L
0	136 L
5	151.6R
0	166.6L
0	180.9R
0	190.2R
0	194 R
0	198.5R
20	208.8L
0	219 R



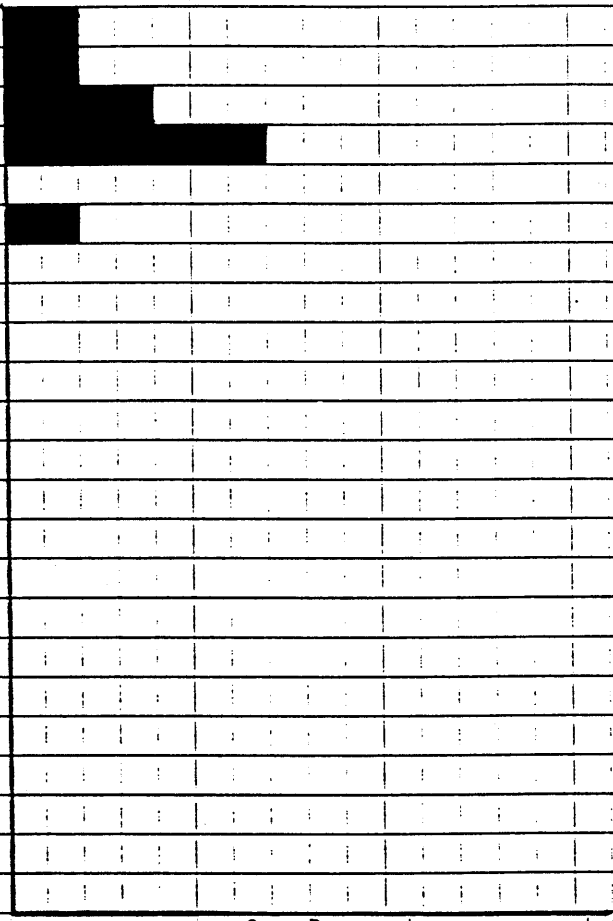
Comments: Grizzly bear was found at mile 53 growing mostly in a dry wash area.

Figure XI- 8. Banana yucca.

Expected elevation: 4,500

Expected mileage: Marble Canyon

#	River Mile
2	18.2L
10	19 L
12	20 L
20	34.7L
0	53 L
2	58.1R
0	65.5L
0	75.5L
0	81.1L
0	87.5L
0	98.2R
0	108.5L
0	120.1L
0	122 L
0	136 L
0	151.6R
0	166.6L
0	180.9R
0	190.2R
0	194 R
0	198.5R
0	208.8L
0	219 R



Comments: Banana yucca grows high on terrace and talus slopes away from the river.

Figure XI- 9. Narrowleaf.

Expected elevation: 4,500

Expected mileage: 75 - 110

#	River Mile
0	18.2L
0	19 L
0	20 L
0	34.7L
0	53 L
0	58.1R
0	65.5L
0	75.5L
3	81.1L
2	87.5L
0	98.2R
0	108.5L
0	120.1L
0	122 L
0	136 L
0	151.6R
0	166.6L
0	180.9R
0	190.2R
0	194 R
0	198.5R
0	208.8L
0	219 R

+ 1 2 3 4 5 6 Percentage present

Comments: Narrowleaf yucca was found high on the talus slope or higher. At mile 120.1, it was on the south side of the river only.

Figure XI-10. Trailing 4 o'clock

Expected elevation: 2,500-4,500

Expected mileage: 75 - 110

#	River Mile
0	18.2L
0	19 L
0	20 L
0	34.7L
0	53 L
0	58.1R
0	65.5L
36	75.5L
0	81.1L
0	87.5L
50	98.2R
0	108.5L
0	120.1L
0	122 L
0	136 L
0	151.6R
0	166.6L
0	180.9R
0	190.2R
0	194 R
0	198.5R
20	208.8L
0	219 R

+ 1 2 3 4 5 6 Percentage present

Comments: At mile 75.5, trailing 4 o'clock was found at the north end of the beach only. It generally grew at the old high water line, near the terrace - talus boundry.

Figure XI- 11. Redbud.

Expected elevation: 4,500

Expected mileage: 20 - 53

#	River Mile
0	18.2L
22	19 L
0	20 L
1	34.7L
0	53 L
26	58.1R
0	65.5L
0	75.5L
0	81.1L
0	87.5L
0	98.2R
0	108.5L
0	120.1L
0	122 L
0	136 L
0	151.6R
0	166.6L
0	180.9R
0	190.2R
0	194 R
0	198.5R
0	208.8L
0	219 R

+ 1 2 3 4 5 6 Percentage present

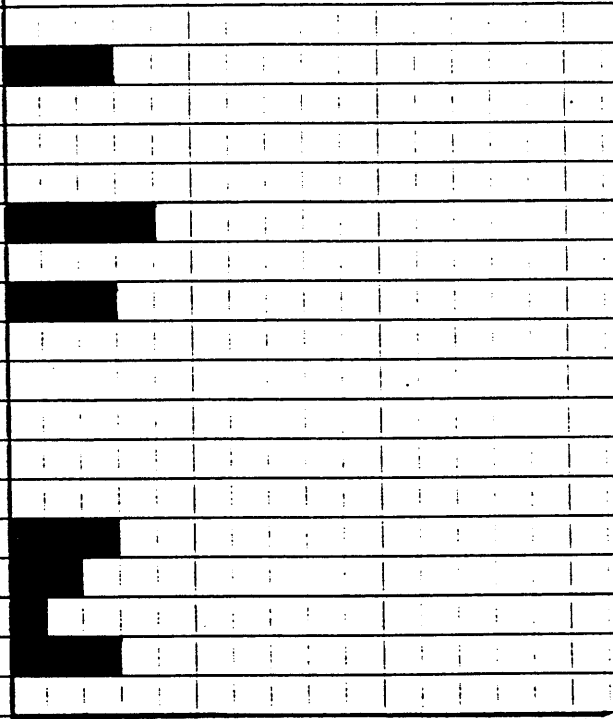
Comments: Redbud was found high in the side canyons where water was more accessible during rainy periods.

Figure XI- 12. Camelthorn.

Expected elevation: 2,500-4,500

Expected mileage: 62 - 167.5

#	River Mile
0	18.2L
0	19 L
0	20 L
0	34.7L
0	53 L
0	58.1R
60	65.5L
0	75.5L
0	81.1L
0	87.5L
50	98.2R
0	108.5L
20	120.1L
0	122 L
0	136 L
0	151.6R
0	166.6L
0	180.9R
7	190.2R
5	194 R
1	198.5R
200	208.8L
0	219 R



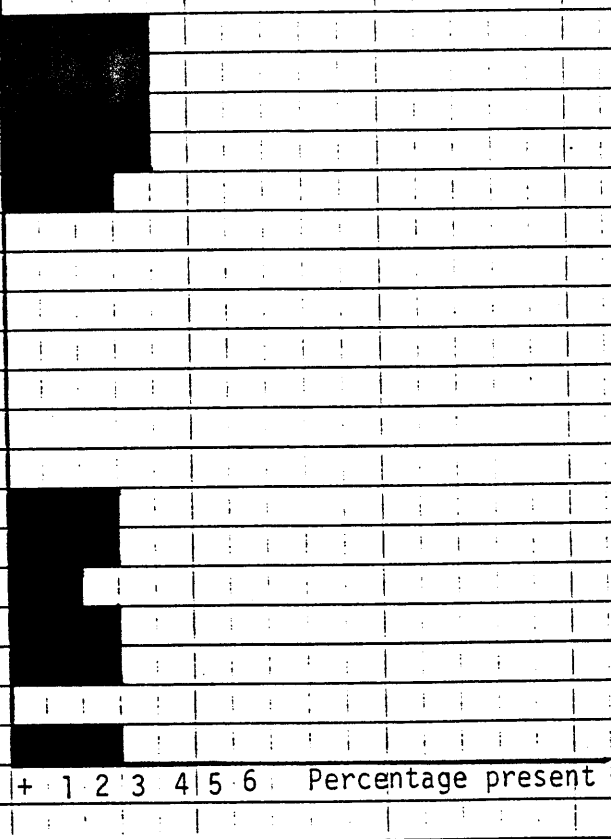
Comments: Camelthorn grew generally near the beach, about 20-30 yards from the river. At mile 120.1 it grew only on the west side of the beach. At mile 209 it grew only on the left side of the beach.

Figure XI- 13. Mesquite.

Expected elevation: 1,000-2,500

Expected mileage: 40 -280

#	River Mile
0	18.2L
0	19 L
0	20 L
0	34.7L
100	53 L
40	58.1R
100	65.5L
60	75.5L
6	81.1L
0	87.5L
0	98.2R
0	108.5L
0	120.1L
0	122 L
0	136 L
0	151.6R
7	166.6L
40	180.9R
3	190.2R
20	194 R
30	198.5R
0	208.8L
10	219 R



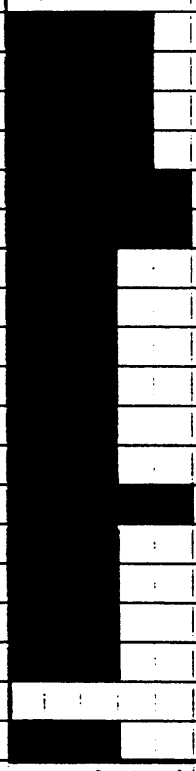
Comments: Mesquite was always found high on the talus slope or on the cliffs above the slopes.

Figure XI- 14. Acacia.

Expected elevation: 1,000-3,000

Expected mileage: 40 - 280

#	River Mile
0	18.2L
0	19 L
0	20 L
0	34.7L
100	53 L
30	58.1R
100	65.5L
60	75.5L
40	81.1L
30	87.5L
8	98.2R
20	108.5L
25	120.1L
8	122 L
20	136 L
20	151.6R
30	166.6L
30	180.9R
6	190.2R
10	194 R
20	198.5R
0	208.8L
10	219 R



+ 1 2 3 4 5 6 Percentage present

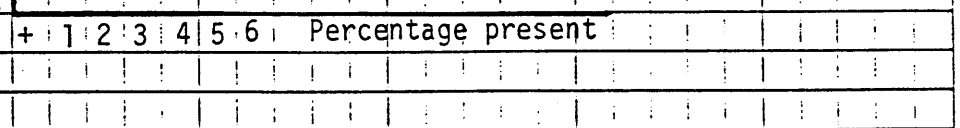
Comments: Acacia was found high on the talus slope, but generally closer to the water than mesquite.

Figure XI-15. Hackberry

Expected elevation: 4,500

Expected mileage: 4-196

#	River Mile
0	18.2L
22	19 L
1	20 L
0	34.7L
6	53 L
0	58.1R
0	65.5L
0	75.5L
0	81.1L
0	87.5L
0	98.2R
0	108.5L
0	120.1L
0	122 L
0	136 L
0	151.6R
0	166.6L
0	180.9R
0	190.2R
0	194 R
0	198.5R
0	208.8L
0	219 R



Comments: Hackberry was found at the back of the beach, generally near or in the dry wash area, where water would be available at certain times of the year.

CHAPTER XII

REPORT ON MESQUITE AND ACACIA SURVIVAL ALONG THE COLORADO RIVER IN GRAND CANYON NATIONAL PARK 1985

Nancy Nahstoll
Assisted by M. Lyman, D. A. House, and F. Lojko

INTRODUCTION

The main purpose of the 1985 Northern Arizona University Colorado River studies in the Grand Canyon was to evaluate environmental changes that may or may not have occurred as a result of fluctuating water releases from Glen Canyon Dam. The effect of such fluctuations on the biology, geology, and ecology have ben documented since about 1980 (Turner and Karpiscak 1980; Carothers and Dolan 1982; Anderson and Ruffner 1984), but prior to then few investigations had been made.

When the Colorado River was wild, its flow varied according to seasonal runoff, with lows of 700-4,000 cfs and highs in excess of 120,000 cfs. Pre-dam flows averaged 86,000 cfs and were capable of periodically watering the higher reaches of the beaches and terraces where the old high water line (OHWL) vegetation prospered. With the construction of Glen Canyon Dam, maximum discharge was generally limited to approximately 30,000 cfs year round. For 20 years, the OHWL vegetation was stranded high above the river, and it was assumed that the new flow regime

would not provide sufficient water to maintain the OHWL zone.

In recent years, however, spills from the dam (particularly the 96,000 cfs flood of 1983) have approached the levels of pre-dam natural floods. With the filling of Lake Powell, occasional exceptionally high releases may be the order of the future.

How the 20 years of "drought" and recent high flows have affected the OHWL vegetation is unknown. This old riparian community is dominated by the deep-rooted western honey mesquite (*Prosopis grandulosa torreyana*) and catclaw acacia (*Acacia greggii*). These two species appear simultaneously at RM 40 and co-exist to RM 80 where the mesquite population discontinues until RM 165. From there to Lake Mead, acacia and mesquite are again the two dominant species along the OHWL. In order to predict the future survival of this community, it is necessary to assess its reproductive success in light of the changing river flow regimen.

OBJECTIVES

The overall objective of this study are as follows:

1. To determine the effects of limited fluctuating water levels on acacia and mesquite seedling and sapling survival.
2. To identify substrate preferences for the seedlings and saplings of each species.
3. To determine if there is a migration pattern of these species from the OHWL to the new high water line (NHWL).

METHODS

Two methods were used to evaluate seedling and sapling population growth:

1. At nine study sites, a broad sweep was made of the beach parallel and perpendicular to the river. The survey extended from the NHWL through the OHWL, and ran the entire length of the site. During the sweep, the observer recorded all acacia and mesquite seedlings and saplings, and noted the substrate (sand, sand/cobble, cobble, or talus) upon which they were found.

2. At seven sites, a transect line of 50 m was laid perpendicular to the river from the inland edge of the NHWL. Four two-meter-wide belts running parallel to and downriver from the transect line were staggered every other two meters to cover a width of eight meters in total. All acacia and mesquite seedlings and saplings observed within the belts were recorded along with the substrate upon which they were found.

RESULTS

Sixteen sites were surveyed in all. Only 180 saplings and one seedling were found. The sole seedling was seen at Awatubi in the NHWL vegetation (Tables XII-1 and 2).

An overwhelming proportion, 96%, of the saplings were acacias; only 4% were mesquites.

More saplings were found on talus than on any other substrate. The breakdown follows: talus (50%), sand (26%), sand/cobble (22%), and cobble (2%).

There were no significant differences in the numbers of seedling and saplings counted between the beach sweep and the belt methods (Tables XII-1 and 2).

Sapling location appeared to be the controlling factor in survivorship. In the sand and sand/cobble substrate zones, there were more saplings at lower elevations where recent high flows penetrated than there were at higher elevations. In the talus, there were greater numbers of saplings at localities nearer the river's edge than at localities more distant from the river. Some saplings were concentrated in small side drainages, suggesting that runoff was an alternate source of water for them.

CONCLUSIONS

The results of this study suggest that the limited water fluctuations of the last two decades have had an adverse effect on seedling and sapling survivorship in the OHWL vegetation zone. Extremely low numbers of new plants were counted even in areas where recent high water flows might have benefited growth. Athough migration from the OHWL to the NHWL appears to be occurring (50% of the saplings were found on substrate other than the talus slopes of the old terraces), survival of mesquite and acacia along the Colorado River seems ultimately threatened.

The fact that only 4% of the saplings were mesquite suggests that that species has been more adversely effected than has the acacia.

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Table XII-1. Summary of acacia saplings found using the beach sweep method.

River Mile	Camp	Substrate			
		Sand	Sand/cobble	Cobble	Talus
43.5	Anasazi Bridge				4
47	Saddle Canyon				4
58.1	Awatubi	8			3
65.5	Lava Canyon (Chuar)				
75.5	Nevills Rapid		6		
81.1	Grapevine	7			37
87	Cremation	3	5		
108.5	Lower Bass Camp	1			
120.1	Blacktail Canyon	2	14		17

Table XII-2. Summary of mesquite saplings found using the beach sweep method.

River Mile	Camp	Substrate			
		Sand	Sand/cobble	Cobble	Talus
43.5	Anasazi Bridge				
47	Saddle Canyon				
58.1	Awatubi	3			
65.5	Lava Canyon (Chuar)				
75.5	Nevills Rapid	3			1
81.1	Grapevine				
87	Cremation				
108.5	Lower Bass Camp				
120.1	Blacktail Canyon				

Table XII-3. Summary of acacia saplings found within the 50m x 8m belt plot.

River Mile	Camp	Substrate			
		Sand	Sand/cobble	Cobble	Talus
151.6	Ledges	4		3	
166.6	National Canyon				3
180.9	Lower Lava Falls	1			
190.2	190 Mile				
194	194 Mile Beach	15			
198.5	Parashant		9		22
208.8	Granite Park		4		

Table XII-4. Summary of mesquite saplings found within the 50m x 8m belt plot.

River Mile	Camp	Substrate			
		Sand	Sand/cobble	Cobble	Talus
151.6	Ledges				
166.6	National Canyon				
180.9	Lower Lava Falls	1			
190.2	190 Mile				
194	194 Mile Beach				
198.5	Parashant				
208.8	Granite Park				

CHAPTER XIII

FURTHER INVESTIGATIONS ON POGONOMYRMEX ANTS ON COLORADO BEACHES IN GRAND CANYON

Scott Thomas and Dave Lindquist

INTRODUCTION

Pogonomyrmex is the genus of harvester ants, familiar to all Southwesterners as the stinging red ant. Their nests form prominent barren areas in the desert with a sandy disk, mound or crater at the entrance. The ants primarily forage for seeds which they store in their nests.

Our observations indicate that ant foraging activity peaks in the early morning hours before the sun has warmed the soil to its maximum temperature, and in late afternoon hours as the ground begins to cool. Ant activity is low or nonexistent during midday as the ants retreat to the coolness of their underground tunnels.

OBJECTIVES

This study was conducted primarily to continue previous investigations to determine if there is a correlation between ant nest density along the Colorado River in the Grand Canyon and human recreationists' campsites on the river's beaches.

Results of the three previous studies have been

inconclusive. In 1982, a correlation was found between ant density and human use on the beaches studied. In 1983, the data were unreliable, and in 1984, the beaches had been swept free of both ant nests and human debris by flooding. As the first study since the flood scoured the ants from the beaches, this year's data should give an indication as to whether the ants are returning, and if so, if they are showing a preference for the more heavily used camping beaches.

The food intake of several nests was also observed in this study to further determine if the ants are benefited by the human presence.

New data not compiled on previous studies that is reported here is information on ant nest density and size in different habitats, and ant nest density and size relative to distance from campsite perimeters.

The investigators in this study also looked at species determination and artificial chemical response in harvester ants to oleic and formic acid.

From observing the results of the previous investigations, a higher ant nest density is expected around campsites that are heavily used than around those of lower use. In addition, the nests closer to a campsite are expected to be larger and have a higher intake of human derived food than nests farther away.

Ant nest densities are expected to have increased from their 1984 lows.

Formic acid should cause alarm among the ants upon exposure as it is the primary constituent of their sting. This alarm may be manifested as an attack posture as if the ants were in danger

from without. Oleic acid, a component found in decaying ants (Sudd 1967, p.11), may aid in finding an ant cemetery of the nest where refuse is deposited. Objects scented with the acid should trigger ants to carry those objects to the refuse pile.

METHOD

Previous studies made use of a 40 meter transect line laid on the beach. Ant nests within 50 feet of the line were counted and recorded. Another method used was to count all ant nests within a paced off 20 meter squared area centered on the campsite. These methods covered only one environment, the sandy areas of the exposed beaches and the new riparian vegetation along the river's edge. This year, all nests on the beach and within 100 feet of the beach perimeter were recorded, noting diameter of the nest mound, the distance from the beach perimeter, and the environment type: new riparian, exposed beach, old riparian (old high water line), and above old riparian (desert scrub). Each nest observed was categorized into one of three areas: Area 1) on or within 10 feet of the beach, Area 2) between 10 and 50 feet of the beach, and Area 3) greater than 50 feet of the beach.

The method of collecting information on food gathered by ants was the same as in previous studies. When time permitted, 25 food-carrying ants from each of fourteen nests were observed, and the food was categorized as being one of five types: plant part, seed, insect part, greasy sand, or human food scrap. Each nest observed was categorized into Areas 1 through 3 as defined

above.

In the chemical study, formic acid was applied to nests using capillary tubes, and the ants reaction to the chemical was observed. Oleic acid was applied in like manner to small pieces of plants and ants, and the reaction was again observed.

RESULTS

After ten days in the field, data collected from 21 Colorado River beaches were tabulated. Densities were calculated in units of ant nests per 100 square meters, and the degree of human use per beach was obtained by asking the river guides. While their estimates are being used in this report, it must be noted that the pattern of campsite use by river runners has changed as a result of the 1983 flood, and judgments at this point about the frequency of beach use are highly subjective. Because of this, data from the medium and high use beaches were combined for purposes of analysis.

Ant nest density for each beach (Area 1 only) is reported in Table XIII-1. Low human use beaches had a mean ant nest density of .01 nests per 100 m^2; medium human use and high human use beaches had a combined mean ant nest density of .16 nests per 100 m^2. Data from Areas 2 and 3 were not included in this table because human use is largely restricted to Area 1, the camping beach, and Area 1 is roughly comparable to the study areas of previous investigations.

Ant nest density and nest size were significantly lower for Area 1 (the camping beach area) than for Areas 2 and 3 (Table XIII-3). Nests were found most often in the old riparian zone.

Few nests were found in the new riparian zone or on the beaches, the areas that had been scrubbed free of ants in the 1983 flood. These results can be seen in Tables XIII-4 and XIII-5.

The ants on and near the beaches gathered human waste to a greater extent than did ants farther from the camping areas (Table XIII-3).

One species of Pogonomyrmex seemed to exist throughout the length of the Canyon. An ant taken at river mile 34.7 and another at river mile 208.5 were closely examined to determine species. The external anatomy of each ant, particularly the mandible structure, strongly correlated with the description of a maricopa species worker as given by Cole (Cole 1968, p.138-140). This conflicts with the report by Peterson that the species in the Grand Canyon is californicus.

The application of formic acid to the nests using capillary tubes irritated the ants as a toxin, but not as an incitement to attack as was predicted. The oleic acid applied to the ants and pieces of plant in the nest did not appear to be regarded as an agent of decay. Ants coming in contact with the scented objects usually turned away quickly and vigorously cleaned their antennae. In no case did the ants make an attempt to remove the object as was expected.

CONCLUSIONS

The ants appear to have partially recovered from the effects of the flood, but only slightly. The data do establish a correlation between ant density and human use; at the very least,

they do suggest a trend toward increased ant presence at the more heavily used beaches. The difference of the means between the low use and the medium and high use beaches was subjected to a student t test and found to be significant.

This year's observation of the nature of the items foraged by ants is consistent with that of previous years. Harvester ants in the vicinity of camping areas do utilize human waste, and they do so to a greater extent than do ants more distant from the camping areas.

The identification of the ants by species was difficult, and the reported identification as *maricopa* is only tentative. Further work needs to be done on this problem.

It would appear from the results of this research that harvester ants do not use a release of formic acid as an alarm signal to alert the colony.

The ants did not react to oleic acid as a product of decay as described in Sudd (Sudd 1967, p.1). It is conjectured that, since oleic acid is a much larger molecule than most organic acids produced during decay, and since such substances generally have a strong odor while oleic acid has very little odor, Sudd may have erroneously identified the acid. More likely propanoic, butyric, or pentanoic acid is the acid produced in decaying ants.

It is recommended that in future studies a more objective means of determining the level of human use for each study beach be found and applied. Preferably, beaches that receive very little or no human use should be incorporated into the study.

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

River Mile	Beach	Nests/100 m^2 1984	Nests/100 m^2 1985	Human Use
8	Badger Creek	0.00	-	high
18.2	18 Mile Beach	-	0.00	low
19.3	19 Mile Beach	-	0.00	low
20	20 Mile Beach	-	0.21	high
34.7	Nautiloid	0.00	0.38	high
43.5	Anasazi Bridge	0.00	0.00	medium
53	Lower Nankoweap	0.00	-	high
58.1	Awatubi	0.00	0.19	high
60.5	Upper LCR	0.00	-	continuous
65.5	Lava Canyon (Chuar)	0.00	0.68	medium
72.2	Unkar	0.00	-	(gone)
75.5	Nevills Rapid	0.00	0.00	high
76 .5	Hance Rapid	-	0.68	high
81.1	Grapevine	0.00	0.00	high
87	Cremation	-	0.00	high
108.5	Lower Bass Camp	0.00	0.00	high
120.1	Blacktail Canyon	0.00	0.00	low
122	122 Mile Creek	-	0.06	low
122.8	Forster	0.00	-	medium
124.4	124.5 Mile	0.00	-	low
131	Bedrock	0.00	-	low
166.6	Lower National	-	0.00	high
179	Upper Lava Falls	0.00	-	medium
180.9	Lower Lava Falls	0.00	0.00	medium
190.2	190 Mile Beach	-	0.00	low
194	194 Mile Beach	-	0.00	low
208.8	Granite Park	0.00	0.12	high
219	Trail Canyon	0.17	0.00	high
220	220 Mile	0.00	0.15	high

Table XIII-2. Harvester ant nest density and size in relation to distance from center of beach.

River Mile	Beach	Density* Area 1	Density* Area 2	Density* Area 3	Nest Size** Area 1	Nest Size** Area 2	Nest Size** Area 3
18.2	18 Mile Beach	0.00	0.00	0.22	-	-	4.0
19.3	19 Mile Beach	0.00	0.95	0.00	-	8.8	-
20	20 Mile Beach	0.21	0.00	0.00	6.5	-	-
34.7	Nautiloid	0.38	0.00	0.00	9.0	-	-
43.5	Anasazi Bridge	0.00	0.37	0.30	-	4.3	7.5
58.1	Awatubi	0.19	0.41	0.17	5.8	8.1	7.0
65.5	Lava Canyon (Chuar)	0.68	0.93	0.40	6.0	8.8	8.0
75.5	Nevills Rapid	0.00	0.15	0.13	-	8.0	4.5
76.5	Hance Rapid	0.68	0.29	-	9.5	6.5	-
81.1	Grapevine	0.00	0.26	0.62	-	7.0	11.5
87	Cremation	0.00	0.86	0.68	-	7.8	9.0
108.5	Lower Bass Camp	0.00	1.08	0.57	-	12.0	6.5
120.1	Blacktail Canyon	0.00	0.36	0.57	-	6.5	9.0
122	122 Mile Creek	0.06	0.38	0.80	5.0	9.1	10.5
166.6	Lower National	0.00	0.12	0.00	-	11.0	-
180.9	Lower Lava Falls	0.00	0.00	0.09	-	-	9.0
190.2	190 Mile Beach	0.00	0.00	0.12	-	-	8.5
194	194 Mile Beach	0.00	0.38	0.06	-	8.0	5.5
208.8	Granite Park	0.12	0.84	1.14	5.5	9.4	9.2
219	Trail Canyon	0.00	0.13	0.41	-	8.5	8.8
220	220 Mile	0.15	1.03	1.15	5.0	9.4	8.6
Mean		0.12	0.41	0.38	6.5	8.3	7.9

* Nests per 100 meters squared
** Measured in inches

Table XIII-2. The relative frequency of food items collected by foraging harvester ants in relation to distance from campsites used on Colorado River beaches in Grand Canyon.

Food Categories	Test Area 1 1984 (n=1)	Test Area 1 1985 (n=3)	Test Area 2 1984 (n=0)	Test Area 2 1985 (n=5)	Test Area 3 1984 (n=9)	Test Area 3 1985 (n=6)
Seeds	-	24(41%)	0	27(21%)	8(3%)	72(48%)
Plant parts	-	5(9%)	0	37(28%)	136(55%)	38(25%)
Insect parts	-	11(19%)	0	31(24%)	60(24%)	39(26%)
Human food	17(81%)	1(2%)	0	13(10%)	2(1%)	1(1%)
Greasy sand	4(19%)	17(29%)	0	22(17%)	40(16%)	1(1%)
Total	21(100%)	58(100%)	0	130(100%)	246(100%)	151(100%)
Total % Human food plus sand	100%	31%	-	27%	17%	2%

Test Areas:

Area 1. On or within 10 ft. of a heavily used campsite.
Area 2. 10-50 feet of a heavily used campsite.
Area 3. More than 50 feet from a heavily used beach.

CHAPTER XIV

A COMPARISON OF REPTILE USE OF OLD HIGH WATER LINE HABITATS VERSUS NEW HIGH WATER LINE HABITATS IN THE GRAND CANYON

Joan L. Dickens

INTRODUCTION

Along both banks of the Colorado River in the Grand Canyon there exists a streamside, or riparian, vegetation community that stands out in sharp contrast to the desert scrub that dominates the Canyon walls above the old high water line. Within this riparian community, consistant habitat zones are found on a gradiant from the new high water line (NHWL) at the river's edge (tamarisk, coyote willow, seep willow, arrow-weed) to the old (pre-dam) high water line (OHWL) on the higher beach areas, and on the talus slopes and terraces just above the beaches (acacia, mesquite, apache plume).

Reptiles, especially lizards, appear to flourish in the riparian habitats of the Grand Canyon. Some of the reptiles commonly found there are:

Chuckwalla (*Sauromalus obesus*)

Side-blotched Lizard (*Uta stansburiana*)

Western Whiptail (*Cnemidophorus tigris*)

Desert Spiny Lizard (*Sceloporus magister*)

Tree Lizard (*Urosaurus ornatus*)

Grand Canyon Rattlesnake (*Crotalus viridis abyssus*)

Rapid changes, both physical and ecological, are occurring in the riparian communities as a result of Glen Canyon Dam, and possibly as a result of high visitor use of the area. What impact these changes are having on reptile distribution along the Colorado River is impossible to assess at this time because little is known about that distribution.

OBJECTIVES

It was the intent of this study to compare the densities of the above listed reptiles between the new and old high water line vegetation communities. It was hypothesized that reptilian use would be the same for both communities.

METHODS

On the selected beaches (early morning or late afternoon stops), two or more observers paced off a 20 meter by 10 meter transect zone in each of the water line communities. The observers then slowly walked through the zones and recorded all reptiles seen. The results are reported in numbers of observations per hour (density/hour).

RESULTS

Figures XIV-1 and XIV-2 present the results of the observations. Although the data are limited for some species, it is felt that sufficient information was gathered to make a comparison for all species except the Grand Canyon rattlesnake

(none were seen in either habitat). A total of 118 density/hours of lizard were observed. Of these, 100 were in the NHWL vegetation, and only 18 were in the OHWL vegetation. Each of the four lizard species observed was more abundant in the NHWL habitat.

CONCLUSIONS

The data gathered during the ten day period, August 1 to August 10, 1985, do not support the original hypothesis. There seems to be a significantly greater use by lizards of the new high water line habitat than of the old high water line habitat.

In future studies of this sort, a specific time(s) of day when the temperature would be optimal for reptile movement should be selected as an observational period. The temperature at the time of the survey should be recorded. The feeding habitats of the various reptiles might also be incorporated into the study.

It is also recommended that attention be paid to the use of the intermediate zone between the NHWL and OHWL habitats. From the observations during this study, there appeared to be a great deal of movement from one habitat to the other.

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Figure XIV-2. RIPARIAN ZONE II

Old High Water Line

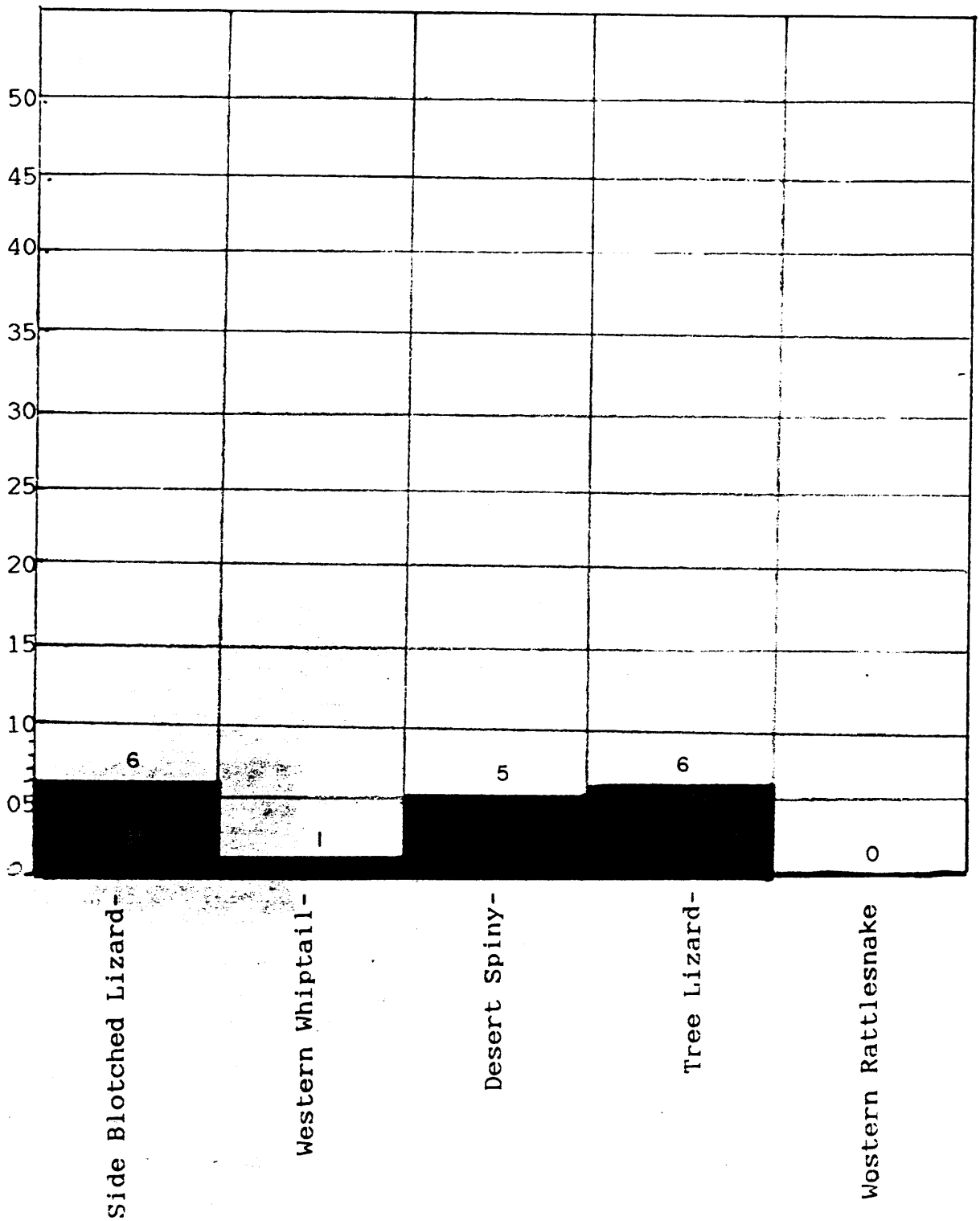
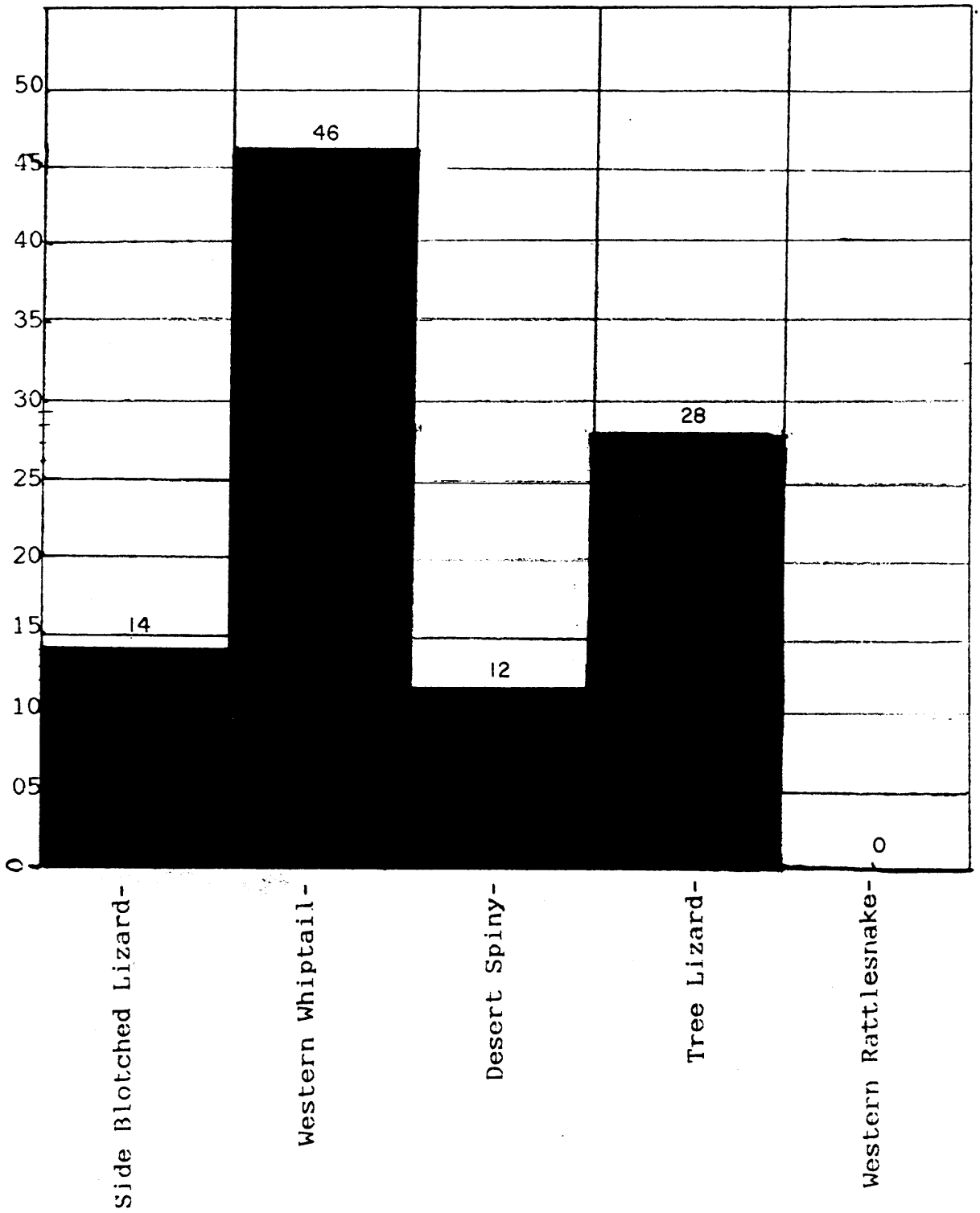


Figure XIV-1.

RIPARIAN ZONE I

New High Water Line



CHAPTER XV

HUMAN IMPACT ON THE BEACHES OF THE COLORADO RIVER

Steven W. Carothers and Charlotte Garnett

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 systems 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 1950s. 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 now released through turbines and gates as a predictable, computer-regulated, icy cold, sediment-free, and 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 Lees Ferry to Diamond Creek (NPS 1981). The high waters and ensuing floods of 1983 unexpectedly disrupted the stabilizing patterns of water flow established during the past 20 years.

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, vegetation and animal community composition, and overall ecosystem stability; b) determining and evaluating the impacts of river recreationists on the changing aquatic and terrestrial systems; and c) mitigating such recreational impacts to the extent that natural park values are not compromised.

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 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 and vegetation density and diversity (Burden and Randerson 1972; Whitson 1974; Dolan et al. 1974; Bates 1935; Dotzenko et al. 1967; LaPage 1967; Liddle 1975; 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 100 plus campsites (Borden 1976) of the river corridor. All of these campsites are on alluvial terraces (sand and silt/sand composition) that were deposited during pre-dam flood discharges. In the 20 years prior to 1983, vegetation previously scoured from the beaches on an annual basis proliferated, while human related debris incorporated into beach sands during normal camping activities accumulated. With no natural purging of recreation related debris (organic as well as inorganic) there existed 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 backcountry campsites where recreational use is clearly in excess of the natural purging capacity of the system.

In an effort to clean up the beaches, the Colorado River Management Plan requires that all wood and charcoal carried into the Canyon by river recreationists be burned in fire pans and the ashes be carried out. Gas stoves are now required for most cooking purposes. Regulations also require all river users to haul out solid human wastes.

The 1983 floods cleaned the beaches, resorted the sand, and gave the system a fresh start. Along with this cleansing, new beaches formed and others disappeared. The 1983 study established important baseline data for future investigations. These data are the control for this study.

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, nine 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). In 1982, human impact data for 35 beach sites in Glen and Grand Canyons were presented and compared with the results of previous sampling efforts.

In 1983, human impact data for 22 Grand Canyon beach sites, including 17 of the beaches evaluated in 1982 and five new beaches, were compared to the 1982 data. Eleven of the original beaches were no longer comparable in 1983 and were dropped from the study. In 1984, two previously studied beaches were not included; however, seven new beaches were added.

OBJECTIVES

The objectives of this study were, 1) to collect data on the degree of sand discoloration and the incidence of charcoal and human litter present on Colorado River beaches in the Grand Canyon, and 2) to compare those data with the findings from

similar studies conducted in 1983 and 1984 to determine the human impact on the beaches in the two years following the flood. It was hypothesized that human use in those two years had resulted in a significant increase in sand discoloration, and in charcoal and litter on the beaches.

METHODS

1. A 40 meter transect line was run through the principal use area of the beach along the same line established in previous years. If the beach was had been so altered by the river as to change patterns of use, a new transect line was established and documented.

2. Black and white photographs of the transect, including the metric tape and river mile marker, were taken from each direction. The river mile number was written on a chalkboard and positioned in the sand for inclusion in the photograph.

3. Ten $1m^2$ plots were laid out equidistant from each other in an alternating pattern along the transect line.

4. Each m^2 plot was inspected, and pieces of charcoal of 1 cm or over and all pieces of human litter found in the plot were counted and recorded. A dry sand sample from the surface of each plot was collected in a whirl pack. If damp sand was unavoidable, it was collected anyway to be dried out later. Each sample was labeled with the beach name, the river mile, and the plot number.

5. Sand samples were also collected at the sand/water interface and from the terrace above the beach.

6. Each sand sample was sifted through a 150 micron stainless steel mesh apparatus until the amount of sifted material completely covered the bottom.

7. A piece of No. 7 course grade filter paper was placed in the lid, hatched side up, and the sifted material shaken against the filter paper 75 times.

8. The filter paper was removed and stored in a labelled petri dish.

9. When all of the samples from a transect were shaken, the discoloration on the filter paper was evaluated with a Colorguard II Reflectometer and recorded on a data sheet (Figure VII-1).

10. The Colorguard II Reflectometer is an instrument operating with an optical system, photocell amplifier, digital readout and portable power system, and is used to make reflective measurements. Hence, with a digital readout display, reflected light can be measured from any source. The reflectometer was used to obtain reflective values from the filter paper discs which were discolored with filtrate from the sand samples. The reflectometer was standardized prior to each series of readings against a white standard and a grey standard to calibrate the instrument.

11. Means and standard deviations of the reflectometer readings

from the ten transect samples were calculated for each beach. These were then tabulated with the 1982, 1983 and 1984 data. A small sample t test for level of significance of difference between the 1984 and 1985 data, and between the 1983 and 1985 data, was then performed for each beach.

EXCEPTIONS TO THE PROCEDURE

1.	Shinumo Wash	39 m transect
2.	Anasazi Bridge	30 m transect
3.	L. Nankoweap	37 m transect
4.	Awatubi	Used Base line established for beach profile (bench mark BS1 to BS2)
5.	Lava Canyon	39 m transect (beach has moved a great deal)
6.	Granite Rapid	23 m transect along 1982 line (transect interrupted by large rock)
7.	Bedrock	30 m transect (last plot at 26 m)
8.	Dubendorff	36 m transect (ten plots)
9.	Deer Creek	18 m transect (ten plots)
10.	Poncho's Kitchen	26 m transect (6 plots)
11.	Granite Park	30 m transect (old shoreline eroded)
12.	Trail Canyon	Center of transect crossed eroded area of beach: plots taken before the water at 2 m, 6.6 m, 9.2 m, 11.8 m, and 14.4 m; plots taken after the water at 29 m, 31.6 m, 34.2 m, 36.8m, and 39.4 m.
13.	220 Mile	38 m transect

RESULTS

Twenty-eight beaches were sampled in 1985. The levels of sand discoloration as measured by reflectometer reading are presented in Table XV-1. For purposes of comparison, these data

are presented with equivalent figures from 1983 and 1984. Of the 25 beaches that were tested in both 1984 and 1985, the differences in sand discoloration are as follows: six beaches showed a significant increase in discoloration, five showed a significant decrease in discoloration, and 14 showed no significant difference in discoloration. Due to lack of data from 1984, four beaches tested in 1985 could not be compared; and one beach tested in 1984 is now gone. Of the 21 beaches that were tested in both 1983 (the year the flood cleansed the beaches) and 1985, 11 showed a significant increase in sand discoloration, one showed a significant decrease in discoloration, and nine showed no significant difference in discoloration.

Charcoal and human debris accumulations are presented in Table XV-2.

There was little difference in the levels of charcoal found between 1984 and 1985. Of the 26 beaches for which there were comparative data, eight showed a slight increase, eight showed a decrease, and ten showed no change. The difference between 1983 and 1985 was more significant. Out of 21 beaches sampled both years, nine showed an increase, only one showed a decrease, and 11 showed no change.

Between 1984 and 1985, the amounts of human litter found changed in the following ways: five beaches showed an increase, 11 beaches showed a decrease, and ten beaches showed no change. Between 1983 and 1985, six beaches showed an increase, four showed a decrease, and 11 showed no change.

The results of a "t" test for level of significance of

differences between 1984 and 1985 sand discoloration measurements are presented in Table XV-3; significance of differences between 1983 and 1985 sand discoloration measurements are presented in Table XV-4.

CONCLUSIONS

Colorado River beaches did not appear to have suffered appreciable degradation between 1984 and 1985. Six of 25 beaches did show increased sand discoloration; however, five showed a decrease and 14 remained unchanged. The same number of beaches showed an increase in charcoal contamination as showed a decrease. A similar number showed no significant change. In terms of human litter found, the beaches appeared to improve overall. More than twice as many beaches showed a decrease (11) in incidence of human litter as showed an increase (5). The levels of charcoal and litter were small for both years. The mean value of charcoal contamination for all beaches in 1984 was

of human litter in 1984 was .19 pieces per m^2; the mean value in 1985 was .09 pieces per m^2.

While the 1985 data show that little overall beach degradation has occurred since the 1984 study, if compared to data collected in 1983, they do show an overall deterioration since that time. Eleven of 21 beaches showed an increase in sand discoloration. Only one showed less discoloration. Nine remained about the same. The incidence of charcoal on the beaches also increased significantly. Nine of 21 beaches showed an increase, one showed a decrease, and 11 remained about the

same. The mean value in 1983 was only .07 cm/m^2; by 1985 it had risen to .29 cm/m^2. The change in the amount of human litter found was less conclusive. Almost as many beaches showed a decrease (4) as showed an increase (6). The mean value of litter found rose from .02 pieces per m^2 in 1983, to .09 in 1985.

The results of this study support the initial hypothesis that Grand Canyon camping beaches have deteriorated since the 1983 flood scoured them clean. This is attributed to human use.

Acknowledgments

We would like to thank David Mail for doing the statistics, shaking sand, and giving us the push we needed to get it all done while we were on the river. We would also like to thank Frank Lojko for finding the transect locations and making sure that we had all the equipment we needed; and Joan Dickens, Celeste Prehmus, and Mayo Lyman for their many hours of shaking sand samples, and counting charcoal and litter particles.

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Table XV-1. Results of sand discoloration analysis of beach campsites in Grand Canyon, 1983-1985 (means only).

Beach no.	Campsite Name	River Mile	Sand Discoloration (Standard Deviation) 1983	(S.D.)	1984	(S.D.)	1985	(S.D.)
1	Badger Rapid	8.0	71.65	(1.65)	69.69	(2.52)	70.55	(1.82)
2	20 Mile	20.0	66.74	(3.53)	68.78	(3.14)	64.29	(3.07)
3	Shinumo Wash	29.0	70.01	(3.00)	69.10	(3.16)	68.62	(3.03)
4	Anasazi Bridge	43.5	73.28	(1.24)	70.55	(1.83)	71.13	(1.80)
5	Lower Nankoweap	53.0	73.21	(2.33)	64.91	(3.16)	69.33	(2.66)
6	Awatubi	58.1	72.40	(1.34)	64.48	(5.73)	66.97	(3.31)
7	Lava Canyon (Chuar 3)	65.5	70.66	(0.83)	65.91	(4.05)	68.56	(3.81)
8	Unkar (gone)	72.2	68.93	(2.67)	67.70	(2.28)		
9	Nevills Rapid	75.5	72.00	(1.91)	66.80	(4.87)	72.21	(1.35)
10	Hance Rapid	76.5			66.87	(5.14)	63.82	(2.92)
11	Grapevine	81.1	71.91	(1.43)	67.62	(2.18)	67.39	(2.95)
12	Granite Rapid (Granite 4)	93.2	68.20	(2.49)	68.48	(3.28)	62.35	(3.50)
13	Lower Bass Camp	108.5	66.53	(2.39)	63.38	(5.69)	64.46	(1.69)
14	114 Mile	114.0			69.22	(2.06)	63.77	(2.39)
15	122 Mile	122.0			71.16	(2.15)	68.55	(2.65)
16	Forster	122.8	70.04	(3.05)	68.65	(5.16)	69.74	(0.74)
17	Bedrock	131.0			70.54	(3.40)	68.20	(2.02)
18	Dubendorff	132.0	69.12	(3.36)	70.22	(2.51)	69.63	(2.35)
19	Deer Creek	136.0	67.82	(2.03)			65.46	(1.38)
20	Pancho's Kitchen	137.0	65.91	(3.11)	65.90	(3.79)	67.20	(3.81)
21	National Canyon (Upper)	166.5	71.22	(0.96)	68.95	(3.00)	73.31	(0.98)
22	National Canyon (Lower) (USGS Site)	166.6	69.39	(2.73)	63.59	(3.00)	67.10	(2.42)
23	Upper Lava Falls	179.0	69.39	(2.60)			67.74	(1.65)
24	186 Mile	186.0			72.06	(1.50)	70.95	(2.18)
25	Parashant	198.5			63.94	(4.77)	68.39	(2.68)
26	Granite Park	208.8	69.70	(3.78)	68.93	(2.17)	69.88	(2.13)
27	Pumpkin Bowl	213.0	73.66	(0.94)	70.83	(1.75)	68.63	(2.41)
28	Trail Canyon	219.0			72.18	(1.45)	68.78	(3.38)
29	220 Mile	220.0	67.50	(2.61)	67.71	( )	66.93	(2.28)

Table XV-2. Results of charcoal and human litter accumulations analysis of beach campsites in Grand Canyon 1983-1985 (means only).

Beach No.	Campsite Name	River Mile	Charcoal cm/m2 1983	1984	1985	Human Litter m2 1983	1984	1985
1	Badger Rapid	8.0	0.8	2.5	0.2	0.1	0.2	0.0
2	20 Mile	20.0	0.1	0.0	0.3	0.0	0.0	0.2
3	Shinumo Wash	29.0	0.0	0.0	0.0	0.0	0.1	1.0
4	Anasazi Bridge	43.5	0.0	0.0	0.0	0.0	0.0	0.0
5	Lower Nankoweap	53.0	0.0	0.2	0.6	0.0	0.4	0.0
6	Awatubi	58.1	.0	0.0	0.0	0.0	0.0	0.3
7	Lava Canyon (Chuar 3)	65.5	0.1	1.6	1.3	0.0	0.3	0.0
8	Unkar	72.2	0.0	0.2		0.0	0.1	
9	Nevills Rapid	75.5	0.0	0.3	0.0	0.0	0.0	0.0
10	Hance Rapid	76.5		0.2	0.9		0.0	0.0
11	Grapevine	81.1	0.0	0.0	0.0	0.0	0.0	0.0
12	Granite Rapid (Granite 4)	93.2	0.0	0.0	0.0	0.1	0.0	0.0
13	Lower Bass Camp	108.5	0.0	1.5	0.4	0.1	2.2	0.0
14	114 Mile	114.0		0.2	0.0		0.1	0.0
15	122 Mile	122.0		0.0	0.0		0.3	0.2
16	Forster	122.8	0.0	0.0	0.0	0.0	0.0	0.0
17	Bedrock	131.0		0.0	0.3		0.1	0.0
18	Dubendorff	132.0	0.0	0.0	0.5	0.0	0.0	0.0
19	Deer Creek	136.0	0.2		2.0	0.1		0.0
20	Pancho's Kitchen	137.0	0.0	0.0	0.1	0.0	0.4	0.1
21	National Canyon (Upper)	166.5	0.0	0.0	0.0	0.0	0.2	0.2
22	National Canyon (Lower) (USGS Site)	166.6	0.0	0.0	0.0	0.0	0.0	0.2
23	Upper Lava Falls	179.0	0.3		0.7	0.0		0.0
24	186 Mile	186.0		0.2	0.6		0.0	0.0
25	Parashant	198.5		0.0	0.0		0.2	0.3
26	Granite Park	208.8	0.0	0.1	0.0	0.0	0.1	0.0
27	Pumpkin Bowl	213.0	0.0	0.0	0.2	0.0	0.1	0.0
28	Trail Canyon	219.0		0.1	0.0		0.0	0.0
29	220 Mile	220.0	0.0	0.4	0.0	0.0	0.2	0.0

Table XV-3. t test for level of significance of differences between 1984 and 1985 sand discoloration measurements for Grand Canyon beaches.

Campsite Number	Campsite Name	t Value	t test	Significant Difference?
1	Badger Creek	t= 2.210	1.210<2.101	No
2	20 Mile	t= 4.180	4.180>2.101	Yes
3	Shinumo Wash	t= 0.440	0.440<2.101	No
4	Anasazi Bridge	t= 0.900	0.900<2.101	No
5	Lower Nankoweap	t= 4.700	4.700>2.101	Yes
6	Awatubi	t= 0.970	0.970<2.101	No
7	Lava Canyon (Chuar 3)	t= 1.910	1.910<2.101	No
8	Unkar	the beach is gone		
9	Nevills Rapid	t= 4.290	4.290>2.101	Yes
10	Hance Rapid	t= 2.060	2.060<2.101	No
11	Grapevine	t= 0.250	0.250<2.101	No
12	Granite Rapid (Granite 4)	t= 5.120	5.120>2.101	Yes
13	Lower Bass Camp	t= 0.730	0.730<2.101	No
14	114 Mile	t= 5.350	5.350>2.101	Yes
15	122 Mile	t= 3.640	3.640>2.101	Yes
16	Forster	t= 0.910	0.910<2.101	No
17	Bedrock	t= 1.620	1.620<2.101	No
18	Dubendorff	t= 0.510	0.510<2.101	No
19	Deer Creek	no data for 1984		
20	Pancho's Kitchen	t= 0.720	0.720<2.101	No
21	National Canyon (Upper)	t= 5.530	5.530>2.101	Yes
22	National Canyon (Lower)	t= 2.780	2.780>2.101	Yes
23	Upper Lava Falls	no data for 1984		
24	186 Mile	t= 1.680	1.680<2.101	No
25	Parashant	t= 3.250	3.250>2.101	Yes
26	Granite Park	t= 1.250	1.250<2.101	No
27	Pumpkin Bowl	t= 7.780	7.780>2.101	Yes
28	Trail Canyon	t= 3.730	3.730>2.101	Yes
29	220 Mile	no data for 1984		

Table XV-4. t test for level of significance of differences between 1983 and 1985 sand discoloration measurements for Grand Canyon beaches.

Campsite Number	Campsite Name	t Value	t test	Significant Difference?
1	Badger Creek	t= 1.798	1.798<2.101	No
2	20 Mile	t= 2.170	2.170>2.101	Yes
3	Shinumo Wash	t= 1.840	1.840<2.101	No
4	Anasazi Bridge	t= 3.920	3.920>2.101	Yes
5	Lower Nankoweap	t= 4.390	4.390>2.101	Yes
6	Awatubi	t= 4.680	4.680>2.101	Yes
7	Lava Canyon (Chuar 3)	t= 2.150	2.150>2.101	Yes
8	Unkar	the beach is gone		
9	Nevills Rapid	t= 0.360	0.360<2.101	No
10	Hance Rapid	t= 2.060	2.060<2.101	No
11	Grapevine	t= 5.510	5.510>2.101	Yes
12	Granite Rapid (Granite 4)	t= 5.450	5.450>2.101	Yes
13	Lower Bass Camp	t= 2.710	2.710>2.101	Yes
14	114 Mile	no data for 1983		
15	122 Mile	no data for 1983		
16	Forster	t= 0.380	0.380<2.101	No
17	Bedrock	no data for 1983		
18	Dubendorff	t= 0.360	0.360<2.101	No
19	Deer Creek	t= 3.860	3.860>2.101	Yes
20	Pancho's Kitchen	t= 0.790	0.790<2.101	No
21	National Canyon (Upper)	t= 2.140	2.140>2.101	Yes
22	National Canyon (Lower)	t= 1.920	1.920<2.101	No
23	Upper Lava Falls	t= 2.140	2.140>2.101	Yes
24	186 Mile	no data for 1983		
25	Parashant	no data for 1983		
26	Granite Park	t= 0.610	0.610<2.101	No
27	Pumpkin Bowl	t= 7.780	7.780>2.101	Yes
28	Trail Canyon	no data for 1983		
29	220 Mile	t= 0.660	0.660<2.101	No

CHAPTER XVI

RIVER EXPEDITION REPORT: SOCIOLOGICAL DATA SUMMER, 1985

John Salvato

INTRODUCTION

This report summarizes field notes compiled during a Colorado River expedition through the Grand Canyon, including details on daily river contacts with other river parties and aircraft encounters. The expedition consisted of four boats, of which two were beach research boats, one a larval seiner, and one an electrofishing boat. There were 38 members of the group: 22 students, two Northern Arizona University faculty members, one Museum of Northern Arizona staff member, four Arizona Game and Fish Department biologists, two electrofishing experts, and a six-person boat crew. David Wegner, Glen Canyon Dam Environmental Studies Project Director for the U.S. Bureau of Reclamation, joined the expedition for three days.

SCHEDULE

Because this was a research trip involving a large number of projects, more stops were made than would be normal for a Colorado River trip. These stops were necessary for testing and other research activities. Stops are identified in Table XVI-1. Thirty-eight were for research, two for attraction points, one

for repairs, two for rapids, and one at the Little Colorado River where one of the electrofishing experts was flown out by helicopter. All camp stops were for a single night except at Awatubi Beach and Lower National Beach, where the party camped two nights each in order to accommodate a full day's research and rest and relaxation in the area.

CONTACTS

Contacts with other groups totaled 32. Ten of these were with private groups, and 22 with commercial groups. The majority were motor-powered trips. We also had several contacts with a private group of four oar-powered boats and four kayaks. They were sighted on three consecutive days, and at Crystal Rapid two of their party rode with our group. Due to the large amount of time spent by the group doing beach research, the greatest number of contacts were shore-to-river. The largest number of contacts for a single day was seven, occurring on day eight at river mile 166.6. Group contact data are reported in Table XVI-2.

AIRCRAFT

To be recorded, aircraft had to be both seen and heard. High-altitude commercial airliners and military aircraft were not counted. Since the observer traveled by motor-powered raft, it is possible some planes were missed. Most planes were observed on days eight and nine, which corresponded to one of our layover days. Two helicopter pick-ups were observed, one for Norman Sharber, the electrofishing expert, and one for an injured member of a Hatch commercial party. Full data for aircraft sightings are recorded in Table XVI-3.

CAMPSITES

We camped alone all ten nights.

AVERAGES

The average daily group contacts and aircraft sightings are presented in Table XVI-4. Group contacts averaged 2.9 per day, and aircraft encounters averaged 8.7 per day.

DATA SUMMARY

Mileage, contacts and aircraft sighted data are presented for each trip day for the years 1982 through 1985 in Table XVI-5.

Table XVI-1. Trip schedule: 1 August - 11 August, 1985.

Stop Number	Location	River Mile	Arrive Time	Arrive Day	Depart Time	Depart Day	Reason For Stop
0	Lees Ferry	0	---	---	13:30	1	Start
1	6 Mile Wash	6	14:50	1	15:30	1	L
2	Badger Rapid	8	15:50	1	16:35	1	BR
3	16 Mile Beach	16	16:00	1	17:10	1	Com
4	18 Mile Beach	18.2	18:10	1	18:25	1	BR
5	19 Mile Beach	19.3	17:30	1	18:40	1	BR
6	20 Mile	20	19:00	1	19:10	1	BR,C
7	Shinumo Wash	29	10:30	2	11:25	2	BR
8	Nautiloid	34.7	12:15	2	12:45	2	BR,L,AP
9	Anasazi Bridge	43.5	15:00	2	16:15	2	BR
10	Saddle Canyon	47		2		2	BR
11	Upper Nankoweap	52	17:25	2	18:05	2	BR
12	Lower Nankoweap	53	18:15	2	18:35	2	BR
13	Awatubi	58.1	19:15	2	8:45	4	BR,C, Layover
14	Lower Little Colorado River	61.8	9:15	4	10:10	4	HP,BR
15	Lava Canyon (Chuar),(Tanner Mine)	65.5	10:45	4	11:25	4	BR
16	Nevills Rapid	75.5	12:40	4	14:10	4	BR,L
17	Hance Rapid	76.5	14:15	4	14:50	4	BR
18	Grapevine	81.1	15:26	4	16:30	4	BR
19	Suspension Bridge (Cremation)	87.1		4		4	BR
20	Phantom Ranch	87.5	17:25	4	18:20	4	Phone,AP
21	Granite Rapid	93.2	19:10	4	9:20	5	C
22	Crystal Rapid	98.2	10:45	5	12:00	5	Rapids
23	Below Crystal	98.8	12:10	5	12:50	5	Repairs
24	Lower Bass Camp	108.5	14:15	5	16:20	5	BR,L
25	114 Mile	114	17:10	5	17:30	5	BR
26	Elves Chasm	116.5	17:50	5	18:20	5	AP
27	Blacktail	120.1	17:30	5	18:30	5	BR
28	122 Mile	122	19:00	5	9:15	6	C,BR
29	Forster	122.8	9:25	6	10:05	6	BR
30	Bedrock	131	11:20	6	11:15	6	BR
31	Dubendorff	132	11:55	6	12:20	6	BR
32	Tapeats Creek	133	12:35	6	19:00	6	BR,AP
33	Deer Creek Falls	136	19:20	6	20:20	6	BR
34	Pancho's Kitchen	137	19:25	6	9:20	7	BR,C
35	Matkatamiba	146	10:35	7	12:30	7	Lecture
36	Ledges	151.6	13:00	7	13:30	7	BR
37	Havasu Creek	156.9	13:15	7	16:45	7	AP,L
38	National Canyon	166.6	18:00	7	9:40	9	BR,C Layover
39	Fern Glen Beach	168	9:45	9	10:10	9	BR
40	Upper Lava Falls	179	12:30	9	13:20	9	BR
41	Lava Falls	180	13:25	9	13:55	9	Rapid

Table XVI-1 continued.

Stop Number	Location	River Mile	Arrive Time -	Arrive Day	Depart Time -	Depart Day	Reason For Stop
42	Lower Lava Falls	180.9	14:00	9	16:10	9	BR
43	186 Mile	186	16:55	9	17:15	9	BR
44	190 Mile	190.2	18:15	9	19:00	9	BR
45	194 Mile Beach	194	19:00	9	10:10	10	BR,C
46	Parashant	198.5	11:25	10	12:15	10	BR
47	Granite Park	208.8	14:00	10	14:45	10	BR,L
48	Pumpkin Bowl	213	15:20	10	15:40	10	BR
49	Trail Canyon	219	17:45	10	18:00	10	BR
50	220 Mile	220	18:30	10	8:00	11	BR,C
51	Diamond Creek	225	9:00	11	11:00	11	TO

BR = Beach Research
L = Lunch
C = Camp
Com= Communication with another group.

AP = Attraction Point
HP = Helicopter pick-up
TO = Take-out

Table XVI-2. Group Contacts.

Day	Miles Covered	River Mile	River-River		River-Shore		Shore-River		Total		
			P	C	P	C	P	C	P	C	T
1	19.8	0-19.8	0	0	1	0	0	2	1	2	3
2	38.4	19.8-58.2	0	0	1	3	0	0	1	3	4
3	0	at 58.2	0	0	0	0	1	2	1	2	3
4	35.3	58.2-93.5	0	0	1	2	0	0	1	2	3
5	28.4	93.5-122	0	0	0	0	1*	0	1	0	1
6	15	122-137	0	0	0	2	1	0	1	2	3
7	29.6	137-166.6	0	0	1	2	1	1**	2	3	5
8	0	at 166.6	0	0	0	0	2	5	2	5	7
9	27.4	166.6-194	0	0	0	2	0	0	0	2	2
10	26	194-220	0	1***	0	0	0	0	0	1	1
11	5.5	220-225.5	0	0	0	0	0	0	0	0	0
Total			0	1	2	11	4	10	10	22	32

P = Private
C = Commercial
T = Total

* Transported two passengers from this group through Crystal Rapid
** At Matkatamiba day contact was shore to shore
*** Floated with commercial boatmen (no passengers)

Table XVI-3. Aircraft encounters.

Day	Miles Covered	River Mile	Single Engine	Multi-Engine	Helicopter	Total
1	19.8	0-19.8	0	0	0	0
2	38.4	19.8-58.2	0	2	3	5
3	0	at 58.2	2	6	3	11
4	35.3	58.2-93.5	6	5	1	12
5	28.4	93.5-122	3	9	2	14
6	15	122-137	0	6	2	8
7	29.6	137-166.6	0	3	2	5
8	0	at 166.6	3	14	1	18
9	27.4	166.6-194	2	13	1	16
10	26	194-220	0	4	2	6
11	5.5	220-225.5	0	1	0	1
		Totals	16	63	17	96

Table XVI-4. Average group and aircraft encounters.

1. Group contacts per day.

River-River			River-Shore			Shore-River			Total		
P	C	T	P	C	T	P	C	T	P	C	T
0	.09	.09	.18	1.0	1.2	.4	.9	1.3	.9	2.0	2.9

2. Aircraft encounters per day.

Single Engine	Multi-engine	Helicopter	Total
1.5	5.7	1.5	8.7

Table XVI-5. Summary data for each trip day for years 1982-1985.

Day	1982			1983			1984			1985		
	M	C	A	M	C	A	M	C	A	M	C	A
1	19.0	2	7	20.0	4	0	24.0	4	1	19.8	3	0
2	15.0	6	3	32.2	3	3	29.0	6	4	38.4	4	5
3	24.5	2	2	0.0	0	8	7.5	3	4	0.0	3	11
4	26.0	3	4	19.8	3	4	15.0	5	4	35.3	3	12
5	27.5	3	13	21.4	6	17	21.0	3	12	28.4	1	14
6	0.0	4	8	29.4	2	31	25.5	3	38	15.0	3	8
7	13.0	3	7	0.0	3	38	0.0	3	29	29.6	5	5
8	17.5	1	4	43.2	14	7	44.0	4	8	0.0	7	18
9	16.0	8	5	42.4	2	28	0.0	4	10	27.4	2	16
10	28.5	2	5	16.1	1	2	42.8	9	10	26.0	1	6
11	26.0	3	3				55.0	2	2	5.5	0	1

Figure XVI-1. Daily miles, contact/groups, and aircraft for 1982, 1983, 1984 and 1985 with averages.

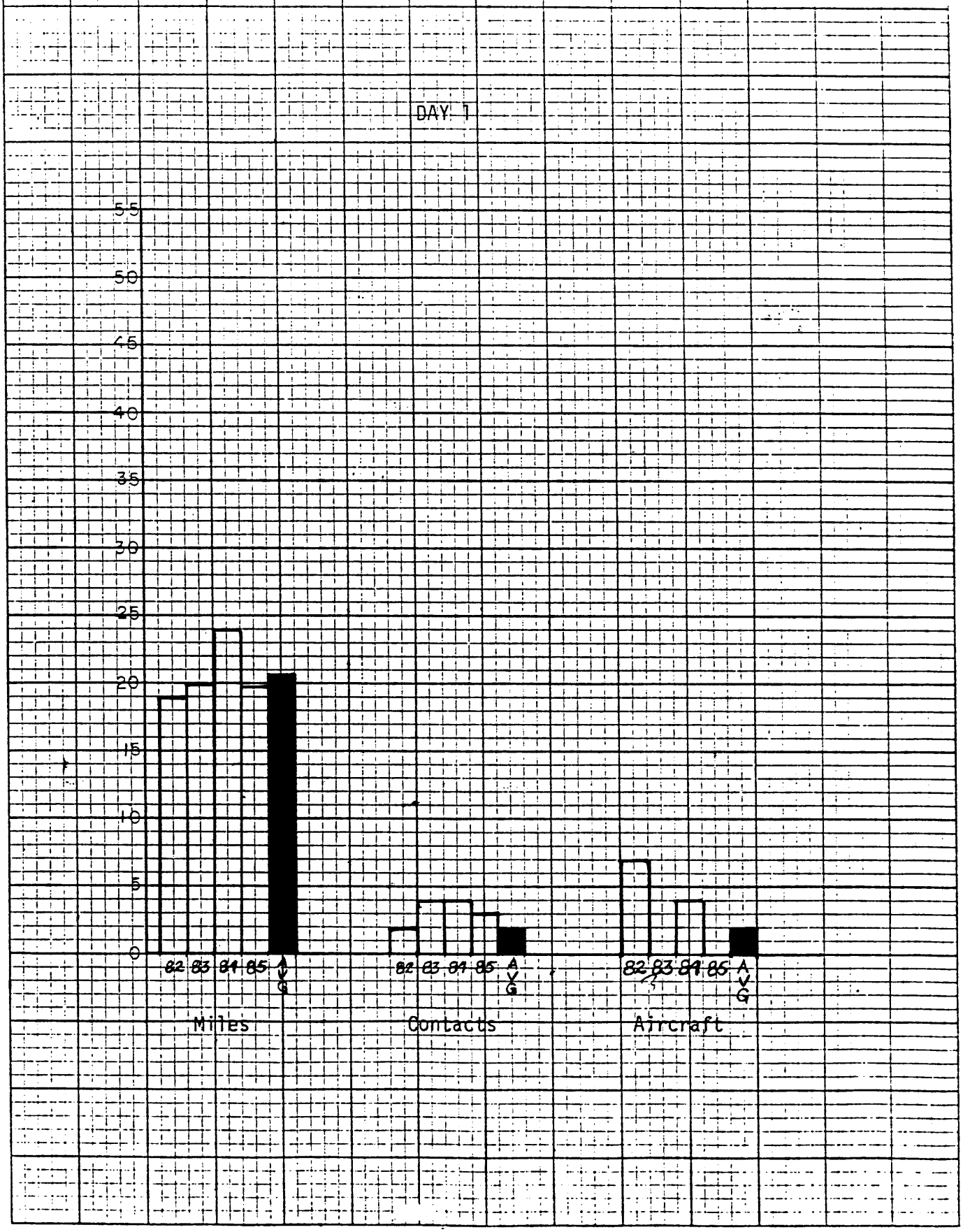


Figure XVI- 2. Daily miles, contact/groups, and aircraft for 1982, 1983, 1984 and 1985 with averages.

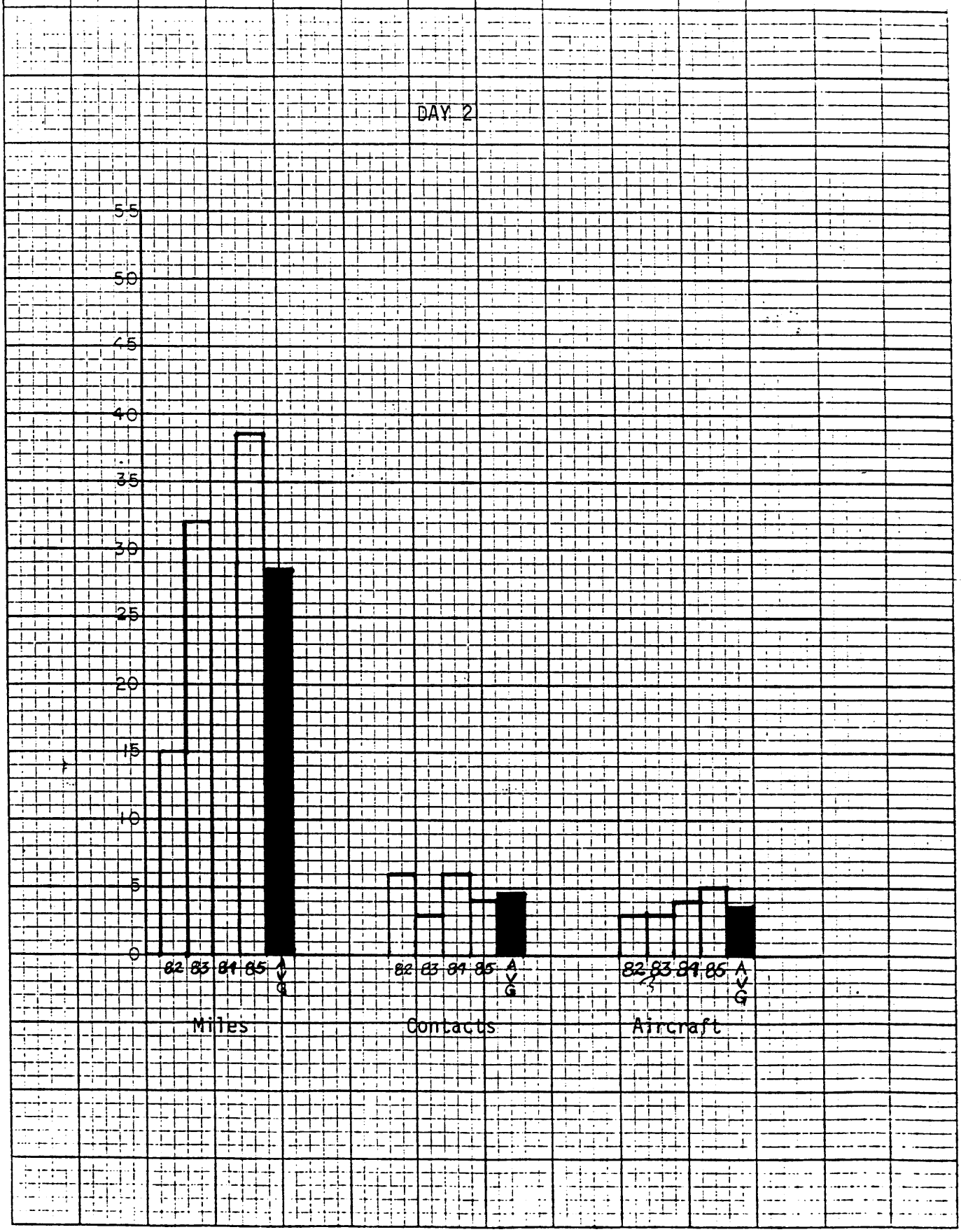


Figure XVI- 3. Daily miles, contact/groups, and aircraft for 1982, 1983, 1984 and 1985 with averages.

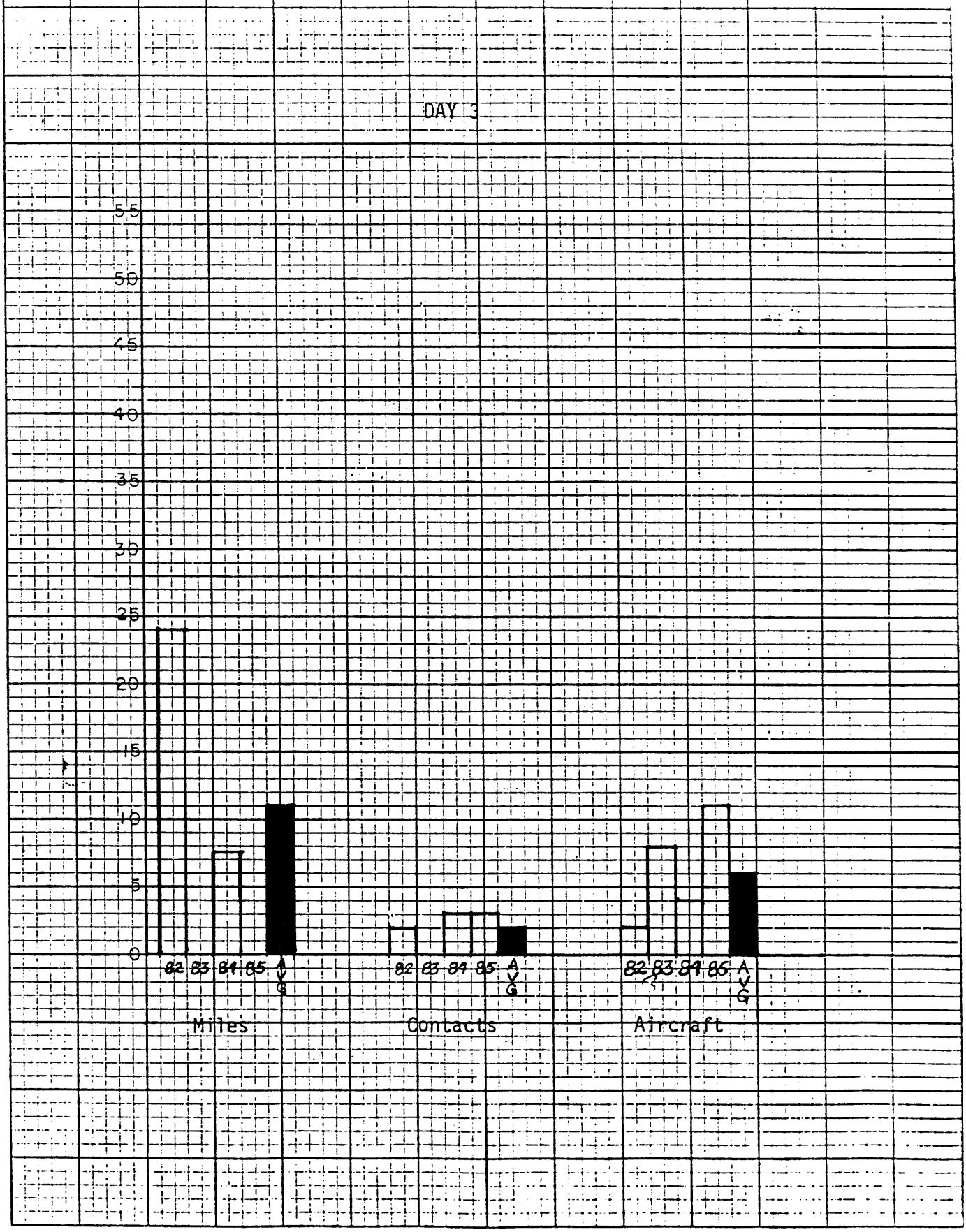


Figure XVI- 4. Daily miles, contact groups, and aircraft for 1982, 1983, 1984 and 1985 with averages.

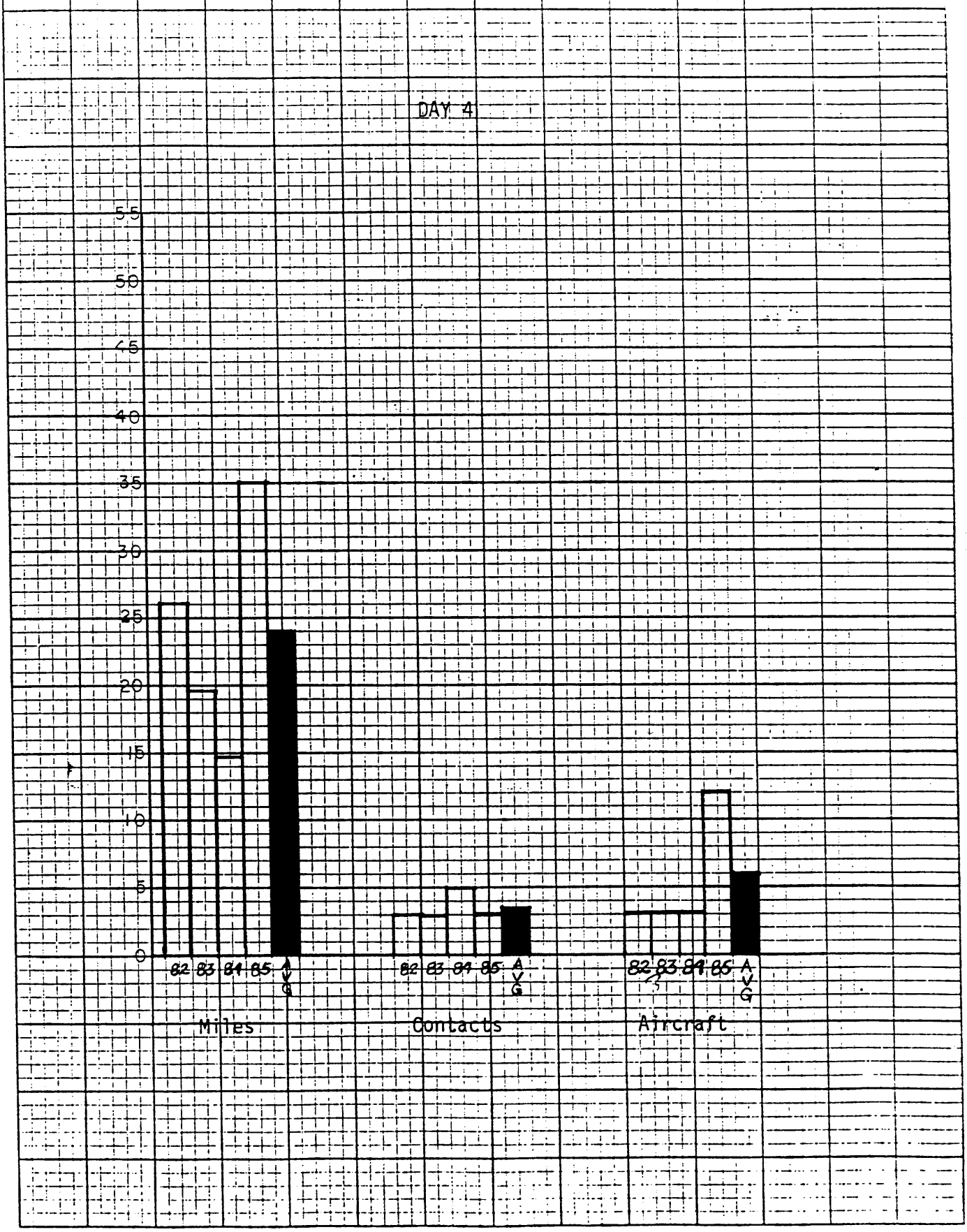


Figure XVI- 5. Daily miles, contact/groups, and aircraft for 1982, 1983, 1984 and 1985 with averages.

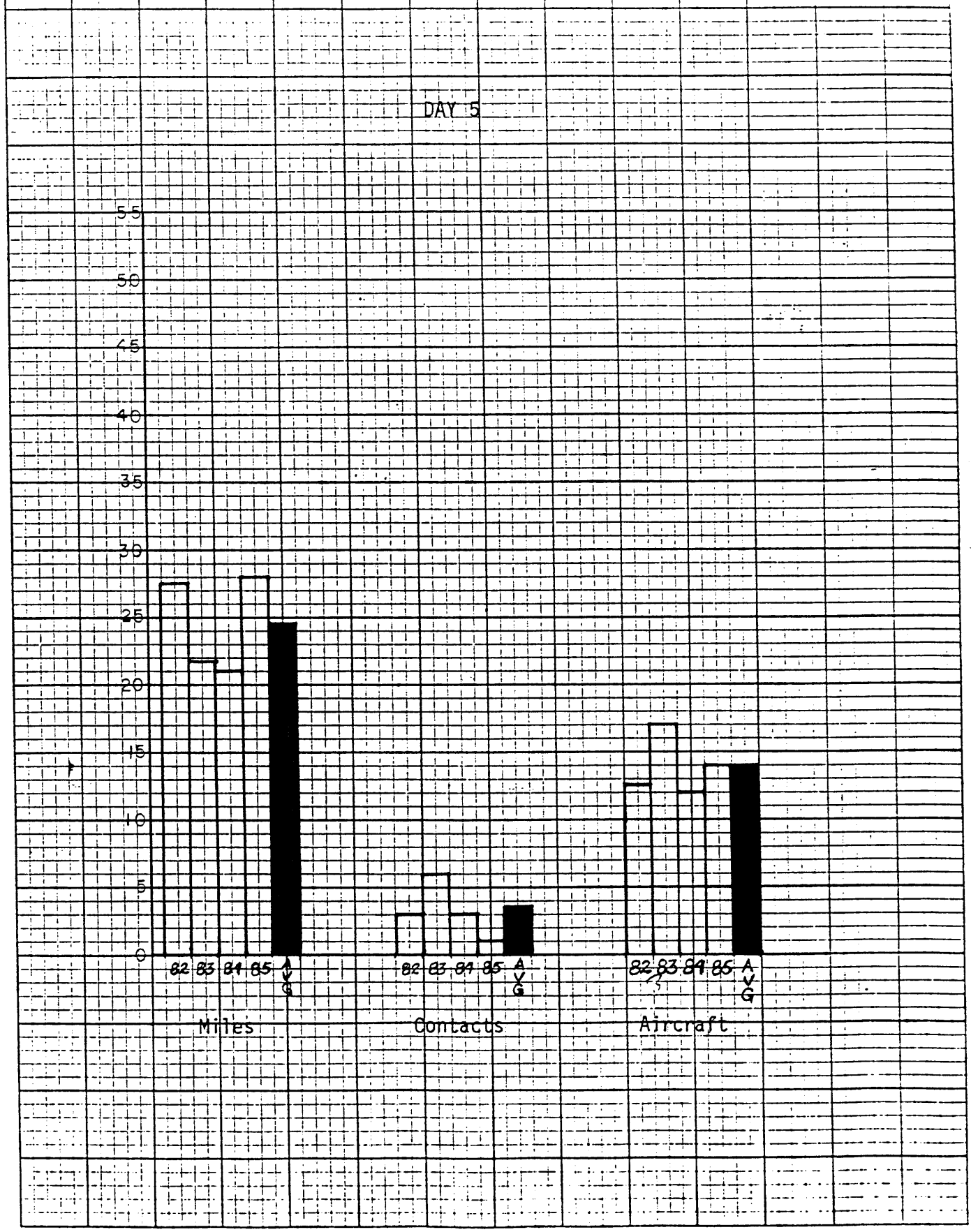


Figure XVI-6. Daily miles, contact/groups, and aircraft for 1982, 1983, 1984 and 1985 with averages.

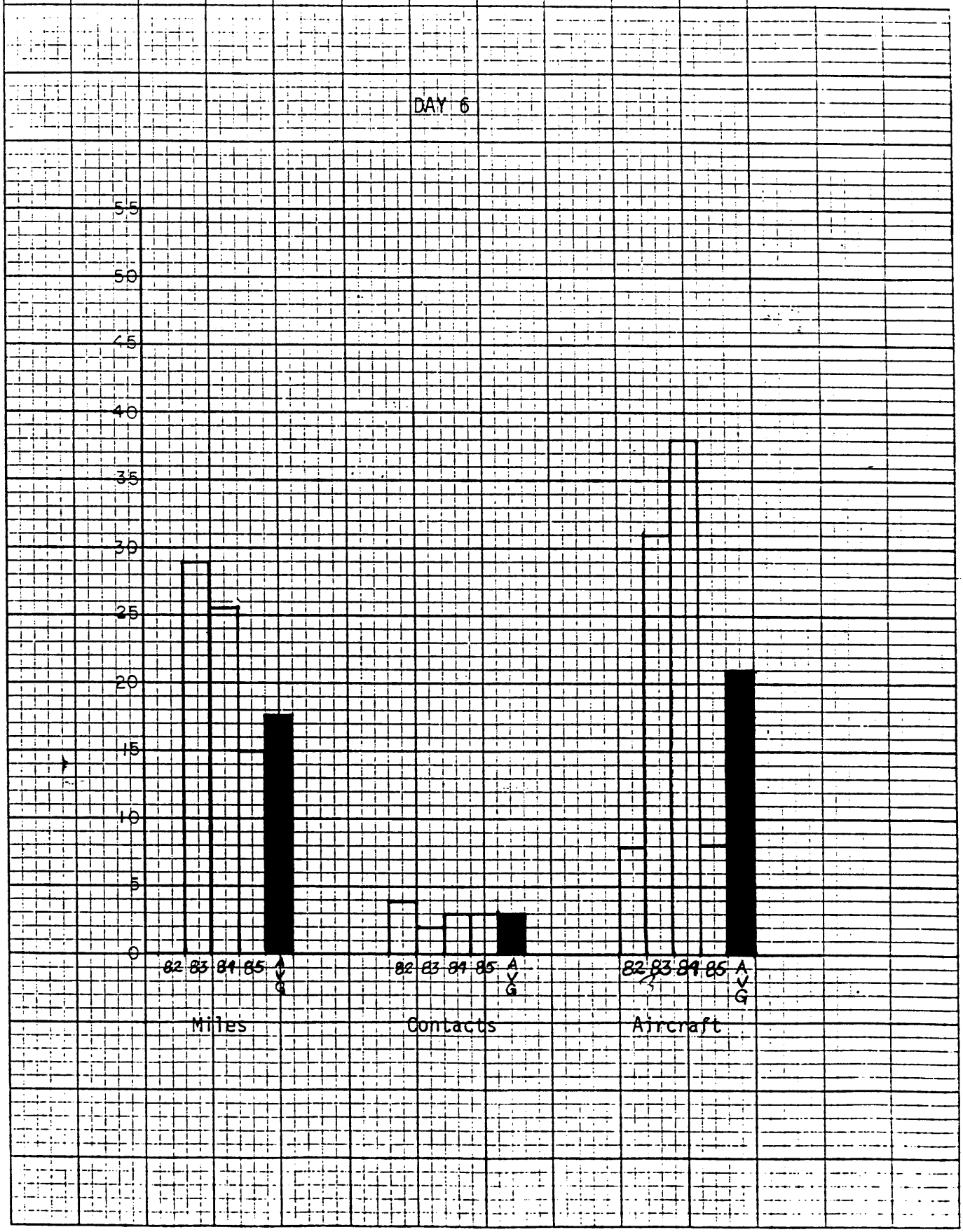


Figure XVI- 7. Daily miles, contact/groups, and aircraft for 1982, 1983, 1984 and 1985 with averages.

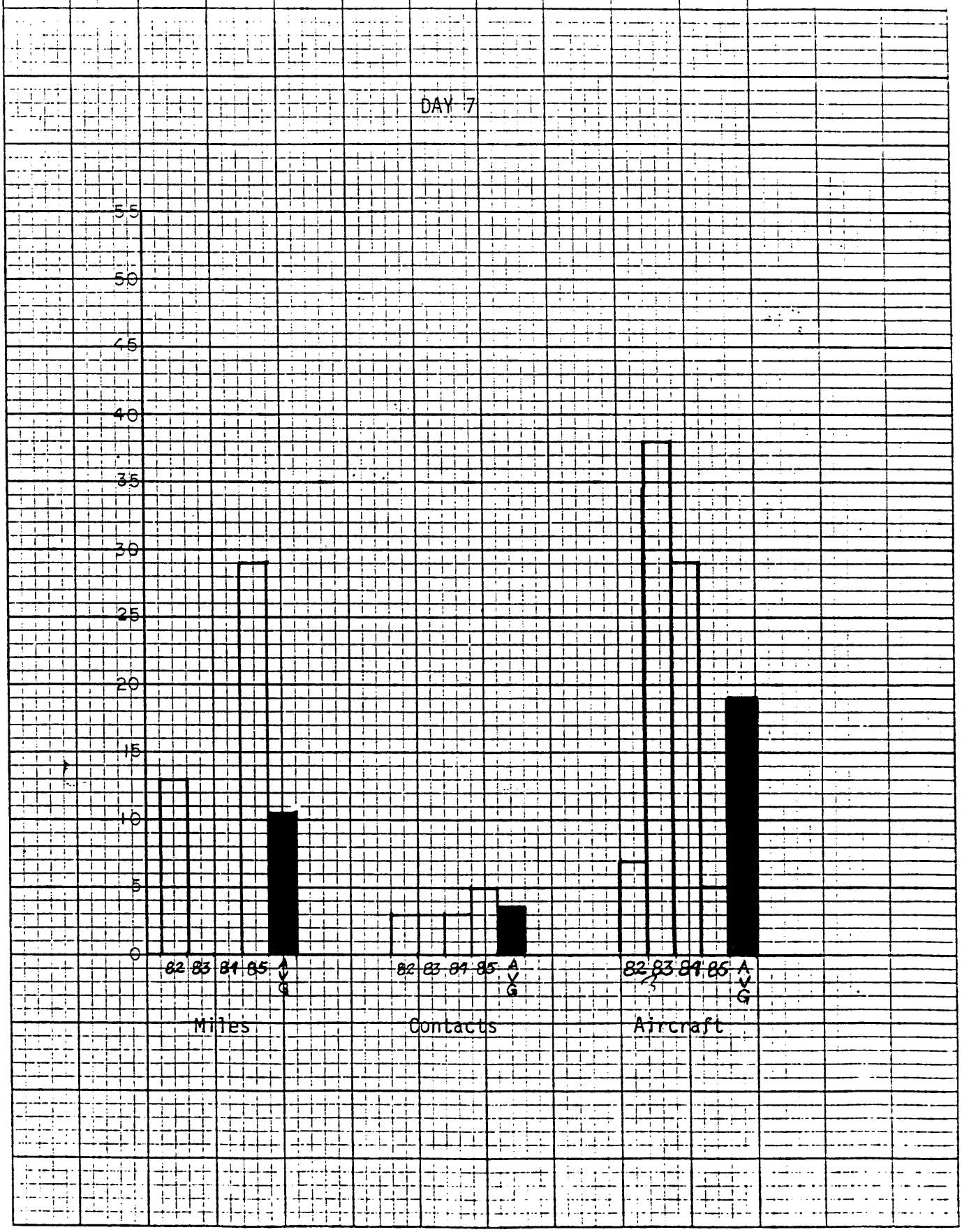


Figure XVI- 8. Daily miles, contact/groups, and aircraft for 1982, 1983, 1984 and 1985 with averages.

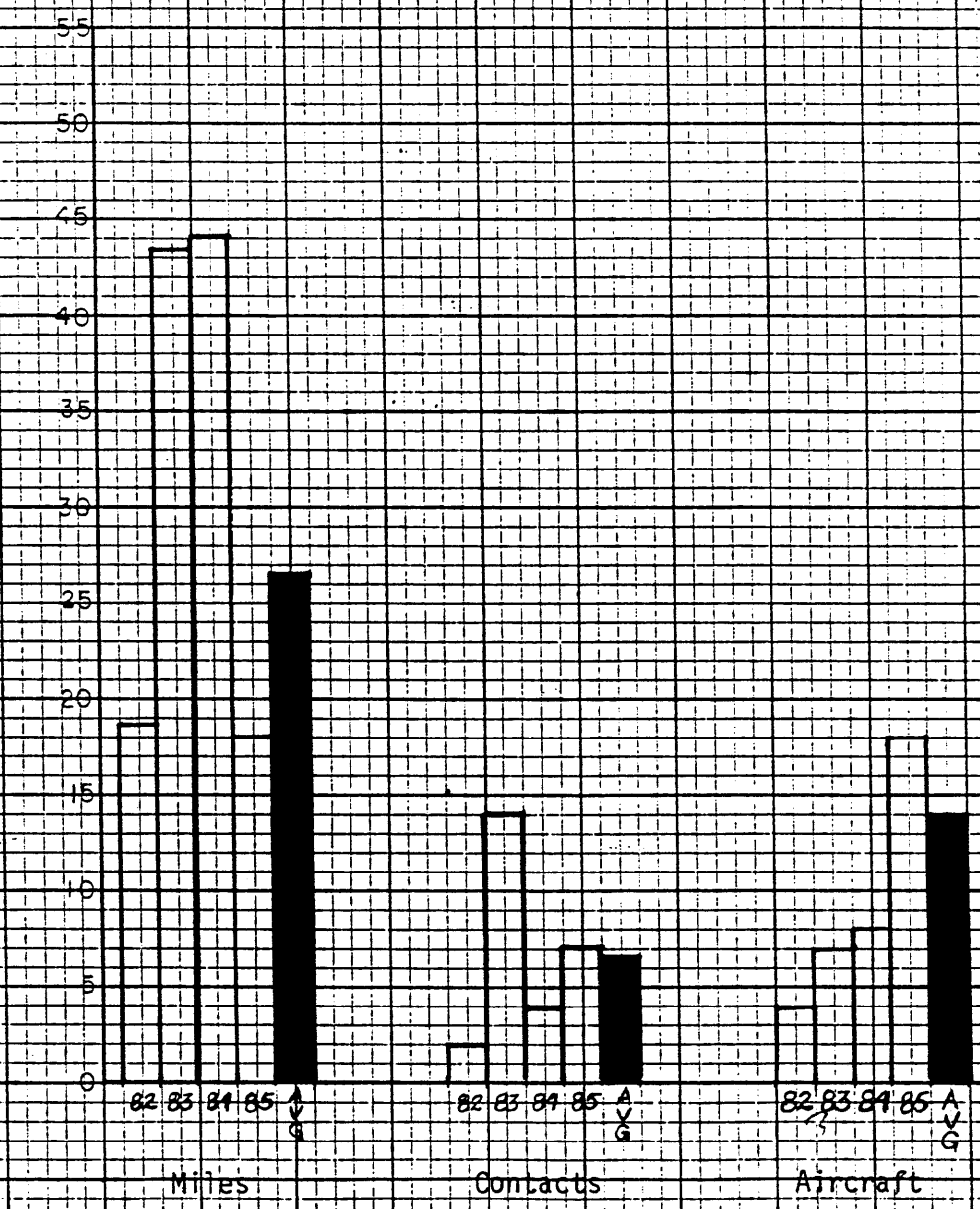


Figure XVI- 9. Daily miles, contact/groups, and aircraft for 1982, 1983, 1984 and 1985 with averages.

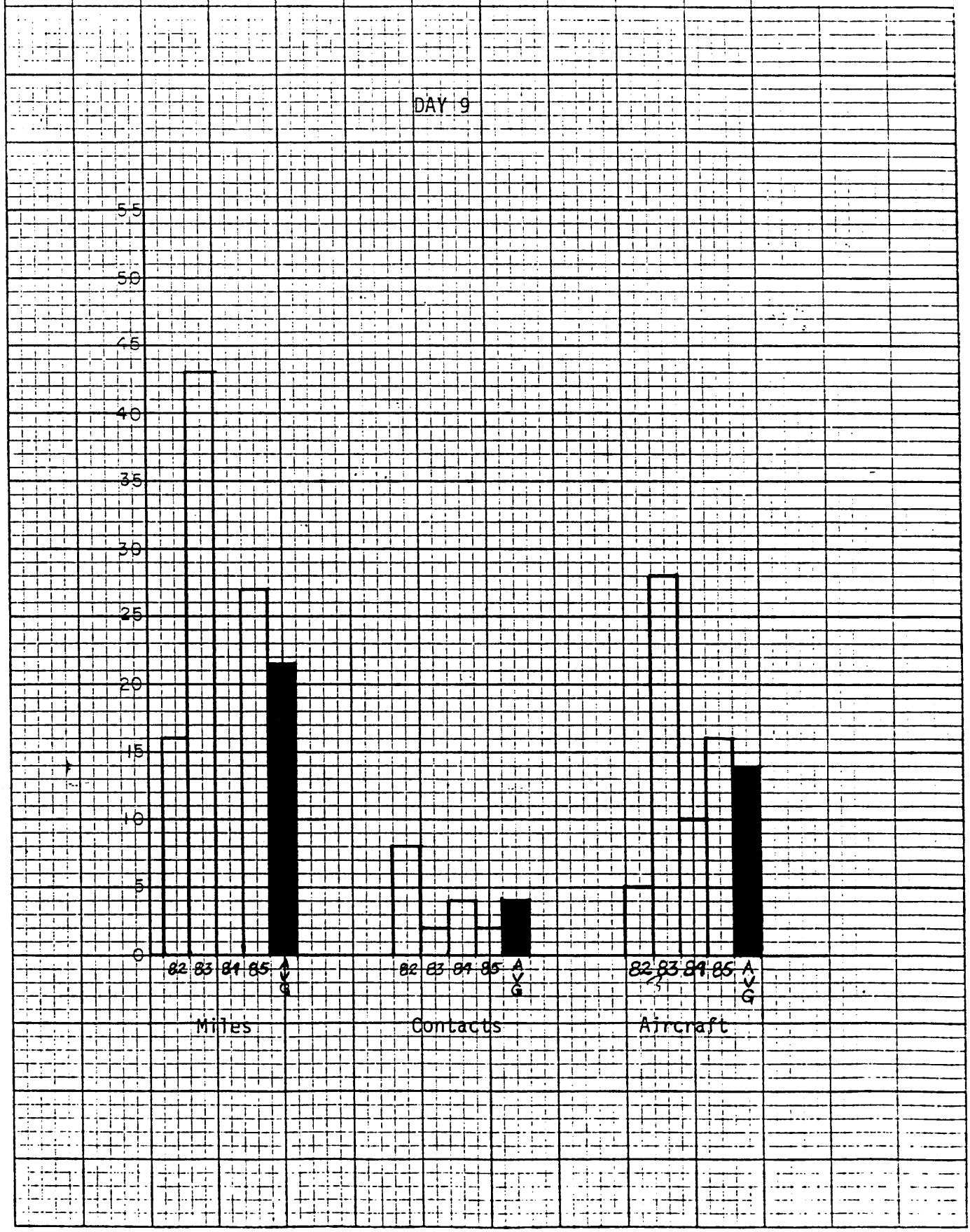


Figure XVI- 10. Daily miles, contact/groups, and aircraft for 1982, 1983, 1984 and 1985 with averages.

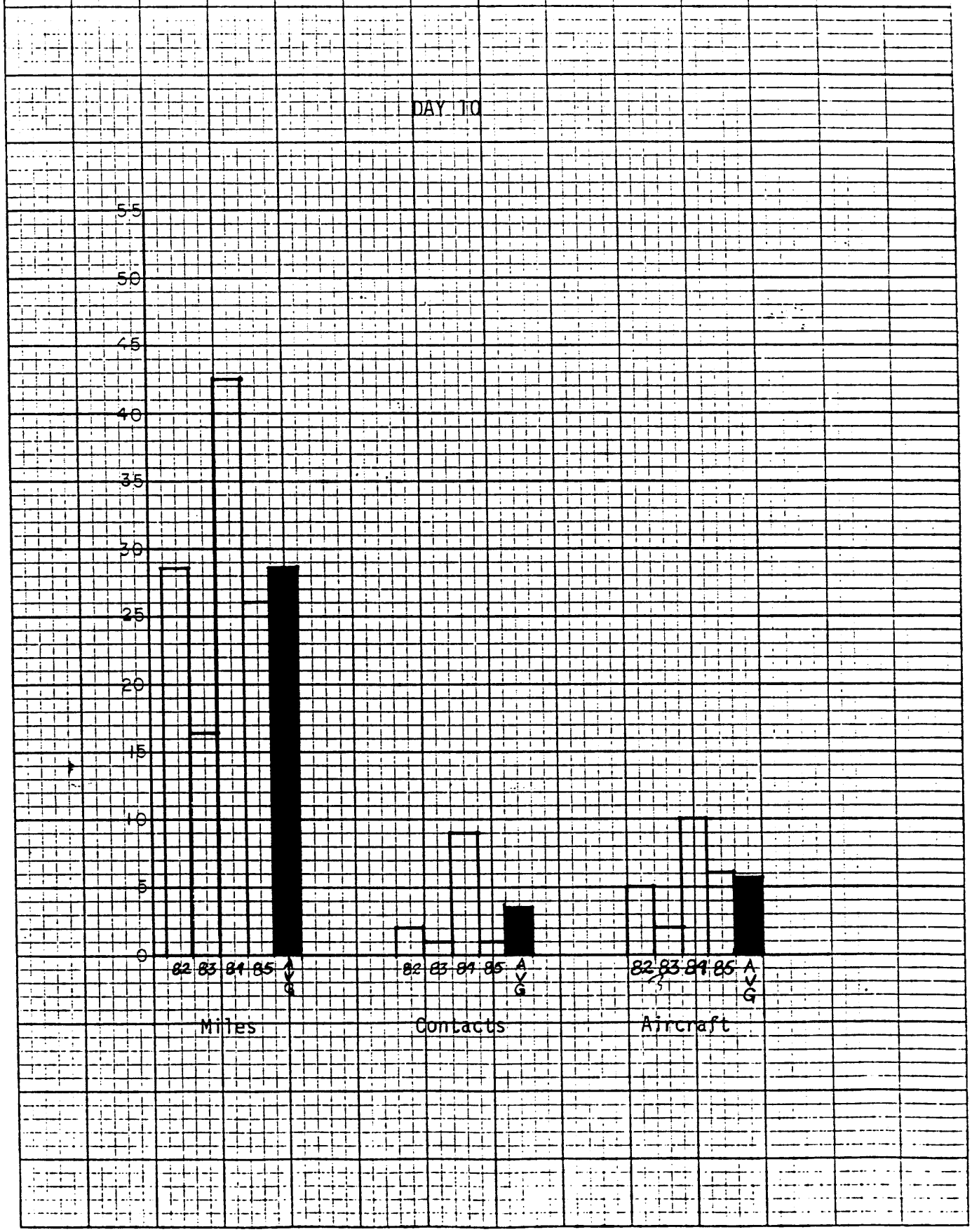
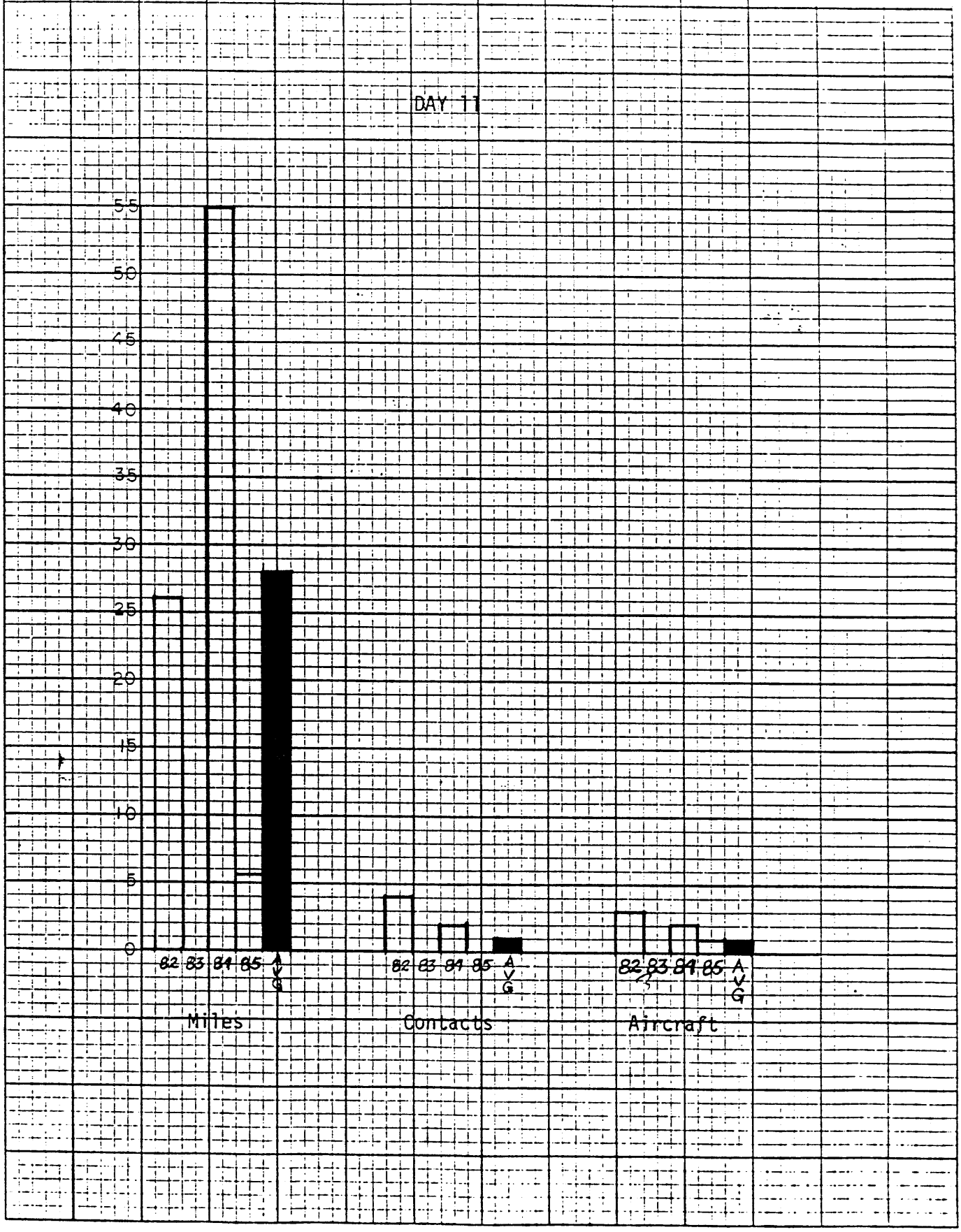


Figure XVI-11. Daily miles, contact/groups, and aircraft for 1982, 1983, 1984 and 1985 with averages.



CAMPSITE LOG

Trip: SNAV Aug 1- Aug 11

Day #	1	2	3	4	5	6	7	8
LOCATION	20 mile Back	Anatubi	Anatubi	Lower Nankoweap	Lower granite	12 mile Back	Pancho Kitchen	Lower National
PROXIMITY (1) See or Hear (2) See and Hear (3) Right Next To (4) Camped Alone	4	4	4	4	4	4	4	4
Alternate Camp? (1) No (2) Yes	1	1	1	2	1	1	1	2

CAMPSITE LOG

Trip: _____

Day #	9	10	3	4	5	6	7	8
LOCATION	Lower National	19 mile Back						
PROXIMITY (1) See or Hear (2) See and Hear (3) Right Next To (4) Camped Alone	4	4						
Alternate Camp? (1) No (2) Yes	2	1						

TRIP SCHEDULE

Outfitter: _____ Propulsion: _____ Trip: _____

LOCATION Name	Mile	ARRIVE Time	ARRIVE Day	LEAVE Time	LEAVE Day	STOP FOR
Lee's Ferry	0					

See attached.

N.P.S. PATROLS - SUMMARY SHEET

Recorder: John Saluato

Trip leaving date: Aug 1, 1985

Length of trip 11 days (first and last included).

Trip type (motor, oar): motor

Trip size:

People in party (include boatpersons): 38

Number of boats: 4

People per boat: 7-10

Take-out point: Diamond Head

Any additional comments or unique aspects of this trip:

Day 5 of 11 DAILY RIVER CONTACTS Trip: NAV

	CONTACT	1	2	3	4	5	6	7	8	9
	Group Name	Private	Private	Wilderness Ad	Comm					
	River Mile	98	99	99	130					
	Time of Day	pm	pm	pm	pm					
	Time in sight (min.)	60	90	5	10					
	Duration of contact (min.)	60	90	1	10					
Trip Type	(1) oar (2) motor	1	1	2	2					
	(1) private (2) commercial	1	1	2	2					
Size of Contact	Total # people	14	14	50	20					
	Total # boats	4	4	2	2					
	# Times You've Seen This Party	3	3	1	2					
Nature	(1) ignored (2) wave only (3) verbal greeting (4) chat (5) conversation	5	5	2	5					
	Information (1) no (2) yes									
	Reprimand									
	Citation									

Day 6 of 11 DAILY RIVER CONTACTS Trip: NAV

	CONTACT	1	2	3	4	5	6	7	8	9
	Group Name	Private	Wilderness Ad.							
	River Mile	137	137							
	Time of Day	pm	pm							
	Time in sight (min.)	60	5							
	Duration of contact (min.)	10	1							
Trip Type	(1) oar (2) motor	1	2							
	(1) private (2) commercial	1	2							
Size of Contact *	Total # people	16	20							
	Total # boats	4	3							
	# Times You've Seen This Party	4	2							
Nature	(1) ignored (2) wave only (3) verbal greeting (4) chat (5) conversation	5	2							
	Information (1) no (2) yes									
	Reprimand									
	Citation									

* Plus 4 Kayaks

Day 7 of 11 DAILY RIVER CONTACTS Trip: NAV

	CONTACT	1	2	3	4	5	6	7	8	9
	Group Name	Wilderness	Commercial	Private	Private					
	River Mile	136	136	138	138.5					
	Time of Day	pm	pm	pm	pm					
	Time in sight (min.)	30	30	2	2					
	Duration of contact (min.)	30	10	1	11					
Trip Type	(1) oar (2) motor	2	2	2	1					
	(1) private (2) commercial	2	2	1	1					
Size of Contact	Total # people	36	20	16	19					
	Total # boats	2	2	2	4					
	# Times You've Seen This Party	1	2	1	1					
Nature	(1) ignored (2) wave only (3) verbal greeting (4) chat (5) conversation	5	5	2	2					
	Information (1) no (2) yes									
	Reprimand									
	Citation									

Day 8 of 11 DAILY RIVER CONTACTS Trip: NAV

	CONTACT	1	2	3	4	5	6	7	8	9
	Group Name	Private	Comm.	Jessie River	Wilderness Ad	White water	Private			
	River Mile	166	166	166	166	166				
	Time of Day	AM	AM	AM	pm	PM	pm			
	Time in sight (min.)	10	30	30	90	5	10			
	Duration of contact (min.)	10	30	30	90	2	5			
Trip Type	(1) oar (2) motor	1	2	2	2	2	1			
	(1) private (2) commercial	1	2	2	2	2	1			
Size of Contact	Total # people	14	30	34	36	50	20			
	Total # boats	4	2	2	2	2	2			
	# Times You've Seen This Party	2	2	2	3	1	2			
Nature	(1) ignored (2) wave only (3) verbal greeting (4) chat (5) conversation	4	5	4	5	2	2			
	Information (1) no (2) yes									
	Reprimand									
	Citation									

ATTRACTION SITE REPORT FORMS

Location: Little Colo.

Elves X

Tapeats ____

Deer Creek ____

Havasu ____

Date: Aug 5 1985

Time: 17:50 – 18:20

Arrival Time	Departure Time	Outfitter/Private	# People
1750	18:20	NAU Humphrey Summit	38

Observer: John Salvato